

CENTRAL BOARD OF IRRIGATION AND POWER

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SYMPOSIUM
ON
DETERMINATION OF COSTS AND BENEFITS
OF
RIVER VALLEY PROJECTS
1953

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FOREWORD

The Board has great pleasure in bringing out in book form the proceedings of the Symposium on 'Determination of Costs and Benefits of River Valley Projects' held in October 1953 during the 24th Annual Meeting of the Board. This subject was proposed to be discussed under the following aspects though the papers actually presented do not confine themselves strictly to the subjects as defined.

(1) *Costs*—

- (a) General review of costs of different items of the Projects and their general variation with different factors such as location, etc.
- (b) Speed of construction and costs.
- (c) Economies that can be effected by—
 - (i) Mechanisation.
 - (ii) Research and Model experiments.
 - (iii) Central Design Office—Standardisation of Designs.
 - (iv) Foreign aid in equipment.
 - (v) Foreign aid in technical personnel.
 - (vi) Special training of engineers.
 - (vii) Suitable executive and administrative control of project execution.
 - (viii) Phased programme of construction of various projects.
 - (ix) Different constructing agencies like foreign contractors, big Indian constructing firms, small local contractors, labour co-operatives and department work.
 - (x) Different agencies for purchase of store and equipment.
- (d) Allocation of costs between different aspects of projects.

(2) *Direct Revenue*—

- (a) Irrigation.
- (b) Power.
- (c) Flood Control.
- (d) Navigation.
- (e) Domestic and industrial water supply.

(3) *Indirect Revenue*.

(4) *Benefits to the Community*—

- (a) Increase in agricultural and industrial production.
- (b) Subsidiary developments resulting therefrom.

- (c) Increase in per capita income.
- (d) New avenues of development.
 - (i) During construction.
 - (ii) After construction.
- (5) *Criteria for fixing Priorities.*
 - (a) General needs of the country.
 - (b) Needs of specific locality.
 - (c) Famine protection.
 - (d) Financial considerations.

In all 17 papers were contributed by various officers including one paper from Gokhale Institute of Politics and Economics on the "Problems presented by an investigation of the economic effects on large irrigation and power projects and the possible ways of dealing with them and another paper by Mr. Thompson of the T.C.A. on the "Criteria for fixing project priorities".

The Symposium was inaugurated by Shri V.T. Krishnamachari, Deputy Chairman of the Planning Commission and presided over by Shri G.L. Nanda, Minister for Irrigation and Power and Member Planning Commission. The Symposium elicited lively discussion especially on the question of best way of levying betterment fee and on the use of machinery *versus* manual labour. Shri V.T. Krishnamachari in an illuminating address laid emphasis on the points which a welfare State has to keep in view for country's development. He pointed out the conflicts between various ideas and how at different times priorities for projects may have to be fixed from different considerations. In the beginning the pressing need of the country was to make itself self-sufficient in food and emphasis had to be laid on projects which promised to make the country self-sufficient in food in the quickest possible time. Later on, however perhaps sooner than later, regional developments may require greater emphasis.

The Board takes this opportunity of thanking Shri C.L. Handa who acted as General Reporter and all the officers who took part in the discussions and Shri V.T. Krishnamachari and Shri Gulzari Lal Nanda for sparing their valuable time in inaugurating and presiding over the Symposium to make it a success.

M.L. AGGARWAL, ISE., MIE.,
Secretary,

Dated August, 1954.

Central Board of Irrigation and Power

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* As this paper was received late no discussions could be held on this paper.

CENTRAL BOARD OF IRRIGATION AND POWER
SYMPOSIUM

NEW DELHI, 1953

INAUGURAL ADDRESS

Inaugural Address

by

V.T. Krishnamachari,

Deputy Chairman, Planning Commission.

Shri V.T. Krishnamachari said : "It gives me much pleasure to inaugurate this Symposium on 'Determination of Costs and Benefits of River Valley Projects, including Irrigation, Power, Flood Control and Navigation.' I find that a large number of useful papers have been circulated to us on these subjects and I am sure that all of you have read them with interest as I have done. The papers do not confine themselves strictly to the subject as defined. It is not possible to isolate this from connected subjects. It is just as well that the writers of these papers have gone beyond the scope laid down by the precise sub-heads under the main subject. It is not my intention in what I am going to say to deal with the various points comprised in the subject but I shall confine myself to a few important general features.

The projects can be broadly grouped into three categories :

- (i) Multi-purpose projects,
- (ii) Medium projects, and
- (iii) Minor irrigation schemes.

Each category of projects has its own place in India. There are relative advantages and disadvantages in each one of these categories. There are certain areas in the country where there is scope for multi-purpose projects but such areas are limited. Again, there are areas, and, these are large in number where there is scope for medium irrigation projects. Minor irrigation schemes are practicable all over the country. There is no conflict between these schemes—as to which should be taken up and which should not be taken up. The question facing the Planners is to give the right place to the different kinds of projects in the general scheme and to decide how many of these different types of schemes should be

included and on what principles. There is, as I have said before, room for all of these projects in India—each one of them has got its own relative place in these schemes. Our programme is a varied one. As India is a large country, all types of schemes are included in the Plan. The only condition insisted on is that they are shown to be remunerative and useful. The present Five-Year Plan includes 8 projects costing above Rs. five crores; sixteen schemes costing between Rs. one crore and five crores; twenty-one projects costing between Rs. 50 lakhs and Rs. one crore; 27 projects costing between Rs. ten lakhs and fifty lakhs. A number of projects costing below five lakhs are included in the Plan either under the Irrigation and Power Schemes or under Minor Irrigation Schemes. Our aim has been to include different kinds of projects for areas for which these are suited.

All of them have their advantages. In 'Multi-purpose Projects' much more secure irrigation is assured than in other kinds of projects. They also generate electricity which can bring about a revolution in the countryside. The disadvantages are that these projects cost large sums and a vast technical organisation is required for them over a series of years. Secondly, much time is taken for development of irrigation and utilisation of power and huge amounts of money are locked up for years.

As regards 'Medium Projects,' these can be completed within a few years; irrigation can be developed in a short time and much capital is not locked up. On the whole, the 'Medium Projects' are advantageous. They can give assured supply. They do not cost so much. Organisation is easier and development of irrigation can take place more quickly.

'Minor Projects' can be spread all over the country, as facilities for these are available almost everywhere. In this case, the cost is small. We can get co-operation from the people for them. The disadvantages are that they depend entirely on rainfall and the protection to the irrigated area is small. They are not connected with streams or rivers. The disadvantage lies in their maintenance which has to be organised by the village communities. It is not possible for the Government Departments to maintain a large number of small works all over the country and responsibility for maintenance has to be placed on the village communities. Such 'Minor Projects' can thus give rise to many administrative and other problems.

I shall now say something about 'Priorities'. Here, every attempt should be made to reconcile All-India needs with regional requirements. The pressing problem is that of making India self-sufficient in food and from this point of view we should carry out the most remunerative schemes as quickly as possible. There are, broadly speaking, two considerations. On the one hand, there are those schemes which yield the largest results with the minimum of expenditure and in the minimum possible time, irrespective of where they are. This cannot, however, be the only consideration in our Plan. It is also our duty to see that regional development is not neglected. Scarcity areas should get their due share of development. Thus the two conflicting points of view have to be reconciled.

In the earlier stages emphasis had to be placed on All-India considerations but sooner or later—sooner than later—regional development must find its emphasis in the programme. It is correct to say that more emphasis was laid in the beginning on the large projects in first Five-Year Plan, mainly because most of them had been commenced already ; but now the Planning Commission is stressing regional development. All of you know that in the remaining $2\frac{1}{2}$ years of the planning period that remain, it is proposed to spend Rs. 40 crores on irrigated works for the benefit of scarcity areas. This of course is in addition to the regional projects to which I referred a little while ago and which are already embodied in the Plan.

There is another important point which I should like to mention. It is this. In regard to large projects we have not yet succeeded in achieving efficiency of organisation and in bringing about a sense of proprietorship in the people ; both are obviously necessary for successful implementation. We have not realised that for carrying out projects of the dimensions of Bhakra Nangal, a revolutionary change is needed in our methods. The old traditional methods that have been followed for comparatively smaller projects will not do. What happens is that our officers prepare estimates, make arrangements for construction of the dams and canals, prepare compensation schedules, etc., in a more or less detailed form. While all this work goes on, the people of the areas concerned do not know what is happening about these great projects. They are not aware of their rights or their obligations. They do not know how they are going to benefit from the project and what obligations they should undertake in return for the benefit. For example, the people who are

benefited do not realise that they should co-operate in resettling the villagers whose houses and lands are submerged in order that the new lands may receive irrigation. In other words, they are uninterested spectators while the works are designed and executed. After the construction of dam the task of developing irrigation begins and the Central Government has to spend large funds for developing lands for irrigation. The finances of the Central Government are limited. As the people have not been prepared beforehand, there is an enormous time lag and development of irrigation waits until finances become available and the result is that projects cease to be remunerative. The people should feel from the outset that they are the owners of the project. It is the duty of the officers to prepare the people concerned for exercising their rights and they should be taught what their obligations are to the community as a whole. They should be taught that the amount spent on the projects would benefit them only if they whole-heartedly give their co-operation and work for the project. Unless this change in the people comes about and the officers work on the project with this aim and the training of the people for development of irrigation and for the utilization of power goes on side by side with the construction of the project, we cannot hope to achieve satisfactory results. Owing to this neglect, multi-purpose projects impose a great strain on the resources of the Centre and Government gets involved in two or three projects for many years and cannot take up and implement many multi-purpose projects for which there is great demand in other parts of India. The amount of water that is going to waste in the rivers of India is stupendous. All this water has got to be impounded for the benefit of the community and we have to take up more and more of these multi-purpose projects. Unless and until there is a mental revolution such as I have described and the people who are benefited are taught to accept the obligations entailed, there cannot be progress in regard to such large schemes. Every locality should regard itself as the proprietor of the project responsible for its working and should be prepared to make the necessary sacrifices. Otherwise the Centre gets tied down to a few projects indefinitely and cannot support others which are badly needed. Our officers must not only work on technical aspects but also organise the people psychologically as partners in a great enterprise.

I shall now turn to other matters. There are a number of useful papers on technical subjects. There is a paper from Central Water

and Power Commission in which the technique of earth dams is dealt with. There are three or four papers dealing with the economies effected by experiments with models. It is always possible for engineers to get the best value of the material by using it economically. There should be a comparison of results in different projects. Some papers discuss the financing of these projects including betterment levees and contributions. This is an important point. The need for the levy of betterment fee is recognised. The basis on which it should be levied will naturally vary from area to area. But once the principle is accepted the basis should be left to the State Governments to decide. Some State Governments base the betterment levy on the increase in market value of the land ; others on the additional yield. Here again, the people who are to benefit by such projects should be taught why there should be a betterment levy. Discussions about betterment levy should take place from the very beginning, while the project is being worked out. Such discussions should be held with the people concerned and they must be consulted as to the manner in which they will contribute to the construction. In Madras, offers from people who are to be benefited by projects vary from Rs. 300/- to Rs. 400/- per acre. Here, the officers who work out their schemes visit the villages concerned, make the villagers understand what the projects are and ask them to contribute towards the projects so that the execution and completion of the projects may become possible. The people are made to feel that the financing of the projects is also their concern. This example should be followed elsewhere.

In discussing the paper on 'Direct and Indirect Benefits of Projects', I should like to sound a note of warning. When you bring in the conception of indirect benefits, there is no knowing where to stop. What are the benefits which you want to take into account ? With the help of the water available, additional crops are grown. In this the agriculturists have to incur considerable expenditure. This should be a set-off when you talk about indirect gains. Similarly, the use of power generated calls for large capital outlays. This has to be allowed for. On the whole, I would suggest that the distinction between remunerative projects and protective projects which is a well-understood one meets all the practical requirements. The Government will have to decide how much they can afford keeping in view their resources for financing protective projects which are not directly remunerative. The conception remains that we have

two sets of projects—firstly, those that are directly remunerative, and secondly those which have to be constructed for protecting scarcity areas whether they are directly remunerative or not. Irrigation projects can be made more remunerative if people are taught economy in the use of water. If a man digs a well on his own land, he uses much less water for irrigation than the man who gets water from a canal. Use of water should be economised as far as possible and practicable. They should also be taught soil conservation. Further, engineers have to study, in regard to scarcity areas, where irrigation ceases to be remunerative and measures like contour-bunding and conservation of moisture should be resorted to. This subject needs careful study.

There is another problem—that of personnel for multi-purpose projects. It goes without saying that we cannot execute the project of such magnitude without efficient technical personnel. This is important at the moment because we find that there is a serious shortage of technical personnel in many projects. The higher personnel—Chief Engineers and Superintending Engineers—form the most important personnel for these projects. To say that there is no shortage of such personnel in the country is not correct. In the last 20 or 25 years there have been no big irrigation projects in India. This was due to serious shortage of funds and also to transfer of political power which was impending. The Governments felt that their main duty was to enact a new constitution and transfer power to the people and did not have the time to launch on large projects. Due to these reasons, a large number of officers who are now in higher grades, have not obtained practical experience in large works. This has to be borne in mind. Senior officers in States should be enabled to obtain practical experience in the large multi-purpose projects. There is also a serious shortage of supervisors, foremen, etc. Thus administration has to make arrangements for the training of a sufficient number of people in these categories not only for existing projects but also for future projects. The Planning Commission envisages a plan for Irrigation and Power projects for the next 15 years. From that point of view the training of personnel should be planned on the long-term basis.

I am afraid I have detained you much longer than I expected. Nothing is more important from the point of view of the Planning

Commission than that there should be closer scrutiny at every stage of the cost and benefits of all projects and to me it is a matter of great pleasure that engineers from all parts of India are applying their minds to this very important problem.

CENTRAL BOARD OF IRRIGATION AND POWER
SYMPOSIUM
NEW DELHI, 1953 **GENERAL REPORT**

General Report

by

C. L. Handa, I.S.E.,

Joint Director, Bhakra Dam Designs Directorate.

INTRODUCTION

In order to facilitate the deliberations on the Symposium, for which 16* papers are before this meeting, the writer, has, on a request from the President, Central Board of Irrigation and Power, prepared a brief general report indicating the main points presented by the authors. So that the discussions may cover some of the specific issues, a set of questions has been framed, embodying the sub-heads given in the circular inviting contributions

No attempt has been made by the writer to prepare exhaustive summaries. This would have considerably lengthened the general report and defeated its purpose. It is expected that the authors will throw light on their viewpoints by addressing the House on relevant issues.

In certain cases, the questions cover somewhat larger ground than is envisaged in the various papers. This, it is hoped will still further add to the interest and value of the Symposium. Many other experienced members of the profession who have not contributed papers, may like to give their opinions in this meeting. This will be of great value.

Some of the papers relating to the Symposium have come to hand only this week. Hence there has not been the requisite time and opportunity for their circulation. It is particularly for this reason that a general report was considered called for, to assist the parti-

* The paper No. XVII by Shri Kissen Kanungo having been received late could not be incorporated in this General Report.

participants in a fuller co-operation for making the Symposium fulfil the object in view *i.e.*, a comprehensive exchange of ideas on a subject fore most in the country's Five-Year Plan—River Valley Projects.

LIST OF QUESTIONS

(Names of contributors in parentheses)

- Q. 1. To what extent should the indirect gains and benefits to the community be considered along with the direct gains in assessing the productivity index of a particular river valley project ? (Kanwar Sain; Thompson; Gokhale Institute; Parthasarthy ; Gole ; Swayambu).
- Q. 2. What should be the yardstick for levy of betterment charges in order to make river valley projects conform to the acceptable criteria for the productivity index ? (Kanwar sain ; Hiranandani).
- Q. 3. What should be the criteria for fixing priorities between various projects from the local, regional and national aspects? (Kanwar Sain ; Thompson ; Rao ; Handa).
- Q. 4. To what extent can differences of cost on various items on the projects be regarded as acceptable in view of special factors such as location, size, local resources and availability ? The term item to be taken as covering :—
(a) Labour costs ; (b) Materials available within the country or to be imported ; (c) Equipment ; (d) Project personnel.
(i) Indian ; (ii) Foreign. (Rao ; Handa).
- Q. 5. What precautions are necessary to ensure permanency of benefits, such as safeguarding against water-logging ? (Mehta).
- Q. 6. What should be the basis and extent for the introduction of mechanisation in construction methods ? (Aggarwal ; Anand ; Handa).
- Q. 7. In respect of the major projects of the country, should the planning, research and detailed designs be carried out by a Central Agency analogous to the United States Bureau of Reclamation ? (Aggarwal ; Anand).
- Q. 8. What is the role of experimental study and analysis through models and research in the planning, design and construction.

of large works? (Joglekar & Gole; Gupta; Banerjee; Rao and Pant).

- Q. 9. What should be the policy in drawing up the construction plant layout for various works and the importation of equipment? (Handa).
- Q. 10. Should the contribution of foreign personnel be taken in a consulting and advisory capacity or should they be given direct responsibility? (Anand; Handa).
- Q. 11. What is the best executive and administrative set up for the execution and control of a project? (Parthasarthy; Anand; Handa).

QUESTION 1.—*To what extent should the indirect gains and benefits to the community be considered along with the direct gains in assessing the productivity index of a particular river valley project?*

KANWAR SAIN: The author invited attention to the necessity of varying the yardstick for a 6 per cent return after 10 years to a 4 per cent return for classifying a project as productive. In 1939 in his paper "Economics of Irrigation Projects" [presented to the Punjab Engineering Congress at Lahore, and later in 1946 in his address to the Institution of Engineers (India), Lahore Centre] he emphasized that the race between "population and cultivation" demanded that India should give foremost priority to Irrigation Projects, even if the cost-benefit ratio is not as favourable as was the case in the earlier and easier projects.

THOMPSON: At the time of project planning cost-benefit studies should consider

- (a) Long range price levels for goods and services to be produced by the project.
- (b) Value of labour, materials, supplies, taxes and interest rates.
- (c) Prospective crop production, farm incomes and farm costs.
- (d) Benefits from recreational facilities, fisheries, wildlife preservation and forests.

GOKHALE INSTITUTE: The benefits that will accrue from a multi-purpose project should be studied on the basis of a short term as well as a long term policy. The short term analysis should include

direct primary benefits such as the increase in agricultural and industrial output. The long term policy should consider indirect primary benefits such as increase in employment and trade, direct secondary benefits such as income from processing agricultural produce, and indirect secondary benefits.

PARTHASARTHY : The indirect secondary and even tertiary benefits should not only be recognised but should be taken into proper account while evaluating the financial soundness or success of any River Valley Project and to determine the productivity and net results from these projects.

GOLE : The economics of Inland Navigation Projects have been analysed and stressed for incorporation in river valley projects while determining their benefit-cost ratio. The advantages to trade and distribution of commodities by adoption of the cheaper transport provided by navigable waterways, have been mentioned.

SWAYAMBU : Assessment of benefits from electric power should be based on its marketable worth. This charge should be fixed on the basis of the anticipated revenues over a period during which the power system could become self-supporting.

QUESTION 2.—*What should be the yardstick for levy of betterment charges in order to make river valley projects conform to the acceptable criteria for the productivity index ?*

HIRANANDANI : It has been brought out that the consideration and implementation of the levy of betterment fee and water rates are not uniform in the country and vary in the different regions. In the case of the land which is being classified on the Hirakud Project, it is considered that cultivators should pay to the Government half of the increment in the value of land in the form of betterment fee.

It is proposed that to avoid the complications involved in the ascertainment of change in land values, levy of betterment charges may be calculated on the net additional profit to a cultivator instead of the increase in the land values.

This is based on the principle that the collection of betterment fee will be ensured if the betterment levy instalments and irrigation

rates are not more than 50 per cent of the increased profits due to irrigation.

QUESTION 3.—*What should be the criteria for fixing priorities between various projects from the local, regional and national aspects ?*

THOMPSON : There is no better way of expression of priorities than through comparative benefit-cost analysis, the most effective use of economic resources being a major criterion. The minimum requirement of selection of a project should be that the benefit to cost ratio be at least unity. Selectivity should be aimed to a point where excess of benefits costs should be a maximum as against the ratio of benefits to cost being a maximum.

RAO : A suitable phasing of projects to suit a realistic development programme will result in considerable reduction of overall capital expenditure. Both dams and canals can be built in stages according to irrigation and other requirements.

~ In order to avoid unequal development in various parts of the country, there should be blending of projects having relatively high or low rate of financial return.

There is a tendency in some of the projects to anticipate an accelerated development. If this does not materialize, then the project will unnecessary burden the finances of the country due to accumulation of interest and depreciation.

HANDA : The best course in fixing priorities between different projects in the country would be to select those which show the highest ratio of benefits to cost. Consideration of the political boundaries of individual States of the Union should not prejudice the fixation of priorities for various projects in the country. Projects which have already been taken in hand should invariably be completed to yield maximum returns. Destructive criticism from persons who are not qualified and experienced should not stand in the way of an objective consideration of fixing priorities.

PARTHASARTHY : The various considerations which influence the drawing up of priorities have been discussed. ~ Stress has been laid on the foremost importance of food production, as an objective.

QUESTION 4.—*To what extent can differences of cost on various items on the projects be regarded as acceptable in view of special factors such as location, size, local resources and availability in respect of—*

- (a) *Labour costs.*
- (b) *Materials available within the country or to be imported.*
- (c) *Equipment.*
- (d) *Project personnel :*
 - (i) *Indian.*
 - (ii) *Foreign.*

RAO: Control is necessary in the unit cost of items of work all over the country. Although rate for masonry is fairly uniform there is large variation in the rates for earthwork and concrete, particularly where mechanization is introduced. More study and experience are needed in the obtaining and operation of equipment to obtain greater uniformity. However rates should not be hastily cut down.

The cost of irrigation projects per cusec or per acre irrigated has greatly increased relative to previous projects because of the fact that mostly storage reservoirs have to be constructed with ancilliary works as against the simpler diversion weirs and barrages of the past. This factor has made the financial returns less attractive. At present due to the absence of a new yardstick, the fact whether a project is productive or not cannot be taken much notice of.

The greatest factor to secure economy will be the willing partnership of the people located in the vicinity of the project. Portions of wages and salaries could be deferred till completion of the project when it starts functioning. Similarly, the land to be acquired may be compensated in kind by the entire community in the project area.

HANDA: Rate of cost of various items of work on all the River Valley Projects cannot be uniform. Example of concrete is given with a table showing a wide variation of rates on various projects in India and abroad. Indian Projects alone show considerable divergence. The two extremes for unit rate of mass concrete per 100 cft. are Rs. 120/- for Bhakra Dam and Rs. 243/- for Konar Dam. The

items need a very careful comparison before any opinion can be formed as to the justification of the rates at each place, as hasty opinions or conclusions are not proper, and can cause a misunderstanding.

QUESTION 5.—*What precautions are necessary to ensure permanency of benefits, such as safeguarding against water-logging?*

MEHTA: It is pointed out that alongwith the direct and indirect benefits accruing from a project some adverse effects have also become evident in the past. The author stresses in particular the problems involving the rise of sub-soil water-table and water-logging; the obstruction of natural drainages; the decrease of soil fertility; soil fatigue; and the incidence of malaria in water-logged areas. He suggests provision for such measures to be made in projects. He stresses the necessity of scientific soil surveys so that deterioration may be detected and arrested at an early stage.

QUESTION 6.—*What should be the basis and extent for the introduction of mechanisation in construction methods?*

AGGARWAL: The magnitude of a job and the time factor may necessitate the adoption of mechanization. At the time of planning, comparative estimates for various modes of construction, the question of availability of machinery and the limitations in the employment of mechanized operations should be given proper consideration. Scarcity of local skilled operators, training of semi-skilled technicians, and the question of co-ordination of manual and mechanical operations should be looked into at the early stages.

ANAND: The desirability, essentiality and economy of mechanised operations should be examined before the method of construction is decided upon. It is advisable to divide a project into sections which should be mechanised and treated separately from sections where construction is to be carried out manually. The economy of mechanised construction should be judged on the basis of competitive rates and the continuous and efficient employment of machinery. Apart from these there are certain sections of a project where accomplishment is not at all feasible without mechanisation, for example, high concrete dams and dredging.

HANDA: For speedy execution of a project, mechanisation is imperative but it should be done to a degree only and we should not

lose our balance in doing so and swing to the other extreme. Plenty of man power is available in India and only a combination of manual and mechanical labour is most suitable. This will also ensure greater employment.

In mechanisation exclusive use of large units is full of greater risk as there is continuous danger of breakdowns which would upset any theoretical lower cost expectations. Relatively lower wages of operating personnel in this country are in favour of smaller units at this stage of the project.

QUESTION 7.—*In respect of the major projects of the country, should the planning, research and detailed designs be carried out by a Central Agency analogous to the United States Bureau of Reclamation ?*

AGGARWAL : Proper training of operators and technicians for complicated machinery should be the responsibility of a centralised agency. Employment of operators in a haphazard manner should be discontinued. Such trained operators should be made available from one project to another.

ANAND : The extent of centralisation and standardization of planning and design should be studied for big projects. The Central Design Office should produce designs of all big items and type designs for smaller jobs.

It is stressed that research has two aspects, basic and applied, and it has been found that certain problems have been taken up at more than one place. This has led to duplication. It is necessary to have effective co-ordination between the various research organisations.

QUESTION 8.—*What is the role of experimental study and analysis through models and research in the planning, design and construction of large works ?*

JOGLEKAR AND GOLE : Hydraulic experiments on models can be responsible for appreciable savings at the time of planning and design of works. Two examples are cited ; (a) Straightening of alignment of Kakrapar weir as indicated by model tests saved Rs. 5 lakhs in its cost, (b) Fluming at Kotah Barrage saved Rs. 30 lakhs in the proposed design of gates.

A tabulation showing the savings due to hydraulic model investigations at the Central Water and Power Research Station, Poona from 1933 to 1953, indicates total savings of nearly 80 crores of rupees in the proposed or actual expenses on these works.

The cost of the experiments has on the other hand been quite insignificant as compared with the economies secured.

GUPTA : Model experiments can be utilized to study aspects of design that cannot be solved mathematically. The engineer has additional advantage of actually seeing his design in three-dimensions. Substantial economies were effected at the following works in U.P. with the aid of model experiments :—

- (a) Dhanauri Escape Dam.
- (b) Sluices at Bhimgoda Weir.
- (c) Elgin Railway Bridge.
- (d) Railway Bridge at Narora.
- (e) River Training Works at Tigri.
- (f) Pathri Bye-pass Spillway.
- (g) Circular Ducts for Sarda Power House.
- (h) Rangawan Earth Dam.

BANERJEE : Discusses the advantages and relative costs of supplementing the information obtained from costly drill holes by employing comparatively cheap electrical and/or seismic methods of exploration and how it helps to extend the direct information from drill holes and minimises the number of such holes. A few examples are also cited.

PANT : Experimental stress analysis can be utilized for the evolution of safer, rational and more economical designs. The cost of experimental analysis is negligible as compared to possible savings as the result of such experiments. Experimental analysis not only provides a check on the theoretical basis of design, but quite often it may provide the only solution to an intricate problem.

RAO : Large economies can be secured through proper planning and design, notably, use of earth as construction material even in dams of medium height. Similarly reduction in the cement content of concrete and use of higher stresses for materials will lead to economy.

Excessive expenses on spillways can be cut down by adequate hydrological studies and limitation of capacity to minimum.

QUESTION 9.—*What should be the policy in drawing up the construction plant layout for various works and the importation of equipment ?*

HANDA : Decisions regarding the construction plant layout for big jobs should be taken promptly, in the early stage of a project, even if there is a risk of small errors in doing so. Lack of such decisions is a major stumbling block in the progress of projects.

Persons charged with such decisions should have thorough knowledge of the problems. It is, of course, not easy to take decisions in border-line cases, but there is generally always more than one way of doing the job, and delays and indecisions lead to mounting of project costs.

Illustrative example of Bhakra Dam is given, where valuable and useful construction equipment which might have been obtained from the T.V.A. was lost due to lack of decisions at the appropriate time.

QUESTION 10.—*Should the contribution of foreign personnel be taken in a consulting and advisory capacity or should they be given direct responsibility ?*

ANAND : In the initial stages it may be necessary to seek advice and services of foreign specialists. Such specialists should help in the training of Indian engineers. Training of Indian engineers abroad will also be necessary for some years, but no engineer with less than 10 years standing should be sent out except as a student. Even those who are sent should be assigned specific problems and subjects.

HANDA : In administrative and financial matters Indian engineers should be acting mainly on their own discretion, and responsibility. Even in technical matters, final decisions should be taken by Indian engineers after obtaining the benefit of consultation with foreign experts, if warranted by the magnitude and importance of the problem. The technique and experience already evolved on India's projects should not be discarded lightly with a view to imitate foreign procedures.

QUESTION II.—*What is the best executive and administrative set-up for the execution and control of a project ?*

PARTHASARTHY : He has invited attention to the various aspects of the different types of administrative set-ups which are now in operation on the various projects under execution in the country and suggests taking full advantage of the experience.

ANAND : Each large project should be under a unit charge and the organization should be suited to its peculiar needs. Financial control should be exercised through an independent accounts and audit office for each big project. Dilution of staff by unnecessary expansion and duplication of organization should be avoided.

It is suggested that on big [projects there should be a Project Committee consisting of the Minister-in-charge, the Finance Minister, the Secretaries of the two departments, and the Project Chief Engineer, with a whole-time Secretary of the rank of a Superintending Engineer. This Committee would administer on behalf of the Government.

HANDA : A lot of thought, care and time should be given to the selection of individuals responsible for planning, design and execution of a project.

Once the selection is made, there should be full trust and a generous chance should be given without shackles and red-tape. Continuity in important charges is desirable.

As a necessary complement to this trust, the administrative machinery should be strong and effective enough to remove a person found unfit to deserve the trust and responsibility, well before he can do much damage.

CENTRAL BOARD OF IRRIGATION AND POWER
SYMPOSIUM

NEW DELHI, 1953

PAPER I

**Certain Suggestions for Economising the Cost of River
Valley Projects**

by

M. L. Aggarwal, I. S. E.

SYNOPSIS

We are in the midst of the "Five-Year Plan" under which large number of development projects are to be executed. Our resources are limited and it is, therefore, our duty to get the maximum out of every rupee spent. The paper presents certain suggestions for economising the cost of river valley projects.

The need for studying in advance the economics of execution through manual labour or through machinery is stressed. Necessity for deciding the mode of execution at the planning stage is brought out. The programme of execution should be co-ordinated at the earliest stage, with the availability of labour and the probability of obtaining requisite machinery in time. The considerations that govern the mode of execution *i.e.*, either by employment of manual labour or machinery are brought out.

It is felt that the system of accounting obtaining in the various projects does not take into account the hourly ownership cost of **machinery** and for proper comparison of working costs of machinery on different projects, it is pointed out that the basis of accounting should be made uniform. In the absence of inclusion of hourly ownership cost in the unit cost of output the great economies that can be effected by getting the maximum out-turn from machines are being overlooked. The necessity for proper use of machinery and the considerations in selecting new type of machinery are also dealt with. Recruitment of operators of machinery in a haphazard manner is not

conducive for economical working. Opening of proper training centres to train operators and mechanics for employment in various projects is suggested.

In framing estimates, the speed, mode and agency of construction should all be kept in view, as co-ordination of design and estimates with the conditions at site is imperative for achieving economy. Standardisation of designs will also contribute in bringing down costs. There should be close co-operation and understanding between the contractor and the engineer. Given their due place the contractors are sure to help in bringing down cost. The existing practice of making the contractors responsible for properly housing the labour at project camps is considered not very advantageous and this responsibility may, therefore, be assumed by the Government. The specifications and schedule of rates should be all-comprehensive covering all likely items of work and leave as little as possible to future decisions. Vesting of little authority with the officers at site to decide questions about rates is deplored and a need for revision of contract forms to remove these anomalies is also emphasised.

1.0.—INTRODUCTION

1.1. The country has embarked on a development plan, which in the first Five Years, will cost Rs. 2,069 crores. Of this Rs. 1,258 crores will be met with from the country's normal budgetary resources of the Central and State Governments and the balance from other sources like external assistance, deficit financing and sterling balances lying at the credit of the country. The schemes for development had thus to be limited according to our resources. The need for getting the maximum possible value from every rupee spent is therefore obvious. The river valley development projects, with which we, as engineers are directly concerned, form the biggest single unit of expenditure in the Plan and it is therefore up to us, as engineers, to go all out for effecting economies in all possible ways.

1.2. The magnitude of expenditure involved in Irrigation and Power Projects envisaged in the first Five-Year Plan can be gauged from the fact that whereas the total capital cost incurred on State Government irrigation works prior to 1947 comes to about 100 crores only, an expenditure of as much as 561 crores is envisaged on Irrigation and Power Projects during the period of the Plan. Thus the expenditure being incurred in any one year exceeds the total

capital expenditure incurred on such works before independence. It is thus obvious that works now being undertaken are on a scale far bigger than those attempted before in the country.

1.3. It is, therefore., proposed to discuss in this paper, certain procedures that should be adopted if proper economies are to be effected.

2.0. PLANNING

2.1. Even where execution of work is possible both by manual labour and machinery, it will be desirable to study in advance the economies of execution through manual labour and through machinery. More often than not, plans and estimates are prepared without giving due consideration as to whether the work will be done through manual labour or through machinery.

2.2. It is not uncommon that estimates are first prepared on the basis of labour rates prevailing in the area before the commencement of a project without making any attempt to assess the probable increase in wages that is bound to result if labour requirements for the project far exceed the locally available labour. Surplus labour in a backward tract before the construction of a project is undertaken is no indication that sufficient labour will be available to meet the requirements of the project when execution starts. It is, therefore, wrong to depend upon the availability of local labour without assessing the extent of that labour and the project requirements. If labour for a project has to be imported from places far removed from the project area, due consideration should be paid to this fact when working out project estimates.

2.3. It is further desirable to plan out in advance which portions of work should be executed through manual labour and which portions through machinery and to frame estimates accordingly. It is bad planning to frame an estimate without deciding on the mode of execution. The estimate for a work originally planned to be executed through manual labour is no guide for the officer in-charge of execution, if it is ultimately to be executed through machinery. Then again it may be more economical to reserve only a part of the work for execution by manual labour depending upon the availability of the labour in the tract and the adjoining areas and executing the remaining work through machinery if importation of large contingents of labour from distant places proves not only more expensive in

actual execution but also involves further substantial expenditure on housing, public health and labour welfare, etc.

2.4. The programme of execution of work should be co-ordinated, at the planning stage with the availability of labour and the probability of obtaining the requisite machinery in time. It is a mistake to fix target dates for a job without working detailed requirements of men, materials and machinery required and the chances of getting these according to the required time schedule. If, under the prescribed procedure for getting machinery from abroad and the usual departmental delays, it be not possible to get the machinery as per required schedule, the target for completion should be modified in accordance with the assured programme of availability of machinery. Alternatively, in reviewing the programme from the point of view of availability of machinery it may become desirable to revise the original plan of execution of work and allot greater proportion of work to manual labour than originally contemplated.

3.0.—MEN AND MACHINES

3.1. **Need for mechanisation** :—Situations where time factor and the nature of work makes the use of machinery unavoidable are becoming more and more common and frequent. As the engineering works now being constructed get more and more complicated and bigger and bigger in magnitude, manual labour has to be augmented by mechanical help to achieve the results. Thus, whereas it may be both desirable and economical to excavate canals especially smaller ones through manual labour, big embankments involving handling of millions of cft. of earth over hundreds and thousands of feet can only be executed within reasonable time with the help of suitable earthmoving machinery. Then again there may be occasions, when, even though the cost by manual labour be less, the time required for doing it by manual labour may make its execution by manual labour out of question. In such situations use of machinery is indispensable.

3.2. **Limitations in the use of machinery** :—Use of machinery in construction can be both efficient and economical in certain situations but is not necessarily always so. The conditions in this country are different from those in Western countries. Here unskilled labour is cheap and in plenty, machinery has to be imported at a huge cost from abroad and requires skilled labour for their

operation which is scarce, whereas reverse is the case in Western countries where labour is far more expensive and manufacture of machinery within the country not only makes it comparatively cheap but helps in easy availability of properly trained technicians for their operation. Thus mechanisation, even if economical in most of the Western countries, is not necessarily so in this country.

In deciding, therefore, whether a work should be executed through employment of manual labour or machinery three points have to be borne in mind :

- (i) How does the overall cost of doing the work by manual labour compare with the cost of doing it with machinery ?
- (ii) What portion of the cost of doing the work by machinery will be spent within the country, and what portion outside the country ?
- (iii) Whether the job can at all be done by manual labour within the time which will fit in with other parts of the project ?

3.3. Necessity to watch output of machines :—Thus use of expensive imported machinery not being unavoidable these days, measures that will ensure their operation with maximum of efficiency and economy must be adopted. One such measure is comparison of outputs and costs of work done through machinery on different projects. This will help in improving on the methods of operation and making it possible to detect at an early stage defects in their handling and operation on a project. It is necessary for that purpose to prescribe suitable proforma for watching the output and operation costs of various machines.

3.4. Importance of keeping proper accounts to know the unit cost of out-turn :—In this country different projects are adopting different methods for working out costs of operation of the machinery being used on these projects. The basis for depreciation allowance is different on different projects. If comparison is required to be made of working costs of machinery employed on different projects to ensure economic working of these machinery, it is necessary that the basis of accounting should be made uniform for all projects. Generally no account is taken of the basic ownership costs of equipment in arriving at the unit cost of out-turn. Thus if machinery worth twenty *lakhs* is purchased for a project and operates for only half the time it was originally intended to, the particular work

concerned is not debited with the extra interest and depreciation charges due to the machine not being kept fully employed. Thus, whereas such costs do not appear in the actual operational cost of a machine, project bears the extra interest and depreciation charges all the same. Thus a system of accounting which does not take into account the hourly ownership costs cannot properly bring out un-economical or un-methodical working of machines on a project.

3.5. Incentives for better output:—One of the chief incentives for efficient and economical working of machinery is a proper planned system of bonus for the machine operators. The great economies that can be effected by increasing the output per hour through proper handling by operators and the great incentive to this proper handling that a proper system of bonus can give, is not being fully appreciated through our not properly evaluating the hourly cost of ownership which is a fixed charge. This hourly cost of ownership comprising of, depreciation, interest, taxes, insurance and storage generally costs as much as the actual operating cost per hour. It is because hourly ownership costs are not being properly indicated in our estimates that we overlook the great economies that can be effected by giving an incentive to our operators for better output through a system of bonus.

3.6. Proper use of machinery:—With the advancement of the Science of Soil Mechanics, earth is finding greater and greater use as building material because of its cheapness and availability at site. Earthen dams of big dimensions not previously envisaged are becoming more and more common because of their low cost of construction and easy availability of materials. These, however, require use of highly specialised earthmoving machinery for moving millions and millions of cft. of earth over long distances which would not otherwise have been possible through manual effort only. The machines and equipment available for moving earth are of a wide variety, types and sizes to suit different job conditions. The correct selection of suitable machinery for a particular job and their proper use requires a thorough understanding of capabilities and limitations of various types of machinery which can only be acquired by proper training, study and experience which must be imparted to officers in-charge of constructions where use is made of such machinery if the job is to be done efficiently and economically.

3.7. Considerations in selecting new type of machinery:—It has often been noticed that operating costs of machinery given

by the manufacturing firms or their agents are far short of what they actually obtain in practice. This gives a very wrong indication of the actual cost of operation of new types of machine not previously dealt with and may also result in wrong selection of machines based on incorrect costs of operation given by manufacturers. It would, therefore, be worthwhile when placing any large scale order of new type of machinery not previously handled to insert a clause by which the manufacturing firms supplies its own foreman to train and operate the machinery within the operation cost stated by the manufacturers. Hourly ownership cost worked out according to prescribed principles should also be added to the operation costs that may be given by the manufacturers before final selection of a new type of machine is made.

3.8. Proper training of operators :—It is necessary that the operators are properly trained and classified. A spasmodic increase in output by overstraining a piece of machinery should be ruthlessly put down. Life of a machine depends, firstly on the way it is handled and operated and secondly on the way it is maintained and serviced in normal operation. The operators and service gangs should be made to realise that their service and income depends upon the way they handle and service the expensive machinery in their charge.

3.9. Need for training centres for operators :—Only properly trained men should be put in charge of operation and servicing of expensive machinery like earthmoving machinery. There should, for that purpose, be proper Training Centres to train operators and mechanics and no one should be put in charge of a machine unless he is fully qualified to operate that machine. Recruitment of operators and mechanics to handle expensive machinery should also be made through these Centres and never direct by any project from personnel employed on another project. The operators should be suitably graded and there should be fixed scales of pay subject to regional adjustment for different grades. They should further have proper history cards in which good and bad points should be recorded and it should not be possible for people who are in the habit of mishandling machines to get jobs elsewhere. The service cards should be in duplicate, one remaining with the operators and the other with the Training Centre. When in service both cards should be with the employer. Before an operator is discharged from a project, the project authorities should bring up-to-date

both the cards and hand over one to the mechanic or the operator and forward the other to the relevant Centre. If a project requires mechanics and operators the project authorities should contact the Training Centres and get the best men suitable for the job. Some such method will prevent undesirable men moving from project to project or projects trying to obtain men already employed on other projects.

3.10. **Precautions against breakdowns** :—For proper and efficient operation of machines it is essential that there should be a sufficient stock of spare parts for replacements as and when required, a proper and efficient system of maintenance and overhauling of machinery and enough spare equipment to allow for breakdowns without seriously effecting the output of work.

4.0.—CO-ORDINATION OF DESIGNS AND ESTIMATES WITH CONDITIONS AT SITE

4.1. Another important factor in ensuring economic execution of projects is that designs should be framed by keeping in view the required speed of construction, mode of construction, availability of materials, machinery, labour and last but not the least, the agency of construction. A design may appear most economical from a purely design standpoint, but may actually prove to be costly if it entails special methods of construction. In framing estimates the speed, mode and agency of construction should all be kept in view. As the cost depends upon all these factors, an estimate framed with a view of getting the work executed departmentally or on piece work basis will not suit, if, it is later on decided to get it executed through big contracting firms on a contract.

Again a job required to be completed in six months is bound to cost more than what it would cost to have it completed within a year. In setting the time limit for the completion of a job, practical possibilities should be kept in view. It is no use demanding a job being completed in six months if it be physically impossible to do so. It only results in contractors putting up their rates and getting away without a penalty because of untenability of original stipulations. This only results in higher costs being incurred without any gain in time.

It will also not do to provide for earth work at so much per 1,000 cft. on the basis of manual labour rates when the work is to be executed departmentally through machinery. Such estimates are no guide or help to those in charge of actual execution. If the work is to be done by machinery estimates should be prepared on that basis *i.e.*, by taking into account the number and type of machinery required and the cost of their operation *etc. etc.*

It is wrong to frame an estimate without regard to the mode of construction and leave the decision in the hands of people who may not be well conversant with the working of machinery.

The designs should be prepared in as great a detail as possible with complete specifications, to avoid later clarifications and frequent references to the designer. The plans should be complete and definitive and still be kept sufficiently flexible so that they can be adapted without loss of time and, if possible, without increase in cost, when changed conditions are encountered in the field.

4.2. Substantial savings can also be affected by standardisation and uniformity in design. The cost of a structure comprising a number of elements is increased if the several elements differ in form, size and details or if the manual or machine procedure involved has to be varied. Conversely, substantial economies can be effected by uniformity of design and adoption of minimum number of craft processes. Standardisation of designs can, therefore, effect substantial economies on big projects.

5.0.—NEED FOR GIVING WEIGHT TO CONTRACTORS VIEWS

5.1. Lesser the hazards for the contractor, less the ultimate cost of construction of a project. If a job is decided to be executed on contract, pre-bidding conference with the contractors may sometimes prove to be extremely helpful by removing ambiguities, making the plans and specifications more definitive and eliminating some unnecessary requirements or stipulations and ensuring closer understanding between the contractors and the engineer's point of view.

5.2. There should be close co-operation and understanding between the contractor and the engineer. It is not unoften even

in more advanced countries, for specifications and designs being changed after signing of contract documents, even where the original designs and specifications are prepared by the best engineering talent available in the country.

5.3. Too frequently, engineering plans and specifications are brought to completion with one's thought solely on the final results and the finished product, and with little serious and experienced attention given to how the project or phase of the work is to be constructed at site by the contractor.

6.0.—CHOICE OF CONTRACTORS FOR CODAL CONTRACTS

Codal contracts with contractors who have not got qualified engineers on their pay rolls and have no code of ethics or sense of responsibility for carrying out works according to specifications are not much good. Codal contracts should only be entered into with reliable firms of standing who have a reputation at stake and who have enough financial resources for any penalty that may be leviable for non-fulfilment of a contract. It is not good practice to have contracts with firms who have no sense of responsibility and no reputation to lose and who are no better than piece workers without any responsibility for the quality of work turned out. For entering into fixed contracts with such contractors the Government binds itself to have the work completed according to plan without having any substantial hold on the contractor if he fails to fulfil his part of the contract. Again codal contracts are not desirable as stated above, unless and until the plans and specifications be complete and full data be available about sub-soil conditions and the contract provides for suitable rates for different sub-surface conditions likely to be met with. If the schedule of rates does not provide for all types of work likely to be met with or a suitable clause for properly arriving at such rates, the contractor may put forth unreasonable demands and there be no other alternative but to accept those demands. Again before entering into codal contracts, regular and timely supply of materials and machinery which the project authorities have to supply must be assured in advance.

7.0.—ESTABLISHMENT TO SUIT THE MODE OF EXECUTION

The decision whether the project is to be executed departmentally or through petty contractors on piece work basis or through big contracting firms or labour co-operatives should be

made at an early stage and estimates and plans drawn up from that point of view. One type of construction agency need not be adopted for the entire job, but if the strength of staff is originally sanctioned for execution of a project through big contracting firms, it will be wholly inadequate and incapable of handling the work if it is later on decided to be executed through departmental agency or on piece-work basis. The requirements of the staff on a project if the work is to be executed on a piece work basis allowing labour rates only, or on codal contract basis giving rates for completed items of work (the contractor supplying his own materials and labour) or through big reputable engineering firms having their own engineers and who can be relied upon to follow the specifications will be widely different in each case. It is a big mistake to fix the staff suitable for one mode of construction and then adopt another mode of construction.

8.0.—RESPONSIBILITY FOR PROVIDING HOUSING AND SANITARY ARRANGEMENTS FOR LABOUR CAMPS

On big projects responsibility for housing the labour and making satisfactory sanitary arrangements for labour camps should preferably be assumed by project authorities if work is to be executed by piece workers or small contractors. Small contractors seldom make satisfactory arrangements for housing the labour or providing suitable sanitary facilities. This responsibility has normally to be discharged by the project authorities. It is, therefore, much better to assume full responsibility for housing all the labour that may be brought in by the contractor according to a predetermined scale and making all the sanitary arrangements for labour camps, rather than holding the contractor responsible for such arrangements on paper and bearing the cost in actual practice. The cost of such works can be included in the project estimates separately resulting in a corresponding reduction in rates. The existing practice of making the contractor responsible for properly housing the labour especially when there are several contractors of small means engaged on a project seldom prove satisfactory. Though, theoretically the responsibility for providing labour welfare facilities rests with the contractor they are either actually absent or have to be provided for at the cost of the project.

9.0.—NEED FOR REVISION OF CONTRACT FORMS

It is time that our present P. W. D. forms for entering into codal contracts be revised in view of present day conditions and limitation on the discretion of officers in-charge of works. The speci-

cations and schedule of rates should be all comprehensive and try to cover all likely items of work and leave as little to future decisions as possible. It often happens that new items of work not specifically provided in the original schedule are often necessary and under the rules the contractor's rate for a new item of work has to be accepted or rejected within a specified period. Generally, these days officers in-charge of works have no authority to decide the issue and it takes a long time to get the orders from competent authority which more often, than not, does not vest even in the highest authority on the project. The result is that work has either to be held up or, if executed, the rate remains a matter of contention for a long time afterwards.

10.0.—CONCLUSION

The above suggestions are the result of the author's own observations. There is nothing very new nor is there any enunciation of new principles. In fact most of the suggestions can be termed as common place, but it is because these common place principles are generally being overlooked in actual practice, that the need was felt for presenting this paper and if the paper succeeds in focussing attention to these points and their implementation in actual practice, it will have more than served its purpose.

CENTRAL BOARD OF IRRIGATION AND POWER
SYMPOSIUM

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PAPER II

**Determination of costs and benefits of River Valley
Projects—Economies possible by various means**

by

D.B. Anand

SYNOPSIS

This paper deals with only item 1(c)* of the subject selected for the Symposium. The possibilities under the various heads have been discussed and methods indicated.

It is felt that complete mechanisation is neither essential nor desirable for all elements of each job ; the criteria for deciding upon the use and extent of mechanisation have been indicated.

The role that Research and Model Experiments can play has been mentioned as well as the advisability of limiting the same mainly to the present needs.

While centralisation and standardisation of designs is inevitable on large projects, the extent thereof should be limited by local and individual factors. Local officers should be given scope and latitude for selection and adoption to suit local conditions.

Foreign aid in equipment and technical personnel is helpful and almost essential. It should, however, be planned for full utilisation and benefits to works and Indian personnel.

The training of engineers is imperative. It is stressed that the training should be specific and planned for full utilisation.

Suitable executive and administrative control of project execution is essential ; methods have been suggested for the set-up and

* (1) Costs—(c) Economies that can be effected by.

economic functioning. The very important role to be played by the audit has been mentioned. The mental attitude of the audit and the engineers, necessary for successful execution of big projects has been indicated.

With limited resources, phased construction of schemes is necessary. So long as technically feasible, and, not too expensive in the overall costs, phasing should keep pace with utilisation.

The kernel of the whole set-up is the project personnel. A plea has been made to give them satisfactory work and service conditions to enable them to give their best to their work

MECHANISATION

1. The present is the age of the machine and mechanisation on our projects has attained great importance and support. It is, however, a fallacy to imagine that, in this country, complete mechanisation of all jobs in all stages would necessarily be cheaper or more desirable.

The desirability and extent of mechanisation should generally be judged by three criteria viz. :—

- (a) Is it essential ?
- (b) Is it economical ?
- (c) Is it desirable ?

2. For jobs like concreting a dam, mechanisation is essential as, by no other device, can vast quantities of concrete be laid to meet the requirements of laying within setting periods and assuring the control needed for the work. Similarly, for a large and high earth dam where the soil is to come from a distance, human labour could not physically cope up with the work, no matter how much time is allowed.

Similar other jobs would be obtaining aggregates where large quantities are needed in a short time, driving of large size long tunnels, dredging under water and the like.

The physical factors in such cases would place the job beyond the capabilities of manual labour. There could, therefore, be no comparison of relative economics.

3. Some jobs can be done either by machinery or by manual labour e.g., concreting of roads, construction of small earthen dams, excavation of canals and the like. In such cases, the matter needs great thought before a decision can be taken.

If the job is to be mechanised, the rate analyses must take into account factors like the location, the transport conditions, facility and costs of repairs and replacements, availability of personnel, the extent to which the machinery would be utilised, whether the machinery would finish its life on the job and if not whether enough salvage value is likely to be obtained, whether the machinery and its crew could be kept employed full time *etc. etc.* Mechanisation can be economical only where the machinery is not allowed to stay idle either for want of work or for breakdowns and where it is continuously used to almost its full useful life. If these conditions are not obtained, it would usually prove less economical than human labour to whom payment is made only for working time and there are no expenses for idle hours nor any debits at the end of the work. This is specially the case in India where manual labour gets low wages and is abundantly available in most localities.

This is forcefully illustrated in canal excavations. In large canals with wide bed widths and high embankments, machinery has usually proved cheaper specially when there were no great debits of residual life. This was proved in the Sukkur Barrage Canals. Though even there, manual labour produced work at almost equally cheap rates and perhaps cheaper on smaller canals, distributaries and minors.

Experience on the excavation of rocky cuts on the Ghataprabha canal, at present under excavation in the Bombay State, shows the manual operations to be cheaper than mechanised ones. This is because the locations are scattered and the work not of enough magnitude at each location to assure continuous functioning of the machines.

Mechanisation is not, therefore, cheaper on all jobs and at all locations.

4. The third criterion of desirability is equally important because, in the long run, it would affect the economics.

Mechanisation, for example, may assure earlier completion of a canal at cheaper unit rates but it would be infructuous if the head-

works are not ready concurrently. Manual labour may, on the other hand, be somewhat more expensive on the unit rate basis and may take longer time. If, however, this synchronises with the completion of the headworks, it may still prove cheaper than the mechanised job in the long run on account the saving of interest and for providing gainful employment to the population of the arid regions through which the canals usually traverse.

Another case is where the planners run ahead of the financiers and mechanise jobs on theoretical bases only to find that mechanisation has become more expensive on account of idle time due to lack of guaranteed funds year after year.

5. Mechanisation may be absolutely essential and unavoidable in other countries where rates for manual labour make it more expensive, where there is shortage of man power, where availability of machines, parts, servicing and skilled personnel is much more favourable than in this country and where the problem is more of keeping employed the skilled worker than the unskilled. The conditions in this country are very different and we have to find gainful employment for a large amount of unskilled labour and the villager who may not have such employment during a major part of the year.

Each element of each project would thus need individual thought before a decision can be taken. In general, it is necessary to employ machinery where manual labour cannot do the work either for physical limitations or to assure the requisite amount of controlled production or for being unavailable or for being more expensive even when taken in the context of the existing unemployment. Where time is not a pressing factor, where funds are not guaranteed and where gainful employment can be economically provided to near-famine labour, it would, in the overall context, be desirable to keep mechanisation to the barest minimum.

Under the present prevailing conditions, it is, therefore, essential to consider machinery as a support to manual labour and not as a wholesale alternative. This overall would be the most economic policy.

RESEARCH AND MODEL EXPERIMENTS

6. All research finally becomes applied *i.e.*, what is considered basic research to-day must, at some time or the other, find an application. Therefore, funds spent on basic research to-day are investments

to yield results in the future but may not show direct economies for the projects in hand. Contribution to basic research should, however, continue to be made as representing payment of the debt, the present projects owe to the application of the basic research done in the past.

The primary aim of research as understood in the present context is to find methods and materials to improve performance and/or to cheapen costs. If it cheapens costs, the economy is visible. For example the discovery of puzzolans has shown the way to cheapen costs and wherever a suitable material is obtained, economy could be affected.

7. On the other hand, when research results in improved performance, there need not necessarily be a visible saving. As for example, if while one puzzolan is known to exist, another is produced by research which would give better performance though at the same cost, there is no visible economy but only a long term one.

It may also happen that the new material may be more expensive to use but lengthen the life of the structure. Even so, it may be considered more economical so long as the improved performance is in step with other elements of the work. For example, it would not be considered economical to obtain a concrete which would stand without deterioration for one thousand years in a dam whose utility may be positively known to be finished by silting, say, in two hundred years.

It may, therefore, be accepted that research will, in general, lead to economy either short or long term and must be encouraged. In the present condition of our finances and resources, however, research should be intensified more for application in the present than as basic for future use. For example, we must intensify research on discovering cheap air-entraining agents, local puzzolans in various parts of the country, cheap methods of soil stabilisation, substitute materials for steel in structures, treatments to wood to increase its uses and the like which should help us economise in our river valley projects.

8. Model experiments are undertaken to assure safety in design, reduce costs and/or improve performances.

At present, however, there appears to be repetition of similar experiments at various stations and even at the same station for

different projects. It is necessary, therefore, to formulise the results of model experiments as far as possible and for application to small structures, and it should not be necessary to run experiments for similar structures every time they are to be constructed.

Such formulisation should be given wide publicity so that the results can be utilised by the general engineer without having to refer every time to the research station and without having to carry out experiments for the same or similar structures every time.

9. Research could, thus, be a long term insurance for assuring future economies or applied to immediate problems. In the latter case, it is likely to usually lead to immediate economies or adoption of methods and materials yielding better performance.

Model experiments are a necessity for satisfactory designs of major elements on all large projects, for which they must be carried out. It is, however, necessary that the practice should not become a fetish nor an escape from responsibility by the designer and the construction engineer. More attention needs to be paid by our research workers to mathematical interpretation and formulisation of the results of model experiments.

CENTRAL DESIGNS OFFICE—STANDARDISATION OF DESIGNS.

10. In all projects of any magnitude, centralisation and standardisation of designs is inevitable. This certainly leads to economy and obviates wastage of effort.

The main point to be considered is the extent to which centralisation and standardisation should be carried. This should depend upon the total work involved, the physical distance between the standardisation office and the field, the calibre of the local staff and the cost and magnitude of structures involved.

While all major structures like headworks, large bridges, canal falls and regulators *etc.* should, necessarily, be dealt with in the Central Designs Office, it is difficult to lay down the limits up to which decentralisation should be allowed. This much, however, is certain that where the number of smaller structures involved is large, it would be best to centralise only the issue of indicative type designs, leaving the detailed work to the local officers who should be allowed enough latitude of selection and modification to suit each situation.

11. It has been suggested above that centralisation and standardisation should be limited to each project of any magnitude or, as a corollary, to units each comprising a number of smaller projects under the same administration. The important point is the physical capability for handling the work. Overloading the centralised office will defeat its very purpose as any benefit proposed to be derived by centralisation would be lost in the delays thus caused and the scanty attention which each item will receive from the overloaded staff. The scope of work and centralisation should be limited to the extent to which an even flow of satisfactory work can be assured. Trying it on a bigger scale would amount to a virtual failure.

This would, automatically, mean a number of such offices handling a number of projects, thus, resulting in a variety of standardised designs. For the maximum benefit to be derived, it would be desirable to start a practice where each office should prepare a compilation of what may be considered standard designs of more than parochial utility and of sending copies to similar other offices and Government departments in the country. Such dissemination of information would lead to improvements in design technique and overall economies

FOREIGN AID IN EQUIPMENT

12. As stated under "Mechanisation", the question of utilisation of machinery should be given deep thought for each individual project and, where found necessary, it has to be acquired wherever and however available.

As most of the machinery needed is still not manufactured in India, foreign aid in the matter is necessary to the very undertaking of the projects. To the extent that the machinery is made available in time and the needed quantities, such aid will be helpful to the carrying out of the projects.

FOREIGN AID IN TECHNICAL PERSONNEL

13. Quite a lot of machinery and technique, necessary for the construction of our projects is foreign to this country at present. If we are to continue to progress with such works, we shall have to start manufacture of machinery in this country and to master the present technique and develop it further to suit Indian conditions.

In the initial stages, however, it is necessary to seek foreign help to assure safety and speed in our designs and construction. Though there is no substitute for experience, foreign aid in the initial stages should save costly mistakes and, thus, reduce wasteful expenditure.

The aid should, however, be in such a form as would assure the training of as large a number of our own engineers as possible and within the shortest possible time. The aid should also be such as permits our own engineers, working with the foreign technical personnel, enough latitude to incorporate methods and techniques peculiarly suited to local conditions. It is only with such arrangements and atmosphere of work that we could derive benefit from such help.

SPECIAL TRAINING OF ENGINEERS

14. The programme of development is certain to continue in an intensified form for perhaps the next 30 years or more ; trained personnel will, therefore, be needed in large numbers.

As the projects, launched from the very start, are of large magnitude, suitable training of engineers is essential. Safety in design and economies would be the obvious result.

15. The method of training should be such as to assure the best results with the least expenditure. It is not certain that our attempts so far have achieved this. The following are some suggestions in the matter :—

- (i) Nobody with less than 10 years' service should be considered for training abroad. Officers with less service should, if at all, be sent out as students.
- (ii) The training should be with a specific purpose. Only officers, having the necessary background should be selected, and, after training, their services should be utilised for the specific purpose.
- (iii) Generalised short-term tours should be avoided. The programme and period of training should be specifically laid down and followed.
- (iv) When foreign technical personnel and technicians are employed on our projects, the Indian counterparts should be overstaffed to assure that at least some of them derive the requisite training.

- (v) Encouragement and facilities should be afforded on our own projects for training of officers of other States. It should be suggested to the State Governments to take advantage of such facilities.
- (vi) Whenever big contracts for design, supply of machinery or construction are awarded, thorough training of some Indian engineers should be a condition in the contracts. State Governments should be prevailed upon to spare officers and make full use of such facilities.
- (vii) The training facilities provided under the various aid programmes should be utilised for well planned and thought-out individual training programmes for a few properly selected officers rather than for fixed-period generalised rush trips by batches.

Only with such planned programme of training would we achieve fruitful results and economies.

SUITABLE EXECUTIVE & ADMINISTRATIVE CONTROL OF PROJECT EXECUTION

16. The primary thing is to devise an organisation best suited to each project ; this will, in the long run, prove to be economical in finance and effort.

As far as practicable, the project should be placed under a unit charge, be it a Division, a Circle or a Chief Engineer. Wide powers, commensurate with the responsibility, must be granted to the Project Engineer ; without such, it would be impossible to do the jobs successfully.

Depending upon the magnitude and type of job, the construction staff must be selected to suit requirements ; no other considerations should prevail.

17. The administrative set-up plays a very important role in the successful implementation of projects. It should be so devised as to cut out delays and short circuit red tap where possible.

Smaller jobs can be handled up to a Circle charge with increased financial powers. The top supervision can be exercised by the department and the secretariat concerned.

In bigger projects, a Chief Engineer becomes a necessity. In such a case, the usual secretariat disposal by Government is bound to be dilatory as the volume of extra work imposed upon the secretariat is likely to be very heavy. In such cases, it would be advisable to have a Project Committee for the project concerned to administer on behalf of Government; the Committee must have a whole time Secretary, of not less than Superintending Engineer's status, and, an independent office. The Committee might comprise the Minister in-charge, the Finance Minister, the Secretaries of the two departments and the Project Chief Engineer. The size should be kept small and the powers wide.

18. The question of proper accounts and audit at these projects is very important. The trouble, at present, really appears to be the shortage of personnel, both technical and accounts. The dilution of staff has resulted in lowering of efficiency and increase in mistakes with attempts by the executive and the audit to lay the blame at each other's door.

There can be no two opinions regarding the need for a proper set-up for financial control. The very aim of the whole set-up should not, however, be forgotten *viz.*, the achievement of the best results with the minimum of expense and friction.

It is, therefore, considered necessary to set-up practically an independent accounts and audit organisation for schemes of big magnitude. The purpose should be to free the technical officers from a lot of avoidable routine work. The cardinal principle should be for the audit organisation to realise that they are meant to render every possible assistance to the administrative and construction staff and for the engineers to remember that the audit is there to help them. There should be frankness and desire to help on both sides, without which no work could run smoothly.

19. A very workable system was adopted for the Sukkur Barrage Scheme as described in the Completion Report of that project. The audit accepted the view that the responsibility for the execution of works economically and speedily rested with the engineers and rendered all possible help towards the attainment of that aim. The helpful attitude is illustrated in the extracts hereunder.

As regards financing the small piece workers for cheapening the costs, the Audit Officer states :—

"The audit office then was faced with the alternative :

- (i) of offending against Government regulations in the matter of 'making advances to contractors',
- or (ii) of adhering to Government rules and inflating the cost of work.

The inflation of the cost of work seemed to be a graver dereliction of duty. As I conceived the position at least, the audit office was constituted in order to help the engineers in every possible way to effect economies. If by adherence to technical regularity the office was to inflate the cost of work, it would largely fail in its primary duty, the observance of economy".

Dealing with the question of expenditure before sanction to estimates, the Audit Officer notes :—

"Again it was a case of adhering to 'technical regularity', thereby adding very largely to the expense of construction by delay imposed, or of consulting the interest of economy by assisting in speeding up the work even at the expense of technical 'regularity'. It always seemed to me, that the interest of Government would best be served by studying real economy, at the expense of 'technical regularity'. I did not, therefore, hesitate to obey the Chief Engineer's orders to get on with the work even though I knew that he was exceeding his powers in giving such orders.

A convention was arrived at with the Chief Engineer that on his informing me that such work was authorised up to a limit of a certain amount, pending submission of the estimate for formal sanction, the audit office would not hesitate to pass and pay the necessary bills".

The intention of these quotations is not a plea for the adoption or condonation of 'irregularities', but merely to show that in large schemes, such instances are bound to arise. Unless dealt with by the audit in a manner leading to overall economy, the work of the engineers can become impossible and disheartening.

The Completion Report records as under :—

"At the outset, the Audit Officer held the view that the audit office would not properly fulfil its object unless it kept before it as

one of its most important ends, the affording of every assistance possible to the administrative and executive officers engaged on the scheme.

Starting with this principle, the Audit Officer maintained it out to the end and probably on no large project ever carried out in India, has the co-operation between audit and the engineers been so close. The engineers realised that Audit Officer and his staff were there to help them and this spirit prevailed throughout the nine years the work was going on".

In big projects trust and faith in each other is a fundamental necessity without which such works can never be carried out successfully. The methods and experience obtained in the Sukkur Barrage Scheme are commended to the attention of all concerned.

20. In the case of big projects located in a single area, work can be speeded up and economy affected by combining the offices of the Chief Engineer and the Superintending Engineers and of the Executive Engineers with their Assistant Engineers. Thus orders can be obtained on files rather than by official and routine letters, delays can be avoided and long-winded correspondence replaced by personal discussions and contacts.

Similarly the design office can be approached by all concerned and the work of preparing detailed drawings made easy and quick. With the location of the Chief Auditor also at the same place or nearby, a lot of red tape and routine can be cut out.

Such a set-up presupposes equal zeal and interest in the work from all concerned and a determination to see the work through in the best possible manner. But then such big projects cannot be executed without such mental attitudes and crusading frame of mind.

PHASED PROGRAMME OF CONSTRUCTION OF VARIOUS PROJECTS

21. India's present financial resources are limited and the demands thereon many and heavy. It is, therefore, necessary to so arrange the construction of the projects as to derive the maximum benefits from the money spent at each stage. It is also necessary not to go far ahead of demand and utilisation. If the benefits provided remain unutilised, they merely accumulate interest and depreciation charges, and, when utilised, prove to be more expensive than planned,

Discretion, therefore, demands that construction of the various schemes be phased so as to assure maximum utilisation at each stage, provided, of course, that such phased construction is technically feasible, and, does not prove to be unreasonably more expensive in the long run. Detailed economic studies can be made for the latter.

This is the only method of stretching the available money to the maximum benefit.

THE HUMAN ELEMENT

22. The methods, enumerated above, can lead to economies at least in theory. But these methods or any other can only be successful if the men who deal with the project are of the right type. There is a general feeling of apathy at present which needs to be removed and a sense of confidence created.

It is the engineers in charge who have to work whatever methods are considered best in the interest of the project. They must feel the work as their own and pride in being a part of the organisation. Unless the feeling of impersonality and frustration, frequently seen at present, is got rid of, no amount of checks and measures, will enthuse life into the projects.

Conditions must, therefore, be created wherein the young engineers grow up with a pride of profession and do not consider it only as a means of earning a living. There must be a reasonable amount of delegation of powers and allowance for honest mistakes. The amount of interference and nagging must be reduced to the minimum and there must be no lack of opportunities to the men who show promise and calibre.

The conditions of work and service must be such as to cause no mental strain and worry to the project staff and to leave them free and eager to utilise their capabilities to the full in the interest of the work.

There are sure to arise hundreds of difficult problems during the construction of these big projects; such problems would tax to the full the ingenuity and skill of the men in charge. This they can give only where their working conditions are such as result in their having:

unbounded pride and zeal for the work and where each one feels it a pleasure to contribute his full to the success of the job.

While, therefore, attention is being paid to creating administrative and technical machinery to satisfactorily deal with these big projects, the human aspect should not be forgotten. It deserves as much attention and care as any other facet of planning of river valley projects.

CENTRAL BOARD OF IRRIGATION AND POWER

SYMPOSIUM

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PAPER III

**Relative cost and advantages of Geophysical
Investigations in Engineering Projects**

by

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ABSTRACT

The paper discusses the advantages and relative costs of supplementing the information obtained from costly drill holes by employing comparatively cheap electrical and/or seismic method of exploration and how it helps to extend the direct information from drills and minimises the number of drills. A few examples are also cited.

1. In any major engineering project of construction of a dam, weir, tunnel and the like costing *crores* of rupees the present practice of foundation investigations costs only about one per cent of the cost of the project. It is made possible only by a judicious application of the different methods for investigating the foundation problem in all its aspects as are at present available to an engineering geologist. Geophysical method is one of the tools and is employed with great advantage to supplement the most direct method of core drilling. The limitations of a geophysical method needs emphasis and so too some of its advantages. It lacks, for instance, the preciseness of core drill information and the estimated thickness of an overburden by a geophysical method is usually within ± 5 per cent of the correct value. The advantage of this method lies in its supplying an overall three-dimensional information say the depiction of a bed rock topography to an above-mentioned approximation. It, therefore, forms a useful supplement to the direct information of a core drill that is obviously

limited to the lines of its traverses. The comparative cheapness and quickness of the geophysical method is responsible for its use in the study of the sub-surface particularly during the reconnaissance, the site selection, and the preliminary design and cost estimate stage of a project when the merits of different potential sites are to be correctly assessed in a quick, cheap, and yet dependable enough manner and the type of the structure best suited for the foundation has to be decided and a preliminary cost estimate made. All these are usually done without as yet undertaking a comprehensive programme of diamond drill investigation of the selected site which might be required later for more detailed sub-surface informations necessary for a drawing-up of the specific design once the preliminary design and the cost estimate have been approved.

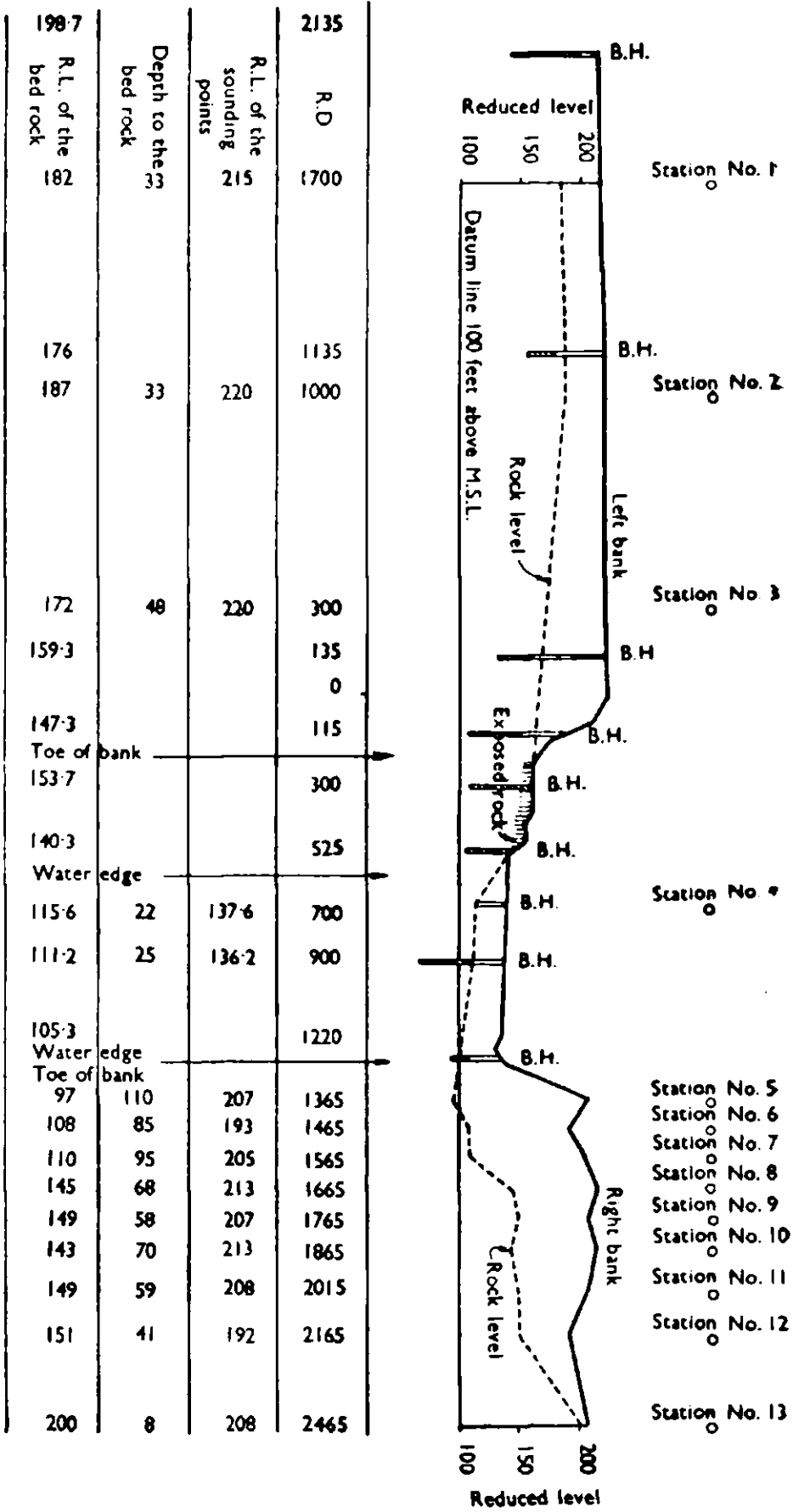
2. The geophysical method most frequently employed for the investigation of an engineering site is either the refraction seismic method or the electrical resistivity method of survey and, if necessary, both of these refraction seismic method is applicable here because of a lower acoustic velocity of the order of 2,000-6,000 ft./sec. in the overburden of weathered materials or alluvial deposits of a river valley in good contrast with a high velocity occurring in the bed rock which is usually 8,000-11,000 ft./sec. for sedimentary rocks and 12,000-18,000 ft./sec. for igneous rocks. In the electrical resistivity method of geophysical survey, however, the usually occurring contrast between the low resistivity of the alluvial overburden and the high resistivity of the bed rock is taken advantage of. In some special cases where the overburden is very highly resistive as for instance in case of thick laterite deposits occurring over some part of Deccan trap country, the electrical resistivity method is unsuitable and only refraction seismic method can be employed. In other very special instances magnetic method of geophysical survey is helpful as for instance in the location of intrusive dykes and sills in the foundation which are not visible on the surface. Usually the result of even a single bore-hole if available for checking a depth to bed rock estimated by seismic or electrical method, enhances the accuracy of bed rock depth estimation by geophysical method by eliminating possible source of uncertainty regarding the nature of the different sub-surface strata involved. In the absence of such a check drill being available, as for example in a reconnaissance survey, the seismic velocity determination on a bed rock exposure in the region, could, however, be used as a sort of control measurements for the seismic depth estimations.

Similarly, the determination of resistivity for exposed bed rock would provide a sort of control on the depth estimations by electrical method. It has been found that where seismic or electrical depth sounding points are in the vicinity of drill holes geophysically estimated depths to bed rock usually checks with drill hole depths to within ± 5 per cent.

3. For the shallow depths of a few tens to a few hundreds of feet in which an engineering geologist is mostly interested, the average cost of geophysical determination of a single bed rock depth whether by seismic or electrical method works out to be about Rs. 40/- as compared to an estimated cost of about Rs. 25/- per foot of core drilling in soft rock. Taking the average depth of overburden encountered in a potential site of a river valley project to be about 50 feet, the cost for a geophysical estimation of depth is about 1/30th of the cost of a core drilling. In other words, 30 seismic or electrical depth determination costs as much as a single core drill. The time taken for them is on an average 1/10 the time taken by core-drilling at the rate of 15 feet of drilling per day. The geophysical personnel comprises a geophysicist, a technical assistant, a surveyor, and a dozen helpers. With their usual pay and allowances, the cost of transport, cost of explosive etc., the cost of the seismic survey at an engineering site works out to be about Rs. 120/- per working day and since on an average three seismic shot points can be taken per day each seismic depth determination costs about Rs. 40/-. For a project the duration of a geophysical survey varies from a fortnight to a month depending on the number and the length of the alternative alignments along which a bed rock profile is desired. The geophysical party usually takes both the seismic and electrical survey equipments so that one or the other or even both types of survey may be resorted to as required by the site conditions. For instance, in that portion of the river bed which may be under water, a seismic survey for bed rock is more easily feasible than an electrical survey. Reverse instances may also be easily cited. The cost of an electrical survey is about the same as that of the seismic survey mentioned above. It is because, on an average 3 electrical soundings can be finished per day and the cost per working day is about the same for either type of survey.

4. Figure 1 shows the bed rock profile of Deccan trap underlying alluvial overburden and it was obtained from 15 electrical depth-soundings along the alignment across the river Tapi at the proposed

Figure 1 : Longitudinal Section showing the geophysical sounding stations and the corresponding bed rock levels along the alignment across river Tapi at Ukai.



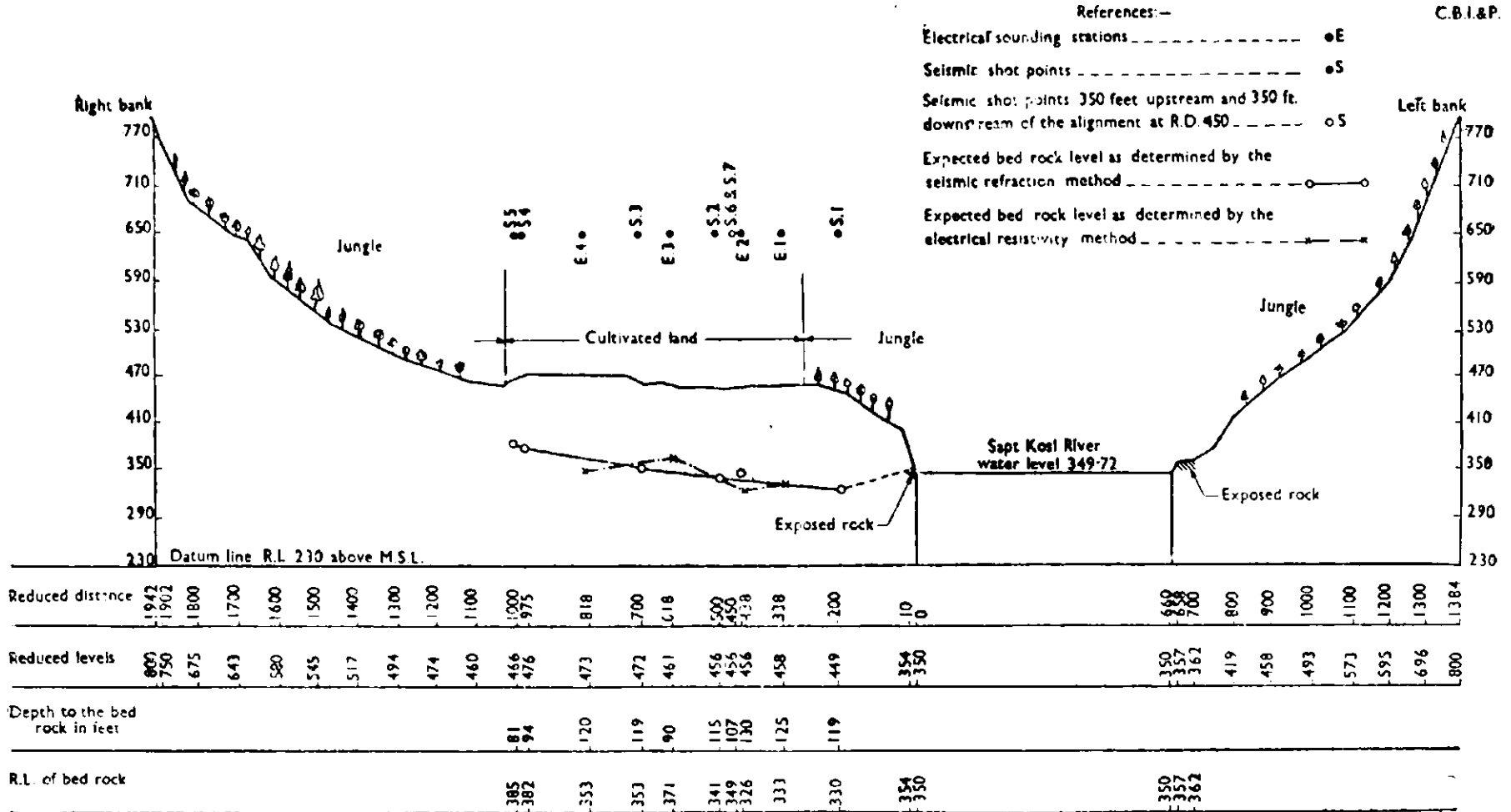


Figure 2: Longitudinal Section showing the geophysical sounding stations and the corresponding bed rock findings along the alignment of the new dam site across Kosi at Chatra.

dam site at Ukai. The results of 7 diamond-drill bore-holes taken subsequently to the geophysical work are also shown in the figure and the agreement of geophysical depth-estimates with bore-hole results is seen to be fairly satisfactory. The time taken on these 15 electrical soundings was only 5 days. Similarly, Figure 2 shows the bed rock profile for Siwalik sand-stones under a 1,000 feet wide terrace portion at the Chatra gorge in Nepal on the river Kosi. Though no bore-hole has yet been taken at this new dam site, it can at least be seen that the bed rock profile obtained from the electrical soundings and that obtained from seismic depth-estimates are more or less in good agreement. It, however, took only 4 days' work at the site to obtain these ten depth-estimates.

**CENTRAL BOARD OF IRRIGATION AND POWER
SYMPOSIUM**

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PAPER IV

**“Note on the problems presented by an investigation
of the economic effects of large irrigation and power
projects and the possible ways of dealing with them”**

Contributed by

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The nature of economic benefits flowing from a multi-purpose project is complex and often elusive to measurement. This has been realised for a long time by students of the problem and considerable thought and ingenuity have been devoted in recent years to the problem of measuring them. As a result, certain agreed procedures have been evolved, at least in regard to certain aspects of such measurements. However, the nature of the problem varies considerably from project to project. It is best, therefore, to consider the problem under reference by visualising the effects, a project may produce at various stages, and to note their complexity and range in order to be able to plan the necessary inquiries in the best manner possible:

Economic benefits arising out of a capital work are usually classified into a series of stages *viz.*: primary, secondary, *etc.* The classification rests mainly on the chronological sequence in which the benefits arise and the closeness of their connection with the investment whose effects are being studied. In each of these stages again the benefits can be divided into two classes, direct and indirect. When for instance, an irrigation dam is completed it makes water available for irrigation of the area under command. Irrigation results in higher agricultural production than before in that region and this is the direct primary benefit. The increased production results in increased incomes, which are partly saved and partly spent, thus giving rise to increased demand for

both producers' and consumers' goods and services. Economic activity increases resulting in more employment, trade, *etc.* and this is the indirect primary benefit. When some of the agricultural produce begins to get processed in the area, as for instance, oilseeds into oil and cake by oil mills, it gives rise to further employment, trade, income, *etc.* These are the direct secondary benefits. Indirect secondary benefits arise when the increased incomes arising from oil are spent on goods and services giving rise to further economic activity. When the oil produced in the oil mills begin to be used for soap making in new soap mills in the area there is a further rise in employment, income, *etc.* These are the direct tertiary benefits. When the increased incomes arising from them are spent they increase economic activity further giving rise to indirect tertiary benefits. This chain can go on *ad infinitum*. But at every remove the benefits become more diffuse and less specific as other factors besides the originating ones, come growingly into the picture. In the measurement and evaluation of these benefits, therefore, it has been recognised that the primary benefits lend themselves to easy measurement and that the measurement of secondary, tertiary, *etc.* benefits becomes progressively more difficult. Direct benefits in these categories again are easier to measure than indirect ones. These limitations must be borne in mind when planning an inquiry for estimating benefits.

Before proceeding further it needs to be stressed that we are interested in measuring the net economic benefits arising from the project and that, therefore, the costs involved at every stage have to be set off against the total benefits. As can be seen from what follows, at every stage there arise certain benefits and they are accompanied by certain costs. In fact costs and benefits go hand in hand and both have to be measured at every stage with equal care and diligence.

The first stage of a multi-purpose project begins when construction is started and ends when it is completed. The project is not potentially productive till it is complete. The very process of construction, representing as it does the expenditure of a vast sum of money in a particular area, does increase employment, incomes, *etc.* during that period. But these benefits are temporary and are coextensive only with the period of construction. As such they do not form part of the more permanent or long range benefits flowing from that project.

The benefits we are here concerned with begin to arise after the multi-purpose dam is completed. All the benefits, however, do not appear immediately. They come slowly first and steadily accumulate till the stage of maturity is reached. Benefits of a major irrigation system may, for instance, take at least 25 years to attain their peak. The primary benefits come first and then the secondary, tertiary, *etc.* follow later. In estimating the benefits, therefore, it would be appropriate to make at least two independent estimates, one for the short period and another for the long period. Even after a dam is completed it requires a certain time for the tract affected to adapt itself to new conditions. The farmers have to adopt new methods of farming, new crops, *etc.* and to make the necessary investment. It is the same with new users of electricity. Roughly speaking, most of the primary benefits would begin to flow fairly fully at the end of 5 years after completion of the project. The benefits flowing at the end of 5 years after completion might be termed the short term benefits and estimated accordingly. In the period that follows, primary benefits will attain their peak and secondary, tertiary, *etc.* benefits will also progressively appear. The system as a whole might be expected to reach its stage of maturity at the end of 25 years after completion. The long term estimate of benefits will cover the benefits arising at this point of time.

Once a multi-purpose project is completed it yields several 'products' or produces many effects. These can be best visualised by classifying them under the different purposes for which the dam is constructed. These purposes may be: (1) Irrigation, (2) Generation of power, (3) Flood control, (4) Navigation. Let us proceed to examine what costs and benefits are associated with each of these.

(1) The dam affects the primary production in the area firstly through its effects on the total land surface and its use. It affects the total cultivated area in various ways. It increases it by making possible the reclaiming of certain lands that were not cultivated before because of lack of water, by making possible year round cultivation of lands that were liable to inundation by floods every year, by preventing the loss of land due to erosion. On the other hand, it reduces it by flooding some area under the lake, created by the dam, by water-logging, by preventing inundation of land whose cultivation depends upon it. Secondly, the dam makes it possible to utilise the available land for a longer period or more intensively, leading to

higher yields of existing crops, introduction of new crops, double cropping of land, *etc.* by making water available for irrigation over the area commanded by its canals. The primary direct benefit from irrigation would thus be (i) increased agricultural production and (ii) the saving in famine relief and cognate expenditures to Government. In regard to (i) it should be noted, however, that its extent will depend, besides irrigation, upon other things, such as the availability of technical knowledge and capital to farmers, appropriate systems of land tenure, *etc.* Against gains from irrigation, moreover, costs incurred by the public authority in maintaining and operating the dam for irrigation purposes and expenses incurred by it in settling new lands, building roads and other public works there, *etc.*, and the costs of investments necessary for irrigated farming by peasants will have to be set off.

Besides agriculture the dam will also affect favourably or adversely forests and their produce, grass land, fish and wild life, and the balancing of both sides in these respects will also have to be done to estimate the benefits from them. The total increase in primary production in the area will also be affected by the good or bad affects produced by the dam on the level of sub-soil water and its effects on well irrigation. Losses or gains of scenic and historical value because of the construction of the dam will have also to be similarly balanced. Any other losses because, for example, of a possible development of malaria in the irrigated area will have to be set off against the total benefits.

As remarked earlier the extent of increase in agricultural production after irrigation will depend to a very significant extent on State policy in connection with land rights, land holdings, agricultural extension activity, public works programme, agricultural credit and marketing structure, *etc.* These will have to be carefully designed and planned beforehand. It is necessary to think ahead, and with the aid of experts in the field to explore what would be the best crops and their combination and rotation that would give the highest increase in agricultural production. What types of land holdings will be the most beneficial? How and in what manner can the farmers be taught the efficient method of irrigated agriculture? What would be the most productive unit of cultivation? How would the credit machinery and processing activities be best organized? These and many other questions will have to be asked, answered

and suitable plans made to translate these into practice. Plans and policies in regard to land revenue, water rates, betterment charges, *etc.* also will have to be formulated. This type of investigation is best exemplified by the Columbia Basin Joint Investigations. This is stressed here because the absence of planning in these matters would make a great deal of difference to the process of adjustment of the costs involved in it and the direction and pace of development of the tract. Quick adjustment with the minimum cost can be planned. If not, the adjustment would be by trial and error. It will involve higher costs, require more time and may even take wrong directions. This will, of course, cut into the total benefit.

(2) Electrical energy made available over the region might be used for different purposes such as lighting, or motive power for industries or for agriculture. The benefit from the use of electrical energy will depend upon how its use is planned by the authorities. The part of it that will be made available to consumers for lighting *etc.* purposes will save so much kerosene or other fuel. The part that will be used by agriculture and industry may well produce further effects. In so far as new industries are made possible by the cheap power available there will be more employment, higher incomes, *etc.* In this regard the plans made by Government for utilizing the power made available will be of crucial significance.

On the side of costs which have to be set off against these we will have to note (i) expenses for maintenance and continuous operation of hydel plants, (ii) investment in transmission equipment, (iii) investment that will have to be made by users of electricity, for wiring, *etc.*, (iv) losses suffered by those formerly dealing in the substituted fuels, *etc.*

(3) The control of annual floods would in the first instance lead to the saving of expenditure on flood relief and will also prevent losses due to floods. It might also lead to the reclamation of lands for year-round cultivation which was not possible before because of floods.

(4) A channel for navigation all the year round will mean facility for cheap transport of men and materials. The benefits can be estimated by the saving that can be effected in the cost of transportation on the new channel as against the old alternative means and channels of communication. But more important than this will be the effects produced on the trade and industry of the region and its neighbouring tracts because of the availability of cheap transport.

For this purpose it would be necessary to know what area the channel will serve, what kinds of goods will or can be transported and what will be the costs of transportation on the channel and how and whether this will facilitate or further any connected economic activity. What the Government expects to do in this regard by way of planning will be of utmost importance. Costs will be, of course, incurred in investing in the new river boats that will carry the goods. The expenses of maintaining them and keeping them in continuous operation also will have to be deducted from the total benefits.

Broadly speaking we can roughly assume that in the short period, (5 years after completion) chiefly the primary benefits will be manifested and even these will not reach their peak.

In the long period (25 years after completion) the primary benefits will attain their peak. The secondary, tertiary and further benefits will be also flowing in and rising towards their highest levels. A description of the expected developments at this stage in connection with the different purposes of the project might make this clearer. (1) Irrigation will have proceeded to the highest pitch possible and the adjustments of peasants, crops, *etc.* will have fully taken place. As a result agricultural production in the area will attain its maximum. Besides this primary effect secondary and other effects will have followed through the development of processing, *etc.*, industries. For example, if as a result of irrigation, sugarcane becomes a permanent crop of the region, it is likely that activities connected with the further processing of it will develop. It might give rise to *gul* and sugar manufacture, which will create additional employment and income. A sugar mill might proceed to process further its own wastes, such as molasses and baggase by starting the manufacture of power alcohol and paper respectively which will again increase employment and income. Or if irrigation leads to an increase in the production of oilseeds this might lead to the establishment of oil mills and the oil available might be used by new soap factories in the region. (2) Electrical power will be used by new industries which might be attracted to the region because of the availability of cheap power. This might lead to the development of new mineral and other resources. So also it might rehabilitate and develop further the existing handicrafts in the region. An increased use of electrical appliances is also possible and might lead to the establishment of industries making these. (3) Availability of the

navigation channel will increase the traffic on the river, and give a fillip to trade in general. Increased use of boats on the river might lead to development of small-ship building industry.

✓ It needs to be emphasized here as in regard to the primary benefits, that how fast and cumulatively they will flow and the highest level they will reach will be governed to a very significant extent on how well the plans for them are prepared now and executed later. Lack of planning will involve lower levels of total benefits, greater costs, undesirable and harmful developments, *etc.*

From the detailed discussion so far the broad contours of a plan for measuring the economic benefits of multi-purpose projects under construction can be discerned. Basically, of course, we will have to take stock of the economic conditions at the time of construction with which comparisons can be made of the economic conditions after the completion of the project. The present conditions can be gauged by the carrying out a survey of the area affected by the project. Conditions after completion have to be projected on the basis of available data, contemplated policies, *etc.* As has been indicated above, two pictures of economic conditions after completion, one after 5 years and one after 25 years, will have to be built up to see the problem in the short and long term perspectives.

An enquiry bearing on all these can be planned and completed in three stages as detailed below :

First Stage.—To build up a short term and a long term picture of the economic conditions in the area in the future on the basis of existing and available data, estimates and policy forecasts made in collaboration with experts from other fields.

For this purpose a wealth of data will be necessary, which, we assume, would be available at the project office. It would be useful to indicate in some detail what are the required data so that deficiencies if any can be made good by the proper authorities. A major estimate, among others, in respect of primary benefits would be that of the future agricultural production in the region. For this purpose the following information would be necessary. (1) Total land surface available for utilization after the completion of the project. (2) The topography, geology and soils of the area. (3) Hydrology of the region which includes precipitation, evaporation, surface water, ground

water, quality of water. (4) Sedimentation. These are mainly physical data, which have a bearing on agriculture. Besides these we will have to know (5) the pattern of land use *i.e.*, land under forest, grass and under cultivation including new and reclaimed land either from floods and/or sea, of the latter the area that will be irrigated. (6) Rotations and combinations of crops. Apart from this agricultural production will be influenced significantly by the future land policy that will determine (7) the conditions of land holding. (8) The size of cultivating units—tenancy laws, *etc.* So also will have to be known the future policy in regard to (9) land revenue, water cess, betterment charges, agricultural credit policy, roads, village and town sites and other public works for agricultural and industrial development.

In respect to the power aspect we will have to know (1) the total power that will be available, the area it will serve, rate at which consumption is expected. The policy of charging rates for various types and at various periods. How much will be consumed in agriculture and transport. (2) How much of it will be reserved for industrial activity? (3) The total consumption of fuels at present in the area which will be served with power later on. (4) Mineral development planned or possible. (5) Industrial development planned or possible. (6) Investments that would be necessary for all these.

In respect of flood control it is necessary to know (1) damage to crops, *etc.* every year that will not occur after completion of the dam. (2) Lands that will ~~not~~ become cultivable for the whole year because they are not affected by floods. (3) The amount of water flow that will be maintained downstream and which can be used by towns and villages on the banks.

Information (1) about the navigation channel and the estimates about its potentialities will be necessary. The points or centres that can and will be served by the channel. (2) The present volume of traffic along comparable and alternative routes. Effect on transport of possible agriculture and industrial development in the region. The possibility of transport requirements originating in other regions being satisfied or being attracted by the navigation channel.

The foregoing has been made fairly detailed. Yet some additional information may become necessary as the inquiry proceeds. This is

only noted here only to indicate that the above by no means exhausts the necessary information. It will be clear that the information required, as indicated so far can be supplied partly by engineers and partly by agronomists attached to the project. Some of the estimates, *etc.* required will have to be worked out jointly by both of them, in collaboration with economists. With the data thus furnished the economist, in consultation with the expert engineer and the agronomist can proceed to build as far as possible a complete picture of physical and other conditions in the region in the short and the long periods.

Second Stage.—The carrying out of a comprehensive socio-economic survey of the area affected by the project. This will have to cover agriculture, industries, trade, transport, occupations, incomes, *etc.* in the area. It will furnish the basic data for making comparisons with the future. Another set of surveys will at the same time have to be carried out, of already developed areas in or outside the area affected, but with mostly similar conditions, for providing the data necessary for calculating future incomes, *etc.* in the region arising from particular aspects of development. Most of the surveys will have to be carried out with the help of local enumerators or fieldmen, who will have knowledge of the local people and of the region and who will be familiar with the local conditions.

Third Stage.—In this final stage the data made available in the first two stages will be integrated for estimating the economic benefits of the project. The data from the socio-economic surveys and other statistical data will be comprehensively tabulated. The whole information will be thoroughly digested, the necessary forecasts and calculations made and an analytical report will be prepared and submitted.

It may be emphasized that the calculation of benefits and costs in relation to a project which will fructify sometime in the future is subject to a large margin of error. Forecasting the probable state of the economy of a tract involves many assumptions regarding future technical conditions, economic situations, government policies, *etc.* ; it also involves basing calculations on observations relating to existing conditions in particular regions which are supposed to be analogous to conditions that might obtain in the tract under consideration, in

the future. The more complex the whole situation and the more distant the future the greater is the risk of the calculations of benefits and costs proving wide of the mark. All that even careful and elaborate calculations today can be expected to indicate is the general level of probable benefits and the main directions in which they might be obtained.

CENTRAL BOARD OF IRRIGATION AND POWER
SYMPOSIUM

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PAPER V

**Evaluation of Benefits and Costs and Economics of
Inland Navigation Projects**

by

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1. INTRODUCTION

The inland navigation is recognized as the cheapest mode of transport and as it is now being revived in this country by initiating a few inland navigation projects, this paper is mainly written up to show how the benefits and costs of such projects are generally evaluated. As 'Benefit-Cost' aspect of the project is closely associated with the economics of the project, this is also discussed at length in this paper.

2. ECONOMICS OF PROJECTS

During the planning stage of the project the first essential item is to collect statistics regarding the volume of existing traffic by rail, road and waterway if any. A forecast of probable traffic which may develop after the proper waterway facilities are provided by the project, has to be made first. This probable growth of traffic has to be based upon total traffic needs and the proportion of total needs which will be attracted towards waterways in competition with other forms of transportation. These two major factors are linked with other variable factors as follows :—

(a) Factors affecting traffic needs*(i) Growth of population.*

Generally the life of a project is assumed to be 50 years. Probable growth of population has to be estimated from the past census reports.

(ii) Production per capita (standard of living).

The volume of goods produced per unit of population is an index of the 'Standard of living'. Statistical figures available for the past years may enable to estimate this. A relative increase of wage rates in the lower income groups will also result in a widespread demand for products previously availed of by higher income group. Generally transportation needs are assumed to vary directly with the volume of production.

(iii) Changing traffic requirements as a result of shifting and growing industry, use of new sources of raw materials and expansion of market areas.

If the project serves some big industries and if the present raw material sources are exhausted, new sources of this in relation to the area served by the project have to be considered.

(b) Factors affecting proportion of traffic needs which will use waterway transportation*(i) Adaptability of commodities of water movement.*

Generally the bulk commodities such as coal, oil, petroleum and petroleum products, ores, steel, grain, lumber, sand, gravel, cement, stone, etc. are very suitable for waterway transport.

The coal is widely recognized as commodity well adapted to river transportation. This is a low valued bulky and non-perishable cargo adapted to bulk handling. Generally the principal users are large power plants which are located at water side where it is practicable to secure the large quantity of condenser cooling water required for efficient operation. Time in transit is not an important consideration due to low value of commodity and it may be stock-piled to cover delays in transit and non-navigable seasons. For these reasons coal has moved by water in large volume for a number of years. Similarly equipment and facilities available can be readily expanded to carry any movements.

Petroleum and Petroleum Products:—Petroleum products are excellently adapted to river movement since they can be handled by pumping, and require relatively simple, low cost water-side handling facilities. Storage facilities can be more conveniently located for access by rail and truck than is possible in case of commodities requiring crane or conveyor handling. A major factor in the choice of waterway transportation is the fact that volatile cargo such as gasoline remains at the water temperature as compared with much higher summer temperatures attained in rail tankers; this results in a substantial reduction in evaporation losses.

Grain:—Grain is also adapted to river transportation as it is bulky and non-perishable cargo adapted to bulk handling by conveyor belts.

- (ii) Accessibility and convenience of water route such as availability of rail connections, terminal and transfer facilities, need for stock piling to accumulate barge loads at origin and for consumption during closure of navigation.
- (iii) Time in transit and interest charges on value of cargo.
- (iv) Degree of saturation of capacities of alternate means of transportation.

3. TRAFFIC SURVEY

A questionnaire regarding traffic survey may be also prepared and mailed to various business organisations, covered by the project area, requesting information as to type of business conducted, principal commodities received and forwarded and origin and destination of the same, estimated water shipments in barge lots and less than barge lots and comments in general on the project. If necessary they may be interviewed and their views may be obtained in detail.

A careful analysis of this should be made to eliminate commodities not considered adaptable to water movement and a proper estimate be made with due consideration to various factors mentioned in (2) above.

A detailed table showing the prospective tonnage by commodities, direction of movement and type of commodities should be prepared, as Table I.

TABLE I

Prospective tonnage and annual savings by individual commodities

1. S. No.	
2. Commodity	
3. Present Directional Movement	
4. Tonnage per year	
5. Movement in miles in a year	
6. Present rate of transportation by means of other than waterway (Average rate ton mile)	
7. Present cost of transportation	
8. Prospective tonnage by water ways	
9. Directional movement in miles	
10. Movement in ton miles	
11. Average rate ton-mile all water traffic	
12. Cost of transportation by waterway	
13. Annual savings (Difference of cols. 7 and 12)	
14. Remarks	

Note:—Where tonnage is likely to be handled jointly by rail, truck and waterway savings should be worked out on the basis of joint rates.

4. ESTIMATION OF BENEFITS ON PROSPECTIVE COMMERCE.

4.1 After estimating the traffic which will be attracted towards waterways, water line haul rates should be computed for these movements. Rates thus computed should then be made comparable to the rail and/or truck rates depending on other existing forms of transportation. The savings on freight charges on the prospective tonnage should then be arrived at by comparing the transportation charges which the shippers would have to pay for shipping the prospective tonnage *via* the waterway with transportation that would otherwise have to be paid for shipping *via* the routes and manners by which it moves at the present time. The method of tabulation is shown in Table I. The savings thus worked out represent the direct benefits of the project.

4.2. The important factors influencing the determination of the water-line haul rates are discussed in the following paragraphs.

The existing tow operators should be contracted to obtain their views as to the make up and size of towing equipment which will operate consistent with the size of the navigation channel and pay load for the barges.

On the Mississippi river, a barge of the size 195 ft.x35 ft. is the most commonly used and tows consist of either four or six of such barges.

Two systems for towing barges are in vogue, one is called 'push' system and another is called 'pull' system. The former is very common in U.S.A. whereas the latter is common in Europe. Push system has certain distinct advantages over the pull system. The former gives less resistance and solves the problems of manoeuvrability and control. Similarly with an integrated fleet in a push system the unit can realise a substantial speed gain over a non-integrated fleet. (In integrated fleet ends of barges where they come in contact are not raked).

After fixing the size of barges and engine power or tow boat, tabulation of various items making up first cost, annual charges, operating cost is made as shown in Table II.

(The following staff is assumed for crew. One master, one pilot, one Chief Engineer, One Engineer, two oilers, 2 mates, 4 deck hands, 2 gully-men).

4.3. If, for instance, tow unit consists of four barges an equal number of barges is generally assumed for a lay over at the points of loading and unloading purposes respectively. In other words for each tow of four barges in actual line haul service there would be additional four barges at the point of origin and four at the point of destination. Similarly, for reserve plant for every 8 tow boats in active service one tow boat is provided as a standby to take up the place of any of these eight which might suffer a breakdown. In like manner for 12 barges in active service (for the illustration give above) one barge should be held in reserve.

4.4. Towing speed to be adopted for any movement is limited by the maximum and minimum speeds at which tows may be safely manoeuvred in the channel available. Within these limits imposed

TABLE II

Annual cost of operation of a towing unit handling bulk cargo
from ————— to

S. No.	Item and its description	Tow boat	Barges Rs.	Remarks
1	2	3	4	5
	I. FIRST COST			
	(a) Active plant Tow boat @ Rs. per H.P. Barges each Rs.			
	(b) Reserve plant 1/ tow boat and 1 barge			
	II. OPERATING COST			
	(a) Crew pay roll and crew subsistence.			
	(b) Fuel oil in Rs. per hour Total number of hours in a year is generally assumed 60% of hours in a year			
	(c) Lubricants			
	(d) Ship supplies			
	(e) Repairs and maintenance (i) Tow boat @ Rs. per H.P. per year (ii) per barge per year			
	(f) Overhaul charges on items (a) to (e) @ 5 per cent.			
	(g) Workmen's compensation insur- ance. This can be taken 5 to 6 per cent of the pay roll.			
	(h) Cargo insurance in Rs. per ton, for total tonnage.			
	III. ANNUAL CHARGES			
	(a) Interest @ 5 per cent. Tow boat Barges.			
	(b) Amortisation Tow boat (25 years life) Barges (15 years life)			
	(c) Fire marine insurance, other insurance & taxes, if any.			
	IV. CONTINGENCIES ON ITEMS I, II, AND III.			

Total cost per year
Number of round trips
Cost of round trip
Cost per ton mile

by the type of equipment and channel conditions, the most economic speeds are fixed by economic studies to determine the lowest cost per unit of commerce moved or the maximum net return for towing unit. They are also based on a study of the existing tow units if any or past experience on other projects having ancillary operating conditions.

4.5. As regards estimation of the number of trips, time spent at terminals for loading and unloading should be properly evaluated. Proper allowances should also be made for delays due to accidents, fogs, floods and other adverse weather conditions. This is generally reduced to a function of the distance travelled by the tow unit. One minute per mile of travel is generally considered lost due to these factors. Time consumed through lockages, if any, should also be properly allowed for. Whether the lockage will be single or double will depend on the size of lock and the formation of tow units.

If for reasons of pay load some barges are used in both directions of movement for handling coal and grain for instance the time and cost of clearing the barges should also be taken into account.

4.6. After estimating the actual and potential traffic in tons and ton-miles over the project waterway and knowing the water line haul rates, the benefits, which consists of lower transportations costs to waterways, are worked out as discussed in para 4.1

5. ESTIMATION OF COSTS

When the lay-out is decided upon an engineering estimate of project cost should be made, The capital cost should be worked out as shown in Table III.

TABLE III
Showing capital cost of project

No.	Item	Quantity	Unit	Cost	Amount
1.	Dykes, spurs, groynes				
2.	Bank revetment				
3.	Dredger and initial dredging				
4.	Other works				
Total		Capital cost in Rs.			

From Table III another table should be prepared for working out the annual costs of the project, as shown in Table IV.

TABLE IV
Showing annual cost

S. No.	Item	Amount
1	Interest on capital cost. Generally taken as 3%.	
2	Amortisation of first cost assuming 50 years life of the project.	
3	Maintenance and operation such as repairs to groynes, dykes, revetment and dredging etc. including establishment, if any.	

Total annual cost in Rs.

Knowing the annual benefits and annual cost, their ratio can be worked out. If this ratio is 1, the project is financially justifiable.

Costs of some of the projects in U.S.A. are given in Table V.

6. Besides the direct benefits, consideration should also be given to indirect benefits accruing from the project such as —

- (a) Enhancement of land values both along the routes traversed by the waterway and in the cities served by the project.
- (b) Improvement of social and economic conditions in the area.
- (c) Value as a backbone of national defence because this can ease the burden placed on other forms of transport.
- (d) Recreational value.
- (e) Creation of a new trade movement.

TABLE V

River	Project Channel (depth x width) (Feet)	Length (Miles)	Capital Cost		Annual maintenance cost	
			(Million \$)	(\$/Mile)	(Thous. \$)	(\$/Mile)
Missouri	9' x 300'	762	218	286,000	4,500	5,900
Upper Mississippi	9' x 300'	659	185	281,000	3,500	5,300
Ohio	9' x 500'	979	156	159,000	3,500	3,600
Columbia	35' x 500'	128	5	39,000	827	6,500
Lower Mississippi	12' x 300'	736	100 (2)	137,000	9,800 (1)	13,300
Middle Mississippi	9' x 300'	195	84	431,000	1,370	7,000

Note :—(1) 1948 maintenance dredging and revetment repair.

(2) Estimated.

CENTRAL BOARD OF IRRIGATION AND POWER
SYMPOSIUM

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PAPER VI

**Economy Effected by Models in River Valley Projects
and Allied Hydraulic Problems**

by

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SYNOPSIS

The paper briefly describes the importance of models and laboratory practice in the design of structures both for safety as well as economy. The experience of the last quarter century has shown that testing of designs on models have resulted in large scale savings. The various aspects of a design which cannot be worked out by mathematics can be fully studied with the aid of models. The functions of a Hydraulics, Soil Mechanics, Materials Testing and Structural Laboratories to solve various problems have been narrated in the introductory remarks.

Eight authentic studies have been summarised on which investigations were carried out at the Uttar Pradesh Research Institute and proved a success when tried in the field. These investigations amply show how economies can be effected in evolving cheap and suitable designs by spending a very low percentage of the cost of a project on models.

INTRODUCTION

All structures such as dams, weirs, spillways, bridges, river training works, power houses, embankments and buildings are universally designed with the aid of models in these days. The models owe their popularity for the simple reason that the design engineer can

see the working of his designs on them at small costs and he can alter the same suitably with confidence. This has resulted in large scale savings in both big and small undertakings whether pertaining to original constructions or maintenance works.

The phenomena of flow is so complex that often, it is not possible to account for all factors in a purely mathematical treatment of design of hydraulic structures. For example, the discharge coefficient of a spillway is primarily dependent on the shape of its profile and curvature of flow upstream and it is difficult to assess its correct value on mere assumption of few relevant factors. Model studies have indicated that a minor alteration, in the shape of the profile determined mathematically or with the help of few empirical formulae, makes a vast difference in its discharging qualities. Design of protection works below a fall, an overflow dam, a spillway or a power house, requires separate treatment in each case and it has not been possible to standardise individual designs so far. The most indeterminate factor is the position and size of staggered blocks and baffles which form a major item of energy dissipation. A little wrong setting of these devices has proved disastrous in the field. Model investigations are indispensable for such structures. A careful study of river bends, curvature of flow, discharge characteristics and other hydrological data in the field has often led to correct positioning of barrages, weirs and bridges but this was generally accompanied with shortcomings. Training works at such places have presented innumerable difficulties and experience has shown that in view of the changing regime of the Indian rivers, it becomes difficult to predict how a particular work is likely to behave. The knowledge about the attracting and the repelling action of spurs and behaviour of the pitched islands and the guide *bunds* though of recent origin, have been a great advancement in the science of river training, but, without the help of models, the correct inclination, length and shape of the spurs, the pitched islands and the guide *bunds* cannot be accurately gauged. Large sums of money had been spent in the past on such works built on the intuition and the judgement of the engineer and were found in several cases a complete waste.

The modern engineer is faced with the design of such structures whose structural design is not amenable to mathematical analysis. These are better understood with the aid of models. Photo-elasticity has been found to be extremely useful in determining stresses indeter-

minate structures under different conditions of loading. With the help of Materials Testing Laboratory, it is possible to test the suitability of different materials such as cement, sand and aggregates to achieve a certain strength in the design of various mixes. Various types of lining for canals, distributaries and minors have been designed after laboratory tests and tried in the field with advantage. Similarly, use of soil cement was advocated and as a result of this, a number of soil stabilised houses were built in Punjab with astonishing success only recently. These were found to be less costly as compared to those built with brick masonry. Most of the airfields in the country were constructed with stabilised soil during World War II.

The soil mechanics has greatly solved foundation problems in respect of power houses and earth dams which are designed on more economic lines as compared to the past, when very little was known about the subject. Various properties of the soils such as their mechanical composition, shearing strength both direct and triaxial permeability, bearing capacity and field density can be readily diagnosed with the soils testing apparatus. Earth dams in olden days used to be built in heavy sections in the interest of their safety and stability. Economical sections are now designed with the full knowledge of the soil characteristics available at site. A number of new design features have been introduced such as, providing berms on slopes, thereby reducing earth dam sections and thus economising in the quantity of earth work involved, use of gravel toe to prevent failure against seepage and of puddle core walls and upstream blankets to safeguard against piping. Electric analogy apparatus has afforded an easy means of tracing phreatic lines whereby economical earth dam sections could be designed. Also, the apparatus has been helpful in determining quantity of sub-soil flow in power house foundations and the arrangement of tubewells or well points for dewatering them.

In view of the above facilities, the engineer is becoming increasingly dependent on laboratory and model tests and almost all designs pass through the stage of experimentation at one time or the other. It would be argued that when it was impossible to reproduce nature in its entirety, the engineer could well base his designs after the study of conditions at site without incurring extra cost in experimental enterprise. Again, some of the major irrigation systems in the country had been built on the clear concept of the engineer in the

past hundred years or so and they are standing without damage or deterioration uptill now. The study of their behaviour could give better insight to the designer. A good deal can be said in favour of this line of argument but when economy combined with speed has to have an upper hand, a scientific and rational approach to study prototype conditions in an abundently true perspective with the help of a model, is a matter of necessity. Of course, a very close liaison is called for between the field engineer and the model builder for an accurate representation of conditions at site otherwise a small unnoticed flaw is liable to give wrong indications. Although cent per cent reproduction of field conditions is an impossibility, yet within certain permissible limits of working, a model always gives dependable results. The model technique has been recognised more an art than science and the correct reproduction of conditions of site and the interpretation of results depends upon the experience and wit of the experimenter. The importance of this science has been established beyond doubt in recent years. There are as many as twelve Hydraulics and Soils Laboratories functioning in the country today and more are likely to come up. This paper briefly describes a few investigations whose designs were studied in models at the Uttar Pradesh Research Institute during the past six years. The recommendations of the Institute were carried out in the field and proved a success. This saved large sums of money which would have been spent otherwise.

1. Checking Retrogression below Dhanauri Escape Dam

Ratmau torrent., Figure 1, crosses Upper Ganga Canal at mile 13 where Dhanauri level crossing was built hundred years ago. The level crossing, Figure 2, is 766 feet long and consists of 57 spans of 10 feet width each with $3\frac{1}{2}$ ft. piers in between. The torrent bed which consists of sand of average diameter 0.36 mm. was continually eroded below the Dam in spite of five boulder crate bars built from time to time to check this tendency. The water surface slope was of the order of 8.23 ft.¹ mile. By 1887, the river bed went down by 15 feet and in 1924 floods, these bars were washed away and the downstream apron which consisted of boulder masonry laid on piles and crates was badly damaged. This maximum flood was estimated to be of the order of 81,700 cusecs based on catchment area. A stepped *pucca* floor covering this drop in three stages was built immediately but for want of proper energy dissipating devices,

further lowering of bed continued. In 1939, a sloping glacis in the cement concrete blocks and resting on wells was built to kill the action of flow but it provided little relief.

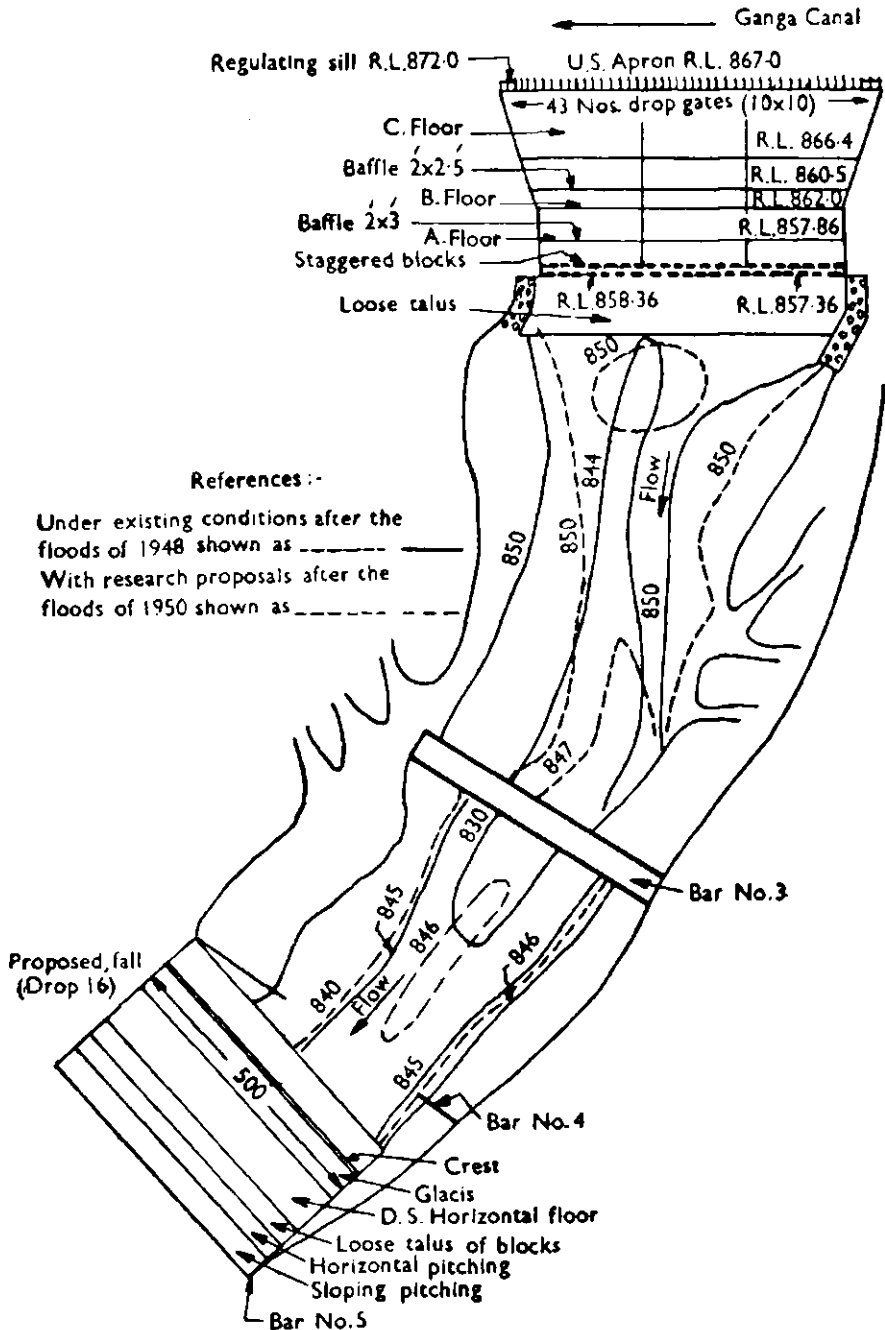


Figure 1: Showing survey plan of Ratmau Torrent below Dhanauri Dam.

During 1947 floods, upper layer of floor 'A' was blown up in a length of 200 feet near left wing wall, and the torrent bed was 10 feet lower than the 1924 level at the toe of the glacis. The present water surface slope reduced to 5.86 ft.¹ mile. The damaged floor was repaired and it was proposed to build a 16.0 feet fall at the site of Bar No. 5 for the safety of the Dam at an estimated cost of Rs. 16 lakhs.

The problem ⁽¹⁾ ⁽²⁾ was referred to the Research Institute where feasibility of constructing this fall along with various other proposals were studied in a scale model. Model investigations indicated that energy of falling water below the dam was incompletely destroyed. This was being carried forward on to the sandy bed of the torrent which was eroded and washed. It was found that providing suitable raised crests at the end of first two stepped floors below the dam and a row of staggered blocks at the end of third, with two baffle walls on the second and third floors, Figure 2, ensured full dissipation of energy and silting occurred below. This proposal was executed at site at a cost of Rs. 30,000/- only in 1948 and 1949 and has given remarkable results. The torrent bed silted by 6 feet to 8 feet during the last five flood seasons. It would thus be appreciated that it was hydraulic model studies alone by which such a low cost device was evolved otherwise it was impossible to arrive at such an arrangement of baffles and blocks with the help of mathematics or a similar source.

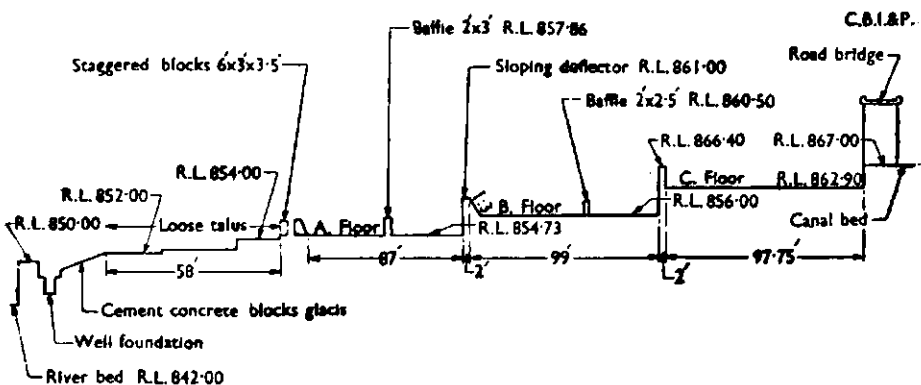


Figure 2: Showing Longitudinal section through Dhanauri escape Dam.

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- (1) U.P. Technical Memorandum No. 19, pages 31 to 35.
 (2) U.P. Technical Memorandum No. 20, pages 9 to 11.

2. Checking Scour below the Sluices at Bhimgoda Weir (Hardwar).

In 1920, Bhimgoda weir, Figure 3, was constructed in Ganga river to feed Ganga canal which drew its supplies a little upstream of the present weir through old supply channel previously. The weir consists of 6 undersluices, each 50 feet wide on its right flank and 6 overflow crests bays, each 300 feet wide on the left. The river upstream bifurcates into two channels with a wooded island in between. The main stream popularly known as Chilla channel was on the left then. To feed the New Supply channel, head, the river was trained to flow along the right bank by raising crests of weir

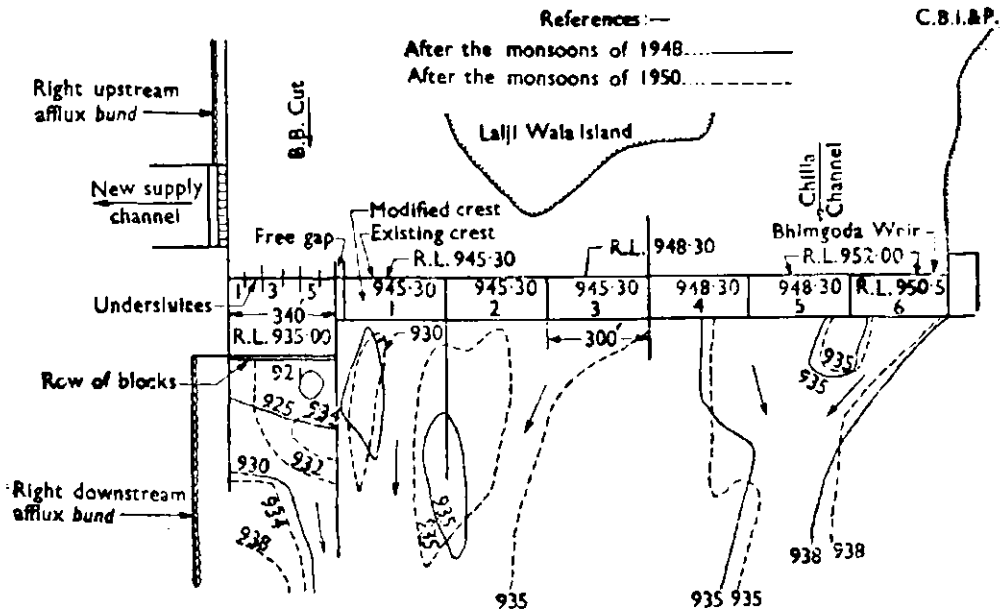


Figure 3: Showing Survey plan of Ganga River downstream of Bhimgoda weir and undersluices.

bays from left to right and this channel was named B.B. cut. Excessive diversion of flow changed regime conditions below the sluices and a 15 feet to 20 feet deep scour occurred there. The standing wave whose effects were most damaging formed below the pucca floor up to floods of 1.5 lakhs cusecs intensity which were of frequent occurrence during the monsoons. The maximum flood is estimated to be of the order of 6.7 lakhs cusecs. A 2'0 feet high baffle and a deflector of equal height on the downstream floor of the undersluices was recommended by the then Central Hydrodynamic Research Station, Poona in 1937 to pull up the standing wave on to the pucca floor and thereby reduce its damaging action. This proposal, however, was not given effect to as it was considered that it would obstruct the free movement of boulders (size 1 foot to 3.0 feet) which in turn, might damage the floor more severely.

When model investigations ^(3,4) were taken up at the U.P. Research Institute, for devising protecting measures, it was found that at a flood discharge of 1.53 lakhs cusecs, 47 per cent. of flow passed through the undersluices against 33 per cent designed. This was the primary cause of excessive scour. Had this training been done with the help of a model, such a situation would not have arisen. The crests were recommended to be lowered suitably for proportionate distribution of flow over the weir and the undersluices, and when these proposals were executed at site, in part, strain at the sluices reduced and silting occurred in the river bed below. Further, a 950 feet long bar consisting of cement concrete blocks was constructed in continuation of the left wing of the sluices to straighten the flow downstream and provide adequate depth for the formation of standing wave on the *pucca* floor at low floods. It was seen during the last five flood seasons that the scoured pool was filled up and the danger of damage to the sluices, completely averted. These proposals were carried out at a cost of Rs. 2.2 lakhs only. In case, such a step had not been taken and the situation at the sluices allowed to deteriorate further, a small damage would have resulted in a loss of about Rs. 10 lakhs of revenue during the period the repairs were undertaken. The model experiments cost Rs. 10,000/- only.

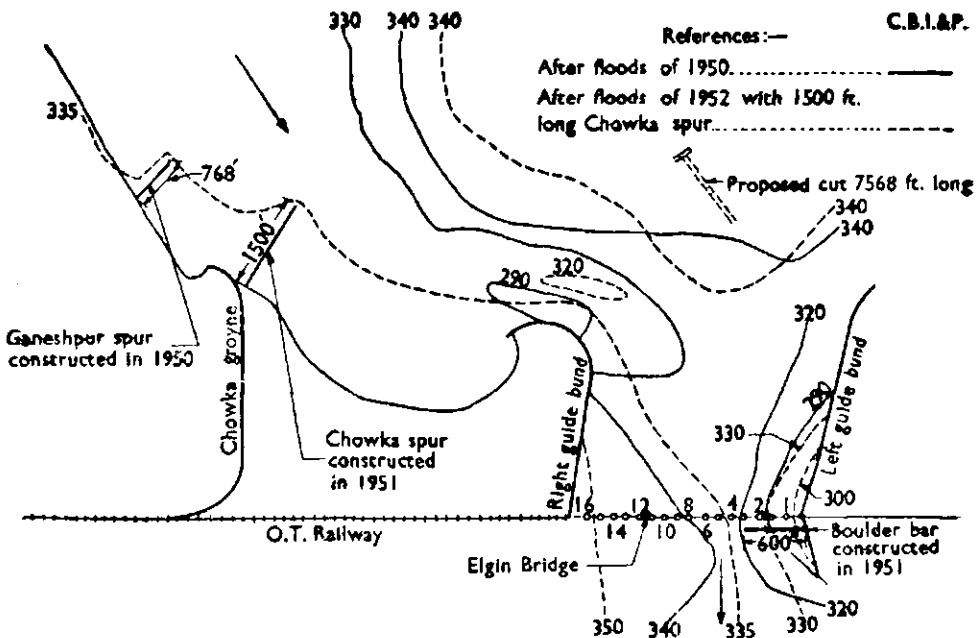


Figure 4: Showing contour plan of Gogra River at Elgin Bridge.

(3) U.P. Technical Memorandum No. 18, pages 54 to 58.

(4) U.P. Technical Memorandum No. 19, pages 35 to 37.

3. Training of Gogra River for Checking Outflanking of Elgin Railway Bridge (N. E. Railway).

Gogra river flowing through Elgin Bridge had its course along the left bank in 1914, flowed centrally in 1924 and shifted towards the right subsequently. The bridge consists of 17 spans of 200 feet each with 11.5 feet wide piers in between. The right guide *bund* at the upstream flank of the bridge and the Chowka groyne, Figure 4, stood the river action for a couple of years but conditions deteriorated and the river started attacking Ganeshpur village in 1949 and it was feared that it might outflank the bridge below the groyne. The maximum calculated flood at the bridge site is of the order of 8.8 *lakhs* cusecs and a discharge of 4.6 *lakhs* cusecs passed in 1950. The river bed consists of fine sand of average diameter 0.18 mm. To train the river course, a cut was proposed by the Railways from the point the river took turn towards the right and it tailed nearly at the centre of the bridge. In fact, an estimate amounting to Rs. 1.5 *lakhs* was sanctioned and work started. Model investigations⁽⁵⁾ in 1950, however, indicated that this cut would not develop as sufficient drop was not available and consequently, the work at site was stopped. Instead, a 768 feet long spur at Ganeshpur was suggested to help shifting of the river course away from it and induce silting along the right bank. This proposal was tried at site before 1950 monsoons and did its job during the following floods. The silting above and below Chowka groyne occurred in a depth of 4 feet to 6 feet and the safety of the bridge was fully ensured. The cost of the spur was about Rs. 6 *lakhs* and the model experiments cost Rs. 25,000/- only. Extension of Chowka groyne in the first instance was a better solution, but this construction was not a possibility, in view of the deep scour at its nose, in a short period at the disposal of the Railways at that occasion. On silted bed obtained with Ganeshpur spur, a 15.00 feet long extension at Chowka groyne was constructed in 1951 on the basis of Research⁽⁶⁾ recommendations. This improved conditions further and the fear of outflanking the bridge completely vanished. This spur also cost Rs. 6 *lakhs* as most of the material of Ganeshpur spur was utilised here. It would thus be appreciated that in the event of delay of one flood season or more, if the river had cut across the right guide bank, the bridge would have been left high and dry as happened at Gandak river railway bridge, thus dislocating the traffic and incurring expenditure of huge sums of money for the restoration of normal conditions.

(5) U.P. Technical Memorandum No. 20, pages 23 to 26.

(6) U.P. Technical Memorandum No. 21, pages 16 to 19.

4. Training of Ganga river for checking outflanking of Railway Bridge at Rajghat Narora (Northern Railway).

3,128 feet long Railway bridge at Rajghat Narora was built across Ganga river in 1872. The river was flowing along its left bank then. After 1915, the river course swung towards the right till in 1949, it shifted towards the left again. 1924 maximum flood that passed through Ganga river at the bridge site was estimated to be of the order of 3.91 lakhs cusecs. The river bed consists of coarse sand of average diameter 0.37 mm. The river action was damaging along the left upstream railway embankment and it was feared that it might not cut across. The railway authorities constructed a 500 feet long spur about 2 miles upstream of the bridge on the left bank to divert the flow away from it, Figure 5, at a cost of Rs. 4 lakhs. The spur did useful work during low floods but developed a tendency of being outflanked at high floods owing to its exercising an attracting influence over the flow. Model experiments ⁽⁷⁾ ⁽⁸⁾ were carried out at the Uttar Pradesh Research Institute and it was suggested that

References:-

Under existing conditions after floods of 1952 shown as -----
 With 250' extension to spur & 120' extension to first tie after running the model with modified hydrograph of 1952 (Maximum discharge 2.568 lakh cusecs) shown as -----

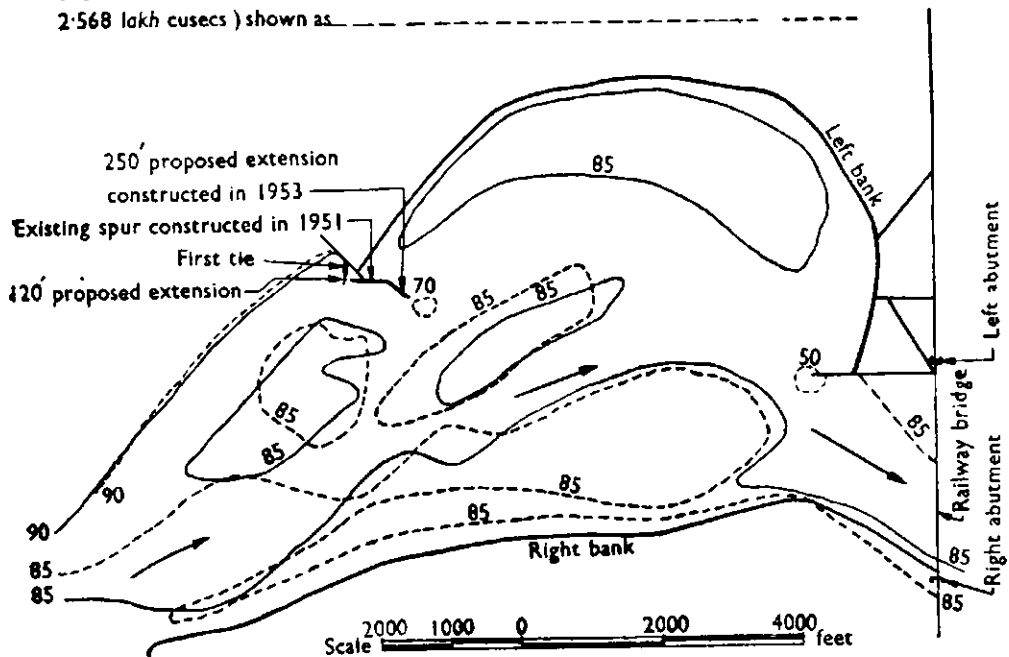


Figure 5: Contour plan of Ganga River above Bridge No 101 at Rajghat Narora—Northern Railway.

(7) U.P. Technical Memorandum No. 22. pages 15 to 21.

(8) U.P. Technical Memorandum No. 23.

an extension of 350 feet at an angle of 35° to the existing spur would make it function like a repelling spur and help in shifting the flow towards the right. The model experiments cost Rs. 25,000/-. Hundred feet of proposed extension was constructed in 1952 and the remaining in 1953 at a cost of Rs. 3 lakhs. During the following floods of both years, it was known that the extension did the desired work. There is no danger to the bridge now, and the flow is following a more central course. A proposal was under consideration to extend the left guide bund suitably as a permanent training measure which would cost over Rs. 10 lakhs. However, conditions at site indicate that there is no immediate necessity of undertaking this proposal in the presence of left bank spur though river conditions after a couple of years would depict further line of action, if any.

5, Training Ganga river for the protection of Tigri Village.

Tigri village is situated on the left bank of Ganga river at a distance of about 5 miles upstream of Garhmukteshwar Railway bridge. The river at this site flows in a 9 miles wide khadir sometimes following the right bank course and sometimes left. During 1951 floods, the Ganga was along its left bank and threatened to wash the

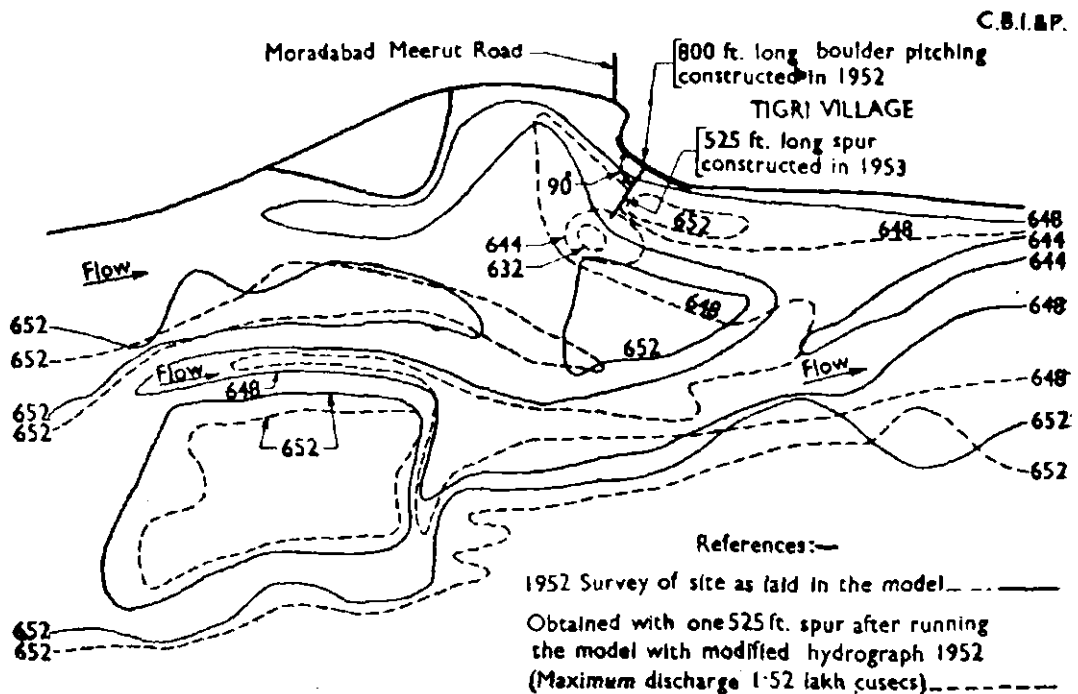


Figure 6 : Showing contour plan of Ganga River near Tigri Village village which owes its importance owing to 'Ganga Ashnan Fair.' The maximum flood was estimated to be of the order of 2.62 lakhs cusecs and river bed consists of fine sand of average diameter 0.21 mm.

Initially, it was proposed to construct 3 Balli Brushwood Spurs to divert the river course away from the left bank but these spurs could not be constructed owing to the paucity of time. Subsequently, the left bank below the village was boulder pitched in a length of about 800 feet at a cost of about Rs. 50,000/-. This provided no relief. It attracted the river current along its toe and created an embayment 600 feet wide upstream. Model experiments ⁽⁹⁾ were carried out at a cost of Rs. 21,000/- to suggest remedial measures for the protection of the village and it was found that a 525 feet long spur, Figure 6, would induce silting along the left bank both upstream and downstream, and shift the river current away from it. This spur was constructed at site before 1953 floods at a cost of Rs. 3 lakhs. It did its work during the floods, shifted the river flow by 600 feet from left bank and induced silting along the left bank to the extent that this land would be available for cultivation during the coming winter.

6. Design of Pathri Bypass Spillway

It was proposed to escape full supply flow of Ganga canal (10,500 cusecs) upstream of Pathri Power House under construction on a bypass power channel at mile 7 of Upper Ganga canal, through a side channel spillway. This 40 feet wide spillway was fed from two discharge weirs each 44 feet 3 inch wide covered a drop of 30.17 feet and tailed into power channel below the power house as per Figure 7. The spillway of this type was considered economical as compared to that having waterway equal to the width of the feeding channel. A design was worked out at the Uttar Pradesh Research Institute after conducting model investigations ⁽¹⁰⁾ at a cost of Rs. 15,000/-. This spillway would cost Rs. 20 lakhs. As an alternative, it was proposed to construct an escape channel, from the same head consisting of two discharge weirs, which would tail into the Ganga canal upstream of the Bahadrabad Power House as per Figure 8. This would cover a drop of 11.17 feet and the balance of 19 feet would be negotiated through the power house which would be remodelled to function as a spillway. Model investigations ⁽⁹⁾ indicated that such a proposal was a possibility and would cost Rs. 14 lakhs only, thereby giving a saving of Rs. 6 lakhs over the previous design. Model studies cost Rs. 10,000/-. The most important design part of the two types of spillways was the silting of the

(9) U.P. Technical Memorandum No. 23.

(10) U.P. Technical Memorandum No. 22, pages 44 to 63.

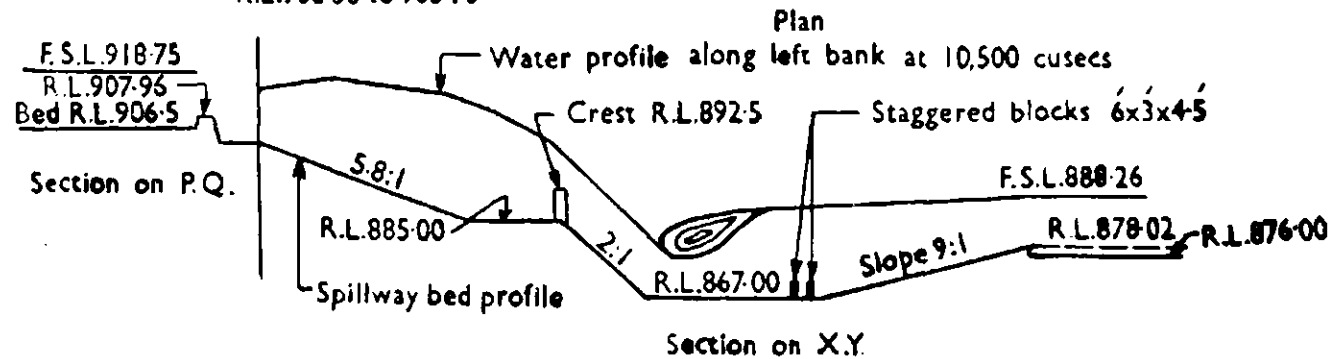
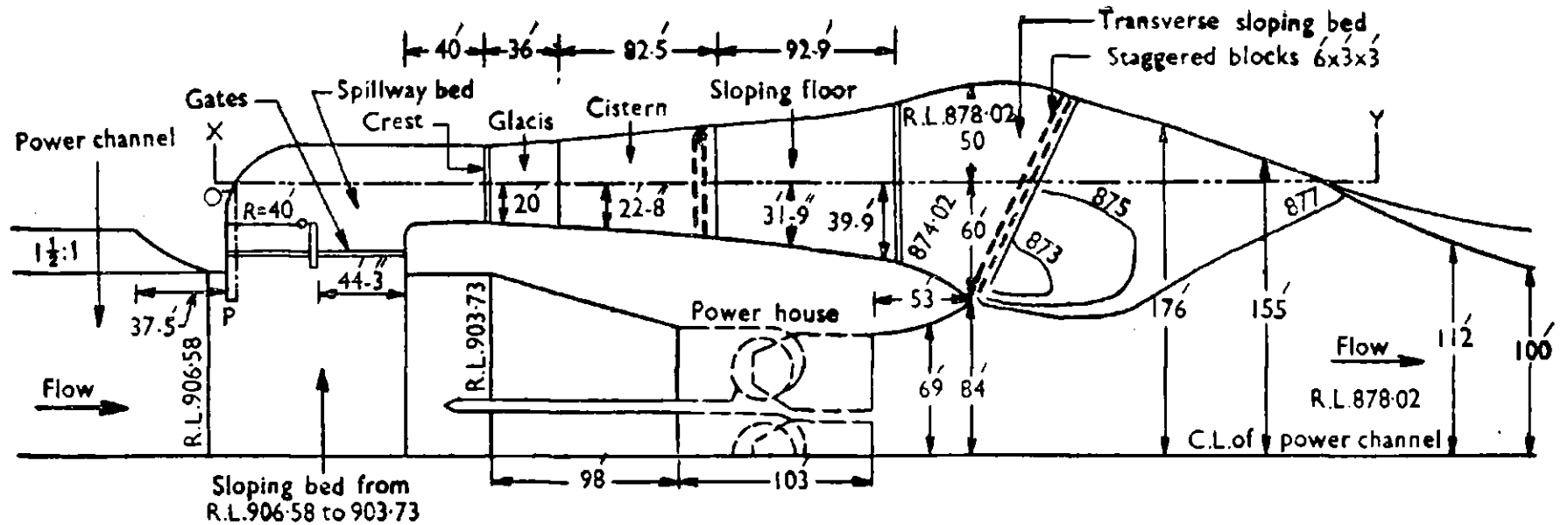


Figure 7 : Showing side channel spillway at Pathri Power House.

spillway discharge weirs and the upstream side splays for minimum silting upstream and equitable distribution on water loads over

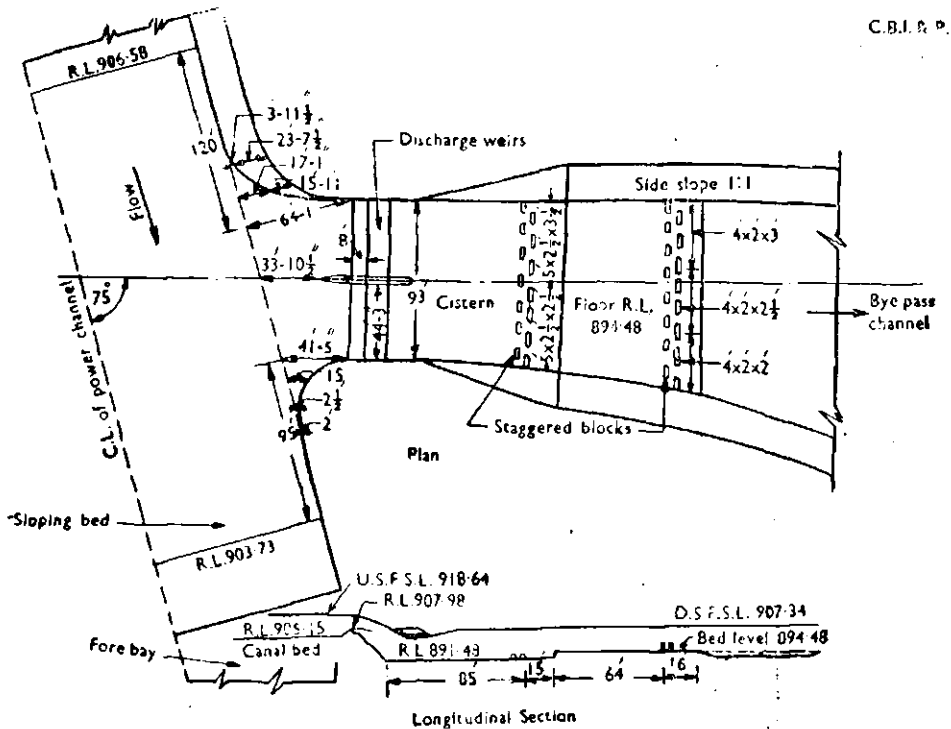
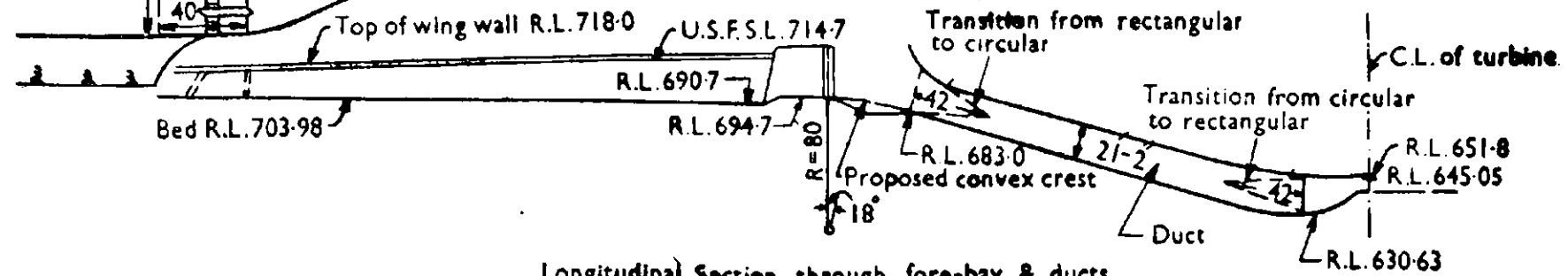
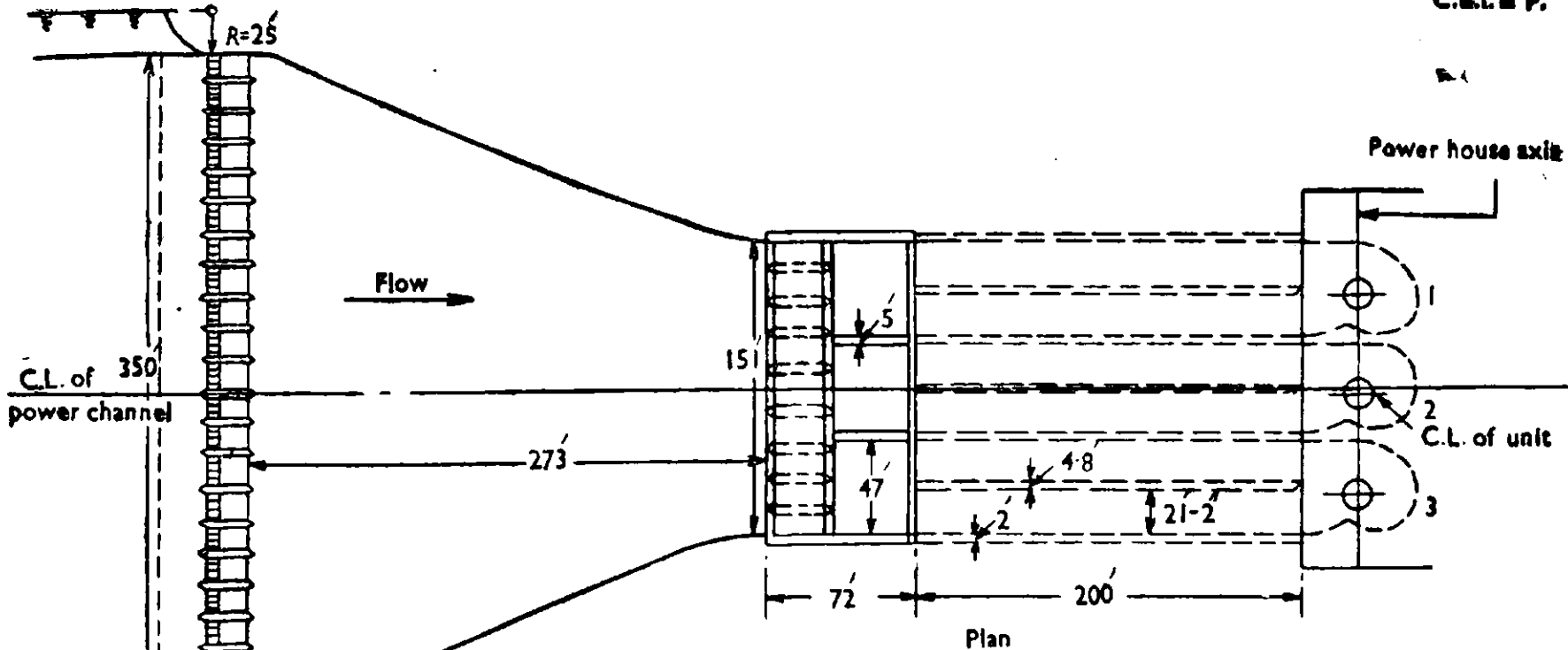


Figure 8: Showing Bypass at Pathri Power House

the tilting flaps for their efficient working. This could only be studied with the help of models alone.

7. Design of circular ducts for Sarda Power House

Sarda Power House is under construction on a bypass channel in the head reach of Sarda main canal. This will produce 41,400 kilowatts of electrical power and utilise a drop of 59.1 feet at a discharge of 9500 cusecs. The feeding ducts to the three turbines each 205 feet long, as originally designed, were rectangular in section (size 12 feet. 4 in \times 21 ft. 2 in.). Three penstocks formed one duct for one machine. These were subsequently replaced by two circular 200 ft. long penstocks (size 21 ft.-2 in. diameter) per duct provided with rectangular entry and exit (size 47.0 ft. \times 21 ft.-2 in.). Figure 9. Model investigations ⁽¹⁾ showed that this replacement was hydraulically sound, and thus adopted. This effected a saving of Rs. 6 lakhs. Model tests cost Rs. 5000/- only.



Longitudinal Section through fore-bay & ducts

Figure 9: General lay out of Forebay and Ducts at the Sarda Power House,

3. Design of Rangawan Earth Dam.

The construction of Rangawan Earth Dam was started three years ago on Banne Nadi, a tributary of Ken river in Vindhya Pradesh. The earth dam is 90 feet high and will have 5,800 m. cft. of storage for providing irrigation facilities to 96,000 acres of land in Banda District of Bundelkhand region. Good rock is available in the bed of the river and there are no foundation difficulties. A typical section of the earth dam as designed by the field engineers is as per Figure 10. It has 2 : 1 upstream slope, 4 : 1 downstream slope, clay core and a pipe drain for escaping seepage flow. Modifications to the design of various sections of the dam were suggested at the Uttar Pradesh Research Institute after analysing soil samples from site and model studies. (12). The design as recommended is also shown in the said Figure. A 50 feet wide berm with a low embankment has been provided at the upstream toe and upstream slope has been changed from 2 : 1 to 2½ : 1 on stability and drawdown considerations. The downstream slope has been reduced from 4 : 1 to 3 : 1 in the upper 34 feet depth and a 20'0 feet berm provided followed by 4 : 1 slope to keep the line of saturation well within the body of the dam. The pipe drain was replaced by gravel toe as the latter was considered more effective. Model investigations thus helped in evolving a safer and more stable section for the dam. In a similar way, a number of earth dams, namely, Saprar, Lalitpur, Kabrai, Arjun, Nagwa, Khajuri, Chandra Prabha, Naugarh and Sirsi were designed at the Institute on the basis of laboratory investigations and have been or are being executed at site.

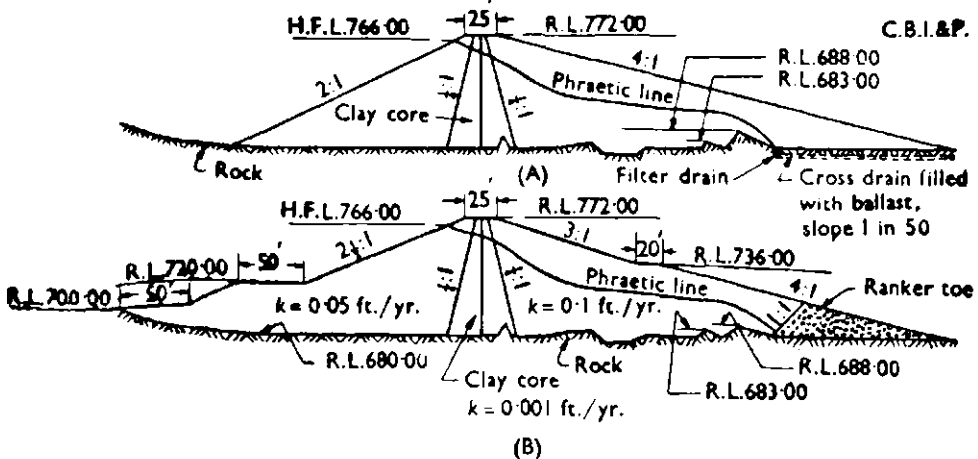


Figure 10: Showing Typical section of Rangawan Dam. (A) As proposed, (B) As recommended.

The primary object of mentioning the above investigations in brief, has been to bring out very clearly the important part models play in the economical and stable design of hydraulic structures. In this era of today when the irrigation engineer is faced with the execution of a number of river valley projects to raise the standard of the common man, it is hoped that the hydraulic, soils, material testing and structural laboratories will be called upon to play their befitting part side by side so that all schemes are carried out in a cheap and sound manner. It is only in the face of the above and many more achievements of the type, the research worker can claim for building more and more laboratories for the advancement of this science for the greater prosperity of this country.

ACKNOWLEDGEMENTS

The author gratefully acknowledges the valuable suggestions made by Shri J.N. Mitra, Director, Irrigation Research Institute, U.P., in writing this paper. Mention will be made of Shri J.P.Sharma, Overseer and Shri M.R. Ansari, Draftsman who prepared drawings enclosed with the paper. Shri K.P. Shukla, Assistant Research Officer (Soils), very kindly supplied material in connection with the earth dam design.

**CENTRAL BOARD OF IRRIGATION AND POWER
SYMPOSIUM**

NEW DELHI, 1953

PAPER VII

River Valley Projects—The need for a new prospective*

by

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SYNOPSIS

This paper deals with item 1—costs ; under subheads (a) to (c). It includes general observations, which are relevant to the objective of ensuring maximum progress on River Valley Projects consistently with soundness and economy in their design and construction.

In order to make the observations specific, parallels are freely quoted from the Bhakra Nangal Project.

Some aspects, like uniformed criticism, lack of comprehension of the difficulties inherent in the preparation of Projects, and the desirability of admitting any mistakes made during the inevitable trial and error stage, are touched upon.

Definite views are given regarding the necessity and manner in which the help of foreign specialists needs to be sought in the first big projects of the country. The introduction of mechanisation in our construction methods, is believed essential and has been advocated so far as it supports our manual labour methods without unduly hampering employment, and economy in costs.

Criticism regarding the frequent revision of Project estimates by engineers, has been examined against the background of unavoidable "unknowns", and the desirability of pitching estimates on the tight rather than the loose side, has been advocated.

* With particular reference to Bhakra Nangal Project.

The advantages of better control and better training facilities, possible with the force-account methods of execution of big and intricate jobs like the Bhakra Dam, have been stressed in the present stage of the River Valley Projects when reasonably economical unit-costs cannot be guaranteed by any foreign or Indian contractors due to the intangibles and uncertainties involved in the accomplishment of the undertakings.

Phasing of the country's Projects and maximum concentration of resources on the Projects now in hand, have been advocated, irrespective of Provincial boundaries. This will ensure the highest overall benefits, as the Projects will reach completion at the earliest and produce a favourable impact on the country's economy.

In order to keep the paper brief and lucid, statistics and figures have deliberately been omitted. The writer's opinions have, however, been stated categorically with a view to invite comment and discussion, particularly in reference to the procedures and techniques that are being adopted in the country's biggest River Valley undertaking—the Bhakra Nangal Project.

INTRODUCTION

As in all big undertakings, there are hurdles in river valley projects also. Some of these difficulties have been overcome by pioneers in the field and they have had to make experiments like in any new venture of an equal size and importance. The value of lessons to be drawn from the experiences of these pioneers would be greatly reduced if one only took the role of a destructive critic and did not see the reasons that influenced the results. Success or failure have an implication much bigger than the mere fact of success or failure. They provide the basis for the laws of the enterprise.

We have to recognise that the variables involved in any one project are vastly different from those operating in another. Some of these can be expressed in definite figures such as the total quantities of work, leads of haulage, and other construction operations. But several of these factors are intangible, and not capable of exact definition. Although these are not so apparent or visible yet they influence the course of events to a very pronounced degree.

NON-CONSTRUCTIVE CRITICISM

Unfortunately for the country, some of the River Valley Projects have come in for a severe criticism. Most of this criticism is

non-constructive. In many cases, the reason has been either local politics of the State or dissensions amongst engineers themselves. This has led to each side arming itself with half-truths. Any stick has been considered good enough to beat the dog after giving it a bad name. This has been often followed upto the press, the platform and the legislatures. Much dirty linen has been washed in public. Whereas cases of individual indiscretion, error or even dishonesty cannot be ruled out, yet we have to remember that the Projects are bigger than a few erring individuals. Hence the need for taking a balanced view so that the very causes which we seek to protect and improve are not stifled by frustration, unhelpful criticism or disproportionate punishments.

EXCESS OVER PROJECT ESTIMATES

One shortcoming which is being very loudly talked about is that engineers are apt to exceed their estimates. On this ground, the authenticity and reliability of engineering projects are being doubted. This aspect requires to be understood in its proper perspective. The public have to be educated to realize that Projects depend for their estimates on investigations and explorations of natural conditions including several "unknowns". One example is the foundations of dams and other big hydraulic structures. The details of these cannot be completely evaluated till construction has proceeded to a fairly advanced stage. The best guess has, therefore, to be made for a lot of items in most engineering projects and infallibility can never be expected. If one was to take no chances at all, then years of investigations and explorations would be needed. Overhead costs on the project would mount, besides postponement of works which may be required in the country's urgent development programme. The public should, therefore, understand that out of the two alternatives, it is in their own interest that engineer's estimates are on the tight side rather than on the loose side. This is such a well known principle of financing that much elaboration is not necessary. If the engineers were to make loose estimates and show substantial savings, that would not necessarily mean that the overall expenditures for the accomplishment of a project were less.

ONE FALLACY REGARDING RATES

One fallacy that needs to be questioned is the belief that the rate of cost of various items of work, for example excavation and concrete should be more or less uniform on all river valley projects.

This is a very erroneous idea and constitutes a pitfall for not only the public but also for non-technical administrative heads, who are in charge of guiding the destiny of many of the river valley projects. The domain of rates belongs to the sphere of the technician because of the multifarious variables that are involved in different projects. As an illustrative example take concrete which is the major item effecting the cost of a big river valley project. The main factors that effect the cost of concrete are :

- (i) Materials, type and proportion.
- (ii) Leads for these materials.
- (iii) Labour costs.
- (iv) Extent of mechanisation and depreciation.
- (v) Magnitude of work involved.

Now all these factors can vary widely depending upon, as they do, on the region of the project. Thus rates for Bhakra are appreciably low in respect of concrete and other items. A reference to Table I will show comparison of rates for concrete on various projects in India and abroad.

TABLE I

Abstract of rates for concrete on various dam constructions

Indian Projects			American Projects		
S. No.	Name of Dam.	Rs./100 Cft.	S. No.	Name of Dam	Rs./100 Cft.
1	Bhakra Dam	100	1	Douglas	286
2	Hirakud	170	2	Cherokee	214
3	Maithon	151	3	Hiwassee	173
4	Tilayya	233	4	Guntersville	270
5	Konar	243	5	Norris	184
6	Vaitarna	218	6	Wattsbar	185
7	Madupatty	195	7	Appalachia	287
			8	Chickamauga	229
			9	Wheeler	281
			10	Pickwick Landing	231

NEW FACTORS CALL FOR NEW APPROACH

The River Valley Projects are big undertakings of the nation. Some of the features involve new types of construction which have never been attempted in the past. It would be unwise to let ourselves be circumscribed by narrow-nationalistic or geographical boundaries. In fact we should be prepared to go to the very ends of earth, as it were, to obtain the best advice and make use of the accumulated experience of other countries and nations. This should in no way, reduce our own responsibility and initiative.

Foreign Consultants

For administrative and financial matters we should be acting mainly on our own discretion. Even in technical matters the final decisions should be our own although we should collect necessary advice of foreign consultants. Indians should be in key positions all along the line. We can ill-afford to have such vital jobs made wholly dependent on whether we get foreign help or not.

Training of Indian Engineers

Training of our own engineers is necessary so that we can ultimately be independent of all foreign help. But the requisite experience can be had only by doing the things ourselves and not by merely being observers or onlookers. A full measure of self-confidence is necessary. We should, in the last resort, be able to deliver the goods even without any foreign assistance. In such a case, we should be prepared to foot the extra cost, as we may have to make own experiments and a certain degree of trial and error is inevitable.

Construction Procedures & Agency

Apart from the question of mechanisation and foreign aid in technical personnel, there is the problem of construction procedures and agency. Our experience has shown that for big works like the River Valley Projects, it is best to get the intricate part of the job done departmentally. Indian Engineers should be responsible for getting the work done with the advice of foreign experts with the view that they should be able to stand on their own legs in the shortest possible time. However, till we are ourselves fit and competent, we should be prepared to respect and pay for the know-how ungrudgingly. Any egoistic foolhardiness is to be deprecated as un-scientific and narrow-minded and against the best interests of the country.

Contracting Agencies

Local contractors who can provide labour only, may be employed to carry out the simpler items of work. Giving out work on contract to large foreign firms is open to several objections. It has very little training value and leaves us relatively uninformed in essentials even when the work is finished. It means 100 per cent. dependence on the contractor right uptill the day when the work is completed. The contracting agencies do not give firm unit bids and usually charge much more than the actual bid without any upper limit, because of escape clauses both regarding time and costs. So far as big Indian firms are concerned they have yet to build up traditions. We wish them all success, but they are still in their infancy. They are not in a position to finance or organize as efficiently as the Government.

Self-Sufficiency

Still we ought to make full use of Indian methods, and techniques, which are suitable not only for self-sufficiency and development, but also in the interest of economy. Instances are wooden poles for power transmission and distribution lines on the Joginder Nagar development, use in mortars of *kankar* lime which has been standardized in the Punjab, and the manufacture in the Government Workshops of scroll cases and penstocks for the Gangowal and Kotla Power Houses.

EXTENT OF MECHANISATION

In India, although previous experience in such jobs is lacking, particularly in respect of mechanisation, a truly scientific approach is being made all the same. The extent of investigations and the degree of thoroughness are, however, different on various projects depending upon their nature, economies and urgency. For speedy execution, the use of machines in big construction jobs is imperative yet we should not overlook the necessity of a proper balance even in this aspect. Whereas we have to advance beyond the stage of the relatively smaller jobs which constituted the construction of earthen embankments, diversion weirs or low head barrages, we must not lightly give up the advantages and good points evolved during a century of irrigation experience. In our enthusiasm for mechanisation we should not swing to the other extreme, as mechanisation is desirable only upto a degree in our present conditions. Plenty of man

power in the non-skilled and semi-skilled categories is available in India and only a combination of manual and mechanical labour is most suitable, for ensuring greater employment even if it means some extra cost.

Use of Large Units in Mechanisation

In mechanisation too, use of large units is not advisable. Recourse to smaller units with a greater number of operating personnel would be more consistent with our present stage of development and labour conditions. We have to remember that so far, very little construction equipment is manufactured within the country. Availability of suitable manual labour is particularly important in case of sudden breakdowns in machinery or non-availability of spare parts. Work can be and should be done by manual labour in such cases rather than losing time in waiting for machines. Excavation of the Nangal Hydel Canal is an example where 300 million cubic feet of earth have been moved by manual labour.

SOME FEATURES OF BHAKRA NANGAL PROJECT

It will be interesting to note how the Bhakra Project has been brought to its present degree of thoroughness under the various aspects which are the subject matter of this Symposium. These aspects are divisible into two categories. Some of the points permit of no difference of opinion, as they represent ideals which are unquestionably necessary. In others, there is room for variation of opinion, although extremes on either side of the middle course would entail unfavourable consequences. Perhaps a brief statement of the conditions and features pertaining to the Bhakra Project will elucidate the matter and then permit a balanced view to be taken. The issues have not been free from controversies and even if some mistakes have been made in the case of the Bhakra Project, it is the duty of the Bhakra Engineers to take the public into confidence so that those mistakes are not repeated on other projects. At the same time good points that characterise the Bhakra Project must also be understood and acknowledged so that their application is also made as wide-spread as possible.

Fast Development Potentialities

The Bhakra Project is by far the best overall development project considering its irrigation and power cost/benefit ratio. The

reason for this is the availability of adequate good irrigable land, which will be transformed from arid waste into a smiling area rich with fodder and food crops and gardens. The regions served by this Project already possess ample man power, who are skilled in the art of rehabilitating land. They will bring to India the accumulated experience obtained by them through their sweat and toil in the well known colonies of Lyallpur, Montgomery and Sargodha. The partition of the country has reduced them to a stage where life is demanding an expansion to their original standards. The same applies to their capacity for expansion of industry. There are quite a number of factories which they have left in the West Punjab and to re-establish which they will be able to provide the know-how, labour and even finance under a sympathetic help from the Central and the State Governments.

Indian Technique in Canal Lining

The completion of the great Bhakra Canals system, as an irrigation network in which the canal and branches have been lined throughout their length, represents a work which is easily world's No. 1 in extent and technique. The specification used employs indigenous material and mortar made of cement or *kankar* and *surkhi* in various proportions. The cost is less than half of that which would have been entailed if foreign specifications as employed in the United States had been adopted. The seepage losses have all the same been verified to be no greater than is claimed in impermeable linings in other countries.

Research and Model Experiments

This was made possible by the extensive model research carried out in the Irrigation Research Institute to confirm the durability and efficiency of various types of lining. The type of construction lends itself to maximum advantage in view of the labour resources that we possess in the region. The large number of joints gives the lining a flexibility which will prevent any big cracks whereas hair-cracks at each joint will neither destroy its structural stability nor increase the seepage. When consultants from the U.S.A. inspected this work they were impressed beyond words and remarked that in this sphere India has evolved her own impressive technique which is well worth the attention of the rest of the world. The economies represented in this specification amounted to *several crores of rupees*.

Standardisation of Designs

The standardisation of design is one of the most important factors which goes towards improving soundness at minimum cost. The Bhakra Dam design has been evolved after extensive and prolonged study of various alternatives. The initial designs were vetted in the United States for the 500 feet high dam and then a new set of designs was taken out for the 680 ft. high dam incorporating most of the features of the previous design and extending them to suit the higher dam. The initial design provided for a tunnel spillway as well as tunnel outlet works. These features were based on similar design for the Boulder dam. Subsequent study and careful examination indicated that we can, without reducing any of the essential safeguards for disposal of flood and irrigation water, eliminate both the works and increase the soundness of the design besides effecting a saving of almost 2 crores. Accordingly a decision was taken in favour of modifying the original design even though it involved a large scale revision of the specifications and previous drawings. It was the open-minded approach and attitude that enabled this modification. It is to be noted that this fact cannot be used as an argument to condemn the earlier design. In such projects, the greater the thought and experience that is brought to bear on the subject, the greater the reward and we should have respect for each case according to its merits.

Review of Costs

It will be a great eye-opener if a comparison is made between the river valley projects currently being executed in this country with those which have lately been completed in foreign countries. Thus the Bhakra Dam undertaking is comparable to Boulder, Shasta, Grand Coulee or Fontana. Both in excavation and concrete, its magnitude is comparable to the largest jobs done in the U.S.A. In the construction plant lay-out and type of equipment used, it is comparable to, but much bigger than, the Fontana Dam. The unit costs estimated for the Bhakra Dam are more favourable than similar dams in the States, because the job is nearly equally mechanised but the wages of operating and maintenance personnel are much less. The rate of progress that is planned for this job is also comparable with that on jobs of this size in the United States. The set up regarding design, construction, procurement of stores, and administration is no less scientific than that adopted on any foreign projects. However the

overhead costs are much less because of lower salaries of Indian personnel. These factors are quoted to indicate that the ratio of first costs to benefits for the River Valley Projects like the Bhakra is bound to be more favourable than on similar projects in the United States. This analogy cannot however be extended to the relatively smaller projects like the earthen dams or stone masonry dams of heights between 100 feet to 300 feet.

Foreign Aid in Technical Advice

In the finalization of the Bhakra Project, we had the advantage of the collaboration of well known firms of Consultants and the Bureau of Reclamation. The experience within the country, available from the Central Board of Irrigation and Power and the Central Water and Power Commission, has also been utilized fully,

Considerations Governing Construction Plant Lay-out

One factor which has influenced the Bhakra Project schedules and costs more than any other factor is the construction plant lay-out and the selection of the most suitable equipment for carrying out the job at least costs. As the project was unprecedented both in its nature and dimensions and a lot of financial stake was involved in each decision, the engineers in charge had to equip themselves with the opinions of foreign experts. For quite a lot of time final decisions were not taken as the persons competent to take decisions were handicapped by their own lack of experience. It is to be remembered that there can be more than one solution for carrying out a construction job and it is not always easy, on account of intangible factors involved, to take decisions in border line cases. As the issue was also linked up for a long time with whether the work should be handled on a firm contract with a foreign contractor or through the agency of the Government by using force-account methods, the decisions were further delayed. The several foreign companies who expressed their interest in doing the job made different technical approaches. Thus M/s. Morrison Knutson Co ; who first tried to secure the job, preferred to use the cableways for concrete placement. The T.V.A. and the present Indian and foreign construction engineers in charge have preferred concrete placement with trestles and hammerhead cranes. This factor has governed the main features of the selection of construction plant, its procurement and its erection at site.

This process has taken almost seven years for a final decision, when the writer of this Paper had the opportunity in 1945 to report on the construction plant lay-out at present accepted, and if decision had been taken promptly much of the specialised equipment could have been obtained from the T.V.A. who were just in the final stages of their dam projects.

The lesson to be drawn from this particular instance (and other instances presumably exist) is that lack of decision can by itself become the major stumbling block in the progress of projects, and the mounting up of their cost. One can say that even if there is a risk of some small error in taking prompt decision, we should still take decisions promptly rather than let things slide. Time lost in indecisions is worth much more than the relatively small and hair-splitting economies which are claimed as a result of examining a never ending series of alternatives.

THE PLACE OF RIVER VALLEY PROJECTS IN THE COUNTRY'S DEVELOPMENT

Our country's need for more food and more power is paramount. The raising of living standards does not mean a thing till the poorest of our people are better fed and better employed. This objective will be achieved even when a few of the country's super projects (Bhakra, Damoder, Hirakud) are complete. Each of these projects will bring in its train, a substantial addition to the country's food and power resources. In fact the country has to prepare itself to be in a position to fully absorb the higher potential, which will be brought within its grasp.

The returns from each of these projects will pay for the capital investment much sooner than the passimists would admit. It is not at all logical to use the yardsticks of the past in planning the scope of all current projects. The rest of the modern world is moving at a very fast rate and India cannot afford to lag behind. Unquestionably the nation has to become river-valley-minded, so that the bountiful resources granted by the providence are exploited for the benefit of a peaceful people;

PRIORITIES AMONGST RIVER VALLEY PROJECTS

Out of a sum total of about 50 major projects which are before the country, we should select those which show the highest ratio

of benefits to cost. The political boundaries of individual States of the Union should not be allowed to make us prejudiced against the projects if it happens to belong to another State. The best course lies in strengthening our efforts on those projects which have already been taken up. Even these require our fullest co-operation and concentrated co-operative endeavour. Destructive criticism emanating from persons or parties who have neither the qualifications nor the experience should be exposed, as any other anti-national activities. It is a sort of poison that must not be allowed to spread, as it will only hamper efforts of workers and give them frustration instead of pride and satisfaction so necessary for getting the best out of individuals or organizations.

While the current projects are in progress, we should give our utmost care to further programmes and schedule for the country's second and third five-year plans. It needs no prophet to say that at least for 20 to 30 years more the river valleys of India provide a fruitful and fascinating arena in which the entire people of the country can look for a challenging endeavour. In this venture the technicians, the administrators and the politicians must pull together and not against each other. In particular the technicians should be invited to take the fullest responsibility because future progress lies along the broad path of science and engineering rather the winding lanes and sub-lanes of administrative policies, which have stemmed the country's progress for many a decade. And to which ever persons or organization responsibility is given let them have also adequate powers by which they can grapple with their tasks unhemmed and unfettered.

PROJECT PERSONNEL

The best course demands that a lot of thought, care and time be given to the selection of individuals to whom responsibility for execution of a project is delegated. But once the selection is made there should be complete trust and a generous chance must always be given without doubt or questioning. Conversely, if an individual or a set of individuals have been put in charge of the execution of a project and there is evidence that things are not proceeding as they should, then the country's machinery should be made so effective and strong that it can dislodge the undesirable set of workers to

arrest the damage. In the case of quite a few projects things would have been different if some of the unsuitable individuals were removed in time. It will do less harm if such individuals are even kicked up into innocuous positions where they can draw their salaries but where they are not able to retard progress or set the hands of the clock back.

CENTRAL BOARD OF IRRIGATION AND POWER
SYMPOSIUM

NEW DELHI, 1953

PAPER VIII

**Note on Water Rates and Levy of Betterment
Charges***

by

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In the case of a multi-purpose project maximum benefits accrue mostly from direct revenue obtained from Irrigation and Power. It is proposed to describe in this note a basis on which water rates and betterment charges may be levied in case of an irrigation system of a multi-purpose project.

2. WATER RATES

Water rate is a charge for the supply of canal water for irrigation. It is fixed with respect to the quantity of water supplied, value of produce and profits from cultivation. Different water rates are, therefore, charged for different crops raised during different seasons, in the same State and different water rates for the same crops in different States. For example water rate for paddy is Rs. 3/- in Orissa, Rs. 5/12/- (average) in Uttar Pradesh, Rs. 8/2/- (average) in Madras. Similarly average water rates of Rs. 6/-, Rs. 48/-, Rs. 12/8/- and Rs. 8/8/- are charged per acre of sugar-cane in the States of Orissa, Bombay, Madras and Uttar Pradesh respectively.

Due to the existence of widely divergent water rates in different States for the same crops, the question of levy of water rates and betterment charges in the areas to be irrigated on the Hirakud Dam Project, has been gone into by a Committee appointed by the Hirakud Control Board.

*Under Item 2 (i) Direct Revenue from Irrigation.

Fairly extensive surveys in regard to classification of land, yield of crops, cost of permanent improvements to land and agricultural operations etc. have been made to work out the net additional profit to the cultivator on which the above charges may be based.

2.1. Classification of Land

Investigations for the present have been confined to the areas to be irrigated in the Sambalpur District.

The topography of this area is mildly undulating. The prevalent local mode of classification of agricultural land into 'at', 'ma.', 'berna' and 'bahal' types is based mainly on its location with respect to the water shed. The last 2 types, situated as they are at a lower level are enriched by soil fines, humus, etc. transported along with the surface run-off from the first two types which are situated at a relatively higher level.

2.2. Yields

Examination of crop cutting experiments conducted by the Agricultural Department of the Orissa State in the year 1950-51 to 1952-53, disclose that the average out-turn of paddy for different types of land is as follows : --

<i>Bahal</i>	...	22 maunds per acre.
<i>Berna</i>	...	16 -do-
<i>Mal</i>	...	10 -do-
<i>At</i>	...	6 -do-

It is evident from the above yields that 'At' and 'Mal' lands suffer to a great extent from the irregular or inadequate rainfall and that *Berna* and *Bahal* lands are comparatively more secure.

The expected increase in out-put when canal water is made available is tabulated in Table I. The yields anticipated for the last two types are rather on the low side, although the actual out-turn is likely to be more :—

TABLE I

	Present average Yield in maunds	Probable increased Yield in maunds
<i>Bahal</i>	22	26
<i>Berna</i>	16	21
<i>Male</i>	10	18
<i>At</i>	6	16

Thus under irrigated conditions 'At' and 'Mal' lands will benefit to a much larger extent than the remaining two types of lands which are situated at a lower level. The 'At' and 'Mal' lands form nearly 75 per cent of the total culturable area in the Sambalpur District.

2.3. Cost of Permanent Improvements to Land

It has been found that before the anticipated increase in the yield of paddy given in the previous paragraph can materialise, it will be necessary to improve the 'At' and 'Mal' type of lands by deepening the fields, strengthening the ridges, removing stones and gravel and clearing patches of jungle growth, etc.

The cost of above improvements including the cost of construction of water courses at Rs. 20/- per acre of culturable commanded area has been estimated. This will amount approximately to Rs. 20/- per acre of 'Bahal' land, Rs. 50/- per acre of 'Berna' land, Rs. 110/- per acre of 'Mal' land and Rs. 160/- per acre of 'At' land.

Before working out the net profit from increase in the yield due to irrigation facilities it is considered that the cultivator should get some credit for the above expenditure at the rate of 10 per cent, of the investment. The annual sums for which he would get credit will thus amount to Rs. 2/- per acre in case of 'Bahal' land, Rs. 5/- per acre for 'Berna' land, Rs. 11/- per acre of 'Mal' land and Rs. 16/- per acre of 'At' land.

TABLE II

Cost of production of paddy per acre in different types of land in Sambalpur District

Items of cost	Bahal		Berna		Mal		At	
	Rs.	As.P.	Rs.	As.P.	Rs.	As.P.	Rs.	As.P.
Preparatory	13-	8-0	13-	8-0	13-	8-0	13-	8-0
Manure	25-	0-0	25-	0-0	12-	8-0	5-	0-0
Seed	11-	4-0	11-	4-0	14-	0-0	14-	0-0
Puddling & thinning	7-	12-0	7-	12-0	6-	12-0	...	
Weeding	13-	0-0	13-	0-0	9-	12-0	...	
Harvesting	9-	6-0	8-	2-0	6-	14-0	5-	10-0
Total	79-	14-0	78-	10-0	63-	6-0	38-	2-0

Note :—Details how the above figures have been arrived at are available on record.

2.4. Cost of Agricultural Operations

After careful enquires the present cost of cultivation per acre of paddy crop on four different types of lands mentioned above has also been estimated and given in Table II. This cost is based on the assumption that the [cultivator has to pay for] all the agricultural operations.

In addition to the above charges a provision of Rs. 15/- and Rs. 40/- has been made for manuring the 'Mal' and 'At' lands which will be subject to intensive double cropping.

In working out the net additional profit to a cultivator per acre it has been further assumed that a net profit of Rs. 20/- per acre on *Mal* land and Rs. 30/- per acre of 'At' land will accrue as a result of *Rabi* cultivation.

2.5. Net Additional Profit per Acre

After allowing for both the recurring and non-recurring costs, the net additional profit which would accrue to a cultivator per acre for different types of lands has been calculated and given in Table III.

TABLE III

Description	<i>Bahal</i>	<i>Berna</i>	<i>Mal</i>	<i>At</i>
Present average yield per acre ...	22 maunds	16 maunds	10 maunds	6 maunds
Present average price of the yield Rs. 7/- per maund. ...	Rs. 154/-	Rs. 112/-	Rs. 70/-	Rs. 42/-
Present cost of production ...	Rs. 79/14/-	Rs. 78/10/-	Rs. 63/6/-	Rs. 38/2/-
Present profit ...	Rs. 74/2/-	Rs. 33/6/-	Rs. 6/10/-	Rs. 3/14/-
Additional yield ...	4 maunds	5 maunds	8 maunds	10 maunds
Additional value ..	Rs. 28 -	Rs. 35/-	Rs. 56 -	Rs. 70/-
Additional cost (Non-recurring and 10% of the additional capital investment & annual recurring cost due to use of manure etc. ...)	Rs. 2/-	Rs. 5/-	Rs. 26/-	Rs. 56/-
Increased profit from paddy crop after irrigation resources are utilised. ...	Rs. 26/-/-	Rs. 30/-/-	Rs. 30/-/-	Rs. 14/-/-
Additional profit for double cropping during <i>Rabi</i>. ...	...	...	Rs. 20/-/-	Rs. 30/-/-
Net increase in additional profit. ...	Rs. 26/ 1/-	Rs. 30/-/-	Rs. 50/-/-	Rs. 44/-/-

2.6. It has been recommended by the Mazumdar Committee (1952) which was appointed to review the revised estimates of the Hirakud Dam Project that "If the betterment levy instalments plus irrigation rates are not more than 50 per cent of the increased profits due to irrigation, the collection of betterment levy will be more or less assured."

This appears to be a fairly reasonable basis on which the water rates and betterment charges may be calculated. The figures as given in Table IV show the net additional profit, 50 per cent of that profit which is available for levy of water rate and betterment charges, water rates and the sum available for annual instalment of betterment levy.

TABLE IV

Types of land	Addl. annual net profit per acre	50% of the additional profit	Water rate per acre	Sum available for annual instalment of betterment levy
<i>Bahalj</i>	Rs. 26/-	Rs. 13/-	Rs. 8/-	Rs. 5/-
<i>Berna</i>	Rs. 30/-	Rs. 15/-	Rs. 8/-	Rs. 7/-
<i>Mal</i>	Rs. 50/-	Rs. 25/-	Rs. 8/- + 5/-	Rs. 12/-
<i>At</i>	Rs. 44/-	Rs. 22/-	Rs. 8/- + 8/-	Rs. 6/-

A basic rate of Rs. 8/- per acre is proposed for paddy crop and an additional rate of Rs. 8/- and Rs. 5/- for cash and light Rabi crops on 'At' and 'Mal' lands respectively.

BETTERMENT CHARGES

3.0. It is presumed that on account of assured and perennial irrigation supplies that are made available at the completion of an irrigation system value of land under cultivation generally appreciates. In order to compensate the Government for expensive works undertaken and to make the Project financially productive, it is considered that the cultivator should pay to Government a certain percentage of the earned increment in the value of land which has been made possible by the above undertakings. This has been fixed at half the increase in the value of land from the date of commencement to the date of completion of the Project by the Government of Bombay while amending the Bombay Irrigation Act in 1950.

By executive instructions the Government of Bombay has also directed that the increase in land values due to betterment may be arrived at from enquiries into actual sale transactions.

It has transpired that in spite of these instructions the Government of Bombay has not found it possible to levy betterment charges in case of irrigation works recently completed as a clear trend of actual increase in land values has not been observed.

3.1. Enquiries into values of lands in irrigated and unirrigated portions of the Mahanadi Delta in the Orissa State based on land sale transactions have shown that the cost per acre of non-irrigated and irrigated lands according to actual land sales amounts Rs. 500/- and Rs. 800/- per acre. This increase of Rs. 300/- per acre has been obtained after the area under reference has been under irrigation for the last 80 years. It may reasonably be assumed that increase in the value of land for this area could not have been appreciable if it had been assessed immediately on completion of the Project.

3.2. The Government of Punjab has recently enacted a legislation for imposition of betterment charges. It has also recognised that the valuation of the price of land on fixed rate is not a matter amenable to exact computation. It has, therefore, prescribed that the increase in the land values may be worked out on the basis of "Net assets".

The "Net assets" have been explained as under :—

"Net assets" of an estate or group of estates means the estimated average annual surplus produce of such estate or group of estates remaining after deduction of the ordinary expenses of cultivation as ascertained or estimated.

EXPLANATION

Ordinary expenses of cultivation include payments, if any, which the land-owner customarily bears whether in kind or in cash either in whole or in part in respect of :—

- (1) Water rates,
- (2) Maintenance of means of irrigation,
- (3) Maintenance of embankments,
- (4) Supply of seed,

- (5) Supply of manure,
- (6) Improved implements of husbandry,
- (7) Concessions with regard to fodder,
- (8) Special abatements made for fallows, or bad harvests,
- (9) Cost of collection of rent,
- (10) Allowance for shortage in collection of rent,
- (11) Interest charges payable in respect of advances made in cash, free of interest, to tenants for,
- (12) Purpose of cultivation,
 - Wages or customary dues paid to artisans or menials whose products or labour are utilised for the purposes of cultivation and harvesting,†

and the share that would be retainable by a tenant if the land were let to a non-occupancy tenant paying rent, whether in cash or in kind, at the normal rate actually prevalent in the estate or group of estates.

The valuation of land is arrived at by multiplying the figure of "Net assets" by 30.

3.3. It will, therefore, appear that it may be neither easy nor safe to base the levy of betterment charges on the percentage increase in the value of land, as the appreciation or otherwise in the land values depends on a number of factors.

For example a change in tenancy legislation in an area where a new irrigation Project is completed may result in the depreciation of land values. Any enactment, therefore, for betterment charges which is based on increase in land values may probably prejudicially affect the financial aspect of a Project if the expected appreciation in land values does not materialise.

In order to avoid these complications it is proposed that levy of betterment charges may be calculated on the net additional profit to a cultivator instead of on the increase in land values and fixed roughly at ten times the sum available or more, for payment of annual instalment for betterment, as worked out in the last column of Table IV in para 2.6 above.

CENTRAL BOARD OF IRRIGATION AND POWER
SYMPOSIUM

NEW DELHI, 1953

PAPER IX

**National Economics Effected by Hydraulic
Models at Poona**

by

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1. INTRODUCTION

Thirty years ago most of the hydraulic structures used to be based on some empirical formulae, the past accumulated experience of the engineers or sometimes the intuition of the designer. The engineering profession did not then have sufficient confidence in the hydraulic models. The concrete proposals put forth by way of model experiments were many times completely ignored. But today the hydraulic models have attained a very important place in the execution of large river projects, river and harbour improvements which offer problems of unprecedented complexity. The models are now widely accepted as very useful aids in Engineering practice in view of the confidence created by the close conformity between model and prototype behaviour.

The Central Water and Power Research Station at Khadakwasla near Poona, since its inception and humble beginning in the field of hydraulics as far back as 1916, has investigated numerous problems on irrigation, river training and other allied fields, navigability of channels and improvements to harbours and hydraulic structures. The application of results obtained from the various model studies has contributed *crores* of rupees to the Exchequer as a result of savings effected by them. Besides the direct savings, innumerable

and substantial indirect benefits accruing therefrom cannot also be ignored and they are also specifically mentioned in the note.

2. River training works cannot be designed by applying some definite formula on account of complex factors involved and reliance has to be placed on model experiments. With the progress made by the Central Water and Power Research Station by the accumulated experience gained during the last 37 years, the Station has developed most modern technique on model experimentation. We have now better knowledge about model limitations, correct interpretation and adaptability to field conditions. It may also be mentioned here that this is the foremost Station in the world to-day where movable bed models are effectively tackled not only qualitatively but quantitatively in respect of rivers where bed load is the governing factor. Even bed changes resulting from suspended material have been markedly reproduced after making due allowances for model limitations. This was only recently demonstrated to Hooghly Expert Committee appointed by the Government of India in connection with Hooghly Port and Estuary model studies under investigation at the Station.

3. Many times training works used to be constructed in the prototype without making any model tests for the same. It has been noticed that in many cases such works make conditions much worse than before, create complications and undesirable results contrary to expectations. In such cases it then becomes very expensive and more often than not very difficult to set right the conditions even with model tests. The Gandak river at Bagaha is such an example. The Railway Bridge across the river Gandak was constructed in 1911 on the principles of Bell's Guide *Bund* system. In 1924, the river upstream of the bridge had begun to embay behind the right embankment and the flow after concentrating at the nose of the right guide bank, flowed across, as a concentrated stream to the left bank to flow with high velocity and sharp curvature through the three left spans of the river. As a result of this, one of the piers on the left side failed and the right guide bank also failed. In the same year after the floods, the Chitauni groyne was constructed with the idea to deflect water through the bridge. The groyne, however, acted as an 'attractive groyne'. It pulled the river towards it causing conditions worse than before in the following floods. The bridge was outflanked and the breach in communication was accepted. In years to come it pulled the whole river towards it. As a result of this the

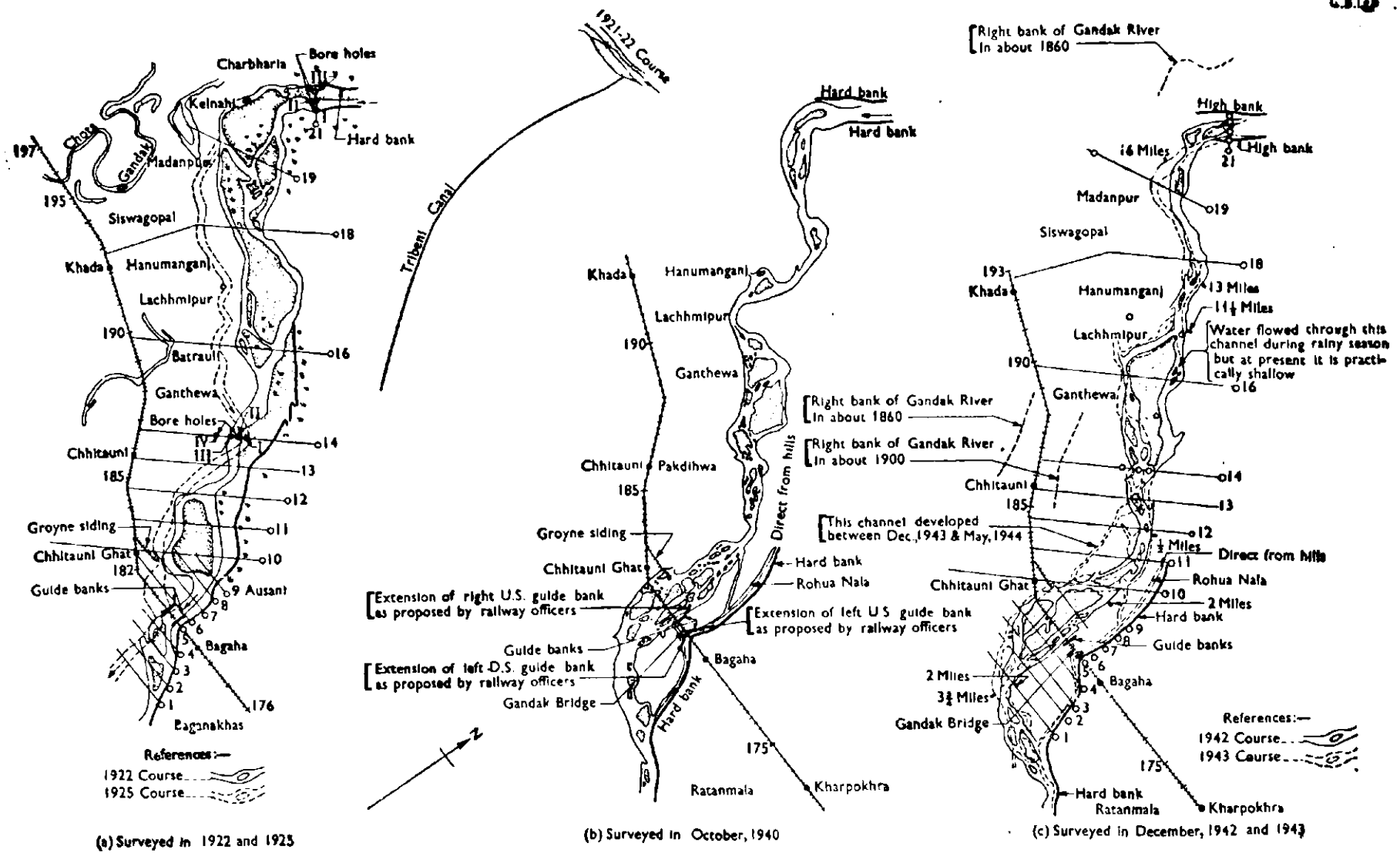


Figure 1: Showing Survey plans of different years of Gandak river at Bagaha,

bridge was left high and dry and the whole river had swung a mile away from the right guide *bund* of the bridge. Figure 1 shows the conditions of 1922 before the breach, after the breach in 1925, 1940, 1942 and 1943. The Railway Company had to abandon the bridge and thus through communications were completely cut-off. The Railway authorities approached the Station in 1942 for advice with model tests. The model showed that the conditions had become so worse that nothing could be done to set right the conditions. A timely advice with model tests would have restored the communications and effected economy. But for that the bridge constructed at a heavy cost of Rs. one crore has to be abandoned and communications have to be maintained by a ferry service.

Another illuminating example is that of an Akra Spur constructed in 1929 to improve the depths required for navigation of the Sankrail Reach 8 miles below Calcutta on the Hooghly river. This is a low water crossing and a depth of at least 22 ft 6 in. has to

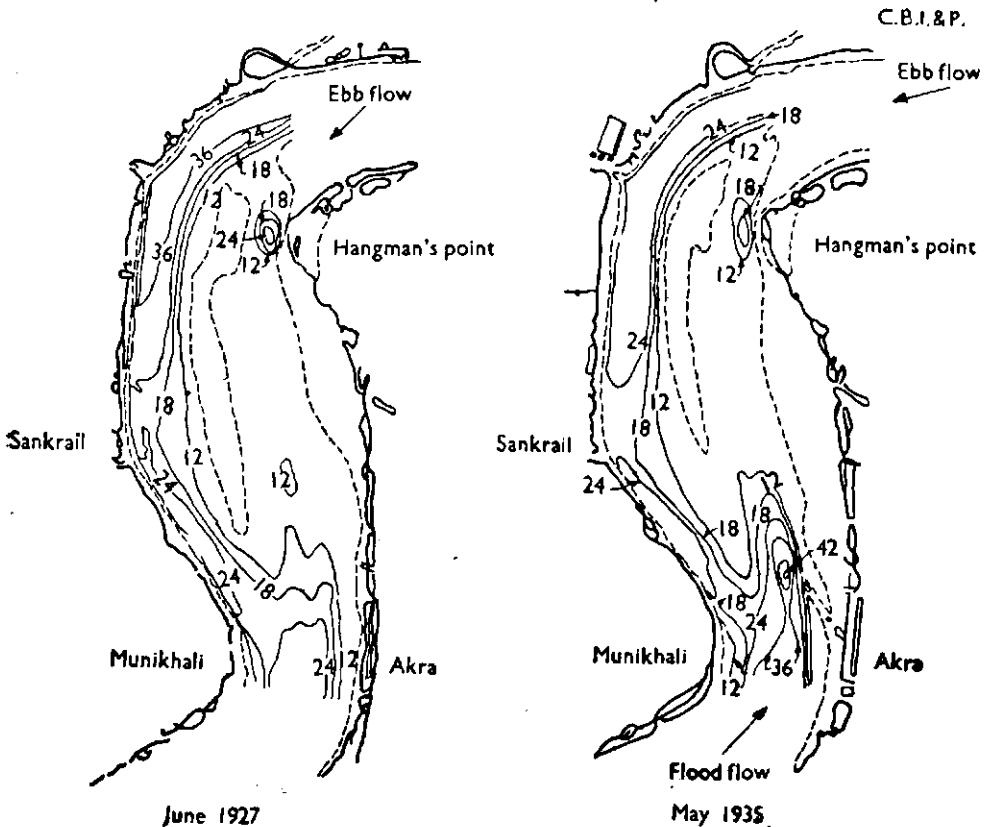


Figure 2: Showing dry weather contour plans for years 1927 and 1935—River Hooghly Experiments, Sankrail reach.

be maintained for navigation purposes. Prior to putting the spur in 1929 the cost of dredging was roughly Rs. 4.8 *lakhs* every year. It was thought that the spur would reduce this cost by improving the depths. The comparison of figures for June 1927 showing the condition prior to the construction of spur and May 1935 six years after the spur was constructed clearly shows (Figure 2) how the spur developed a deep channel along it at the cost of the navigation channel along the bight which it was expected to improve. The Calcutta Port Commissioners therefore approached the Station for suggesting a suitable remedy, though, the conditions had not become so worse as to be beyond control by dredging. Extensive and exhaustive model tests showed that a spur should have been constructed the other way *i.e.*, facing the flood flow instead of away from it. The proposed spur would cost Rs. 30 *lakhs* and effect an annual saving of Rs. 4 *lakhs*, even allowing for some maintenance of spur and channel of Rs. 0.8 *lakh*. This amount when capitalised over 20 years works out to Rs. 80 *lakhs*. The proposal has been approved by the Hooghly Expert Committee and the construction of the spur would soon begin after the end of the freshets of 1953.

4. The following few illustrations will show how the designs of new projects perfected after conducting intensive model tests not only save a few *lakhs* but also eliminate designer's doubts and controversies.

Kakrapar weir constructed across the Tapi river is such an example. A U-shaped alignment of the weir, having a length of 4,213 feet was proposed with an idea that such an alignment would pass the discharge with a lower afflux. The model tests showed that on the contrary a straight alignment having a length of 2,028 feet would achieve the desired results much better and with a lower cost. The direct saving thus effected was 5 *lakhs* of rupees which is about 25 per cent of the cost of the weir. Besides, the weir profile was made free from sub-atmospheric pressures, the design was made safe by recommending proper length and arrangement of apron on the downstream side; weir alignment and location of head regulators were tested to give satisfactory sand exclusion and suitable heights and lengths of divide walls to eliminate dangerous and undesirable crossflow were recommended. The heights and lengths of divide walls as recommended were much less than proposed in the preliminary designs resulting in a saving of Rs. 0.50 *lakh*.

The Kotah Barrage, proposed across the Chambal river, is another notable example where for the first time fluming is proposed by Rajasthan P.W.D. as shown in Figure 3 to reduce the height of the gates. If fluming were not done the barrage gates required would have been 40 ft. in height and the cost of the gates would have been roughly Rs. 95 lakhs approximate. With fluming the gates would be only 27 ft. in height. The cost would be reduced to Rs. 65 lakhs approximate effecting a saving of Rs. 30 lakhs approximate. This would also save an initial cost of hoisting machinery and power required to operate it. Besides, the design was tested in respect of—

- (a) Afflux with maximum flood discharge and with corresponding water level in the river downstream of the barrage.
- (b) Discharging capacity of the barrage with different water levels upstream and downstream and the number of vents required to pass the maximum flood discharge.
- (c) Flood conditions on the downstream glacis and pavement with various gate openings.
- (d) Pressure distribution in the bellmouth entrance of the vent.
- (e) Whether the profile of the barrage weir as proposed, together with the row of blocks was adequate from the point of view of dissipation of energy of flow and elimination of scouring tendency downstream of the pavement.

Similarly, Hirakud Dam Project was also studied by model tests and suitable bucket for dissipating energy and making the structure safe was recommended along with designs of training walls between masonry spillway portion and the earth dam portion. Sluices were tested for satisfactory design as regards pressures and discharging capacity. The use of upturned sluices was also recommended.

5. A few of the following examples will show how with model tests the Station has effected substantial savings in the existing structures.

The Hardinge bridge on the Ganga river (now in East Bengal), about 200 miles from Calcutta constructed in 1915 at a cost of Rs. five crores. was in danger of being outflanked in 1933. During two years more than Rs. one crore were spent to save the bridge. But the bridge conditions continued critical. By model tests at the Station a cheap remedy *viz.* removal of stone from Sara Protection Bank made the bridge safe and maintained the communications.

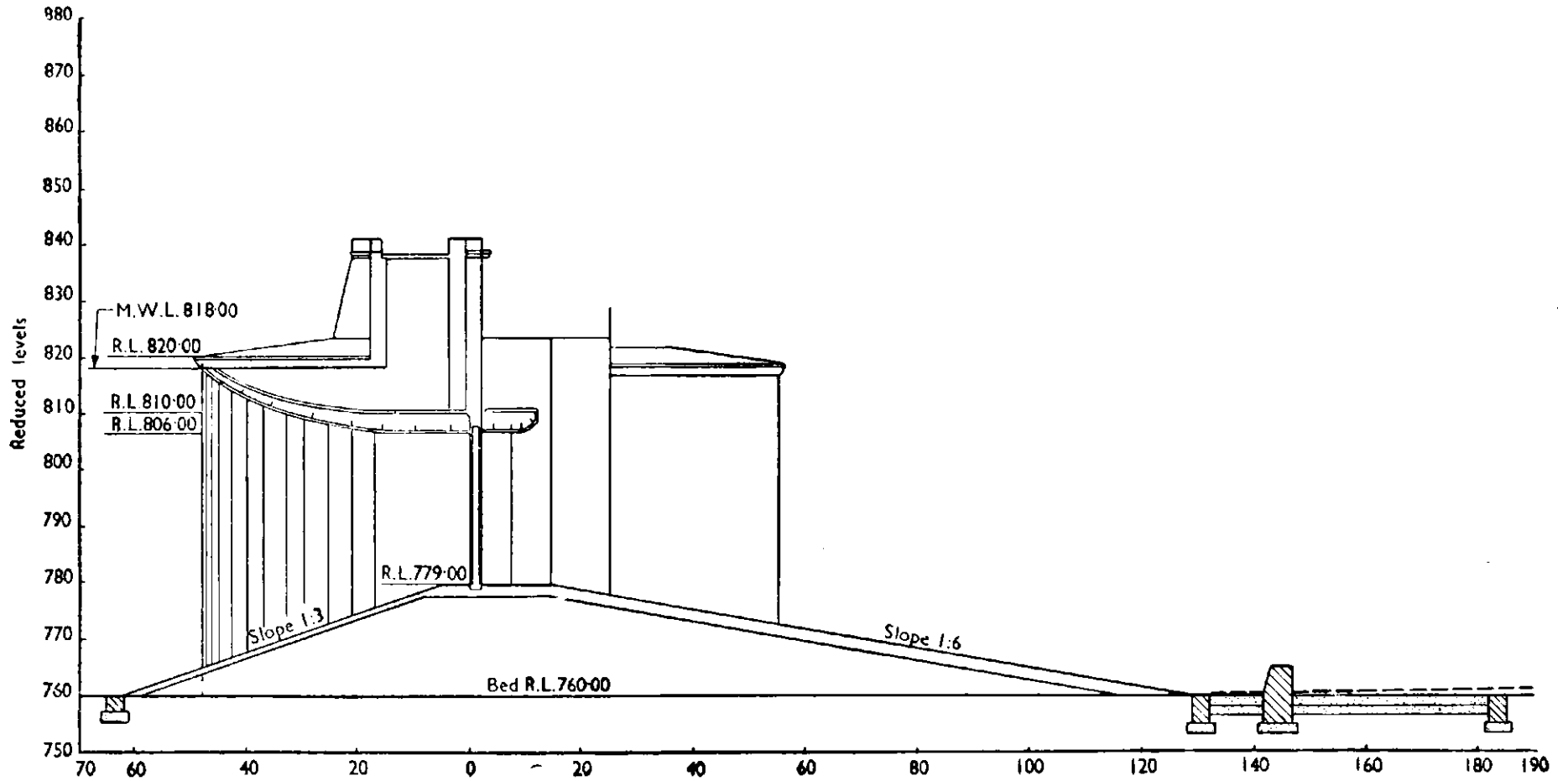


Figure 3: 1/40 scale sectional model of Kotah Barrage (Irrigation Project) Showing pressures distribution in Bellmouth entrance.

Another illuminating example is that of Sukkur Barrage, where it was predicted from model tests carried out in 1929-31 when the construction of the Barrage was in progress that the right bank canals would sand up very badly immediately after the opening of the Barrage. Suitable remedies were suggested but were ignored at that time. Later on when the conditions became so critical that the right bank canals especially the Rice canal could not carry even as much as 40 per cent of the designed discharge as a result of which the canals worked to a very steep slope, the area under command was markedly reduced and there was a substantial drop in the revenue of the State which amounted to as much as a *crore* of rupees. The Station was again approached for advice with model tests. The capitalised amount of this loss of revenue over a period of 20 years alone comes to Rs. 20 *crores*. Besides frequent scouring operations, interfering with the normal irrigation at the time when water was needed badly for early sowing and maturity of crops, had to be done to get sand-free water in the canals.

As is well known the approach channel (Figure 4) as recommended by the Station was constructed in 1940-41 and markedly improved the conditions of the 'right bank canals. Thus the

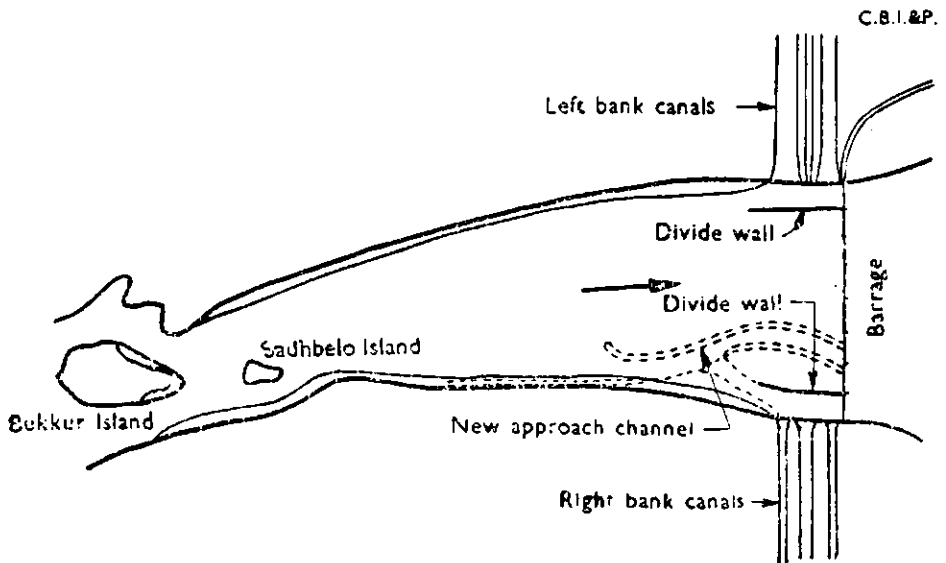


Figure 4: Showing design of new approach channel along right bank to exclude sand from right bank canals at Sukkur (shown dotted).

future of irrigation under right bank canals which was in serious jeopardy was safeguarded at the time when the food problem was critical. These are the benefits which cannot be estimated in cash value.

Under item C (1) against column 2, is shown half the capital cost of the barrage and canal system which would have otherwise been sunk in the Project without any return had the suitable remedy not worked satisfactorily.

The Railway bridge across the river Rupnarain at Kolaghat (B.N. Railway) is another example worthy of note, where the groyne as recommended by the Station and constructed immediately after safeguarded the bridge costing 2 crores of rupees from outflanking. It thus helped to maintain communications at a time when Japan was knocking at India's door and all supplies—fuel, food, ammunition, clothing—had to be rushed to Calcutta and thence to the battle front; this was the only rail link to Calcutta as other railway bridges were washed away due to very heavy Damodar floods. This was another major contribution by the Station towards the war effort.

Experiments carried out on Hooghly Estuary model showed that if a ship canal (costing Rs. 30 crores) were constructed to obviate the necessity of using the difficult route from Calcutta to Diamond Harbour were constructed, the Hooghly river would gradually deteriorate as dredging would then not be done in this reach. This deterioration would also progressively work downwards below Diamond Harbour and eventually navigation to Calcutta would suffer resulting in an incalculable loss to the country.

6. Table I shows the direct savings effected by hydraulic model investigations carried out by the Station since its inception. The table is broken up in four parts A, B, C & D. The items under A deal with savings effected by safeguarding the bridges, while those under B deal with savings effected by way of affording town protection. The list C covers savings effected in barrages, dams and sluices. The list D deals with harbour improvements. The total savings effected so far amount to about Rs. 80 crores.

TABLE I

Showing savings due to Hydraulic Model Investigations

Problems solved	Year	Approx. saving in capital cost in lakhs of Rs.	Annual maintenance cost or reduction in revenue in lakhs of Rs.	Capitalised maintenance cost in lakhs of Rs.	Total cost (Col. 2 plus Col. 4) in lakhs of Rs.	Indirect benefits	Remarks
1	2	3	4	5	6	7	8
A. Safeguarding the Bridges							
(1) Prevention of outflanking of the Hardinge Bridge over Ganga and removing threat to the right guide bank (now in Pakistan).	1933-33	500	50 (incurred one year)	100	600		
(2) Prevention of damage to Garhmukteswar railway bridge over Ganga by extension of the guide bank.	1948-49	200	...	...	200		
(3) Reduction in the proposed width of the road bridge over Gautami-Godavari river.	1951-52	30	...	...	30		Anticipated
(4) Arresting erosion at and along the right abutment of the railway bridge over Vatrak river at Mehmabad.	1952-53	20	...	...	20		Anticipated
(5) Protecting the railway Bridge over Katjuri at Khannagar (Orissa) and also valuable bunds of Cuttack.	1947	200	...	...	200		

(6) Prevention of outflanking of the E.I. railway bridge over Rupnarain at Kolaghat.	1943-44	200	...	...	200 1,250	Had the bridge been washed away, only communication by rail-road to Calcutta, at a time when the Japanese were at threshold of India, would have been completely disrupted. This was a major contribution by the Station to the war effort.
B. Protection to Towns						
(1) Protection to Surat town from Tapi floods by means of a groyne.	1948-49	...	2.5	50	50	Erosion of the town, resulting in dislocation of normal life, prevented.
(2) Protection to water collecting system of Surat waterworks by driving a submerged pile line as indicated by the model.	1948-49	2	...	...	2	Breakdowns in water supply prevented.
(3) Ensuring deep water channel along the Delhi Gate Pumping Station on Jumna.	1946	...	0.5	10	10 62	-do-
C. Barrages, Dam-Spillways, Sluices etc.						
(1) Exclusion of sand from right bank canals of the Sukkur Barrage by means of a suitable approach channel.	1939-40	1,140	100	2,000	3,140	Irrigation would have suffered and food production would have been less.
(2) Remodelling of the approaches to the Mithrao and Khipro branch-canal-offtakes so as to supply sand free water	1938-39	100	1	20	120	-do-

TABLE-I—(Contd.)

Showing savings due to hydraulic Model Investigations

Problems solved	Year	Approx. saving in capital cost in lakhs of Rs.	Annual maintenance cost or reduction in revenue in lakhs of Rs.	Capitalised maintenance cost in lakhs of Rs.	Total cost (Col. 2 plus Col. 4) in lakhs of Rs.	Indirect benefits	Remarks
1	2	3	4	5	6	7	8
(3) Reduction in the proposed length of the Kakrapar weir and height and length of divide walls as suggested by the model tests.	1951-52	5.5	...	...	5.5		
(4) Reduction in the size of gates from 60'x40' to 60'x27' in the Kotah Barrage Project as determined by model experiments.	1951-52	30	...	...	30		Anticipated
(5) Prevention—scour below the central sluices of Jobra weir over Mahanadi by modifying the apron in accordance with model experiments.	1946-47	...	0.50	10	10		
(6) Ensuring security of Khodsi weir on Krishna river at Karad by proper aeration of the nappe of falling sheet of water.	1951-52	2	...	...	2		Anticipated
(7) Remodelling of Tansa dam spillway.	1948-49	2	...	...	2		
(8) Resectioning of weir profile of Sukkur Barrage.	1948-49	10	...	...	10		

(9) Bellmouthing of Nira R. B. Canal sluices to pass increased discharge without additional sluices.		2	...	...	2		
(10) Bellmouthing of Ghataprabha Canal Regulator sluices to augment their capacity.	1951-52	2	...	...	2		Anticipated
					3,323.5		
D. Harbours							
(1) Minimising the dredging requirements in the Hooghly river and estuary by proper training measures (Sankrail reach).	1953-54		4.0		80		
(2) Obviating the probable waste which would have resulted had the ship canal proposal been implemented contrary to model indications.	1952	3000			3000		
(3) Reduction in dredging in Mattancherri Channel of Cochin Harbour.	1953-54	...	8	160	160		Anticipated
(4) Reduction in range action in Madras harbour.	1953-54	...	6	120	120	Loading and unloading can be done unhampered.	
					3,360		

Total under items :

	Rs. in lakhs
A. Bridges	1,250.0
B. Town protection	62.0
C. Barrages and dams	3,323.5
D. Harbours	3,360.0
	7,995.5

Say about 80 crores of rupees of direct saving.

CENTRAL BOARD OF IRRIGATION AND POWER
SYMPOSIUM

NEW DELHI, 1953

PAPER X

**Village Labour Co-operatives Working on Bhakra
Canals in Hissar District**

by

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Hissar.*

SYNOPSIS

The efforts to get the Bhakra Canal excavation works done through village co-operatives started from the end of the year 1951. The first attempt was made through village co-operatives under Civil Department which lasted from December, 1951 to December, 1952. Some inherent difficulties were faced by this method and the improved method of Co-operative labour and Construction Societies was introduced in January 1953 under the direction of Ch. Lahri Singh, Irrigation and Power Minister. This system has worked for nearly nine months now and has progressed rapidly. This note discusses the difficulties faced by the first system and method by which the success has been achieved in the second system.

1. On 21st. September, 1951, a meeting was held between the Planning Commission and the representatives of the Punjab Government at which question of public co-operation in irrigation projects was considered. In opening the meeting Member (natural resources) pointed out that a plan of this size cannot be carried out unless there was wide support from the community. Betterment fees were one way of enabling the community to contribute. Another way would be to have canal works carried out by villagers. This would mean some saving and what was not less important, in this way the participation of the villagers could be secured.

2. It was explained on behalf of the Punjab Government that they were prepared to try out the suggestions in selected districts in respect of works requiring unskilled labour. For this purpose they would carry out the proposals in the Hissar District on the Branches and Distributaries and also on the Main canal from Tohana to Dabwali. The State Government anticipated that the cost of canal works might be reduced by as much as 25 per cent. The total value of canal works to be done in Hissar District was reckoned to be about Rs. 5 crores. It was felt that the Hissar District offered a sufficiently large field to begin with in which the new methods could be carried out. It was also suggested that village labour co-operatives to whom work could be assigned should provide for entertainment etc. from their collective earnings. It was pointed out that the Punjab Government would place the administrative organisation required for working out the scheme under the Deputy Commissioner, leaving the technical works in the hands of the Irrigation Department.

In continuation of this meeting His Excellency the Governor held a meeting in connection with famine conditions in Hissar District on the 6th October, 1951 and one of the decisions taken by this meeting was as below :—

"Para. 3. It has been decided that the earthwork may be allotted on piece work basis to village co-operatives organised by the Deputy Commissioner Hissar, immediately, on Bhakra Main Branch, Fatehabad Branch, Barwala Branch and its Distributaries. There is also scope for absorption of labour by raising and strengthening of banks. Every effort should be made to absorb as much labour on these works as possible with the least possible delay."

3. This decision was conveyed through the Superintending Engineer, 2nd. Bhakra Main Line Circle to the Executive Engineers for giving effect to the decision mentioned above and they were asked to contact the Deputy Commissioner, Hissar and inform him about the labour required on different jobs to be carried out in different areas in Hissar District. So started the village co-operatives in Hissar District.

4. This system required that a Group Leader was to be appointed by the Tehsildar of the Tehsil under which the particular group leader had to take up work. He will engage local labour for getting the work done and be paid weekly by the Irrigation Department. Group Leader was solely responsible for measurement of the

work done by the individual worker and disbursement of the money to all the workers in that particular group. Planning Commission had decided to pay such labour from 50 per cent to 70 per cent of the rates which were being paid to the contractors, for the digging of canals. So first payments were made on 75 per cent of the sanctioned schedule to the labour, plus $2\frac{1}{2}$ per cent for supervisory staff and $2\frac{1}{2}$ per cent for the Group Leader who really organised the work. The average labour strength, however, continued to be of the order of about, 1,500. Government then decided that with effect from May 5, 1952, the payments to the workers should be 95 per cent of the full rate. Balance 5 per cent was the cost of the Group Leader and the supervisory staff. In spite of this increase there was a rapid fall in the labour strength and by the end of May, 1952, only about 500 men were left on the job. These village co-operatives started working in November, 1951 and carried on till December 1952. During this interval of nearly 13 months they did 328 lakh cubic feet of earthwork and for which about Rs 2,40,000 were paid to them in this Circle.

5. The Irrigation Department gave the maximum co-operation for this system and in spite of the fact that the famine conditions existed throughout the length and breadth of the district, the highest labour strength attached was only during the week ending February 23, 1952 and then it gradually dwindled down. The Figure I shows the labour strength under this system continuously for the whole period. It would be seen that by the July, 1952 the labour strength came to such a stage when it could be said that people hardly showed any interest in the work.

The Irrigation Department was very keen to complete its job and also comply with the wishes of the Planning Commission. The system of village co-operatives under Civil Department had been given very fair trial for one full year even at the cost of progress of works. Payments were made regularly and work was allotted according to the wishes of the Group Leader. But still it was found unattractive in the irrigated areas, where this work was taken up. The Civil authorities wanted the sphere of activities shifted to Barani areas. Even then the things did not improve the excuse then being that some contractors were also working at some close range hence they could not attract labour and cannot show progress. Full trial was given by reserving a length of about 25 miles on Fatehabad

Labour strength

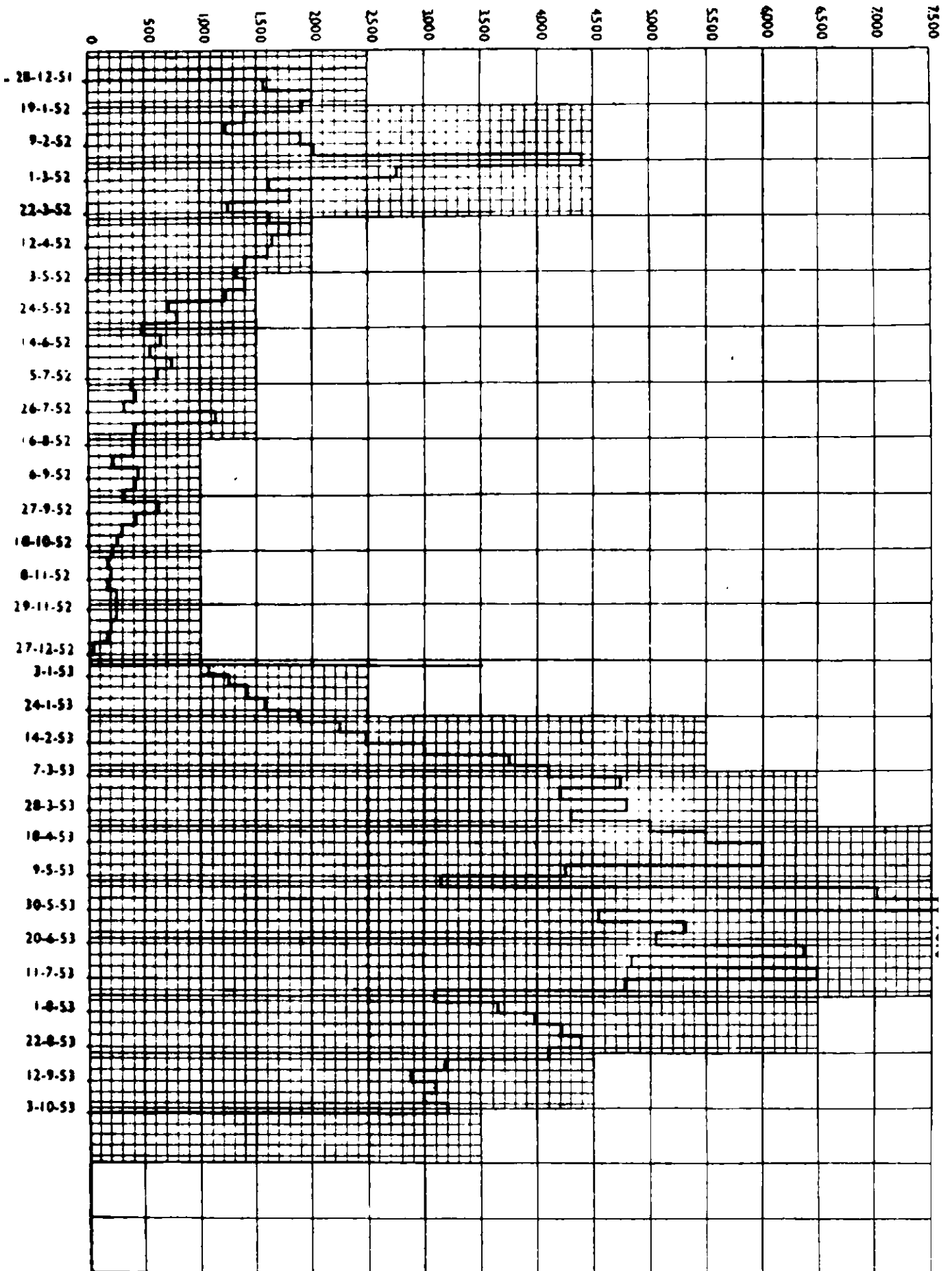


Figure 1: Graph showing weekly labour strength of village co-operative under civil and co-operative labour and construction societies.

Branch for full five months. Even with this the progress did not improve.

6. The chief reasons for the failure of village co-operatives seem to be—

(a) *Appointment of Group Leader by Tehsildar.*

This gave the Group Leaders an outlook that they were Tehsildar's men and as such were only responsible to him. Utter lack of sympathy was shown by the group leaders to the workers which they could not have done otherwise, if the labour had some say in the matter of their selection. In one or two cases actually the labour refused to work under certain group leader. In other words the system was of appointment of group leader by the Tehsildar and there was no democratic selection of the people. There was thus no co-operative effort. The system was one of the 'Beaurocratic' type.

(b) *Selection of wrong type of men as Group Leaders*

Men of integrity and character should have been appointed for which there is no dearth in the rural areas.

(c) Lack of propaganda amongst the masses on the right lines making them understand the real object of co-operative system.

(d) *Not keeping proper account*

Many a number of cases came up where the Group Leader did not pay the labour at all or made short payments

(e) Last but not the least the important factor of all this was that it was being treated as a passing show by most of the people connected with this work as is the case in mostly all the new movements. People go in for cheap and temporary popularity but the real ideas and the real objective of the movement is lost. No one worked with the idea that this system though worked crudely should stay and raise the general standard of living of the masses and also change their outlook of life and give labour a real place of honour. Only selfless workers and who are really genuine in their desire to serve their own brothren can do this.

NEW SYSTEM INTRODUCED BY THE IRRIGATION & POWER MINISTER, PUNJAB

7. By about September, 1952 it was quite clear that the system of village cooperatives under the Civil Department cannot achieve much success. Ch. Lahri Singh Irrigation & Power Minister, Punjab, then directed that all the Superintending Engineers of the Bhakra Canals and their Executive Engineers should attend a meeting under the Presidentship of Pt. Ram Dhan of the *Janta Sudhar* Cooperative Societies at Sonipat on the 14th, September, 1952. In this meeting it was stated that Pt. Ram Dhan would form societies all over that area and would be able to supply as much labour as any one required for digging of Bhakra Canals. The figure of 50,000 was given to the president as the requirements of the 2nd Bhakra Main Line Circle. The Executive Engineers took the responsibility of providing them with work.

Everyone realised the difficulty of transporting such a large number of men over long distances. There was no dearth of labour requiring employment in the Hissar District itself, which was also in the grip of scarcity conditions. To get over this difficulty the Irrigation & Power Minister then directed that a meeting of different departments in the Punjab interested in the organisation of the Co-operative Labour & Construction Societies should be called at Sirsa when the details regarding this job could be considered. The meeting of the officers of the Irrigation Branch, Cooperative Department, Civil Department, Employment office District Public Relations Office and of the local M.L.As was held at Sirsa on the 13th November, 1952.

8. It was decided that the area south of Dabwali Sirsa road and Sirsa Hissar Railway line was the worst stricken area and needed help immediately. If the societies are organised in this area, these will prove of maximum benefit to the people and they will immediately take up this idea of Co-operative labour & construction societies and start the work immediately. This having been decided a clear cut programme was chalked out for getting the schemes of the channels prepared, sanctioned and laid out at site. The organising of the Cooperative labour and construction societies was also discussed and estimates of the works were got sanctioned, in order of priority where the societies were to be first formed so that people do not have to wait for work which may cause disappointment and in the

end failure of the system. This having been done, every member of the staff was impressed to render sympathetic treatment towards the individual workers and the societies themselves with the result that 53 societies were formed within a period of five months and the present total is 63.

9. Figure 2 shows the location of these societies. Perusal would show that they have been formed all over the area so as to make it possible for a large number of people to join in and to obtain benefits of Cooperative work. A separate list, Table I shows the quantity of work done by each society, payment received by each society, its membership and the total labour strength employed by the society.

Upto now about 11,00 crore cubic feet of earthwork has been done and about 15.0 lakhs of rupees have been paid. Before the crop cutting season started just over 6,000 men have been working daily through these societies for the digging of channels. The labour is expected to increase again after the *kharif* crop is cut and *Rabi* is sown. This new system has proved to be a big success over the old Deputy Commissioner type which was tried from December 1951 to December 1952. Figure 3 shows the weekly payments for the work done, to the labour co-operatives under the Deputy Commissioner and to the labour and construction cooperative societies. The difference which depicts the work done per week is obvious'

CAUSES WHICH HAVE LEAD TO THE SUCCESS OF THE NEW SYSTEM

10. It appears that the biggest reason for the success of this system is that it has been organised properly on democratic lines. Every member gets himself registered by paying a nominal registration fee. Members get together and elect their own nominee who is given power of attorney to sign the work orders and then to receive payment from the Irrigation Department for the work done by the society and also for conducting other business affairs of the society. The accounts of the societies are properly audited by the Co-operative Deptt. This has given an individual worker the feeling to think in the terms of his society and his outlook stands changed. Every worker considers himself to be the master of the job who is not being paid like an ordinary labourer but has a share in the earning. Regular weekly payments are made by the Department in spite of the fact that there is big shortage of staff. Every individual officer who is connected with this work has to put in much more work than

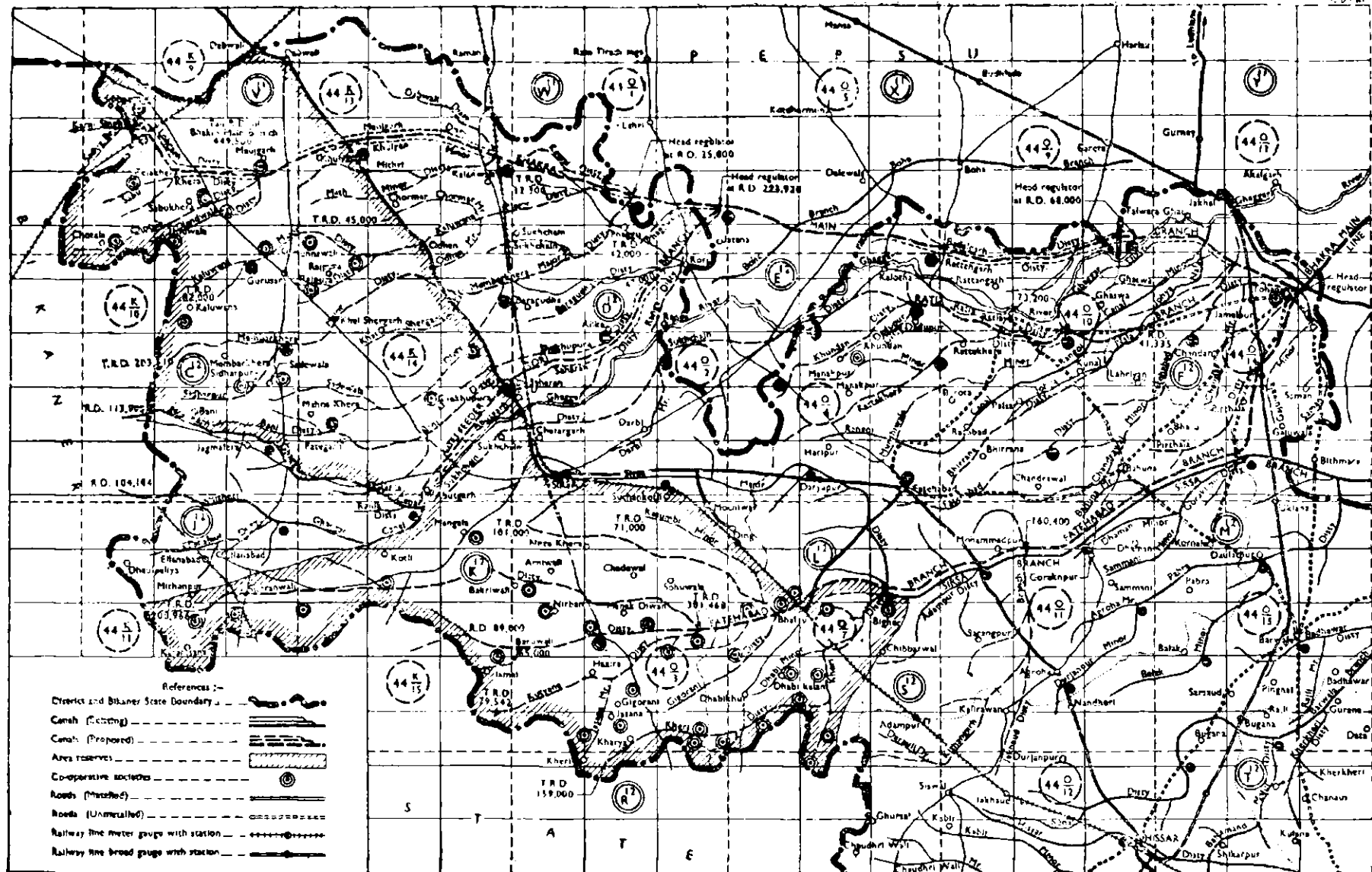


Figure 2: Index Plan of Bhakra second main line showing the location of the co-operative societies

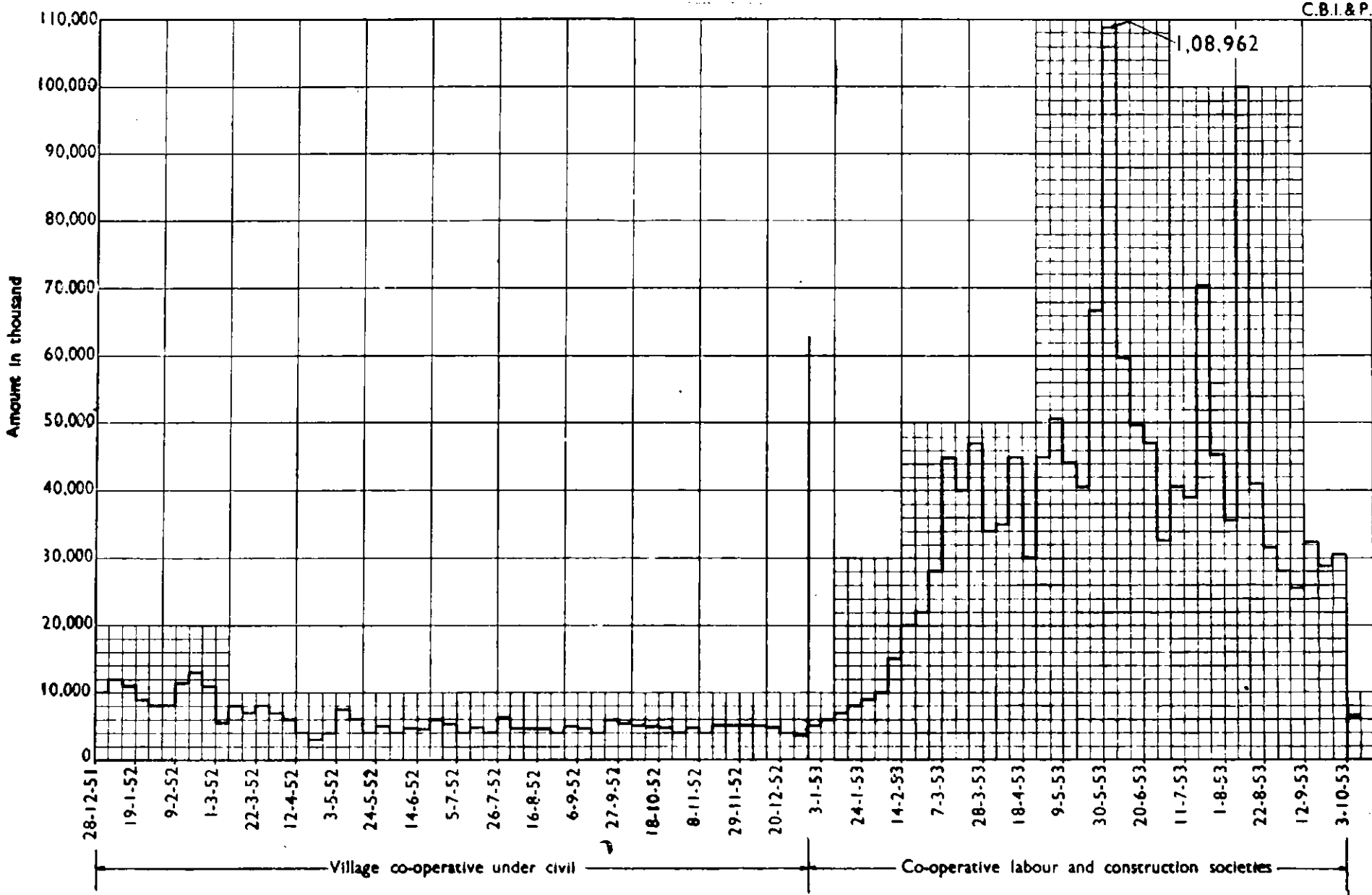


Figure 3 : Graph showing weekly payments made to village co-operative under civil and co-operative labour and constructions societies

TABLE I

Statement showing earthwork done and payment received by the co-operative Labour and Construction Societies upto September, 1953

S. No.	Name of co-operative labour and construction society	Labour strength	Earthwork done upto-date in lakh cft.	Payment received up-to-date
1	Bhattu cooperative labour and construction society.	55	43.48	60,231/-
2	Banmadauri -do-	35	35.81	51,777/-
3	Rupana-jatan -do-	58	33.11	46,923/-
4	Chharwala -do-	30	15.70	22,540/-
5	Jandwala -do-	60	32.82	41,963/-
6	Pilimadauri -do-	55	59.01	82,776/-
7	Nahrana -do-	10	67.30	96,381/-
8	Nathusari -do-	50	29.86	40,853/-
9	Hazira -do-	10	11.79	15,970/-
10	Rupawas -do-	30	25.84	35,661/-
11	Ludesar -do-	30	26.02	34,859/-
12	Khabra-khurd -do-	...	18.38	24,825/-
13	Chulli-Bagriani -do-	...	20.36	26,354/-
14	Ramsara -do-	...	7.70	11,697/-
15	Khabra-kalan -do-	50	31.35	45,914/-
16	Kagdana -do-	30	30.55	41,895/-
17	Jogiwala -do-	50	17.30	25,017/-
18	Kheri -do-	50	11.72	17,429/-
19	Chulli-khurd -do-	20	9.03	12,686/-
20	Dayar -do-	50	16.11	23,667/-
21	Dhabi Kalan -do-	100	10.43	15,046/-
22	Darba -do-	30	32.95	42,828/-
23	Brasri -do-	20	7.49	1,005/-
24	Dhurka -do-	30	38.56	49,552/-
25	Mehuwala -do-	45	21.08	30,042/-
	Total		653.75	8,97,891/-

TABLE I—(Contd.)

Statement showing earthwork done and payment received by the co-operative Labour and Construction Societies upto September, 1953

S. No.	Name of co-operative labour and construction society.	Labour strength	Earthwork done up-to date in lakh cft	Payment received up-to-date
	Total B.F.	...	653.75	8,97,891/-
26	Madhu Singhana Cooperative Labour and construction Soc.	45	8.65	11,343/-
27	Randhawa -do-	150	18.10	25,544/-
28	Bakrianwala -do-	75	15.76	21,069/-
29	Gudia -do-	50	8.45	11,084/-
30	Irnianwali -do-	60	13.37	17,470/-
31	Bhurtwala -do-	60	13.09	16,765/-
32	Sheranwali Dhani -do-	55	3.86	5,118/-
33	Krishanpura -do-	90	12.82	16,664/-
34	Poharka -do-	100	10.05	13,414/-
35	Sahuwala -do-	45	13.90	19,588/-
36	Bajeka -do-	40	7.11	9,610/-
37	Chilkani Dhab -do-	17	6.14	8,041/-
38	Panniwala -do-	90	12.02	16,168/-
39	Banwali -do-	100	16.31	20,792/-
40	Ghookanwali -do-	15	7.18	9,137/-
41	Kherwala -do-	10	3.06	3,925/-
42	Rasaliyakhera -do-	75	16.18	21,463/-
43	Chakkan -do-	50	8.71	11,638/-
44	Mammerkhera -do-	...	2.22	3,037/-
45	Sadeva -do-	...	3.00	3,759/-
46	Nahianwali -do-	40	21.25	24,524/-
47	Kharian -do-	110	15.72	21,976/-
48	Mangolia -do-	...	3.60	4,993/-
*49	Rampura -do-	80	2.70	2,220/-
	Total		897.00	12,17,233/-

TABLE I—(Concl'd.)

Statement showing earthwork done and payment received by the co-operative Labour and Construction Societies upto September, 1953

S. No.	Name of co-operative labour and construction society	Labour strength	Earthwork done up-to-date in lakh cft.	Payment received up-to-date
	Total B/F		897.00	12,17,233
	Madhu Singhana Cooperative labour and construction Soc.			
50	Chotala -do-	...	45.81	63,567/-
51	Goriwala -do-	120	8.00	16,473/-
52	Maujgarh -do-	...	8.40	10,996/-
53	Ganga Co-operative Labour and construction society.	130	9.65	14,078/-
54	Lohgarh -do-	17	12.70	17,153/-
55	Tajekhara -do-	...	3.40	4,699/-
56	Kaluana -do-	170	8.70	15,547/-
57	Tohana -do-	210	49.29	62,400/-
58	Allalwas -do-	60	9.63	11,622/-
59	Nagpur			
60	Bharolianwali	75	11.83	13,370/-
61	Phool			
62	Fatehabad	140	28.07	18,190/-
63	Sadzwala -do-	...	2.99	3,755/-
	Total		1095.47	14,69,083/-

what he should do in a normal way of working. Thus when the societies, see that the department is absolutely serious and sympathetic about their work and makes payments to them regularly every week, they get great confidence. Monthly meetings of local representatives of all the departments, local M.L.A's have also been held where the progress achieved during the past month is discussed and any bottle-neck that remain are removed. This helped to remove all acrimonious correspondence between the departments, and all the departments themselves first of all learned to work in a co-operative manner.

11. As per Irrigation and Power Minister's orders Tuesday every week is the date for payment when the representatives of the labour Co-operative and Construction Societies know that they have to attend the Sub-divisional Office to receive the cheque which is already there waiting for them. This also gives a chance to the nominee of the society to contact the Sub-divisional Officer and put before him his difficulties, if any. The weekly payments and the weekly contacts with the nominees of the societies have, in my opinion, helped to remove the chances of complaint regarding corruption. These contacts and full explanations on the part of the officers of the Irrigation Department have further helped to bring home to the worker that digging of the canal is actually their own job and it is for their sake that these channels are being dug. It is for them to see that the channels are constructed strictly according to specifications so that there is no possibility of breaches later on which in turn damage their own irrigation system and the standing crops. By this propaganda the quality of work has improved. Although the masses are uneducated yet they possess the feeling of responsibility. It is felt that this new system has been quite a success. Further improvements are still possible.

The Government has been paying the full scheduled rate to the cooperative labour and construction societies. The result is that these societies are paying -/16/- to -/17/- per 100 cft. of earthwork done to individual worker against -/14/- which is being paid by the contractors to their labour.

The differences in the rate being paid by the contractor to the labour and by the societies to their workers is due to the fact that due to strict control and regular calling of tenders the earthwork rate in this circle has shown the tendency to fall. When the work of these societies was started the contractors were also getting payment at schedule of rates. At the present moment tenders are of the order of about 10 per cent below sanctioned rates. The rate being paid to the cooperative societies has not been reduced for the reasons that the benefit goes entirely to the workers who deserve help as they are badly affected due to scarcity conditions and also for the reason that there should be no complaint that contractors are trying to undercut and so destroy this system. The cost of the project has to be compensated later on by levying of betterment fee on the irrigated area. So if this cost is slightly higher it will be recovered out of the irrigators of this area, otherwise the difference can be charged to famine relief funds.

It can safely be said that the movement of cooperative labour and constructions societies has been a great success. The societies only started working in January, 1953 but the labour rapidly rose within 2 months. The work is becoming quite popular and demands are being received from even other areas for the formation of Co-operative Societies there. I would only to add one word of caution, that we must consolidate our position so that the movement does not get unpopular. The societies must be asked to increase their membership much as possible and reduce the number of non-members workers. Then we must have sufficient staff to check the accounts so that there is no possibility of any disputes between the workers. If these particular precautions are taken the system will get well-ground and the co-operative societies which are being formed now only for doing excavation work on distributaries can very well start cultivation of the areas when water is available on the same co-operative system. After cultivation there will be marketing of produce and obtaining articles of necessity for the workers. This can also be taken up on the cooperative basis.

To recapitulate it can be stated that the system of labour and Construction Co-operative Societies introduced by Ch. Lahri Singh, Irrigation and Power Minister is proving a success and the societies can be expected to finish the construction of the distributaries allotted to them in time. The Co-operative department may be asked to look into the improvements suggested so that the position is further consolidated.

**CENTRAL BOARD OF IRRIGATION AND POWER
SYMPOSIUM**

NEW DELHI, 1953

PAPER XI

**The place of Experimental Stress Analysis in Effecting
Economics in Structural Design**

by

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1. INTRODUCTION

Frequently, in structural design problems arise which cannot be satisfactorily analysed by the conventional methods of stress analysis. The mathematical methods of analysis involve several simplifying assumptions and the designer has no means of checking the applicability of these to the actual structures. The cut and try method of testing the structures to destruction under increasing loads, although applicable to small machine parts is out of question for large structures like dams, bridges and buildings. Consequently, this ignorance of the precise stress values, compels the designer to adopt high factor of safety-which has rightly been called the factor of ignorance-resulting in a considerable increase in the cost.

The increasing demand for ever lighter yet stronger structures particularly in the air-craft industry has, in recent years, led to the development of new techniques of structural analysis which give a truer and more reliable prediction of structural behaviour. These techniques are grouped together under the name of Experimental Stress Analysis. There are two ways in which the experimental methods of stress analysis effect economics in structural design.

- (1) By model analysis of structure prior to construction suggesting the best utilization of material for added safety and economy.

- (2) By tests on prototype structure to give data on the actual behaviour of the structure enabling a check on the original design calculations and suggesting improvement in future design.

In this note the applications of the various experimental methods of stress analysis are indicated and idea of the possible economics that could be effected is given. As yet, the Science of experimental stress analysis is in its infancy in this country and consequently no exact cost data applicable to local conditions, are available. However, an example is cited of the design of a conduit for a large earth dam in Canada in which substantial economics were suggested by photoelastic and Beggs deformer analysis.

2. VARIOUS METHODS OF EXPERIMENTAL STRESS ANALYSIS

The method or group of methods to be used in any particular case depends on the nature of the problem.

Problems of stress concentrations round openings, notches and fillets, problems involving sudden changes in sections or involving non-linear distribution of stresses are best dealt with by the photoelastic method. Numerous examples could be cited in which photoelastic analysis has helped to evolve lighter and stronger machine parts and thus contributing to large savings to the manufacturers. R.E. Orten of the Acme Steel Company of Chicago cites a case in which an examination of the stress patterns of a sealing tool steel, low carbon steel by providing necessary surface strength by case carburizing. The tool was designed accordingly and the success of the design was indicated by continued absence of failures. This led to a substantial economy, not only by the lower initial costs and production costs but also by substituting a more easily available material for one which was difficult to obtain during the last war. Similarly drastic economics have been reported by locomotive, aircraft and machine tool manufactures who have based their designs on photoelastic studies. In the field of Civil Engineering the photoelastic data provides at present, perhaps the only rational method for economical design of reinforcement around large galleries and opening in dams.

When the designer is not interested in the stress distribution but only in the total thrust, moment and shear at any section of the

structure, methods like the Beggs Deformeter and the moment indicator are the most convenient to use. These methods are particularly useful in analysing statically indeterminate structures such as single and multiple arches, conduits, sewer sections, continuous portals, subway caoss-sections and secondary stresses in rigidly connected frames. Because of the difficulty in mathematical analysis of these statically indeterminate structures, there had been a tendency among designers to select statically determinate structures even for cases where a statically indeterminate structure would be not only economical but also aesthetically superior. It has been found by several authorities that, on the whole, statically indeterminate structures are more economical in material and show much smaller deflections than the corresponding determinate one carrying the same loads. The deformeter analysis therefore definitely contributes to economy in design not only by saving time in tedious computations but also by making analysis possible of rigid designs which thus far had not been given a trial because of the obstacles in the analysis.

For studies of stresses and deflections in large and important structures like dams, models made of concrete, plaster celite or rubber litharge are used. Such studies have been conducted for Boulder, Norris, Grand Coulee and several other dams in U.S.A. and the Continent. Timely information on deflections, stresses and strains due to dead and live loads as well as due to temperature is obtained from these models. The effect of the non-linear distribution at the foundation, stress concentration around fillets and galleries, and the deviations from the mathematically computed values of stresses, strain and deflection are readily indicated by such studies. This important structure like dams.

Methods of experimental stress analysis have also rendered possible the measurement of the actual deflections, strains and stresses occurring in the prototype. Hundreds of stress meters, strain meters pressure cells, thermometers etc., are being incorporated in all major dams that have been constructed in recent times. In certain cases the data obtained during a period of several years have, already been analysed and compared with design calculation and observations in model experiments. For example in the case of the Calderwood Dam (U.S.A.), the design was found to be very conservative and the possibility of considerably lighter construction is suggested for future dams.

Several other methods such as the brittle laquer techniques and slab analogy can be utilized to effect economics in design. It will not be possible to include the details of these methods in this brief note.

3. A SPECIFIC EXAMPLE

It will be of interest to go into little more details of a specific concrete case, to substantiate the general statements made above. While in Canada, the author was closely associated with a project involving the analysis of a R.C. multibarrel conduit for river diversion and ultimately for power for a large earth dam proposed across the South Saskatchewan River. Different mathematical methods of analysis gave widely varying results. Each method was based on different, more or less arbitrary, assumptions and the designer thus had no reliable analysis on which to base a satisfactory and economical design. An experimental approach was therefore suggested.

The conduit section suggested by mathematical analysis is given in full line in Figure 1. Photoelastic analysis was carried out of this and two other sections shown by the dotted lines in the same

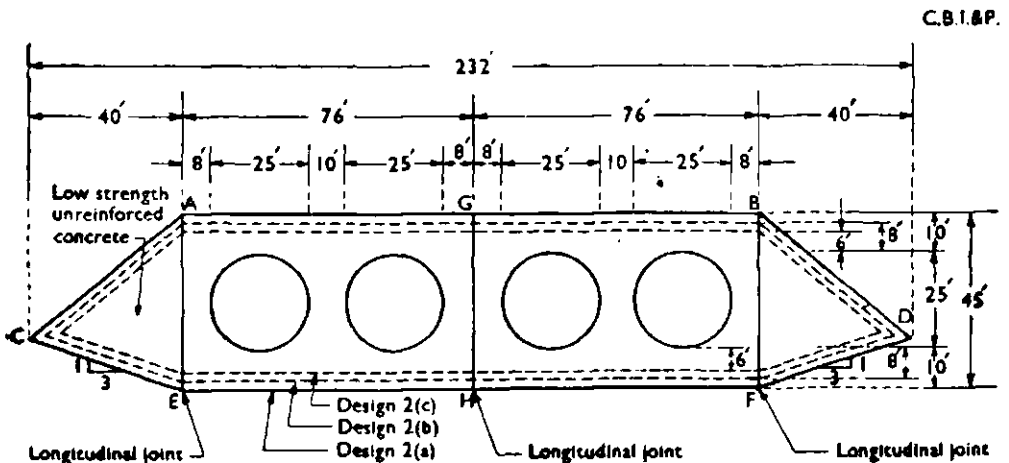


Figure 1 : Preliminary designs (a), (b) and (c) Cross Section of conduits

Figure. Fringe patterns of which a typical one is shown in Figure 2, were obtained for various earth and hydrostatic loadings. The

boundary stresses (typical example in Figure 3) and the difference in principal stresses were obtained from the fringe pattern sum of

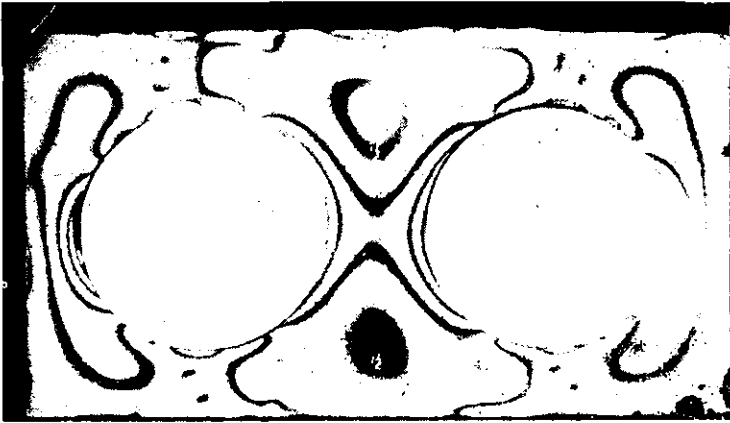


Figure 2: *Typical Fringe Pattern for earth Pressure loading*

principal stresses was obtained by relaxation method and from these data the thrust, moment and shears at critical sections were

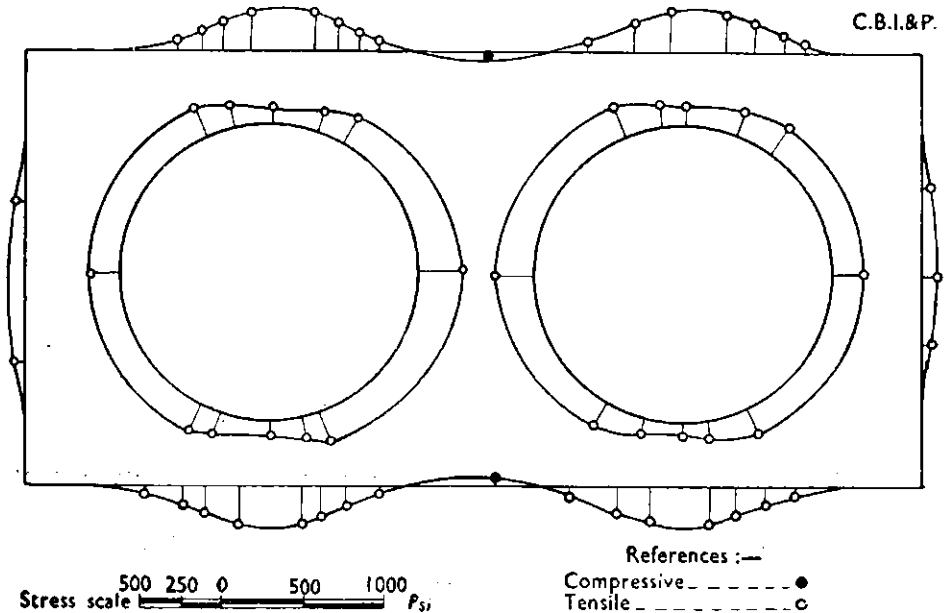


Figure 3: *Tangential Boundary Stresses—Case XVII (c)*

computed. For the case of uniform loading by 200 feet of saturated soil (neglecting side thrust) a maximum stress of about 800 lbs per square inch at the crown section was obtained by mathematical analysis. On the other hand photoelastic analysis gave a value of 900 per sq. inch for a section reduced by 4 feet on either side (section C in Figure 1). The photoelastic analysis further showed that lateral earth pressure and the hydrostatic pressure inside the barrels had a tendency to reduce the maximum stresses. These conclusions were verified by another independent experimental method i.e. the Beggs deformer. The experimental analysis therefore suggests a reduction of 8 feet on maximum section of the conduit without in any way decreasing the strength. Making allowance for

TABLE I

Item	Unit	Unit cost \$	quantity	total \$
A. Photoelastic Analysis				
Material Catalin $\frac{1}{4}$ " 61-893	$8\frac{1}{2}$ " + $11\frac{1}{4}$ " sheets	25.00	3	75
Grinding, Polishing, Anearling	Man hour	00.75	20	15
Loading jig, material, labours etc.	Lump sum			50
Machining Models	Man hour	1.50	25	37.50
Photographic Materials, Film and chemical	Lump sum			15.00
Photoelastic Observation	Man hour	1.50	60	90.00
Photoelastic Analysis	Mau hou	1.50	120	180.00
B. Beggs Deformeter Analysis				462.50
Material, Calluloid	36 " + 48 " sheets	15	1	15.00
Machining Model	Man hour	1.50	20	30 00
Observations	Man hour	1.00	30	30.00]
Analysis of data	Man hour	1.50	50	75.00
Grand Total				160.00
				622.50
or say Rs. 3,000/-				

experimental errors and other factors an average reduction of 4 feet may be assumed. The length of conduit is 2,750 feet.

$$\begin{aligned} \text{Total volume of concrete saved} &= \frac{4 \times 152 \times 2,750}{27} \text{ cubic yards} \\ &= 6190 \text{ cubic yards} \end{aligned}$$

Assuming the usual rates of concreting structure like conduits @ \$ 15 per cubic yard.

$$\begin{aligned} \text{Total saving} &= \$ 6190 \times 15 \\ &= \$ 92850 \quad \text{approximately} \\ &\text{or say 5 lakhs of rupees} \end{aligned}$$

Against this we could compare the cost of the experimental analysis which can very roughly be summarised as given in Table I

The above estimates are only very approximate and are based on the high cost of labour at present time in Canada. In India, cost of analysis would be much lower due to the lower rate of wages. However, the example serves to bring out the point that the cost of experimental stress Analysis is almost negligible (in this case $\frac{622 \times 100}{912,000} = 0.63$ percent compared to the ultimate saving it leads to.

4. CONCLUSION

An attempt has been made in this paper to briefly indicate the potentialities of the experimental methods of stress analysis in evolving safer and more economical designs. An example has been given which indicates that the cost experimental analysis is negligible compared to the economics that can be effected by an intelligent use of these methods. In view of these facts an up-to-date Experimental Stress Analysis laboratory has recently been opened as part of the Central Water and Research Station Pooná. It is hoped that in future these methods of analysis would find an ever increasing application and contribute to economies in our national reconstruction plans.

CENTRAL BOARD OF IRRIGATION AND POWER

SYMPOSIUM

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PAPER XII

River Valley Projects, Items (2), (3) and (4)—Benefits to the Govt. and Community—Some adverse effects of

by

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There is no gainsaying the fact that almost all irrigation projects, at least in the Punjab and also some of the other states have paid heavy dividends and, considering food production, development of industries and other indirect benefits, they have really proved to be a boon. But looking at the last half a century of irrigation some painful experiences have been met. These are described in this note, with a view to bring them prominently to the notice of those, connected with the planning and execution of River Valley Projects, so that, all possible efforts may be made to prevent recurring of these experiences and meet such contingencies.

1. *The rise of sub-soil water-table and waterlogging.*—The introduction of canal irrigation invariably disturbs the water balance of its sub-soil water-table. In most areas this water-table tends to rise and continues to do so, till the soil zone in which crop roots lie becomes completely saturated or the land is waterlogged. In either case the land becomes unfit for cultivation of normal crops.

2. A characteristic of semi-arid tracts before irrigation is the presence of salts in the soil profile and a sub-soil water-table containing large quantities of soluble salts—chiefly sodium salts. The

raising water-table when it comes within the root-zone of crops has an adverse effect on them and hinders their growth. With continued evaporation at the soil surface, this salt charged water, leaves a residue of salts till their concentration reaches a limit when no vegetative growth is possible. In this condition the soil is called 'Salt Soil'. Besides the rising water-table, faulty irrigation practices have also been responsible for the movement of the salt initially present in the soil profile towards the surface thereby causing accumulation and turning the soil into a salt soil.

It is not the intention in this paper to discuss all the factors that are responsible for the rise of water-table or the relative role that each factor plays in its movement upwards. These factors have been studied in considerable detail and described in other publications; further investigations are also in progress in almost all parts of the world where canal irrigation has been introduced. At this time the idea is to draw pointed attention to the fact that problems like rise in water-table, waterlogging, salt accumulation, and land deterioration, do arise so that provision may be made in project estimates for measures to prevent their occurrence or affect cures if damage has already occurred.

Some idea of the rise in water-table that has occurred in some of the Punjab canals can be had from a reference to the Table I.

Similarly some idea of the damage done to land on account of water-logging and salt accumulation can be gained from the fact that in joint Punjab, before partition, in an area of 120 lakhs of acres which had been subjected to surveys, approximately 24 lakhs of acres had been damaged.

It will probably be argued that in newer irrigation projects, provision has been made for lining main canals and branches to reduce seepage losses. While admitting that that will be a great advantage it has to be remembered that of the total quantity of water that enters from the river into any canal, only 17 per cent. is lost through main canals and branches, the rest 28 per cent. is lost through distributaries, minors and watercourses. Of the water that is actually delivered in the field for irrigation of crops, another 30 per cent. travels down and gets added to the water-table. So that in a system where main canals and branches are lined, if 182 cubic feet of water are taken from the river into the canal hardly 78 cubic feet will be

TABLE I

Mean Depth of Water-table Below Ground Surface (Feet)

Year	Name of Canal or Doab						
	Upper Jhelum Canal	Lower Jhelum Canal	Upper Chenab Canal	Lower Chenab Canal, upper area (above Sangla)	Lower Chenab Canal, lower area (below Sangla)	Sirhind Canal upper area (above Barnala)	Sirhind Canal lower area (below Barnala)
1904	46.7	35.1	29.5	40.3	52.3		
1905	45.8	33.8	29.0	38.8	51.2		
1906	45.1	32.7	28.4	37.2	49.9		
1907	44.3	31.5	27.9	35.4	48.7		
1908	43.5	30.3	27.3	33.8	47.5		
1909	42.7	29.2	26.7	32.2	46.2		
1910	41.9	27.9	26.2	30.6	45.0		
1911	41.1	26.8	25.6	28.8	43.8		
1912	40.3	25.6	25.1	27.2	42.5		
1913	39.6	24.4	24.5	25.8	41.5		
1914	39.0	23.2	23.9	24.5	40.5		
1915	38.3	22.0	22.4	23.2	39.5		
1916	37.6	20.9	22.2	21.9	38.4		
1917	36.4	20.0	20.4	20.8	37.6		
1918	35.3	19.2	17.2	19.8	36.8		
1919	34.1	18.3	17.8	18.7	36.0		
1920	32.8	17.4	15.6	17.7	35.1		
1921	31.3	16.7	15.9	16.7	34.4		
1922	29.6	15.9	14.2	15.8	33.7		
1923	27.9	15.2	13.4	14.8	33.0		
1924	26.3	14.4	12.4	13.8	32.2		
1925	24.3	13.8	11.3	12.9	31.6		
1926	22.3	13.3	10.8	12.1	31.0		
1927	20.3	12.8	11.0	11.2	30.3		
1928	18.3	12.3	12.1	10.3	29.8		
1929	16.3	11.7	12.0	9.4	29.1		
1930	14.4	11.2	11.9	8.5	28.5	17.8	89.3
1931	14.5	11.7	11.6	8.2	27.8	17.7	88.6
1932	13.8	11.6	11.5	8.3	27.2	17.8	88.0
1933	13.9	11.4	10.5	8.2	26.7	17.9	87.0
1934	12.9	10.6	9.7	7.5	25.0	15.2	85.6
1935	13.0	9.9	9.8	6.6	24.0	16.1	85.9
1936	12.4	9.7	10.1	7.0	23.0	15.8	88.9
1937	12.7	9.6	9.7	6.9	22.7	15.2	88.0
1938	12.5	9.4	10.2	7.2	22.4	15.3	87.1
1939	13.4	9.7	10.7	7.3	21.9	16.1	86.9
1940	13.9	10.0	10.6	7.7	22.1	16.9	86.4
1941	13.5	10.5	10.4	7.6	21.7	17.1	85.4
1942	13.3	10.0	10.3	6.6	20.7	17.3	84.9
1943	13.1	9.2	9.8	6.4	19.9	15.6	83.7
1944	11.9	9.1	9.5	6.3	19.2	15.8	82.3

utilized by crops, the rest 104 cubic feet will go underground slowly and steadily adding to the water-table, causing a rise in its level and ultimately waterlogging.

Another factor which deserves the attention of the planners is the obstruction of natural drainages. Instances are numerous where either insufficient provision has been made under railway lines, roads and canals for storm water to pass through or if there has been sufficient provision, the whole of the land under the drainage line has been sold or allotted and cultivated, thus causing obstruction to the free flow of storm water. In a particular instance, the writer noticed that, to save fields from damage from this storm water, field *bunds* had been raised to a height of three or four feet.

A story of similar nature has been repeated in building up the New Delhi area. A large number of natural drainage lines have been filled up; these have been converted into building sites and buildings constructed.

For determining the suitability of any area for irrigation and the changes that are likely to take place as a result of irrigation, it is now a standard practice in India to have a scientific soil survey done. It is painful to record that in modern practice, scientific soil surveys are becoming more of a farce than a really useful institution. Scientific soil surveys were never done before 1930. About that year soil surveys started, the standard laid was one soil profile for every 400 acres of land. On financial considerations alone the grid was later raised to 600 acres; then to 1,000, later to 4,000 and 16,000 and in the year 1953 to 25,000 acres. Imagine one sample taken out of every 25,000 acres what idea will it give of the quality of the soil, the problems that it presents and the problems that are likely to arise. In American practice, in the Bureau of Reclamation, the standard laid is one soil profile per 40 acres with more as necessary.

Experience of soil surveys in India has shown that when it comes to grappling a problem, such soil surveys afford very little assistance. It is at that time that the need for more detailed soil surveys is recognized; then unfortunately the opportunity is lost, for, after the introduction of canal irrigation, considerable changes take place in soil conditions. Inadequate provision for scientific soil surveys in project estimates, therefore, is not a wise policy.

3. *Gradual decrease of fertility of the soil on account of the slow increase in alkalinity by action of sodium salts.*—It has already been mentioned that the excess of salts is a characteristic of almost all semi-arid tracts. Under canal irrigation, long before land goes out of cultivation or any significant decrease in crop yields occurs, a very gradual un-noticeable decline in yields takes place because of the action of the sodium salts on the calcium-clay resulting in progressive increase in the degree of alkalisation. In fact, such is this unnoticeable gradual process that even in matters of standardization, or crop assessments the soil fertility is stabilized at a comparatively lower level. This is evident from the fact that, even for standardizing, the whole range 7.0 to 8.5 PH values has been given the status of a good normal soil. The word 'stabilized' of course does not mean that no improvement in soil fertility is possible. What it actually means is that the Indian farmer is content, if he gets yields in accordance with this fertility. There is no gainsaying the fact that a soil with pH value 8.5 or even 8.0 is an alkaline soil and is, therefore, capable of being amended further.

It must be remembered that an acre of land in India is the same amount of land as an acre in any other country and yet the yields of crops in this country are proverbially low. The reason is not far to seek. Poor soil structure has developed from handling an alkaline soil over a period of centuries and also from failure to use any correctives.

It is unfortunate that injuries of the above nature are not manifested until the soils reach the stage when costly reclamation is needed. Careful checks on soil properties and crop production have shown that crop losses develop gradually. That is, there is no critical point at which crop losses drop off sharply. The loss is gradual and increases with increase in alkalinity or severity of structural deterioration. Another reason why this gradual decline in fertility remains unnoticed is that no regular records of yields of crops are kept and during the process of deterioration, the land passes through so many hands from generation to generation.

Until the farming community rises to the occasion and they take to scientific examination of soils as a regular part of good agriculture, it remains the duty of the State to initiate scientific soil surveys of all tracts to be repeated at regular intervals. Provision for these surveys should be made at the time of planning.

If signs of declining fertility are noticed from detailed soil analyses then it would be relatively easy to suggest or adopt soil corrective measures at an earlier stage of deterioration than when the damage has exceeded the limit. These correctives can be in the form of the use of gypsum or sulphur or even a change in agricultural practice or rotation of crops. Light annual applications of chemicals or slight change in cropping systems will contribute much to maintaining the soil in a good productive state and avoid the cost and loss of crops involved in reclamation.

An appropriate case to quote in this connection is the formation of sodium carbonate soils in Karnal District. The formation of sodium carbonate has developed in the course of a long series of years. Had regular soil surveys been carried out, it would have been possible to note this deterioration much earlier and undertake remedial measures. These soils are now presenting formidable difficulties in reclamation.

It is satisfactory to note that the Punjab Waterlogging Board have recommended to Government to set up a permanent organization to- regularly surveying and re-surveying soil conditions throughout the State and regularly advising land-lords and Government on remedial measures.

4. *Soil fatigue.* With flow irrigation, large heads of water and large size fields, canal water is generally applied in excessive quantities which results in leaching of plant food from the surface to the sub soil layers. This coupled with inadequacy of available manures results in fatiguing of soils and decrease in crop production.

5. *Malaria.* Rise of water-table, waterlogging and later construction of drains etc. afford ideal opportunities for malarial mosquitoes to breed, causing wide-spread malaria amongst the living population.

6. It is common experience that with sub-soil water-table (fit for irrigation) near the root-zone, crops require a relatively small amount of water. Experiments carried out by Dr. Rege show that a reduction in irrigation requirements by 16.1 and 34.4 per cent. could be effected for partial and continuous proximity to the water-

table with 2½ feet depth of sub-soil below the ground and 13.2 and 31 per cent. for 4½ feet depth. With decreased water requirements, water becomes available for use elsewhere. This will bring additional revenue and alter the financial forecast. This aspect should be foreseen in taking cognizance of advantages and benefits.

7. When measures for lowering the water-table are undertaken, the water supplies pumped from the sub-soil water-table become available for irrigation either direct or after mixing with canal water. This increase in water supply brings in additional revenue and should, therefore, form a part of financial considerations at the time of planning.

The Punjab affords a typical example of what happens when a canal is constructed and irrigation is introduced. the prosperity it brings, the way in which living standards rise and the trend of industrial developments. It also shows how gradually decline in agricultural production takes place, large areas go out of cultivation on account of waterlogging and salt accumulation thus terribly upsetting the agricultural regime and also the way Government sets about finding ways and means of applying remedial measures and the defeatist mentality it begins to develop. In spite of the fact that they have spent over three *crores* of rupees in instalments, there is no abatement in either the rate of rise of the sub-soil water-table, the spread of waterlogging or the formation of salt soils. The Punjab Government has confined its activities to the construction of surface drains and has postponed more expensive measures to later dates.

My 38 years study of this problem has convinced me that when a vast tract of fertile land has become waterlogged or infertile otherwise it presents such a dismal look that the national productive impetus to accomplish anything becomes lacking. Besides other sociological condition, administrative organization, philosophies and technical mis-understandings become the limits of practicability. If on the contrary such contingencies, as have been mentioned, are taken into consideration right in the beginning at the time of the preparation of the project, then the so called human weaknesses will never stand in the way of amelioration.

While, therefore, we are rejoicing ourselves over the idea of river valley projects, their advantages direct and indirect and the prosperity they bring, we might as well consider the difficulties that

will appear later and take the public and the farming community into confidence and ask them to keep themselves ready with measures that are required to meet these difficulties. Their co-operation is essential.

CENTRAL BOARD OF IRRIGATION AND POWER

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PAPER XIII

Some Aspects of Cost-Benefit Studies of River Valley Project

by

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INTRODUCTION

The string of this paper is wound round certain aspects relating to cost and benefits of river-valley projects. The broad heads covered by this would be:-

- (a) Direct and indirect, socio-economic benefits of multi-purpose projects.
- (b) Organisational set-up for their execution.
- (c) Criteria for fixing priorities.
- (d) Financial soundness and economic justification.

2. With due regard to limitations of space and time it is intended to indicate the broad lines of approach on these aspects placing such emphasis as I have found necessary in certain directions. Certain facts which I have come across are merely put forth leaving the reader to judge for himself and come to considered opinion of his own. The paper is by no means exhaustive and I have endeavoured to put down my own thoughts on these aspects. The paper is spilt up into four parts, each dealing with the aspects mentioned above.

3. The country has a large programme of development under the Five-Year Plan for irrigation and river valley projects which consume the bulk of the expenditure under the Plan and on which the country rests its hopes of a better socio-economic and richer life.

The costs of river valley projects are being revised from time to time for one reason or the other. The effect of the increase in cost of estimates would be to upset the Plan unless (i) increased resources can be tapped by the State Government concerned or (ii) savings are indicated or adjusted either in the same work or in some other work included in the Plan. The latter alternative may prove unsatisfactory if increased production, taken credit for, does not materialise.

4. The need for increase in estimates for river valley projects should be established convincingly. The subject appears to be one of vital importance for, to a certain extent, the very success of the Plan is bound up with the careful solution being found for it. Public opinion is often critical of the manner in which colossal river-valley projects are being executed and, in particular, of the ascending tendency in cost, slowing down of progress and other such adverse factors. If, in the long run, the increase in production or benefits falls short of the anticipations or targets set out in the Plan and the costs turn out to be higher, the charge of having put forward a misleading Plan may be levelled against the authorities concerned.

PART I

DIRECT AND INDIRECT BENEFITS

5. A view is expressed that the extension of irrigation, power *etc.* is seriously handicapped by the restricted view taken of the value of irrigation to the community at large. Apart from the direct returns in the shape of land-revenue, water rates, *etc.* there are innumerable indirect benefits flowing from these projects. The need for assessing, at least to an approximate degree, the benefits, both direct and indirect, is being increasingly recognized. A variety of benefits accrues to the local body, State Governments and Central Government and to the community at large. Apart from direct benefits which constitute tests for gauging the productivity of projects they provide increased opportunities for employment to the people and substantial indirect benefits to the Central and State Governments, local administrations *etc.* They have famine expenditure, bring indirect additional income from taxation and registration fee, excise and other sources. The Central Government obtains increased revenue from income on taxes on business under takings, agricultural produce, from railway fares *etc.* The community at large derives

profits from increased land-values and production. Though these indirect, secondary and tertiary benefits are generally recognised these are not taken into proper account while evaluating the financial soundness or success of river-valley projects, that is in determining the productivity of, and the net returns from, these project.

6. A broad indication of the benefits, direct, and indirect, resulting from different types of projects such as irrigation, power, navigation and flood control projects may be indicated as under :

(6.1) Irrigation

(a) DIRECT BENEFITS

- (i) Water rates and betterment levy.
- (ii) Increase in land revenue.
- (iii) Sale proceeds of crown waste lands.
- (iv) Miscellaneous receipts from plantations, lease of land along the canal banks *etc.*

(b) INDIRECT BENEFITS

To the community

- (i) Increase in land value, employment, living standards & livestock production.
- (ii) Stimulation of business.
- (iii) Reduction in the cost of pumping water due to rise in the water table by the introduction of the net work of irrigation canals.

To the local body.

- (iv) Water cess.
- (v) Increase in land revenue.
- (vi) Increase in duty, taxes *etc.* due to influx of more population.

To State Governments

- (vii) Saving in famine and flood expenditure.
- (viii) Revenue from registration and stamps.
- (ix) Income from excise, Sales tax, agricultural tax *etc.*

To the Central Government

- (x) Income tax, super-tax factories utilising agricultural produce, sugar cotton factories, flour mills etc.
- (xi) Increase in income from railway on account of movement of agricultural produce and labour as well as extra traffic.
- (xii) Income from duty on petrol, motor goods used for movement agricultural produce and labour.
- (xiii) Increased income from posts and telegraphs, income from customs duty on account of increased import of machinery and material.
- (xiv) Arrest activities of unlawful elements.

(6.2) Power**(a) DIRECT BENEFITS**

- (i) Sale of electric energy.
- (ii) Income from licences.

(b) INDIRECT BENEFITS

- (iii) Power for defence purposes.
- (iv) Higher utilisation of land, community development.
- v) Stimulation of business.
- (vi) Decentralisation of population in towns and cities on account of better living standards in rural areas.
- (vii) Cheap haulage of railways on account of electric trains and saving and better quality of coal which can be used for other nationally important work.
- (viii) Reduction in cost of lifting or pumping water.
- (ix) Better living and working conditions.
- (x) Better standards of health.

(6.3) Navigation**(a) DIRECT BENEFITS**

- (i) Receipts from water carriers and shippers and receivers of cargo.
- (ii) Savings in cost of maintenance and operation of existing water ways.

(b) INDIRECT BENEFITS

- (iii) Protection of life and property by elimination of obstructive and other hazards of existing water-ways.
- (iv) Savings in water carrier and new development stimulated by improved transportation facilities.
- (v) Less strain on railways keeping as complementary to the latter.
- (vi) Assistance to downstream people by regulation of river flow.
- (vii) Improvement of sanitary conditions.

(6.4) Flood-Control**(a) DIRECT BENEFITS**

- (i) Savings in agricultural, residential, commercial etc. losses.
- (ii) Savings in increased cost of transportation charges due to circuitous routings, delays etc.
- (iii) Savings in cost of evacuation in flood area, rehabilitation of the affected, and building temporary quarters for the evacuees.
- (iv) Savings in cost of temporary or emergency flood relief measures.
- (v) Savings in cost of anti-malarial and other health measures.

(b) INDIRECT BENEFITS

- (vi) Higher standards of living due to higher utilisation of property and more employment of the community.

7. It is desirable to conduct economic surveys in the project affected areas to assess these direct and indirect benefits conferred by these projects. To get fairly reliable and accurate idea of the advancement in, and uplift of, the life of the people in the area these surveys would have to be carried out both before and after completion and operation of the project. Such surveys are being undertaken in the Hirakud Project area in Orissa.

8. It would be interesting to cite an example or two where in a record of some results of a quantitative study of direct and indirect

benefits were carried out. Let us take the Yume Project in the U.S.A., (which was constructed in 1910 at a cost of 9.7 million dollars to irrigate 69,000 acres of land). Data gathered are given below :—

(i) *Annual Return from Crops—*

1910-1914	\$ 445,000 to \$ 700,000
1947	\$ 14,000,000

(ii) *People residing on the farms—*

1912	1,500
1947	3,000

(iii) *People residing in the towns—*

1912	3,150
1947	30,000

(iv) *Car load^s shipments of farm commodities from the project area—*

Prior to 1917	300
1946 and 1947	over 17,000

(v) *Business gross income*

1939-46	\$ 21,000,000 annually against 6.5 million ¹ dollars annually previously.
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(vi) *Post-Office receipts—*

1921	\$ 22,000
1943	\$ 161,000
1946	\$ 191,000

(vii) *Expansions in the use of modern conveniences since 1925*

Telephones—	Increase by 160 per cent
Gas connections—	Increase by 116 per cent
Water connections—	Increase by 107 per cent
Electrical Connections—	Increase ¹ by 62 per cent

(viii) *Federal taxes paid directly or indirect from the project—*

1931 to 1947	\$ 37,000,000
	\$ 2,660,000

9. Coming nearer home, another typical example of an assessment of direct and indirect benefits resulting from the Godavari and Pravara canals system in Bombay State may be cited. The following table gives the capital investment, the sum-at-charge and the return.

Agency	Capital Expenditure in Rs. Lakhs	Net Return Rs. Lakhs	% Return (3)/(2)×100
1	2	3	4
<i>On actual capital outlay</i>			
Government ...	257	5.9	2.30
Farmers ...	40	20.0	50.00
Sugar Factories ...	32	10.0	31.25
Total ...	329	35.9	10.00
<i>On total Sum-at-charge</i>			
Arrears of interest on Govt. investment	173	—	—
	<u>502</u>	<u>35.9</u>	<u>7.2</u>

an idea of the benefits accruing to the various agencies which is sufficient to justify the capital outlay can be gained from the statement below :—

A. Central Government

*Increased income per annum
(Rs. Lakhs.)*

Sugar Excise	15.00
Railway Income (Net)	7.90
Income Tax	3.00
Petrol & Miscellaneous Import duties	0.58
Posts & Telegraphs	<i>Negligible</i>
TOTAL.	<u>26.48</u>

On Rs. 257 Lakhs of initial investment, this gives a return of 10.3 per cent.

B. Provincial Government

Misc. Canal produce	0.125
Land Revenue (Kapargaon Taluk only each year, for 20 years)	0.900
Motor Vehicles Registration, Security of Assessment	0.180
Famine expenditure saved	0.500
Registration, Stamps, etc.	negligible
TOTAL	1.705

On Rs. 257 lakhs, this works out 0.7% return.

C. District Local Boards.	Negligible
Grand Total (A+B+C)	28.18

10. From such an assessment it will be clear that the individual investments by farmers and factories would not have been possible without the public investment. Hence the public investment is a direct cause of high return on private investment. In other words, this high return on private investment is a direct effect of State investment. It appears to be substantial enough. Although direct income on actual capital outlay of Rs. 257 lakhs is only 2.3 per cent the State Government derived in addition an indirect benefit of 0.7 per cent. and the Central Government 10.3 per cent with very little additional expenditure, if any. Even on the total Government sum-at-charge, inclusive of arrears of interest, namely 430 lakhs (257+173), the indirect revenue adds up 6.5 percent to the meagre direct revenue of 1.4 per cent. Apart from return to investors, benefits pile up to the community at large by way of employment to persons who make no contribution to the investment. thus reducing the problem of burden some population and raising their standard of living. Employment to the entire canal staff and to a substantial portion of staff employed in other cognate departments arises from irrigation facilities made available.

11. An analysis of the increased value of gross income per acre, responsible for giving birth to, and calling forth, all the growing economic activities can yield a clue to its scope of extension and direction. One of the surveys conducted reveals that, from the order

of Rs. 500 to Rs. 600/- in a 40-acre typical dry farm unit, agricultural business and productivity shoots up to Rs. 1200/- under second class irrigation and to as much as Rs. 3500/- or 4000/- in extensive irrigation, dominated by a perennial crop like sugarcane.

12. Viewed at from the expansive growth made possible in the whole economic system, the measure of success has to be judged in relation to the opportunities thrown up and created for new and fresh avenues of employment of capital and labour resources. The expansion and development resulting from public investment may lead to a diversion of resources and labour from one employment to another or to the employment of unemployed or under-employed resources and labour. The scope and extent of these effects, direct as well as expansionary, secondary, and indirect, appear to be dependent on the nature of crops grown.

PART II

ORGANISATIONAL SET-UP

13. Once the project is prepared and sanctioned, the project proceeds to the execution stage. There are a variety of opinions regarding the type of administration, vested with due powers and responsibilities, in the construction and management of river valley projects. In the paragraphs below are set out the different opinions now obtaining. This has a vital and important bearing on the economic and efficient execution of the project.

Unitary Control

14. The most important thing being administration of the project, one view is that the Chief Engineer of the project should assume the position of a General in charge of a campaign or war. The best available man for the job should be selected and, having chosen him, he should have full confidence in the support and backing of the Government. With such a pattern of set-up and given goods will and necessary cooperation and understanding all round, it is felt that there will be no difficulty in executing any big river-valley project.

Corporation or Valley Authority

15. Another form of management is the semi-autonomous corporation, the standing example being the D.V.C. The subject

has been under such raging controversy and during the recent past there has been much heated talk on this pattern of set up. It is thought worthwhile to enumerate the various points in favour of and against the valley authority or Corporation for executing river valley projects.

16. The following viewpoints in favour of setting up of a Corporation for execution of river-valley projects are generally advanced :

(i) A regional authority, such as the D.V.C. has all the flexibility of action of a private corporation, and such an authority is centralised and less subject to red tape and bureaucratic delay.

(ii) Plans for development of a river basin, under a valley authority, possess the virtue of unity and every phase of development can be planned in its proper relation to the whole. Such planning is apt to be more balanced and unencumbered by traditional and possibly hampering procedures. Instead of a dozen agencies concerned with fragments of the problem, one agency or organisation, supposedly responsible to the people, can do a better total job.

(iii) Offices of the authority would be located in the area in its very heart itself with all the attendant advantages which flow from such a situation. Among these are more familiarity with, and appreciation of the immediate circumstances of the problem, ability to render decisions on the spot and fix responsibility, and better coordination and cooperation with different local agencies.

(iv) Nothing is lost of the valuable assistance available from other government agencies, as most of the Bills to create a Damodar Valley Corporation provide that the Corporation may call on other federal agencies for any information they may possess as well as for technical assistance.

(v) Those in favour of a D.V.C. say that any authority established by Parliament is subject to its control. It is no absolutist, all-powerful agency but subject to any checks Parliament may see fit to impose.

(vi) In using the corporate form, more businesslike management is possible with a probable actual money savings.

(vii) A Corporation will have the power to engage in activities, essential to a full development of the resources of a region, which are

not now the concern of any single agency at all. Among these are soil erosion control, topsoil rebuilding, provision of terminal facilities, development of new industries and the like.

(viii) Someone must decide the present conflict of interests between navigation as well as power etc. An authority such as the D.V.C. can make these decisions for the benefit of the region as a whole.

(ix) A D.V.C. might be self-liquidating or self-supporting. Power or other revenues might be sufficient to finance an entire comprehensive programme.

17. Those who are inclined to the view that the establishment of a Damodar Valley Corporation will hurt or be harmful to our nation, have strong arguments which run somewhat on the following lines :

(i) It is contended that States governments are developed of a large share of tax revenues as a result of any valley authority which withdraws from taxation large areas of land within its jurisdiction

(ii) The river basins so administered would divide the entire nation into many valley and other regional authorities, and then would render the Indian Union and States, nearly obsolete. In other words, the Constitution may be circumvented and the rights of individual States would soon cease to exist and a stage reached when States would exist in name only.

(iii) Another reason advanced by opponents of a D.V.C. may be that such authorities engage in activities which are in direct competition with private business and industry. They are of opinion that "Government in business" is not a constitutional activity.

(iv) Long established government agencies with fine records of achievement and specialised techniques can do a better job than new and inexperienced special authorities.

(v) The powers of Valley authority are constitutionally limited to the Central Government's power which in turn may rest on the constitutional power to regulate commerce, navigation etc. Any powers beyond these are assumed at the expense of the States, and such an assumption appears constitutional.

(vi) A.D.V.C. might well become a super-agency, above any control by anyone. The Act creating such an authority would need

to be carefully evolved lest the only check on its power be solely that of approval or disapproval of an already accomplished fact.

(vii) Another objection is that neither a D.V.C. plan nor any existing proposals for Valley authorities, will provide for fusion of the Central and State powers, nor for the means by which the powers of the State, and certain laws of the nation, are to be exercised over such a corporation.

(viii) Plans for a D.V.C. possess the essence of State management and are so extreme that they border on communism.

Control Board

18. Another form of set-up where the interest of more than one State is involved would be to constitute non-statutory boards called Control or Advisory Boards. There are already (i) the Bhakra Control Board and (ii) The Hirakud Control Board. There is a proposal to constitute a board for Tungabhadra Project which, after October 1953, would involve the interests of Hyderabad, Mysore and the new state of Andhra. It is believed a proposal to set-up a Control Board for Chambal Valley Development by the Government of Rajasthan and Madhya Bharat is also under consideration. The pattern of these Boards may not be uniform in all cases but may vary to suit the local requirements or needs and circumstances. To give a rough idea of the functions and powers of such types of boards, it may be interesting to mention the functions and powers of the Bakhra Control Board.

19. The functions and powers of the Bakhra Control Board are set out below :—

(i) To scrutinise the estimate of the project, advise necessary modifications and recommend the estimate for administrative approval.

(ii) To examine and lay down where necessary specifications and schedule of rates for various items of work with a view to sound and efficient execution.

(iii) To examine and approve from time to time the delegation of such powers both technical and financial, as it may deem necessary for the efficient execution of the project to the various categories of officers working on the subject.

(iv) To approve of proposals for award of work or supplies on contract other than those based on public tenders

(v) To approve of special estimates and contracts the cost of which exceeds the sanctioning powers of Chief Engineers

(vi) To decide the programme of construction of different arms of the project in all the three participating States of Punjab (1), Rajasthan and Pepsu

(vii) To decide on the state development of power and withdrawals of water from the reservoir during the construction period for irrigation and power purposes to secure the most optimum and economic use of the available waters

(viii) To obtain monthly progress reports and review the progress on different units of the project and lay down such steps as may be necessary to expedite work

Joint Construction

20. There are cases where joint construction by two or more states has been carried out by mutual cooperation and good-will. In the case of the Tungabhadra project, work has so far been carried out jointly by the Governments of Madras and Hyderabad. Meetings and joint consultations, whenever found necessary, were held between the two Chief Engineers of Madras and Hyderabad, in-charge of the project, to discuss and solve mutual problems of design and construction and it is really very gratifying to note that work on this project has proceeded without any major hitch. It is understood that whenever differences of opinion arose, the matter was referred to a Chairman (agreed upon by both the Chief Engineers). The project is nearing completion and there was perhaps no single occasion for any major differences of opinion to arise.

21. A few examples may be cited to show the need for one or the other types of execution when more than one interest is involved.

(i) *Tungabhadra*: The centre line of the river forms the boundary between Madras and Hyderabad. Each Government constructs its half of the dam. After the formation of the Andhra State the benefits of power and irrigation on the right bank would go to Mysore and the new State of Andhra. There would thus be three interests enjoying the benefits of the project.

(ii) *Bhakra* : The submerged area of the reservoir will lie in Bilaspur State. Construction of the dam is being done by Punjab (1), Rajasthan and Pepsu

(iii) *D.V.C.* : The reservoir sites are located in Bihar. The benefits of irrigation will go entirely to West Bengal.

(iv) *Machkund* : This is a joint enterprise by Madras and Orissa Governments. 70 per cent of the benefits of power will go to Madras and 30 per cent to Orissa. Construction work is being done by the Government of Madras on behalf of Orissa.

(v) *Bhairavanitippa* : The dam site is situated in such a fashion that the reservoir area which will get submerged lies in Mysore while the entire benefits will go to the new Andhra State.

(vi) *Chambal* : The Gandhisagar dam (the first in a series of three dams and one barrage in the Chambal Valley Development site is located on the boundary between Rajasthan and Madhya Bharat. The benefits of power and irrigation will go to both the States.

Construction Co-operatives

22. The system obtaining at present on departmental work is to call for tenders for labour contracts for items of work every season and let out work to a number of piece-contractors at the lowest rates quoted. The merit of the system is that once a rate has been fixed, portions of the work which are beyond the capacity of the contractor or cannot be tackled by the contractor, who, at times, may not possess adequate and timely resources to take up the whole job, can be quickly entrusted to other piece-work contractors. On the other hand, the great drawback would be that all contractors may combine together with a view to secure higher rates. It is not proposed to go here into the merits and demerits of this system of contract except pointing out that a Committee constituted by the Ministry of Works, Housing and Supply has recently submitted their report to Government.

23. A suggestion is sometimes put forth that the existing pattern or set up of Public Works Department should be reorganised so that the government departments primarily concern themselves with the planning and technical features of public works and leave the actual execution or construction to an entirely different organisa-

tion. It is claimed that these cooperatives which will be responsible for construction of public works will be a self-supporting organisation and will considerably reduce the present cost to Government. It is claimed that through such organisation a reduction on the P.W.D.; establishment by about 90 per cent and, on the execution of works by about 25 per cent can be effected. The advantages, it is stated, would be better quality of work at less costs, elimination of corruption generation of local initiative under free play and completion of individual capacities resulting in overall efficiency and economy.

PART III

CRITERIA FOR FIXING PRIORITIES

24. It is a striking thought that river basins which have, perhaps, made the greatest imprint on the rise of culture of pre-historic times persist even to this day in an age of atom bomb, jet plane *etc.* Very few would dispute the fact that they play a leading role in man's destiny. Generally speaking, all major river valleys of the nation are of surpassing importance from the socio-economic development point of view. Though national interests may have over riding considerations in determining priorities as among the various schemes, regional interests and special needs should not be lost sight of. At the same time, the development of the potentiality of one region despite its own problems, cannot be considered without careful and due regard to its bearings or effects on the economics of the other adjacent and neighbouring regions and that of the nation as a whole.

25. Speaking from considerations of regional needs, it would hardly be in the public interest to spend colossal sums of money for increasing industrial production in an area which has greater and pressing needs for realising its agricultural potential. There are certain parts of the country where power development is the urgent need. Similarly, the big need in the upper reaches of a river basin would generally be irrigation and that in the lower reaches flood-control.

26. Let us now proceed to examine certain problems in this direction. Bombay suffers from a serious shortage of electricity and this has jeopardised the industrial development in and around the area. The Koyna project included in the first Five year Plan will promote industrialisation on a large scale and, at a later stage, is

expected to provide additional irrigation facilities to areas which are frequently and chronically subjected to famine and scarcity conditions. The Ganga Barrage Project in West Bengal is designed to serve the navigation needs in the area and head-water control of the Hooghly River.

Food Production

27. Our primary and crucial objective in the coming few years is to obtain a marked increase in the output of food-grains. It is really an up-hill task for our population is increasing 4 to 5 millions a year. The existing low consumption levels call for an expansion of food production or output by several million tons a year. During the recent past we have been importing food-grains at the rate of about 3 million tons a year. Even during the pre-war days India remained a net importer of food. The aim of the Five-Year Plan is to dispense with our food imports by the end of 1955-56. For an adequate solution of the food problem in the country, it is estimated that the area now under irrigation should be doubled within next 15 to 20 years. Therefore, any scheme which is designed to give a substantial outturn of food-grains within a very short period will deserve a high priority in any scheme of national development.

Scarcity Affected Areas

28. During the year 1952-53 scarcity conditions prevailed in 10 states where about 26 million people were affected. Scarcity areas may be classified into three categories, namely

- (i) Chronic,
- (ii) temporary and
- (iii) areas of seasonal scarcity.

Chronic scarcity occurs where rainfall is not only scanty but also irregular and erratic. Crop Failure and destruction prevail almost once in 3 to 5 years. Even though minor irrigation schemes will give some relief, major irrigation works will provide ultimate solution. Temporary Scarcity areas also have low rainfall. Crop failures are less frequent. Seasonal scarcity conditions occur in many States at the end of harvest, particularly after May when employment opportunities decrease. Although problems of chronic and temporary scarcity have received some attention, the seasonal aspect of scarcity has to be more fully studied so that concerted and effective measures may be formulated and adopted.

29. The Government of India in October 1952 decided to send team of experts to make on-the-spot study in scarcity-affected areas in certain States. Accordingly, teams of officers were sent to Bombay (Maharashtra and Gujerat), Hyderabad Mysore and Madras (Rayalaseema) during the period November 1952-January 1953. The teams were charged with task of studying in detail the nature and extent of distress and recommending suitable measures for relief on a permanent and semi-permanent basis. Table I gives particulars regarding districts affected, rainfall, the problems thereof and some of the measures for solution. This will emphasise the need for rounded and extensive development of the various regions confronted with peculiar problems of their own.

Floods and their damages

30. Indian rivers during the monsoon of the current year (1953) would appear to have had more than their due share of run-off and almost all major rivers have overflowed their banks and brought about considerable damage to life and property. The Kosi in Bihar, Brahmaputra and other damaging rivers in Assam and the Godavari in the South are reported to have caused considerable damage whose value, it is reported, may run to several crores of rupees. This state of affairs which repeats itself almost every year, in greater or lesser degree, calls for urgent attention, both from the point of view of short-term and long term measures for solution. The economics and feasibility of one or more of the following methods for flood-control would need careful attention.

- (i) Dykes to contain the angry waters within the two banks.
- (ii) Works to increase the capacity of the existing channel such as river training and cut-offs.
- (iii) Secondary channels to deal with excess water such as natural and artificial diversion channels and spillways.
- (iv) Storage reservoirs or detention basins to store or detain the excess water
- (v) Soil and water conservation

31. The Damodar which has notoriously been called Bengal's "River of Sorrow" will be progressively tamed with the creation of the reservoirs behind the various dams included in the Damodar Valley projects. Similarly, the Hirakud Project will provide flood-protection in the Mahanadi basin.

Power Shortage

32. Bombay is suffering from a serious shortage of the much-needed power required for its industrial development. Recently, frequent and large cuts have been imposed on electric-supply in Madras State owing to the insufficiency of rainfall in the catchment area upstream of the reservoirs such as Mettur, Papanasam etc. Unless proposals to overcome the shortage of power in both Madras and Bombay and other States are actively pursued and implemented urgently, there is every likelihood of industrialisation getting into jeopardy in the near future let alone future advancement in that sphere.

Navigation

33. The navigation of the Ganga river near its mouth has been very unsatisfactory. The Ganga Barrage Project is designed to control the head waters of the Hooghly.

Drainage and Reclamation

34. In certain areas where canal irrigation has been introduced on an extensive scale, the problems of water logging and drainage have arisen. The topographical features in certain parts of the country may be such as to create depressions where the rain water collects and finds no escape to run and throw itself into a big river or the sea. Here the problem of disposal of surplus and unwanted waters is thrown up. Such situations obtain in parts of Punjab (I), Travancore-Cochin and Sunderbans in West Bengal.

35. These regional needs will have to be taken into consideration while formulating an all-embracing or comprehensive nation wide Plan.

36. Generally speaking, the principal basis on which the irrigation schemes have been included in the First Five Year Plan is the maintenance of the tempo of construction work on schemes which were started before the Plan period and on which considerable sums of money had already been spent. A high priority was assigned to projects or parts of projects which were designed to yield additional food at an early date and they have been phased with view to the early completion of their irrigation aspects, the power development being carefully regulated and taken up in stages as the demand arises. The Planning Commission has laid down certain broad principles or

TABLE I

Scarcity areas

Statement showing scarcity conditions in the certain States

Area	Districts Affected	Average rainfall (inches)	Occurrence of Famine and its problems	Measures for solution
1	2	3	4	5
Bombay Maharashtra	Sholapur, Bijapur Abmednagar, Poona Belgam and Dharwar	15 to 25	10 years out of last 30 years 10 years " 5 years " 4 years " storage of food and fodder; difficulty for drinking water.	Construction of Ghataprabha 2nd stage, Kukdi and Gangapur canals, large No. of tanks, bhandares and wells and contour bunding would remove distress.
Gujerat	Admedabad Panchmahals, Banaskantha and Sabarkantha.	30 to 40	10 years out of 25 years 5 years out of 15 and 2 years out of 4 years.	Construction of 4 river schemes. Contour bunds and Bunds across several strenms and creeks in west Gujerat would control salinity of water.
Hyderabad Marathwad	Nanded, Parbhani, Jalna Bhir and Auran- gabad		In the last few years	Medium reservoirs each benefiting one district and bunding work would remove scarcity conditions.
Andhra Rayalaseema	Bellary, Anantapur, Kurnool and Cuddapah	20	36 years out of 77 years. Paddy cultivation has suffered during the last 4 years due to acute shortage of rains.	Irrigation schemes, contour bunds and soil conservation measures would benefit the area.
Mysore	Kolar, Tumkur, Chit- aldrug and Shimoga.	15 to 35	Once in 4 or 5 years. Con- tinual scarcity in the last three years.	Early completion of Bhadra and Tunga schemes and construction of minor irrigation schemes in distress areas. Boring set to draw off water for drinking.

criteria for inclusion of new projects in future Plans and for fixing priorities as among those that may be sponsored in different parts of the country. They are briefly set out below :—

(i) A project for inclusion in a Plan must have been investigated in sufficient detail. All preliminary investigations relating to the availability and adequacy of the water potential, the broad features of design, firm and reliable estimates of cost, availability and suitability of land for irrigation, financial aspects including betterment contributions, water rates etc., in the case of irrigation schemes and to possibilities of loads for absorbing the power, the necessary machinery for its utilisation have all to be carried out. Detailed financial forecasts, estimates, and plans should also be worked out. Thus the schemes should be prepared after detailed investigations and surveys. The estimates should be reasonably correct and the financial forecast reliable.

(ii) Projects which will add to the food production of the country must receive a priority over and above projects designed for other uses of river waters.

(iii) Projects which are financially more bright and remunerative in direct financial returns, in terms of capital cost per acre of irrigation or per unit of power generated and those which will yield quick benefits should be given preference.

(iv) The regional requirements of food, power, flood protection, erosion control, drainage, protection against scarcity and famine conditions etc. must receive due consideration, as also the special and peculiar needs of backward areas.

(v) The labour absorbing capacity of the project should also be an important criteria in the present context of the intricate unemployment situation in the country. Normally speaking, projects which would offer better opportunities or avenues for utilisation of manual labour should receive priority over and above those where mechanization would be introduced on a large scale.

PART IV

FINANCIAL SOUNDNESS AND ECONOMIC JUSTIFICATION

37. According to the existing, orthodox financial yard-stick, a scheme is classified as productive if it yields a direct return (in terms of direct net revenues) of, at least, 3.75 per cent on the capital investment, 10 years after construction of the project. Otherwise,

the scheme would be dubbed as "unproductive" and financed from general revenues or special grants. This appears to be rigid and an out-date dated method of gauging the financial soundness of river-valley projects.

38. Perhaps, the most controversial of the numerous criteria for any literal interpretation of the marginal-cost rule has been "the recoupment of full cost". On fiscal grounds, opponents of this rule have made a somewhat convincing case in favour of the alternative standard-full cost pricing. May be that the full cost standard is a guide in the case of single purpose public ventures. Nevertheless, it can only lead to confusion where enterprises such as a Damodar Valley Corporation, with two or more distinct purposes, are involved. If a narrow or limited viewpoint of benefits, equated in terms of rupees, annas and pies, is taken, such arbitrary conventions are likely to interfere with the optimum utilization of the resources.

39. A number of special solutions to the problem have previously been advanced, but their limitations are not appreciated widely. One of the most famous of these is the formula employed by the T.V.A namely the "Alternative Justifiable Expenditure" method. In brief, this consists of allocating common costs among the various "products" in proportion to the minimum costs required to provide each of them in isolation. (This gives a rough approximation to "benefits-received" standard). It would guarantee "ideal" output of each product only in a case where the enterprise was confronted with demand curves, all of which were perfectly inelastic. In any other situation, it may be possible [to enlarge the production of benefits, and to recoup a greater proportion of the common costs from those where demand is not elastic.

Similarly, there is a special assumption implicit in the proposal that prices of individual products be set proportional to their marginal costs. In this way, of course, full costs could be ploughed back and users could set their marginal rates of product for the enterprise.

41. Unfortunately, this criterion is useful only under important restrictions; first, the products must be close substitutes for one another; second, and more significant, none of them must be close substitutes for any commodity produced outside the enterprise. This method of pricing does nothing to ensure an optimum rate of consumer's substitution between the products of different enterprises.

42. There are many facets to the argument, but so far as possible, let us avoid compounding the difficulties. The following basic assumptions may be adopted:—

- (i) There is no distinction between long-run and short-run cost functions. All factors of production are instantaneously variable.
- (ii) The total cost function for the enterprise should be ascertained, known accurately, and reflect all social costs.
- (iii) For each product, there is a unique demand curve confronting the enterprise.
- (iv) Consumer's surplus constitutes a satisfactory index to the welfare of consumers. The "net social product" may be looked upon as the excess of all consumer's surpluses over the social costs of the enterprise.
- (v) Price discrimination is not feasible either for reasons of equity or of administrative difficulty.

43. To the extent that these revenue considerations cause a departure from the strict canons of financial soundness and feasibility, there is, of course, a welfare loss, just as in the classical examples of the private monopoly or the excise tax. In principle, all such losses in social welfare could be avoided by discriminatory pricing or cost-benefit accounting. The only justification for inquiring into a one-part price appears to be the conviction that the alternative would generally require the enterprise to strike a separate bargain with each individual consumer.

44. Only the most naive will suppose that to assume the optimum price of each commodity exceeds its marginal costs by an amount proportional to the excess of its marginal costs over marginal revenue is an open sesame to all problems in social welfare economics. (The most serious limitation, in my opinion, is the use of consumers' surplus rather than the social welfare function). It is all too easy to conceive of problems where consumers' surplus might be invalid, and where inter-personal comparisons would be relevant. If, in a particular case, the distributive considerations are significant, a solution in terms of consumers' surplus might nevertheless be a worth-while point of departure for further adjustments.

45. Perhaps the most interesting feature about a "constrained optimum" rule is the fact that it gives sanction to practices or conventions that are already understood at an intuitive level. It provides justification for charging a price well above marginal cost on products where demand is relatively inelastic, while at the same time permitting a price nearer to marginal cost on other products. Some welfare loss is inevitable in any departure from the strict marginal-cost rule, but it is important to realise that the magnitude of these losses is directly related to the elasticity of the demand curves.

Public Co-operation

46. With a view to reduce the costs of river-valley projects which involve expenditure of colossal sums of money, to arouse nation-wide enthusiasm and enlist the widest measure of public support in the execution of these projects, the Planning Commission has been making proposals for adoption of the following measures :-

- (i) To adopt a system of village cooperatives for the excavation of canal systems.
- (ii) To organise labour camps where conditions would permit.
- (iii) Introduction of legislation for betterment contribution.
- (iv) To take such other steps as may be possible in the circumstances of each project with the object of securing public support.

47. The advantages flowing from the implementation of one or more of these measures would be that the villages will benefit by the large sums spent on the canal system which will come into the cooperative movement and will be available for agricultural improvements. Secondly, it inculcates habits of thrift and investment in usual ventures for the benefit and enrichment of their own selves and the nation. It generates cooperation amongst village over large areas in executing works of such magnitude. This will lead on to further cooperation in other spheres and assist in raising or uplifting the general level of their life. From a long range point of view, the organisation that is set up during the execution of the canal will be useful in its maintenance, in the distribution of water and in suitable measures for economy in the use of the available irrigation waters.

48. To state in concrete terms, the canal should be dug, not through contractors, but by mobilising the labour of villages in the

area through which they pass. One proposal would be to divide the area into suitable blocks each one of which could have a local committee constituted of leading men of the villages. To this committee can be assigned definite reaches or sections of the canal work. The technical department concerned (irrigation or agricultural) can give the necessary technical and other assistance. It would be worth-while to pay the wages on a piece-work system through village cooperatives by which owners of land as well as landless labourers should be free to join.

49. Another suggestion carrying a different objective is that on each of the major projects there might be, to start with, a labour commission, consisting of a thousand and odd persons to be drawn from colleges, youth organisations and foreigners. Each batch may, perhaps find time to work for a month at a time. With the help of such commissions it might be possible to emphasise, more and more, the importance and dignity of physical labour. Work in these camps will constitute an enriching experience in the lives of those concerned and help gradually in impressing the shining features of the project on the minds of the local people and educating them. These camps may serve as a forum to disseminate available material for publicity in order to secure further public cooperation in various ways including contributions to loans through small savings campaigns and so on.

50. In the following paragraphs is briefly set out what has been or is being done in this direction in some of the major States in India:-

(i) *Bombay* :-

The Government of Bombay are attempting to entrust minor works to labourers' Co-operatives without calling for regular tenders. It is understood these societies are having a membership of 2,000 and their share capital is about Rs. 29,000/-. It is hoped that they would contribute to the improvement of the social and economic conditions of the poor labourers.

(ii) *Madras* :-

Labour camps consisting of men from various districts have already been organised in Madras; but the experience gained shows that this does not have any marked advantage over contracted labour.

(iii) Uttar Pradesh :—

The Government of U.P. are of the view that inducements may be provided to village organisation to undertake work on voluntary basis so that they may begin to appreciate that they are working in their own cause. The nature of inducements will depend on local conditions but they must be such that there is an ultimate economy in the total cost.

(iv) West Bengal :—

Attempts to form a village labour co-operatives for the execution of canals were made at Mayurakshi Reservoir Project during the last two years but the results were not a success. However, attempts are being made to start labour camps with the help of the students of the local colleges.

Betterment Levy & Water Rates

51. It has been observed that land for which irrigation facilities are provided immediately appreciate considerably in price. This rise in land-value which, in some cases, is of the order of 5 to 10 times is an unearned increment to the land owners and it is now generally recognised that Government which provides the capital for construction of irrigation facilities is entitled to take a part of the increase in the land value; otherwise the Government would find it very difficult or almost impossible to launch upon new irrigation projects. It may be reasonable to assume that half the increase in land price may be recovered as Betterment Levy.

52. The State Governments of Bombay, Punjab (I) Hyderabad, and Mysore have already enacted law for this purpose. Bills which have yet to crystallise into Acts are under consideration with the Governments of Madras, Rajasthan, Pepsu and West Bengal. Other States like Uttar Pradesh, Bihar, Orissa Madhya Bharat and Travancore-Cochin have accepted in principle the levy of betterment charges.

53. The Betterment Levy may be recovered either in one lumpsum or in suitable number of instalments and become effective either soon after the advent of irrigation or 2 to 3 years after the irrigation waters are made available to the beneficiaries. The charges may be paid in cash or the landowner may exchange land in lieu of the betterment charges.

54. The water rate charged depends on a variety of factors ; but it is generally fixed at a small percentage of the benefit the cultivator derives from irrigation facilities. There is general feeling and, rightly too that the old water rates which continue to apply even in these days of spining costs, are unreasonably low and in order that major river-valley projects may find their way to pay themselves and prove self-supporting, the need for revision of the existing water rates is long due. The Government of U.P. have recently revised their water rates. The Government of Punjab also increased their water rates by 50 per cent but it is understood that there has been lot of agitation against this step.

55. Another way by which the co-operation and support of the public may be obtained is by floating public loans for specific schemes. Cash Certificates such as the Postal ones on which the name of the scheme such as 'Blakra" may be inscribed may be instituted. Small savings scheme may also be launched. This will enable every one to constitute his might. A small savings scheme is being intensively persued by State Governments of Rajasthan and Madhya Bharat and it is understood that the proceeds from such a small savings drive will be wholly earmarked for going ahead with the multi-purpose 50 crores Chambal Project.

56. The above are some of the avenues by which the cost of the projects can be met and revenues realised in order that they may prove a remunerative and effective proposition.

CONCLUSION

57. It was not the author's intention to present an exhaustive technical discourse. If it has helped to draw attention to certain contributory factors having a bearing on the costs and benefits of river-valley projects and be of some use in arriving at certain definite lines of future action in respect of this subject for the symposium, it would more than have served its purpose.

ACKNOWLEDGEMENT

58. My grateful thanks are due to Shri, Yadava Mohan, Chief (Natural Resources) Planning Commission, for his valuable advice. The permission to present this paper at the Symposium is also thankfully acknowledged.

CENTRAL BOARD OF IRRIGATION AND POWER

SYMPOSIUM

NEW DELHI, 1953

PAPER XIV

Planning for Minimum Project Costs

by

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SYNOPSIS

Reasons for increase in costs of present day irrigation projects are not only due to the increase in the prices of materials and labour but also due to the fact that irrigation development hereafter has mostly to depend on storage projects. During the earlier Period, the flow in the river could be utilised by constructing comparatively cheap weir structures. The costs of some of the projects since 1900, per acre irrigated and per cusec are compared. It is shown that in other Himalayan rivers, storage projects are essential to make economical use of the canal system. The economy obtainable by careful planning and design is examined in detail. Some suggestions are made advocating employment of earth dam wherever possible. reduction of cement content, raising the allowable stresses, using stone masonry, canal lining and strengthening a well established Central Designs office.

The Unit rates for important items of work on different projects have been discussed and it is shown that for concrete and earthwork rates, some more experience in this country would be necessary before ceiling rates are fixed. It will then be possible to effect considerable economies by controlling the rates.

It is shown that by a scientific phasing of a project, considerable economies can result. At present each project authority assumes

its own accelerated programme for calculating the returns. A standardised procedure has to be formulated after obtaining data regarding actual place of development in the past. Practical suggestions are given for phasing of a project. The cost of the projects will be reduced if the vast human energy can be utilised. Some methods are indicated.

1. BASIC FACTORS AFFECTING COSTS

There has been a great rise in the cost of irrigation projects during the course of last twenty years. One of the chief factors contributing to this is the basic change in the method of providing water to the fields. In the earlier phase, the available supplies of the rivers were utilised by simple weir or barrage structures to irrigate lands. As India is particularly fortunate in having a large number of rivers, there were ample opportunities to develop weirs, which are about 67 in number. The list of the weirs together with a few details are given in Table I. It will be seen that the number of weirs were largest in Madras and Uttar Pradesh sharing between them nearly half of the total number of weirs in the country.

As these do not involve any deep foundations or large amount of masonry, the cost of the works is generally smaller than the storage structures. A large portion of the cost of weirs is in aprons and economy can be obtained if accurate methods of analysis can be developed for their design. It is to be noted that the best rational design of weirs has been evolved in India. A better control is obtained if the weirs are fitted with shutters which can be raised or lowered. Such structures known as barrages are common in North India. Of the eighteen weirs in Madras, only two are barrages.

The serious limitation to the extension of weir irrigation is that the system will have to depend only on the run of the river. Thus while the maximum flow in Godavari between June to October exceeds twenty lakhs of cusecs, the minimum flow goes down to less than a thousand cusecs, thus restricting the irrigation mainly to a single crop. Any further irrigation development on Godavari in Andhra State must depend only on storage reservoirs. Most of our important rivers have been exploited by this type of weir irrigation. The main rivers left out still are Tapti, Narmada, distributaries of Godavari and Ganga.

Kakrapar weir project will develop practically all the irrigation that can be developed by diversion. Broach weir across Narmda is

under contemplation and will, in spite of its unusual height, still prove much cheaper method of providing irrigation than the storage structures. There are a large number of Himalayan rivers draining into Ganga, such as Gandak, Kosi, *etc.* All these rivers are practically untouched. Only a *lakh* of acres are irrigated from Gandak with an open channel regulator. But as the minimum flow in the river is 10,000 cusecs, construction of a barrage will enable a large area to be irrigated. Similarly Kosi and other rivers have yet to be mastered and waters utilised for irrigation.

Storage reservoirs

The future development of the country is, however, to be based on the storage system. Water flowing to waste has to be trapped, conserved and used gradually for irrigation. Storage structures offer other advantages such as development of continuous power, fish culture, attractive recreational area and navigation, *etc.* One of the important methods adopted for control of flood is formulation of reservoirs. Storage reservoirs have certain disadvantages besides their cost. They cause a lot of submersion and uprooting of the people living in the reservoir area. Also silt brought by the river is trapped and it is not yet established how much of this silt is removed through sluices or by density currents or with flood waters escaping on the spillway crest. Table II gives a list of important reservoirs built and under construction.

Cost per causec and acre irrigated due to diversion weirs and storage projects are shown in the figure. From Figure 1 it can be seen that projects on rivers other than Himalayan and irrigating rice fields form a distinct group as compared with projects on Himalayan rivers. The latter have two advantages. The area irrigated for each causec is nearly double as wheat and other dry crops require less water than rice. Also the flows in the Himalayan rivers in the minimum period are very appreciable being 3000 causecs in Sutlej, 10,000 causecs each in Sarda, Gandak, Kosi, *etc.*, while even in big rivers like Godavari, the summer flow is hardly 3,000 causecs. The large perennial flows in the Himalayan rivers enable two crops to be raised from the same canal system while no such possibilities exist on South and Central India rivers unless storage reservoirs are constructed and water stored. The Figure 2 shows that the cost per causec of headworks and canal system are continually rising from 1900 and are at present as much as three times the rates in 1900. Thus

TABLE I
List of Weirs in India

S. No.	Name	State	Description	Canal discharge
1.	Madhopur	Punjab	Headworks	6,900
2.	Rupar		-do-	9,040
3.	Tajewala		-do-	5,000|2,266
4.	Ferozepur		-do-	6,950|3,320
5.	Ghaggar		-do-	1,530
1.	Bhingoda	United Provinces	Weir	8,400 180 200 9,500 2,000 5,500
2.	Hardwar		-do-	
3.	Khoh		-do-	
4.	Ramganga		-do-	
5.	Rudpur		-do-	
6.	Nagla		-do-	
7.	Kichha		-do-	
8.	Bambasa		-do-	
9.	Duni		-do-	
10.	Karamanas		-do-	
11.	Okhla		-do-	
12.	Narora		-do-	
1.	Bhaisalotan	Bihar	Headworks	(No weir open head)
2.	Chanrodand		-do-	
3.	Goabari		-do-	
4.	Dehri		-do-	
1.	Anderson	Bengal	Weir	
2.	Eden canal		-do-	
3.	Mohanpur		-do-	
1.	Pattia	Orissa	Weir	
2.	Berura		-do-	
3.	Mahanadi		-do-	
4.	Naraj		-do-	
5.	Russel Kunda		-do-	
6.	Ghumsur		-do-	
7.	Janavili		-do-	
1.	Wainganga	Central Provinces	Headworks	
1.	Hathmati	Bombay	Weir	
2.	Raipur		-do-	
3.	Thengoda		-do-	
4.	Polkhed		-do-	
5.	Ojhar		-do-	
6.	Nander		-do-	
7.	Vir		-do-	
8.	Bewadi		-do-	
9.	Khudahi		-do-	
1.	Nellore	Andhra	Weir	7,760
2.	Sangam		-do-	
3.	Sunkesula		-do-	3,000
4.	Vijayawada		-do-	1,5571
5.	Dowleshwaram		-do-	1,4930
6.	Nagavalli		-do-	414

TABLE I (Contd.)
List of Weirs in India

S. No.	Nama	State	Description	Canal discharge	
				Designed	Actual
1.	Marudur	Madras	weir	1,595	
2.	Srivaikuntam	-do-	-do-	2,855	2,070
3.	Peranai	-do-	-do-		
4.	Grand	-do-	Barrage	4,100	
5.	Upper Anicut	-do-	-do-	2,377	
6.	Pelandorai	-do-	Weir	7,40	301
7.	Kaniyam Pallayam	-do-	-do-		
8.	Coleroon (Lower)	-do-	-do-		
9.	Mehamattur	-do-	Weir	263	
10.	Vriddhachalam	-do-	-do-	351	
11.	Tirukkoilur	-do-	-do-	1,271	
12.	Cheygar	-do-	-do-	1,542	
13.	Poiney	-do-	-do-	3,217	
14.	Palar	-do-	-do-	5,631	
15.	Vallur	-do-	-do-	113	
16.	Kattalai	-do-	Regulator	1,671	
17.	Shatiatope	-do-	Weir	850	
		Mysore			
1.	Saigehalla	-do-	Weir		
2.	Tunga	-do-	-do-		
3.	Bhadra	-do-	-do-		

the irrigation projects cost more due to the fact that we have to depend hereafter mainly on storage projects instead of the cheaper

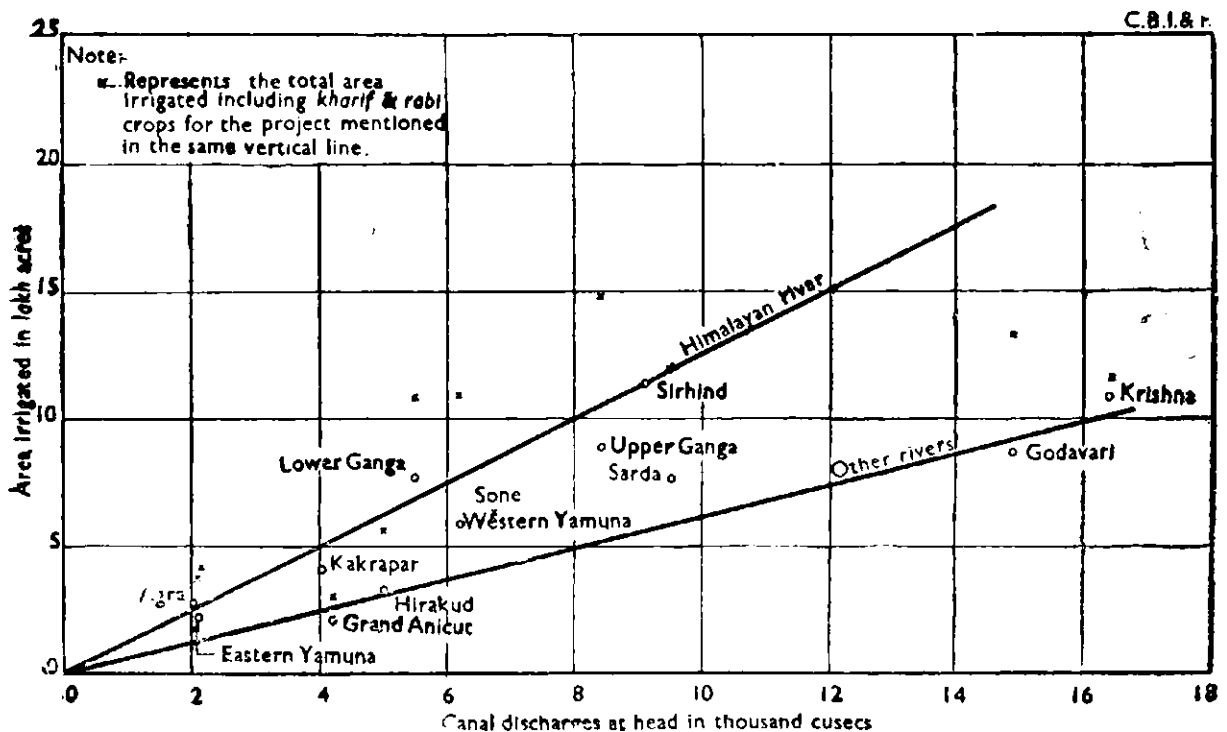


Figure 1: Canal discharges versus areas irrigated

TABLE II

Important Storage Works Under Operation and Construction

S. No.	Name of Dam	State	Year of Completion	Purpose	Depth in feet above		Useful capacity in ac. ft.	Cost in lakhs	Area under irrigation lakhs acres	Cost per acre ft. of useful capacity	Remarks
					lowest bed	lowest foundation					
1	2	3	4	5	6	7	8	9	10	11	12
1	Paricha	Madhya Pradesh	1885	Irrigation	53.00	54.80	67,723	43.71	1,80,000	64.00	Under operation
2	Periar	Madras	1897	-do-	158.00	176.00	225,321	33.92	1,95,000	15.00	
3	Ganga Weir Dam	Vindhya Pradesh	1915	-do-	43.00	53.00	48,324	17.96	1,42,561	37.00	
4	Tandula	Madhya Pradesh	1921	-do-	82.00	107.00	222,950	33.86	1,50,524	15.00	
5	Maramsili	Madhya Pradesh	1923	-do-	83.70	105.70	131,267	31.17	2,00,000	24.00	
6	Lloyd	Bombay	1928	-do-	168.00	194.00	555,586	172.00	1,71,079	31.00	
7	Nizamsagar	Hyderabad	1931	-do-	115.50	157.50	587,660	383.10	2,75,000	38.00	Under Construction
8	Tilaiya	Bihar	1953	Multipurpose	99.00	122.00	260,000				
9	Konar	Bihar	1953	-do-	160.00	189.00	211,000	994.00	11,41,000	472.00	
10	Maithon	Bihar	1954	-do-	162.00	178.00	963,000	1063.00		110.50	
11	Panchet Hill	Bihar	1955	-do-	133.00		1066,003	1080.00		102.00	
12	Lower Bhavani	Madras	1954	Irrigation	160.00	160.00	630,000	572.20	207,000	90.70	
13	Tungabhadra	Mysore	1954	Multipurpose	80.00	160.00	3,000,000	1481.00	900,000	49.60	
14	Mayurakshi	West Bengal	1955	-do-	123.00	155.00	500,000	541.00	600,000	108.00	
15	Hirakud	Orissa	1956	-do-	180.00	195.00	4,510,000	4172.00	1,785,000	92.30	
16	Bhakra Nangal	Punjab (India)	1960	-do-	600.00	680.00	5,730,000	5,501.00	3,604,000	96.30	

diversion systems and the rise in the prices of materials and labour. After another 30 years, the projects may be still more costlier as the more favourable sites would have been built upon. The revenues have not increased proportionately so that the returns are necessarily unattractive. Also the impact of democracy and freedom to shape pattern of development, has led to the thought, at least for the time being, that no notice need be taken whether project is 'productive' or not. The criterion of productivity was that a project should begin to pay at the rate of 3.75 per cent ten years after completion. While this helped in development of irrigation in some places extensively, in others, specially in scarcity areas, it had a deleterious effect. No work of any type was done. Both the extremes must be avoided. There must be a blending of projects having a relatively high or low rate of financial return. No single State should be allowed to embark simultaneously on a number of works all of which are relatively weak financially. As the increase in the cost of materials and labour are beyond the control of the engineer it is necessary for him to probe into other factors to effect economy and evolve designs to cheapen the cost of a project.

2. ECONOMY DUE TO PLANNING AND DESIGNS

2.1 Utilisation of earth dams

One of the useful tools that a present-day engineer possesses is the possibility of utilising earth as a material of construction in dams. The cost of an earth dam will be approximately a third of the cost of a masonry dam for equal length and height. This will be even more in favourable conditions where good earth is available at easy distance. Lower Bhavani dam was originally designed to have 8,400 feet of masonry dam and the rest, earth dam. The masonry dam was to be located in the reach where the ground level is very low. The designs were changed later to have only 1,400 feet of masonry and the rest in earth. This has resulted in considerable reduction of estimated cost of the project. As the earth dams of more than 90 feet were not built in Madras State and directions given not to design earth dams of greater height, earth dam could not be provided for the river section where the height of the dam would have been 140 feet. By locating the earth dam in the river section and providing spillways on the flank, more savings could have been effected. The unsatisfactory foundation prevailing at Gangapur dam site together with the long

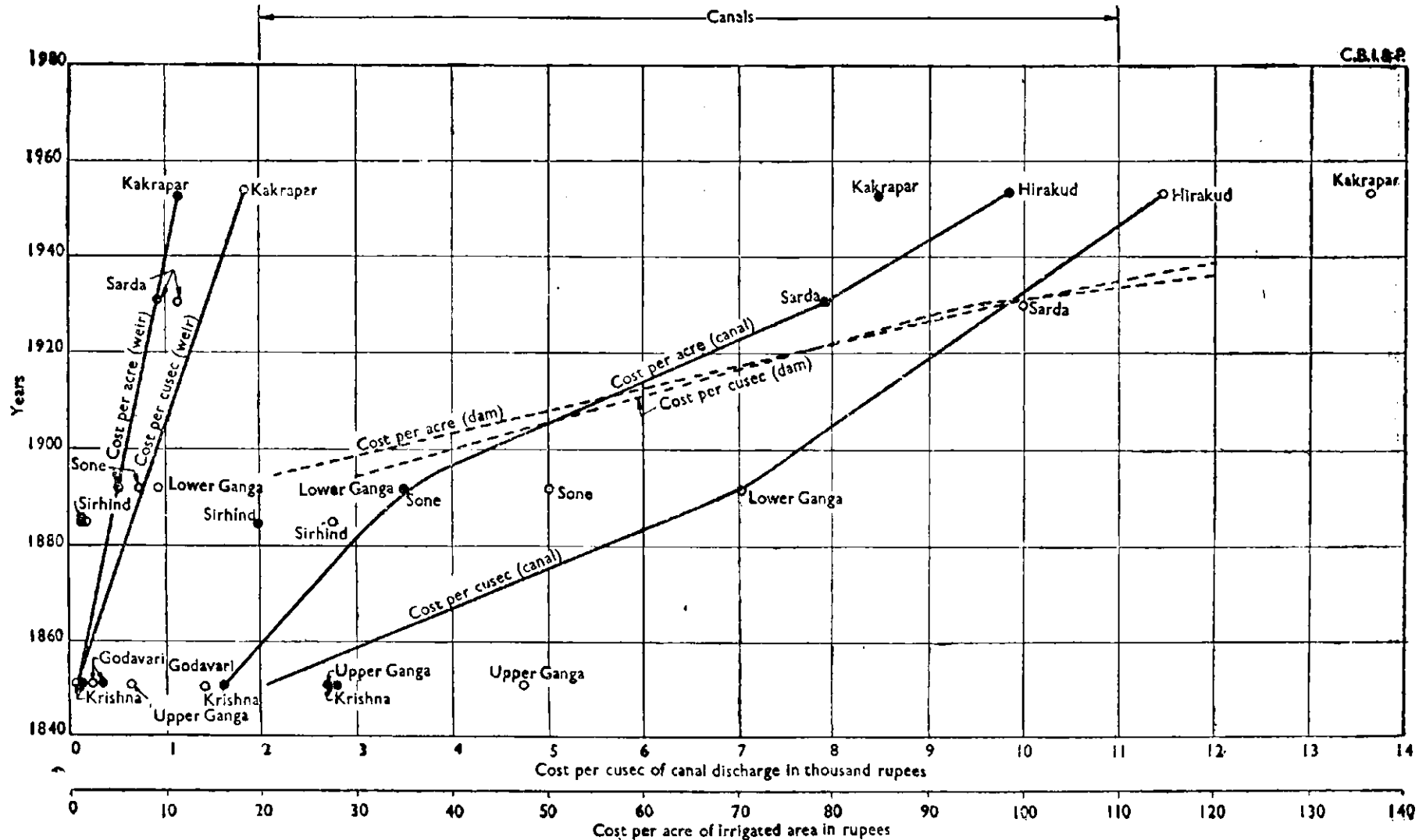


Figure 2: Costs of Canals and Head works per cusec and per acre

length of the structure would have made a masonry dam prohibitive but by constructing an earth dam, Godavari Project at Gangapur became possible. Any number of similar instances can be given. The location of spillway on the side and placing earth dam in the river reach has been adopted at Maithon, Panchet Hill (D.V.C.), Kotah (Chambal) and Ukai (Bombay) Dams.

It is true that caution should be exercised in designing structures for which no precedent exists in the country or elsewhere. When deciding upon the type of a hydraulic structure on permeable foundations at Imperial Dam, the American engineers hesitated to adopt the extensively used and reputed type of Indian weir. The report says "As for the Indian weirs, although important dams of this type are in existence which have functioned properly over long periods of time, conditions at the Imperial site would require the raising of the low water surface to a height approximately one and one half times as great and the dissipation of an amount of energy per linear foot at least four times as great, as ever previously accomplished with this type of dam. In view of the long step in advance of any existing precedent that its adoption would involve, and the availability at lower cost of other types of dam susceptible of more accurate scientific analysis, it was deemed inadvisable to use the Indian type of weir for this site." The Imperial Dam is an overflow structure in which the maximum water level in front is plus 191 and the minimum tail water level is minus 168. For control of Kosi flood, a structure on permeable foundations with a differential head of 55 feet is designed at Belka site. The caution sounded by the American engineers at Imperial Dam is unfortunately forgotten in the case of Indian structure. Thus at Bhakra it was proposed to instal huge hydro-electric plant inside the body of a big dam. Provision of gates to operate under a head of 365 feet, as against the maximum head of 232 feet at Shasta to which they have been built anywhere in the world, is another example of similar advice. Instead of installing the usual type of gates, Harza type of gate, never used before, has been proposed for DVC structures. It is most necessary in the present development of our country that great speed should be attained in the completion of the projects and to achieve that it will be necessary to avoid experiments with structures which have not been done anywhere else in the world. But distinction has to be made in the case of structures which have been built successfully elsewhere in the world. Earth dams have been built quite successfully for heights

up to 456 feet (Anderson Ranch) and a failure of an earth dam here or there as at Ahrura in Uttar Pradesh should not deter us from adopting the economic material of construction. It is possible that considerable savings can be effected in Koyna Dam (Bombay) if the structure is built of earth instead of in concrete. The maximum height of the dam is 260 feet above river bed and rapidly decreases towards the abutments and there would be no necessity to excavate 80 feet into rock structure to start the dam as it is proposed in the case of concrete dam. Replacement by earth dam at abutments of Pykara and Peechi dams has effected large reduction of the costs.

2.2 Selection of type

Almost all the masonry structures in India are gravity type. The large volumes of water in the rivers and absence of suitable sites in gorges make adoption of any other type such as Hollow, Buttress or Arch unsuitable in India. If it is possible to construct either an arch type or arch gravity type, instead of purely gravity type, it will no doubt reduce the amount of work to be done. The only alternative to gravity dam that may be possible at some of the sites would be the buttress type but unless the cost of reinforced concrete is brought down, it will not be economical to adopt the reinforced concrete structure.

But economy can be effected in the sections of the dam by careful design work. No single pattern should be allowed. Each site calls for a special type and the sections should be designed taking into account the foundation, rock conditions, the characteristics of the materials, etc.

2.3 Reduction of cement content

At present we are utilising more cement in dams than is necessary. The cement content should be fixed after conducting laboratory experiments with the available materials at site and in accordance with the strength required. It is wasteful to attain a strength of 4,000 lbs. per sq. inch when only 2,500 lbs. per sq. inch is required. Attempts are made successfully in U.S.A. to reduce the cement content of concrete. Thus at Bull Shoals only 280 lbs. of cement are used for a cyd. of concrete while usually 350 to 400 lbs. of cement are used in India. Puzzolanic admixtures like *surkhi*, fly ash, etc., would decrease the cost without affecting the strength characteristics.

Masonry dams with 1.5 mortar cost only Rs. 100 to 110 per 100 cft. while the corresponding rate of concrete is Rs. 150 to 200. Considerable savings could be effected by utilising a masonry dam wherever design features permit its utilisation. Even in the same dam, proportions are varied according to the height and location. In localities where lime is available at cheap prices and strength requirements not great, the structure can be built in lime *surkhi* mortar as at Krishnarajasagar or even lime sand mortar as in many of the Bombay dams. At Tungabhadra the non-spillway sections are built in lime *surkhi* sand mortars while the overflow sections are built in cement mortar. The possible economies that can be effected by the various proposals are summarised below :

<i>Proposal</i>	<i>Percentage savings in cost</i>
1. Masonry instead of concrete	33.3
2. Variation of mortar, strength 1 : 5 instead of 1 : 4	10
3. Admixture of a puzzolana like <i>surkhi</i>	8
4. Utilisation of lime <i>surkhi</i> mortar instead of cement <i>surkhi</i>	15

2.4 Economy in features

One of the important aspects that should receive attention at the hands of Indian engineers is the provision of spillway in dams. Flows in Indian rivers are both large, flashy and dependent on a number of meteorological factors prevailing at distant places. A correct estimation of flood discharge will lead to considerable economy in spillway length. The spill length should neither be large nor small. In Tungabhadra Dam, it is definitely very large and could have been economically cut down. Provision of a breaching section to take care of extraordinary floods will be a commendable measure to be thought of seriously.

A considerable advance in the art of design is noticeable in India. The old empirical methods are now replaced by scientific lines of approach. Relief of uplift pressures by grouting of foundations and provision of foundation galleries, *etc.* are now features which have resulted in considerable economy and increased factor of safety. By incorporating the latest knowledge in the subject it has become

possible to design the gates to operate under considerable heads without developing cavitation and vibration troubles.

The seepage losses in canals is generally great and is taken as 10 to 30 per cent in different projects. The water which is obtained after considerable trouble and expenditure, specially in the case of storage projects, should not be thus lost. It is most desirable to line the canals and avoid the loss of water. There are different types of lining being used in the country but they are essentially on an experimental stage. Development of a reliable cheap type of lining will minimise the irrigation costs.

2.5 Allowable stresses

At the site of dams, if careful controlled work is assured, it will be possible to raise the allowable stress in concrete from 750 lbs. per sq inch to 1,000 lbs. per sq. inch as is done now in United Kingdom. Similarly raising the limit of 18,000 lbs. per sq. inch to 20,000 lbs. per sq. inch for steel will effect savings in the large amount of steel that is now buried round the galleries, penstocks and other openings in the dam. Thus the amount of reinforcing steel that will be utilised in Hirakud Dam is 12,500 tons and by raising the stress as indicated above, there can be reduction of 1,250 tons or 10 *lakhs* of rupees.

The strength characteristics of masonry are not known. Special testing experiment has to be developed to determine the strength of stone masonry with different mortars. If this is done, and if experiments show considerably higher strengths than are now associated with stone masonry, we can introduce stone masonry on a much larger scale affecting considerable economy in project costs. Care has to be exercised in any case to ensure sound field construction avoiding void spaces.

2.6 Well established Central Designs Office

The advantages of well prepared designs ahead of construction are now well established. The rapid progress of work at Lower Bhavani, Mallampuzha, Hirakud and Tungabhadra, etc., may be attributed to the complete preparation of designs ahead of active construction. It is noted that proper construction plant could not be ordered at some project sites due to non-availability of designs. Quotations were called for gates for a dam before and after the preparation of detailed designs. It was found that the amount of quoted price was reduced by half in the case of later quotation.

Considerable waste can be avoided by insisting on well planned designs before any work is started. Even now there are a number of projects under construction for which designs are in preliminary stages while really the detailed designs should have been in progress. A Central Designs Office properly staffed and catering to the entire needs of the country is a great factor in achieving considerable economy in the costs of projects.

3. CONTROL OF CONSTRUCTION COSTS

The unit rates obtained at different dam sites in India have been analysed by the Central Designs Organisation of C.W.P.C. and the study shows that the cost of masonry is practically the same at all the sites. Taking 1 : 5 cement mortar masonry, the lowest cost is observable in Malampuzha where it is Rs. 88 to Rs. 111 per 100 cft. at Mayurakshi. At most of the dam sites, it is generally between Rs. 100 to 110 per 100 cft. This uniformity indicates that people in this country are accustomed to stone masonry work and can work to accurate estimates.

The same cannot be said of concrete. The rates are considerably different at various sites. The rates are high at Konar, Tillaiya and Vaitarna being Rs. 243, 233 and 218 per 100 cft. respectively. It is, however, to be remembered that the rates at Konar are inclusive of incidental expenses like roads, camps, *etc.* and the rate at Vaitarna includes cooling of the concrete. Even so the rates must be considered high. The rate at Hirakud is Rs. 170 per 100 cft. and is working between Rs. 150 to Rs. 180 at other places. At Bhakra a rate of Rs. 100 per 100 cft. has been provided in the estimate. Favourable conditions for securing aggregate without crushing *etc.* are said to be responsible for this low rate. This great variation in the rates for concrete shows that constructors in the country have not yet sufficiently become accustomed to this material and many corners have to be rounded off before the rate becomes finally stabilised.

The earthwork rates done by manual labour were practically the same throughout India being about Rs. 7 per 1,000 cft. for embankments, with lead up to 150 feet. and lift of 10 to 15 feet. This rate has now increased to nearly Rs. 21 or three times. In the recent times, construction of earth dam has necessitated the use of machinery due to long leads to secure proper type of material. The rate of earthwork as done by machinery varies very widely, the

reported rates being under Rs. 50 at Lower Bhavani to Rs. 72 for 1,000 cft. at Gangapur. A careful analysis of items such as depreciation, provision for major repairs, etc., shows that the difference is mainly due to the ownership costs which form 50 to 60 per cent of the total earthwork rate.

The present conditions indicate that we have to get more experience of earth machinery before we can confidently stabilise the rate. No undue haste however should be shown to cut down the rates without proved analysis as in that case we get into the danger of underestimating. By constantly keeping watch over rates it will be possible to fix control, or ceiling rates for important items of work and ensure economic control of project costs.

4. ECONOMIC PHASING OF PROJECTS

The full benefits of a project will take time to be realised. Each project authority has assumed their own accelerated programmes for calculating the returns. It will be necessary to have a realistic picture after a thorough investigation into the period of development in different parts of India. It is amazing to see how even in most needed areas, full development has not occurred. Thus the Cauvery Mettur Project was intended to irrigate 3.9 lakhs of acres while nearly 20 years after completion, the irrigated area is a little over two lakhs. It is necessary to formulate in order to select the most desirable projects, a standardised procedure for calculating returns. Elimination of probabilities of false economy is a major step in the reduction of any overall plan cost.

Completion of a project in all respects at one stage will prove neither economical nor useful specially when dealing with storage projects.

According to the requirements of irrigation, the dam may be built in stages, ensuring that foundation is laid for ultimate height. This will involve less work and less machinery. As against this, it will be stated that it will work cheaper to do the entire work in one stage. This can be proved to be incorrect most of the times specially if interest and true development are taken into consideration. Hyderabad engineers have drawn admirable plans for stage construction of Nandikonda Dam, across Krishna. Adding additional masonry to heighten the dams afterwards is now a proved art and a number of examples have been given by the author in his paper

'Strengthening of Masonry Dams'. Marshal Ford (Mansfield) O' Shaughnessy (Hetch Hetchy), Ross, Cascade, Rock Island (Colorado River) are examples of some of the dams in U.S.A. which have been subsequently raised after first construction. The biggest dam, the Grand Coulee, was programmed to be built in two stages. Asswan dam (Egypt) has been raised twice and a third heightening is under construction.

Similarly if a project consists of a number of dams as in D.V.C., it is definitely desirable and economical to construct the dams in subsequent stages. Likewise the canal system need not be built all at once. The programme of construction on canals should closely follow the pattern of development. This kind of scientific phasing will ensure economic utilisation of the capital and equitable distribution of projects all over India.

5. COMMUNITY EFFORT

The greatest factor to secure economy will be the willing partnership of the people located in the vicinity of the project. The human energy has produced almost unimaginable massive feats like constructing pyramids in Egypt. It is stated that in the development of Huai Valley in China, manual labour is fully mobilised. But the latent energy requires great effort and great skill to start. Co-operative societies and local banks can be of considerable assistance in channelling this energy. It was a well established practice in ancient times to assign the engineers and labour engaged on a project, some lands under the tanks. There is no reason why this practice should not be revived. While a portion of wages and salaries may be paid as the work proceeds, a portion can be deferred and the persons or their dependents be given the payments after the project begins to function. The land to be acquired for a project may be compensated in kind by the entire community in the project area. The land acquisition costs in the case of Mettur dam were only 8 per cent. of the cost of the dam while in Hirakud it is 25 per cent. This abnormal increase in the land costs is definitely not a charge on the entire land and the people of the valley must bear the responsibility. A scientific scheme for utilising the community effort in projects is not yet available but even partial success in that respect will ensure great economies in the projects.

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CENTRAL BOARD OF IRRIGATION AND POWER

SYMPOSIUM

NEW DELHI, 1953

PAPER XV

**Determination of Costs and Benefits of Power
in River Valley Projects**

by

S. Swayambu,

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SYNOPSIS

In view of the multiple benefits for which the River Valley Projects are being planned, the question of an equitable allocation of costs has become important. The main objective in doing this is to ensure that each aspect of the project conducts its operations on strictly commercial lines and the benefits derived conform to accepted financial standards of productivity. Furthermore, a correct assessment of the benefits realized is necessary to justify that the investment of large public funds in such projects has been really beneficial. By and large, the River Valley Projects in India provide for irrigation, flood control and power. The benefits from irrigation and power are directly assessable in terms of the monetary worth by direct levy of rates. The benefits of flood control are not easily assessed but can only be realized by indirect results of the well being of the community due to avoidance of damage and destruction to crops and property. The assessment of the power benefit derived from a multi-purpose project and the most satisfactory method of allocating its cost are dealt with in this paper.

BASIS FOR POWER RATES

In a small supply system or in a private undertaking, rates are generally fixed on the basis of meeting all expenses plus a "fair

return" on the "capital base." In the case of State undertakings operating large grid systems, there appears to be strong justification that the cost has to be renounced as a basis for rate making. The following are some of the more important reasons :—

- (1) The State has far-reaching responsibilities in regard to the healthy growth of industry and to the development of rural electrification with a view to spreading the benefits to as large a section of the community as possible.
- (2) The various industries will have to be catered at rate levels which are "acceptable" to them in line with the competitive power market and alternative means of generation.
- (3) The rural extensions call for considerable capital outlay but are not productive of good financial returns; at the same time, the rates will have to be fixed at reasonable levels which the market can bear.
- (4) The disposal of large blocks of power generated at sites, often located remote from load centres, call for considerable flexibility in power sales policy and this will not be possible if the rates are rigidly tied up with a capital cost base.

A satisfactory basis, therefore, will be to determine the tariffs for a grid system on a knowledge of :

- (i) the comparative rate levels in neighbouring systems ,
- (ii) alternative means of generation (say, from a modern thermal station of comparable size),
- (iii) the element of power charge in the economics of the large industries which would provide the market for power, and
- (iv) the promotional feature essential for the sale of power in the area of supply.

ASSESSMENT OF POWER BENEFIT

From the foregoing, it follows that the benefits derived from the power produced from a River Valley Project can be assessed directly from its "marketable worth" in the area and it does *not follow* the capital cost. This capital cost is made up of (i) the "direct expenditure for providing the power station, transmission and distribution lines and (ii) a part of the cost of the major civil works (such as the dam) which are common to power, irrigation, flood control, etc. If from the revenue realized from the sale of power, the power system operation expenses and the interest and depreciation charges on the

"direct" capital outlay are deducted, the surplus would represent the benefits of the "common works" to power. If this surplus cumulated over a period of say ten years and expressed in terms of the power actually generated over the same period, it would give us a rate per kW. per year for the facility of providing "falling water" for energy generation. This rate would reflect the ability of the power system to pay its way having regard to the various inherent advantages and disadvantages in which it is placed. This payment for "falling water" would be met from the revenues of each year on the basis of the kilowatts actually generated and would, therefore, bring in increased income to the common works with the growth of power sales in course of years, thereby making fuller use of the power potential of the project.

MERITS OF THIS METHOD

Unlike the various other theories of allocation, the above method is based on the true worth of the benefit. If a good power market exists nearby and if the public power rate policy so justifies, there is no reason why substantially large power revenues cannot be realized, which may even pay for the entire cost of civil works. There is no question of limiting the return, on the basis of any hypothetical cost allocation, at say 4 per cent or 5 per cent. Alternatively, if the power market is far away and has poor potentialities, the contribution from power would necessarily be small and there is no point in overburdening the power operations with heavy capital apportionment. The financial results of the Bhakra-Nangal and the Hirakud projects have been examined in the Central Water and Power Commission (Power Wing) in connection with the framing of power tariffs and the following facts will be interest in this context.

Bhakra-Nangal

Due to the incidence of high 'direct' costs on generation, transmission and distribution works, it was found that the project would only yield a return of about 3% in the 10th year and about 4% in the 20th year of working, despite the rates being fixed at fairly high levels, partly justified by the high cost of thermal power generation in the Punjab, which is far away from coal fields. The Bhakra Control Board had fixed the following rates of payment by the Electricity Branch towards the cost of common civil works :-

Nungal Power House

For the first 5 year - at Rs. 5/- /kW/ year of max. demand.

For the next 5 years - at Rs. 7/8 -do-

For the next 5 years - at Rs. 10/- -do-

Rates to be reviewed thereafter.

Bhakra Power Houses

For the first 10 years -at Rs. 5/- /kW/ year of max. demand,

Rates to be reviewed thereafter.

The above rates, prima facie, would appear low but the results of power operations would not justify even this payment, for causes beyond their control. The waters of the Bhakra Dam has a power potential of over 1100 MW, available as soon as the dam is completed say, by 1960; but the power load of the system is expected to be 125 MW only in 1963-64 (10th year of working) and about 190 MW in 1973-74 (20th year of working). If only there is a ready demand for even half the power potential of the project, the power revenues alone could pay for the entire cost of the dam. The absence of the power market and the large time lag in the utilization of power potentialities of certain River Valley Projects, rules out the ability of the concerned power systems to share the heavy capital allocations of common civil works.

Hirakud Project

Unlike the Punjab, coal is locally available in Orissa and the comparatively low alternative cost of thermal generation is a point to reckon with. Fortunately, a reasonably good power demand is anticipated from certain large industries, such as aluminium and ferro-manganese. Preliminary calculations indicate that based on 'rational' tariff levels, the power revenues would be in a position to permit of a payment of about Rs. 25/- per kW per year towards the "Common" Civil Works. On this basis, the scheme is expected to reach self-sufficiency by about the tenth year of working when it will be able to sell the entire firm power of 123 MW that can be generated at the main dam power house. This rate of Rs. 25/- per kW. per year would bring forth a payment of about Rs. 25 lakhs and Rs. 30 lakhs in the sixth and tenth year of working, which if capitalized at 4.25 per cent. would amount to Rs. 6 crores and Rs. 7 crores respectively. In this connection, it will be of interest to know the suggestions made by the Majumdar Committee on P. 17 of their printed

report of March 1952. While admitting that the subject is a controversial one, they have attempted to make the cost allocation by (i) the "alternative justifiable cost basis" and (ii) the "use theory" based on respective storages utilized. The results have worked out to Rs. 12.0 crores by the first method and Rs. 15.45 crores by the second method, allocable to power. However, the Committee have finally recommended an allocation of Rs. 7.725 crores only to power for the reason that all the water, after power generation, would be used for delta irrigation and also because irrigation would benefit by "betterment levy". It is to be noted that in either method, a great deal of arbitrary assumptions have been made, which essentially have little bearing on the "marketable worth" of the power produced.

LOAD AND REVENUE ESTIMATES

The above method of annual payment by power for the common civil works underlines the need for a detailed study of the power market and the probable revenues realizable, before deciding upon the scope of the power portion of any River Valley Project. In the preliminary project reports, assumptions have often been made that the entire energy equivalent of the water potential including secondary power of any kind, is saleable. Apparently low but arbitrary rates for the energy at the busbars are assumed as "safe" figures; but detailed load and revenue studies would indicate that such assumptions are entirely erroneous. In fact, even free power at certain locations and under certain conditions will become prohibitive in its end-cost if the load densities and the cost of transmission and distribution are unfavourable. The following preliminary cost figures of a large multi-purpose system now under construction would give the order of cost incurred in transmission and distribution as compared with that of generation :

Average cost during the 5th year of operation	Per kW. per year	Per kWh (at respective group load factors)
At the power station	Rs. 124/-	Rs. 0.33
At the grid sub-stations	268/-	0.74
At the consumer's premises in distribution centres	475/-	1.29

CONCLUSIONS

1. In view of the commercial nature of power supply operations, the benefit from power should be assessed on its "marketable worth" and should be charged for on annual kW. rate towards the common civil works. This charge should be fixed on the basis of the anticipated revenues over a period of say 10 years over which the power system could become self-supporting.

2. No capital allocation should be made on common civil works based on arbitrary assumptions and on methods of doubtful value as the public power rate policy should not be encumbered with large capital incidence which it cannot put to reasonable commercial advantage.

3. A detailed load and revenue study should be made at the investigation stage of any River Valley Project before deciding upon the scope of its power development programme.

CENTRAL BOARD OF IRRIGATION AND POWER

SYMPOSIUM

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PAPER XVI

Criteria for Fixing Project Priorities

by

A. N. Thompson.

This paper is prepared with the idea of bringing to you some of my personal experience and association with the subject Criteria for Fixing Project Priorities. However, it is primarily desired to acquaint you with an intensive study of this perplexing problem which was conducted by the Federal Inter Agency River Basin Committee in the U.S. These latest findings can be obtained by you here today but only a limited number of copies are available.

I have felt that in India there is an increasing interest in overall river basin planning which will lead more to the need of definite policy formulation to weight the relative merits of one project with another. If this is true, all persons and public organisations concerned with project sanction must be aware of the local, regional and national need for good and services to be produced as well as the intended costs required to secure them.

Perhaps you know that for many years my work with the Bureau of Reclamation had to do with planning of single purpose and multiple purpose projects many of which have since been constructed or are now under construction. During these 16 years the approach to determine project feasibility gradually moved from the simple method of project selection by determining earning on investment and repayment willingness of water users, to the more public minded view-point of evaluation project costs and benefits somewhat as presented in the Federal Inter Agency study.

There are so many factors and events which can be taken into consideration in making the cost benefit findings that one group or

agency of government, general speaking, is not equipped with all of the skills needed to pursue the subject to conclusion. Selection of long range price levels for goods and services to be produced by the project, value of labour, materials, supplies, taxes, and interest rates, and other economic variables, all a part of benefit and cost analyses, are principally the function of economists. Increased crop production, farm income and farm costs are studies to be made by agriculturists and economists. Expert advice on recreational facilities, fish and wildlife propagation and afforestation, soil and moisture conservation is required. Engineers have the prime responsibility of project formulation and administration. Co-ordination of effort is needed between qualified groups to bring about a final project or basin report presented with reliance, and a clear view of the need for the project or projects, and at the same time reflect the logical sequence of undertaking.

To better understand the following discussion of benefit and cost determination it is well to establish basic definitions for each.

Project costs are the value of the goods and services such as land, labour, and materials used for the establishment, maintenance and operation of the project including allowances for induced adverse effects whether these are compensated for or not.

As an example, the project costs for irrigation would be the annual costs over the life span of the project of making water available to the farmer.

Associated Costs are the value of the goods and services needed over and above those included in *Project Costs* to make the immediate products or services of the project available for use or sale. For example, the farmer's costs of producing the irrigated crop other than any charge for water would be associated costs.

Primary Benefits are the value of the immediate products of services resulting from the measures for which the project costs and associated costs were incurred. For example, the market value to the farmer for products produced are primary benefits. The net primary benefit is the foregoing less the associated costs.

Secondary Costs are the value of any goods and services (other than those of project and associated costs) which are used as a result

of the project. For example, the transporting of wheat from farm to market, storage costs, milling and bakery costs would be secondary costs.

• Secondary Benefits are the values added over and above the value of the immediate raw products or services of the project as a result of activities stemming from or induced by the project. For example, the value of the bread over and above the value of its wheat content would be a secondary benefit.

It is important to keep in mind that there are many categories of benefits which would form the basis for project justification. But whatever they are a true picture of intended project accomplishment will be had if all project costs to produce these benefits are evaluated and accounted for. The major portion of this paper will have to do with only primary costs, associated costs, and primary benefits since these are the major values in project feasibility determination. The evaluation of costs and benefit should be on an annual basis, expressed in the appropriate monetary unit of the country.

It is fitting here to quote briefly an example for development of the cost and benefits of a typical multiple purpose project.

A cursory review of the project capabilities might appear to include irrigation, power generation and transmission, flood control, recreation, and fish and wildlife propagation. Next, the economic studies should be undertaken with the physical surveys which will show the demand for the project services and products. These studies are time consuming. My experience has been that we engineers too often find ourselves with a great mass of survey data but very little economic data to pass final judgement for selection of project plans at the appropriate time. The net effect is a lack of proper guidance in designing the project to meet the intended needs.

For the determination of irrigation benefits wheat, sugarcane, rice and dairy products would be important crops. Sustained increased production and crop value, such as the price received by the farmer, should be forecast over the intended life period of the project. The primary benefit due to irrigation is the market price of all crops to the farmer less the associated costs in producing those crops which include the increased operating costs of production, interest on

increased farm investment, cost of land preparation, maintenance, depreciation on equipment, property taxes, family living expenses and other associated costs. However, any adverse effects due to increased crop production should be evaluated to scale down the primary benefit.

The benefit from the generation and transmission of electrical energy can be taken as the fair market value of that energy based on local and regional values. The primary benefit would be equal to the above less the associated costs to deliver the power including costs of facilities plus their annual operation and maintenance costs, and cost of replacement not a part of project costs. There may be special and unique load requirements, such as those incurred by new industry which could only be undertaken with the low cost power to be produced. In such cases, the benefit of power would be the saving in cost of power over the cost by the least alternative means.

River basin projects which include measures for flood control provide benefits in two general ways—(1) *by preventing the loss of goods or services which would otherwise occur from floods,* (2) *by making possible increased production of goods and services through more intensive use of real property by removal or reduction of the flood hazard.*

Primary benefits for (1) above may be summed up as the difference between the evaluated damage that is expected to occur over the life of the project without project construction and residual damage expected to occur with project construction. The annual value of these removed damages should include the cost of replacing, repairing or rehabilitating the affected property. Saving in loss of life under each condition may be evaluated and included. In addition to physical damage, primary benefits include the reduction in cost for the evacuation of flood victims, the cost for relief and for rehabilitation, the direct loss through disruption of business and the increase in cost of doing business due to floods. Prevention of losses to agriculture pursuits may be summed up as the change in net income to farmers with and without flood control over the expected life of the project.

With respect to (2) above the primary benefit should be measured as the difference in the productive capacity of the effected property under conditions expected with and without flood control.

The preferred method of measuring this benefit in productive capacity is by direct estimate over the life of the project of the difference in net incomes. This will account for the associated costs in realizing the benefits. Where a project produced both prevention of flood damage and increased productivity care must be taken to avoid duplication of benefits. For instance, direct loss of crops would properly fall within the category of (1) above. It can readily be seen that increased productivity might be analysed to include the total crop value thus duplicating that loss already accounted for.

I am including the discussion of recreation, fish and wildlife benefits because it appears from reading the India Press that increased interest is being given to their improvement, propagation and preservation. These values are being evaluated in America as a public benefit and sometimes astounding results are secured in view of the monetary value placed upon recreation, fish and wildlife from a sporting and commercial standpoint.

Certain multiple purpose projects may include specific measures designed for the purpose of protecting or enhancing recreation, fish and wildlife resources. Other projects, without such specific measures, may have incidental effects of importance on these resources. In either case, there may be beneficial or adverse effects which should be taken into account.

Primary benefits to commercial fishing and trapping consist of the value of an increase in the volume of the products expected to be marketed. This increase is measured by comparing volumes of future production with and without the project in operation. The value of the increased production should be obtained by applying expected market prices for these products. Associated costs to be deducted from benefits are all costs incurred by fishermen and trappers in harvesting and marketing these products.

Primary benefits from hunting, fishing, and other forms of outdoor recreation are the value of any increase in the amount of recreational use expected as a result of the project. Such an increase may be expressed in terms of recreational days or in terms of sport, that is, fish and game harvests.

Under one procedure which has been used to estimate such values, the value of a recreational benefit to an individual is assumed to be equal to the sum of expenditures by that person for

such items as gasoline, food, lodging, and sporting equipment to use those recreational features afforded by a project. This method, however, provides a measure of gross rather than net values and from the project standpoint does not measure benefits creditable to the project.

By another currently used method, recreational benefits are assumed to be equal to the cost of installing, operating and maintaining these facilities, plus an equal amount considered to be the value of the benefits attributed to the recreational use of project facilities provided for purposes other than recreation. This method does not provide an objective and independent criterion for determining recreational benefits creditable to the project.

To provide an approach consistent with the general measurement procedure outlined in this statement, it is suggested that the benefits of recreational use be based on informed estimates of the annual value of these recreational facilities to prospective users. In estimating these tangible values, consideration should be given to all pertinent factors, including the charges which the person who may be expected to use the facilities would be willing to pay, and any actual charges being paid by users for comparable facilities in other areas. All applicable associated costs must be deducted from such values to provide primary benefits attributed to the project.

Frequently a multiple purpose project may damage or destroy existing recreational opportunities or the fish and wildlife values without providing comparable substitutes for them. In addition, there may be other adverse effects which are important from a resource conservation standpoint and are not fully measurable under the procedure described above. Examples of such intangible effects would be the elimination of the last sambur herd in a particular State, the destruction of an unusually scenic area, such as a portion of a national or other public park; or the destruction of a historically important site. Conservationists, generally, prefer that the project includes measures to prevent such losses rather than requiring that other project benefits be sufficient to offset the value of such losses. In many cases, these losses can be prevented in a manner compatible with the primary purposes of the project. The costs of such prevention should be included in project estimates costs.

Project Costs and Associated Costs—present no peculiar problems since they are based, for the most part, upon known

quantity factors. The selection of proper price levels for labour, supplies and materials over the period of construction can be made from a study of prices and production and construction trends. Interest and discount rates used to develop annual cost are generally the market value or are established by policy or by law for project planning.

While all problems associated with the determination of project costs should be treated with judgement and care, too much stress cannot be placed on the need for adequate physical data concerning elements that determine the location, type and scope of project features. In essence, this refers to the authenticity of all surveys and explorations which have a direct bearing on the determination of project cost. Too often data are assumed in the rush for completing a project or basin planning report.

The foregoing statements of costs and benefits are necessarily limited for presentation before this group. These should be considered to need expansion in actual practice of planning for resource development both as to objective needs and details of analysis.

It is imperative that the viewpoint from which the effects of a project are evaluated must be in the public interest and must be comprehensive. A summation of project effects whether beneficial or adverse to whom ever they may accrue, in terms of market value would approach full coverage from a public viewpoint if allowance could be made in the summation for all offsetting factors. Obviously there is a practical limit to the extent which benefit analysis is justified in view of data available and existing conditions. Only those benefits and costs which can be reliably estimated in terms of the local currency should generally be used in the determination of project feasibility.

Those beneficial and adverse effects of project development which cannot be reliably evaluated in currency terms should be considered and described in such a way that their importance on project formulation is clearly shown. The scenic beauty of a valley may be impaired by the construction of a reservoir having a wide fluctuation in water surface level resulting in an unsightly condition after construction ; or a shrine may be obliterated in project development. These are examples of the effects of project development.

The agenda for this Conference raised the point of "Criteria or Fixing Project Priorities". From the standpoint of the general needs.

of India there appears to be no better way of expression than through the benefit cost analysis since the primary purpose of any public undertaking should be the most effective use of economic resources. The most effective use of these resources is made if they are utilized in such a way that the amount which benefits exceed cost is a maximum as against a maximum benefit cost ratio.

If a graph is prepared showing the direct relationship between benefits and cost it will be found to resemble an efficiency curve for an operating machine which in essence it really is. If economic studies have been properly carried out for various projects, scope and capability can readily be determined by consideration of the following :

- (1) The point where the ratio of benefits to costs is unity,
- (2) The point of maximum excess of benefits over costs,
- (3) The point of maximum ratio of benefits to costs.

First of all, it should be an accepted principle that no project will be undertaken whose benefit to cost ratio is below unity unless there is dire need from the standpoint of relieving critical conditions of unemployment, famine, etc. But, even under such conditions, it must be assumed that project benefits equal or exceed the cost due to the relief benefits to be bestowed at least during the construction period.

If the scale of development was established at point 3, the full economic possibilities of the plan would not be utilized since there would remain additional increments of development for which additional benefits exceeds additional costs to be incurred. This holds true until the point of maximum excess of benefits over cost is reached (point 2) beyond which incremented costs exceed increments of benefits.

Throughout this range of selectivity the planner must make his recommendation for the plan of development in view of the national, regional, and local needs and the financial position of government, state, and local entities. In recommending the project or any separable part it should be more economical than any other actual or potential means available for accomplishing the specific purpose.

Through analysis of benefits and costs along the lines presented the needs of the nation and of the region will be met only when the benefit costs ratio is greater than unity and conforms with the criteria

noted. Where two or more plans are of equal merit, choice may be made by consideration of such factors as financial position and local needs. This may lead to stage development of one or more of the plans. The effects of stage development may accelerate the need for full development as the result of new industry, migration of population into the newly developed area resulting in increased business and raising the general living standards of the areas involved.

The local need is met if the foregoing criteria are satisfied and the direct beneficiaries may be expected to pay no more for retiring construction costs and meeting annual operation and maintenance charges than they are able and willing to do. No project is in demand if the goods and services produced will not bring a fair return on investment. If the project reimbursable costs exceed the ability and willingness to pay these, the excess must be non-reimbursable or otherwise accounted for, say, from power revenues or other means.

It is my opinion in meeting famine and other dire needs that only those economical separable segments of projects be constructed which can be completed in time to meet the emergency. Care should be taken, however, in selecting these developments that once the emergency has been met the constructed plan will remain an economical and beneficial unit within the total scheme of development.

In conclusion, it is well to remember that any project developed for providing goods and services for which there is no demand has no economic value.

CENTRAL BOARD OF IRRIGATION AND POWER
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PAPER XVII

**A Note on some Aspects of Measurement of Benefits
and Costs as outlined by Dr. J. Thompson Lund**

by

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The "Benefits" and "Costs" when used as indices for assessing the justification of projects have to be measured on a sound and comparable basis for which price level, interest rates, risk allowances and period of analysis which also includes consideration of amortization of investments and salvage values, form the various standards of measurement. Further, treatment of tangibles and intangibles, adjustments for levels of economic activities, costs of public facilities effected, acquisition and improvement of land, taxes, displaced facilities and extension of useful life, constitute the particular problems of measurement.

Since benefits and costs of projects are spread over a period of time in diverse forms, it is necessary to provide a common basis of measurement to facilitate a comparative study. For this purpose the monetary unit has a wide approval as a common basis.

The use of the monetary unit for measuring the benefits and costs of a project in common terms and translating them to a basis on which their comparison is possible entails the selection of three important standards, *viz.* (1) the prices by which the physical effects of projects are converted to monetary values; (2) the interest and discount rates by which these physical effects are related to a common time and risk basis; and (3) the selection of a period of analysis for any project.

PRICE LEVELS

It will be ideal, if the standards of measurement stated above should reflect the interests of the society as a whole. As such these standards should concern themselves with "real" costs and benefits. But since assessment of real costs is difficult, real cost estimates would be merely theoretical in character.

The most satisfactory approach would be to use prices reasonably expected to prevail at that time of the accrual of benefits and the incurring of costs. Practically this would mean the application of prices current at the time of the formulation of the project *i.e.*, estimates of investment-costs. Benefits to be obtained and other costs to be incurred later would be expressed in terms of price levels expected to occur at a future point of time. This approach is considered a satisfactory, working method in view of the following considerations :—

(i) By this a useful working method of determining repayment is established and (ii) this method of computation takes into account the price trends of the future and the changes in price relationships based on sound judgment and anticipation.

According to this method of evaluation of benefits and costs on the basis of *ex-ante* prices, costs and benefits may be classified as follows :—

INVESTMENT COSTS

These costs are usually incurred in the initial stages of construction. The initially investment-costs should usually be evaluated in terms of current prices.

OPERATION, MAINTENANCE AND REPLACEMENT COSTS

These costs occur at various times spread over the entire life-time of the project and all these items refer to *ex-ante* prices. The very nature of *ex-ante* prices calls for theoretical estimates. The most practical approach and procedure suggested is to estimate the average price level expected over the life of the projects based on the considerations of population growth, technological advance, changes in the consumption pattern, levels of employment, the state of foreign trade, possibility of substitute and alternate sources of supply and the monetary and fiscal policy. The calculations of

future trends in development and price levels involve mature judgment and discretion but we cannot escape this.

BENEFITS

It can be assumed that these would accrue throughout the life of the project at uniform or varying rates and also call for evaluation in terms of *ex-ante* prices.

In view of the fact that the soundness of analysis depends partly on the accuracy of the benefit and cost estimates it is of utmost importance that the estimates should intrinsically have a high degree of certainty of realisation and the expected average price levels forecast for the evaluation of these estimates should also be expected to prevail to a fair degree during the life-time of the project. These considerations show that we should prefer both estimates and price level forecasts to be made on a conservative basis.

INTEREST AND RISK ALLOWANCE

Interest and risk allowance are means for giving monetary expression to differences in "time" and "certainty" of occurrence of benefits and costs. Current interest and discount rates are indices of time and risk elements and the wide range of the rates indicates the risk involved on the types of loans or investments. Hence to the extent possible direct or specific allowance should be made for this. Since interest rates are a measure of the value attached to time differences, they provide a means for converting the estimates to a common time period. As the projects are financed by government agencies, and the charge is made for the use of money over a period of time--the entire economic life of the project--the interest should be charged at the rate for long-term government bonds. Interest may be reduced to an annual basis to facilitate the computation of annual costs and benefits.

Allowance for risk takes care of the hazards and uncertainties that may occur between investments and the accrual of benefits. There are two categories of risk: predictable and unpredictable. It is possible to earmark a reasonably certain amount of money to cover the losses of predictable risks and this should either be added to, or deducted from, the cost or benefit after the sum has been reduced to an annual basis.

On the other hand, there is no precise basis for calculating the value of unpredictable risks, the evaluation of which largely depends upon judgment. These risks include the probability of error in estimates of costs and benefits which may be due to one or all of the following: (1) fluctuations in the levels of economic activity (2) technological changes and (3) the unforeseeable developments adversely affecting the costs or value of services.

SELECTION OF PERIOD OF ANALYSIS

The economic life of every project is limited by a number of physical and economic forces and is determined by the point in time at which the effects of physical depreciation, obsolescence *etc.* make the cost of operating the project more than the additional benefits expected from its continuance. Consequently the economic life of any project is less than its physical life.

Even though the economic life establishes the upper limit of the period of analysis it is always advisable to take a period short of the economic life as it provides (a) an additional allowance for the risk factor and (b) a solution to some extent to the difficulties and uncertainties associated with the estimation of the value of remote effects. On the lines given above, generally a period of hundred years is considered to be the economic life of a project.

The remaining resources at the end of the period of analysis should be valued in terms of their junk-value or in terms of their opportunity-costs except in the case of land which may be assessed in terms of its intrinsic worth at that time which should not exceed the original value of the land minus the charges for any damage.

This determines the period and the amount of the net capital investment to be amortized which should be sufficient to cover all capital investment-costs in excess of salvage.

In conclusion one can say that the maximum period of analysis should be the economic life of the project or 100 years, whichever is the shorter. Even for projects involving basic structures of extended life, and, those having continuing replacement possibilities, it is recommended that a 100 year period of analysis be used as the upper limit on economic life, with allowances for salvages at the end based on non-project uses. The amortization charge should be sufficient to

cover the capital investment during the period of analysis, calculated on a sinking fund basis using the investment cost interest rates. Except in special cases, the basis for estimating benefits and costs should be under the assumption of maintaining the project at full operating capacity".¹

1. Formulation and Economic Appraisal of Development Projects, pp. 125, Vol. 1.

CENTRAL BOARD OF IRRIGATION AND POWER

SYMPOSIUM

NEW DELHI, 1953

DISCUSSIONS

Discussions

SHRI KANWAR SAIN said that this subject actually engaged his attention for the first time in 1939 when he was engaged on the Haveli Project. There was some criticism about the economy of the project and this led him to find ways and means of working out the economics of a project and the factors which go to make projects feasible. In this connection he said he had presented a paper on the "Economics and Finances of Irrigation Projects" to the Punjab Engineering Congress held in 1939. He had brought out that prior to 1854 all public works in India except railways were carried on by the Engineering Department of the Army. The expenditure incurred was treated as ordinary revenue and was charged to the revenue of the year. No capital or revenue accounts of the works were kept.

It was in 1866 that the Government of India pointed out what the Government desired was a permanent and persistent effort to carry out gradually large extension of irrigation works. They desired to raise loans to be devoted exclusively to this purpose, for they feared, that, unless the principle of the steady progress based on loans was definitely accepted, it would never be found financially convenient to carry on the projects from beginning to end with proper vigour. It was in 1866 that this policy was adopted and loans raised with the result that between 1867-1869 many schemes were proposed and undertaken. Large sum of £ 10 million was raised by loans and was spent on irrigation schemes. Soon after came depression in the money market in India. The returns were not nearly as large as were predicted. This led to the appointment of a Select Committee by the House of Commons in 1879. The Select Committee reporting to the House of Commons in 1897 said :—

"The financial result of works of irrigation are in the opinion of your Committee the best test of their utility. A rail road may

traverse between its termini. certain districts which it does not materially improve, yet the work may be on the whole beneficial to the country. Unless, however, an irrigation work benefits the immediate locality in which it is placed it can be of no use to outside districts."

As a result of the recommendations of the Select Committee a standard was fixed for judging the final productivity of the irrigation projects. It was decided that the results of irrigation works in India should be tested as below :—

- (i) By considering the capital cost of any work to be simply the sum actually spent on its construction.
- (ii) By debiting the revenue account yearly with :—
 - (a) The simple interest on the capital cost of the works at the commencement of the year.
 - (b) The working expenses of the year.
- (iii) By crediting the revenue account yearly with :—
 - (a) Direct receipts,
 - (b) Indirect receipts.

The difference between (ii) and (iii) for one year will show the profit and loss for that year. It was generally admitted at that time that irrigation works in India could not be expected to pay within 10 years of opening of the Canal for irrigation and this was, therefore, the period fixed for testing the financial results of any project. The sum at charge was found as the capital cost of construction plus the arrears of simple interest up to that year. This period of 10 years was then fixed as a standard before any project was passed. He said that this test had been applied since then almost rigorously. In deciding whether heavy expenditure on new projects should be incurred he said the Government must take the widest possible view. In considering the financial aspect of a new project the extra revenue which would accrue to the Provincial exchequer on the completion of that project could legitimately be treated as credit to the accounts of that project.

SHRI KANWAR SAIN said that in his paper he had produced a table which showed the direct percentage of receipts on the Punjab Canals which he had studied. The percentage varied from 3 to 47.

It had always been a vexed question whether income from the enhancement of land revenue and from sale proceeds of Crown waste lands was correctly creditable to the canal projects or not. In 1879, Sir George Campbell the Ex. Lt. Governor of Bengal in his evidence before the Select Committee of the Indian Public Works, contended that it would be impossible to express in figures the exact increase which might be due to canals as there might be many other causes operating at the same time. This view, however, was not shared by the House of Commons and Lord Hartington in his financial statement in the House of Commons on the 17th August, 1880, recognized the justice of crediting the amount on account of enhancement of land revenue to irrigation works. It was then conceded that revenue on account of the so called indirect receipts owed its very existence to the introduction of canal irrigation and was the direct offspring of the canals. This source of revenue was born with the canals and would disappear with the extinction of these canals if that deplorable event ever took place.

If the private companies had taken up these Projects, these indirect benefits would not have been taken into account. These indirect receipts could only be taken into account when these projects were undertaken by the Government.

In 1939 he had emphasised on three points in his paper. The first was that the rate of productivity which had been fixed at 6% was very high. For works sanctioned before 1st April 1919, the test of productivity was 4% for works sanctioned between 1st April 1919 and first August, 1921 it was 5% and for all works sanctioned after that date the test prescribed was 6%.

Although the rate of interest in the open market had fallen to 3 per cent the Punjab and the Madras Provinces had not till then lowered the test of productivity. It had also been suggested by financial experts that a small percentage should be added to cover the risk of having to pay a higher rate of conversion and the risks inherent in any estimate. As a result of this, it was latter decided that this rate of return should be reduced from 6% to 4% which was first adopted in Punjab and subsequently in other States.

SHRI KANWAR SAIN said that the second point which he had emphasised at that time was about the 10 year period by which time it had been expected that the irrigation projects would develop fully

and start paying returns. But now it was felt that the period of 20 years or 30 years might be the full period in which an irrigation scheme could develop.

Third point which he had emphasised was that even the receipts credited to canal projects did not represent the actual wealth created by the project. In Germany and France it had been estimated that on navigation canal schemes, 45 per cent and 47 per cent respectively of the capital cost was directly returned to the Government in the form of taxes, duties, etc. They estimated in Germany that 31 per cent of even the operation charges were likewise returned to Government. There could be no reason to doubt that vast revenues were derived by the Central and Provincial Governments in India as a result of development of irrigation besides the direct and indirect receipts.

It was for this reason that the Central Board of Irrigation and Power had recommended in a resolution as under :—

“That an economic survey should be carried out with a view to estimating the direct and indirect financial benefits accruing to the Central and Local Governments from irrigation projects. If it is ascertained that indirect revenue accruing to Central Government is appreciable the Government should see its way to contribute towards the cost of future irrigation projects in order to encourage Provincial Governments to extend irrigation facilities, which, without such a subsidy could not otherwise be undertaken.

The Board is also of the opinion that when irrigation projects benefit proprietary lands, and therefore, enhance their value, some means should be devised for recovering a portion of that enhancement for credit to the cost of the projects”.

A definite suggestion had been made by the Central Board of Irrigation in 1936 that a portion of the enhanced value of the land should be credited to the project. As a result thereof Thal increment tax bill was passed and it was said that a maximum of about Rs. 30/- per cent would be levied per acre as a part of the increment value of the land on that account. This was considered reasonable at that time.

Subsequently, two out of these three recommendations made by him in 1939 in his paper were almost accepted. The first was

that the test of productivity be definitely reduced from 6 per cent to 4 per cent. The second recommendation about full development period being extended from 10 to 30 years was also accepted in practice though not actually incorporated in the Accounts Code. It was decided that it was enough if a project paid in 30 years, and it should not be thrown out on that score. The third recommendation then made was with regard to indirect receipts besides land revenue and that the indirect receipts should also be credited to Irrigation Projects. That point still remained to be decided.

SHRI KANWAR SAIN said that difficulty had arisen in financing the various schemes and in his opinion there was a confusion between two schools of thought on this point.

It was true to say that man power and materials should be the only limiting factors, but should be clearly understood that whatever the system of finance, the country actually pays for all work at the time it was carried out, in that, it had to provide the food and clothing and other requirements of all those engaged on non-productive work and also for their dependents. No production was, or could be, borrowed from the future, even though works might be financed by "loans", they could be constructed only by the use of existing labour and existing materials. No increase in wages could increase the quality of goods available if the whole working population was employed. Shri Kanwar Sain said that this was the point which had already been emphasised by Shri V.T. Krishnamachari in his inaugural speech.

SHRI KANWAR SAIN said that if the object of post-war development was to raise the general standard of living of the whole community it was essential that men should be engaged on non-productive works only to the extent that they could not be employed on the production of consumer goods and services, or on development works which although temporarily unproductive would upon completion, result in continued production of new wealth.

SHRI KANWAR SAIN added that people were apt to urge an expenditure of *lakhs* or even *crores* of rupees in the interest of development of projects which appeared desirable; but which would give very low returns, because, they did not realize that the carrying out of such projects would deprive the community of equivalent

other works, which might be much more desirable in the interest of the country as a whole. The widest definition of a productive work was whether the net result of their construction would be a gain or a loss to the community as a whole.

He said that in his talk given to the Institution of Engineers, Punjab in 1946 he had quoted instances where an additional charge for bringing the project had been levied in project areas in other countries and as well as in this country. The great Aswan Dam which supplied water to the Nile Valley was financed by an increase of half a pound per acre in the land tax per acre over a very large area which received supplementary summer irrigation from the reservoir. Similarly in financing the Sydney Harbour Bridge scheme part of the cost was met by a betterment tax on land values so also on the Colombo Basin Project and Mysore and Thal Projects. It would be interesting to tell you that the United States appointed a Committee in 1946 called the "Federal Inter-agency River Basin Committee on Benefits and Costs" for the purpose of formulating mutually acceptable principles and procedures for determining benefits and cost for water resources projects. Determination of costs and benefits was a very complex problem because it was difficult to determine the actual cost. There were other factors which were not reflected in the project estimate. Similarly it was not so easy to estimate the benefit to the community or to the country at large. This subject had been under study for about 4 years with several engineering agencies in U.S.A. American Society of Civil Engineers had their own sub-Committees on the subject.

He said that the symposium was essentially on the subject of "Determination of Costs and Benefits of River Valley Projects", but he had also allowed papers which dealt with the ways how the cost could be reduced and how the benefits increased.

SHRI C.L. HANDA said that the General Reporter's task on the subject of "Determination of Costs and Benefits of River Valley Projects" was very difficult, as it would be seen from the very small statistics that he had collected and circulated amongst the members of the House. Thirty two contributors had taken pains to give their specific opinions on the 12 questions that he had framed after getting the papers about a week ago in order that the subject might be presented before such an unusual gathering which was presided over

by the leaders who are at the helm of affairs. It was desired by the President that during the short time available that the maximum exchange of views should take place on the subject. He was happy to say that Shri V.T. Krishnamachari more or less had provided excellent and very considered answers to nearly all the points, but it would still be appreciated and it would help the proceeding that would follow if he mentioned very briefly during a few minutes in respect of the various contributors and the aspects which they had dealt with in particular. Prominent amongst the various bodies and individuals who had contributed on the subject was the T.C.A. The T.C.A. had taken the trouble of indicating to us their point of view through Mr. Thompson as to how they viewed the direct and indirect benefits. They had given importance to every minor aspects, *i.e.*, fisheries and recreation facilities. It appeared that in that country a very great development had taken place and they had taken into account all the details. Mr. Rawhouser of the T.C.A. would give us the benefit of his views. Gokhale's Institute of Economics and Politics had contributed a paper and Mr. Champhekar would introduce this paper. CWPC through Dr. K.L. Rao had thrown light on the design aspect of the projects and had made suggestions how best economy could be brought about by the use of earth dams and also by co-ordinating the design considerations. Shri M.G. Hiranandani had presented a paper about the levy of taxes. The net benefits to the cultivators were many which did not appear at the surface. There were many direct and indirect benefits which Shri V.T. Krishnamachari had just stated, and which benefited the people in a long way.

Every region had contributed some papers giving their experience on their projects. Bhakra had given two papers, one by Shri C.L. Handa and other by Shri Kalha. Shri D.V. Joglekar had given 4 papers in which he had shown how research played its part in the construction and economy of different dams. From his own experience of Malikpur he could say that the research had been responsible for a large extent of economy and also in the adoption of improved design. Almost every big aspect of the Bhakra had been experimented upon on models and much useful results had been achieved and made use of in the project. The use of such things as *surkhi*, mortar, *etc.* had been brought on a scientific basis.

SHRI S.N. GUPTA had summarised the results of a half dozen model experiments in his paper.

Shri M.L. Mehta, the retired Reclamation expert of the Punjab had been kind enough to give us a negative but in fact a strongly positive note. He had brought out in his paper that the lands were likely to deteriorate in about 20 or 30 years time and the steps that should be taken to prevent this deterioration, and that these steps should be kept in view just from the very start of the project.

SHRI SWAYAMBO had pointed out what was the real work of the power that was going to be generated from Bhakra, Hirakud and other dams.

SHRI C. L. HANDA said that he had drawn attention in his paper to two or three main facts. The first was to shed some of our old mentality, and to modify ways and means that had been used in smaller projects in the last two or three decades as had been worthily pointed out by Shri V T. Krishnamachari. Secondly the rather optimistic beliefs had been believed a great deal in the execution of the Bhakra Nangal Project. Even the liberal estimates had to be revised. People generally asked why when the cost in the first instance was so much, why had it doubled or trebled. There were two ways of preparing the estimates; either to prepare them very loosely even in the first instance or revise them off and on as and when necessity arose. The revision of the estimates was in his opinion the lesser evil than preparing the estimate very loose. The third point he had mentioned in his paper was that insistence on uniformity of rates, should not be laid. Rates depended always on the local conditions and they were bound to vary not only State wise but even from project to project.

Often engineers were much criticised for getting foreign experts. It was high time that this false sense of prestige should be given up. In the projects of such magnitude as Bhakra even the slightest error meant a huge expense and on it depended its success or failure. Advice from experts on the subject should be freely sought. That would not necessarily mean that Indian Engineers should lose confidence in themselves. Engineers should always be alert but certainly they should not be prejudiced against getting advice where advice was really needed.

SHRI C.L. HANDA said that as regards training of engineers was concerned nobody could learn simply by observing but by doing the work himself. He said that Bhakra Project, was unique in its technical aspect. Six or seven years experience in the use of

machinery had shown that the best talent had been employed in the Bhakra Project. If Indian Engineers had more self-confidence and if the whole of the work was left to Indian Engineers, the results would be quite satisfactory—

SHRI G.L. NANDA at this stage added he would like to know the place which should be assigned to foreign experts. The trend of all the talk seemed to be that foreign experts should not have been placed in administrative charge and, that they should have been only in technical capacity.

SHRI C.L. HANDA said that all what he had said was in his personal capacity. He said that all executive responsibility particularly of the financial and administrative nature should be entirely left in the hands of Indian Engineers who had been responsible for dealing with such matters in many projects since long. Best technical advice might be obtained from the foreign experts. Greatest benefit could be derived from them if they were not saddled with ordinary executive details. The foreign experts should be allowed to devote their time to the greater intricate problems in which the Indian Engineers had much less Experience. There was no question of their prestige being hurt. Executive and administrative duties and also of working out estimates were sometimes entrusted to the foreign experts, which was wrong if their advice was obtained in the field in which they had experience, than best use of their services would be obtained. In this way Indian Engineers could learn a lot from the foreign experts.

SHRI G.L. NANDA said that that was correct, though it did not settle the point on which he had raised objection. There was some suspicion regarding the so called tight estimates that these were deliberate under estimates, in order to secure sanction for certain projects which otherwise might not have been secured.

CRITERIA FOR FIXING PRIORITIES

MR. THOMPSON said that in India there was an increasing interest in overall river basin planning for water resource development. Therefore, all persons and organizations concerned with project planning and project sanction must be made aware through properly developed reports, of the local, regional and national need or goods and services to be produced by the intended projects as

well as the costs of works and associated costs to produce the needed goods and services. Essentially, this meant that criteria be established for evaluating project feasibility and project priority.

There are many factors to be taken into consideration in establishing the needed criteria. Mr. Thompson referred to the application of the benefit cost analysis as being sound for determination of project feasibility and priority of development.

Attention was drawn to the Report of the Federal Inter Agency River Basin Committee on Proposed Practices for Economic Analysis of River Basin Projects, prepared by the Sub-Committee on Benefits and Costs in the United States, and dated May 1950. The Report presents a comprehensive discussion of benefit cost analysis and the role these determinations can play in the planning of water resource projects.

In river basin planning MR. THOMPSON stressed the importance of the determination of intended project benefits along with the determination of project plan, design and estimates of costs. This means that economic studies be kept abreast or even ahead of the studies of plans and designs. Project plans and designs are directly influenced by economic factors related to the need for project goods and services. Therefore, their early determination is paramount if a project or basin plan is not to be over designed or misguided.

In project planning two or more project plans or separable segments thereof may be of equal merits and, choice of one over the other can be made on the basis of current financial position and local needs without jeopardy to other projects or segments of the plan. Thus, stage development might be encouraged and the immediate effect could well accelerate the need for full project development, as a result of increased living standards of the population, increased business, and needs of established new industry.

MR. THOMPSON stated the needs of the local, the region and the nation could best be presented in their true light through the benefit-cost-analysis. These needs are met if the benefit cost ratio is greater than unity. In conclusion, he added it is well to remember that any project or separable segment thereof developed for providing goods and services for which there is no demand has no economic value.

Shri B. K. Kapur said that the criteria for justification of projects was different in different countries, in the east as well as in the west. As regards financing of projects, the entire cost of the project was borne by the Government in Burma and Thailand, but the income was obtained by acquiring the rice at controlled price and selling it at a higher price and the difference between these prices was tremendous. In Ceylon the Government, not only was bearing the cost of construction of projects but also the cost of development of land.

In Taiwan (Formosa), China 50 to 60 per cent of the cost of irrigation project was subsidised by the Government, the remaining being paid by the land-owners benefited. The government had special arrangements for co-operation with the public. Hydraulic associations were organized for each canal of which the members were the land-owners. These members elected their own chairman and a Board of Commissioners and this Board was subject to the approval of the Government. These associations were in entire charge of the operation and maintenance of the project including distribution of water, collection of water, fees, so that the public was very closely connected with the whole work. They were responsible even for the construction of projects commanding an area of upto about 50 acres or so. The economic feasibility of projects in many of these countries as mentioned before was not judged by the direct return. Both direct and indirect benefits were taken into account. As regards benefits from other aspects of water resource development, flood control made possible the development of additional land and prevented loss of existing land which would produce indirect benefits of the same nature as those from irrigation, and lower cost of power to consumers would leave them with increased purchasing power for other goods and services and thus indirectly benefit the supplier of such goods and services. Cheap power would also bring certain manufacturing enterprises. He suggested that comprehensive analysis to determine the total benefits, both direct and indirect, might be undertaken in India with a view to determine the extent and nature of indirect benefits resulting from water resource development. Some work on the effect of irrigation was done by Prof. Gadgil, at Poona but as far as he was aware the results though useful were not very conclusive. The Bureau of Flood Control was preparing a manual for planning multi-purpose river valley projects which included an important chapter on cost and benefit.

In mechanisation the primary benefits were received by the country from where machines were imported. In case of manual labour the primary benefits would go to the country where labour belonged. Regarding mechanisation of earth work; he had the opportunity of using machines for earth work construction about 25 years back and also recently in connection with the Nangal Hydel Channel. His experience was that the ultimate cost of operations was much more with machines than by manual labour due to numerous debits. In addition the quality of work was not so satisfactory. He was of the strong view that the possibility of operations by manual labour must be given consideration. It was always argued and this argument had been repeated in the papers before the House that the economy of mechanized construction should be judged on competitive rates. This was correct in so far as the present method of appraisal was concerned. He felt that this comparison should be made on the real economical cost, which in the case of unemployed labour was very little indeed comprising only of the extra food and clothing that the unemployed labour needed and the cost of its transport, the rest of the cost being only a transfer and not real cost. The economic benefits of a project would start from the day when surveys would be started and increased considerably when construction was taken in hand. The project employed labour that would otherwise be unemployed and might also result in the use of otherwise idle plant capacity in the country. In countries where unemployment compensation was paid, the advantageous effects of the use of labour for project could be approximated by estimating the amount of reduction of unemployment compensation, but some other methods had to be devised for countries where no unemployment compensation was paid. He said that as long as there was unemployed labour available, most earth work construction could be economically done by labour and must not be done by machines irrespective of the cost as long as the real cost was less. Machines were no doubt essential where it was physically impossible for human labour to do the work or where time was an important factor.

Sometime ago Mr. E.W. Lane of the U.S. Bureau of Reclamation submitted a memorandum to the Government of India on the need of a study of earth work construction methods. He suggested a special study of the application to the use of manual labour of the principles of time and motion study which had done so much to increase production in the construction and manufacturing industries

in the States. The Bureau of Flood Control had included this problem in its work programme for 1954 and 1955 and would start work on it soon after the approval of the programme by the Economic Commission for Asia and the Far East.

MR. RAWHOUSER said that stage construction of river valley development projects had been suggested as a means of spreading the available funds over a larger number of projects which would lead to greater ultimate benefit. While strongly in favour of stage construction, he pointed out some dangers that should be recognized in this scheme of development. One of the unfavourable factors was that the benefit-cost ratio for the first stage was usually lower than for subsequent stages so that a given sum spent on a large number of first stage might not show as high a return for the money as if spent on a few fully completed projects

One of the reasons for this disparity in the cost-benefit ratio of the stages was the tendency to overdesign the first stage, to think too definitely of the ultimate development, and incorporate features in the first stage that were unnecessary to that stage. Of course, work could not be postponed which, if carried out subsequently, would endanger the work that had previously been done. He suggested, therefore, that engineer should not design and install beyond the requirements of the stage to be constructed that we let our sons design the work we expect them to build. He added that they would be able to do it better than we can, for they would have the advantage of new procedures and new materials that were not available to us.

Another tendency was to build the first stage as an entering wedge to force the administration to produce more funds to finish the job. An instance was cited where a bond issued was passed to build a municipal subway. The 6 million dollars authorized were spent but the subway only half completed. A second bond issue was defeated at the polls. Later, after a change of administration, an engineering firm was engaged to appraise conditions. They recommended that part of the unfinished line be abandoned and estimated that to salvage the remainder and produce a serviceable system would require the expenditure of an additional 10 million dollars. The subway was never completed. The conclusion was drawn that each stage, including the first, must be economically feasible, otherwise the project was not amenable to stage construction.

SHRI S. A. GADKARY referring to the criterion for priorities said that the subject was really a vast one and covered a very wide field. Projects to be considered for priorities have to fulfil various requirements such as cost benefit ratio, completeness of investigations, suitability of location, urgency, etc. He said that while considering priorities, we should also have an objective and an aim in making our plan really a national one. In applying certain criteria, limitations involved such as in cost-benefit ratio should not be overlooked. The mentality of purely making money by investing money cannot always develop a young country. An undue importance to this aspect may not lead us to the fulfilment of our ideals and objectives. Mr. Gadkary stressed the importance of smaller projects spread over the entire length and breadth of the country as against few large projects concentrated in highly developed localities. The administration must create a feeling that the unemployment problem is also being solved. The medium and small sized projects should take a reasonably short time to complete. It would spread out employment and benefits over a very wide area. Our unemployment troubles are chronic and cannot be removed very lightly. In formulating our immediate objective we should keep our eyes to the ground under our feet instead of gazing at the stars. Therefore smaller projects should receive preference over very large projects which would need a very long time to complete.

Mr. RAWHOUSER has just stated many don't's while undertaking large projects. Among these he felt that large projects should not be undertaken in stages, as it would effect the economy of the project. Mr. Gadkary, however, was of the view that large projects should be undertaken in stages as far as possible, without killing the possibilities for its optimum development at a later date. He said that instances could be quoted even from American practice wherein stage development had been taken advantage of. It was much better to install one, two or three generating sets depending upon its size instead of putting in all the six or eight machines required to complete the development. Similar practice of stage development is very necessary in transmission lines, and local distribution costs, because, ultimately development of the project could not be taken as the only objective. Other aspects such as development of load possibilities, availability of raw materials, transport facilities, skilled labour, general study of development of locality, etc. had all to be taken into account with the right perspective.

MR. GADKARY pointed out that in estimating the costs and indirect benefits, indirect costs also deserved attention. Many subsidiary projects would arise demanding similar priorities or even higher priority while executing some major irrigation or power projects. For example, construction of a bridge, extension of railway lines, augmentation of rolling stock, etc. would appear most essential for the successful completion of the project in hand.

He further stressed the need of spreading out of projects over a wide area. He said that this point had been already emphasized by Shri V.T. Krishnamachari, so he would not elaborate it. People in different regions should be given an opportunity to exert themselves in their own interest in developing the region with which their lines are most vitally interlinked.

Full consideration should be given while examining projects for priorities to all the usual points such as completeness of investigations, reliable cost data, reality of the benefits involved, requirements of foreign exchange etc. He suggested that the Planning Commission should circulate a comprehensive note indicating all the relevant points which are likely to be taken into account while deciding priorities. He felt that if the matter is carefully gone into, it could be reduced to a scientific study. The subject really is not so general and vague as it appears on the surface and therefore the interested parties should supply all the detailed could be information as collected while insisting on priority sanction for their individual project.

SHRI M.L. CHAMPHEKAR said that there was little doubt that the paper by Gokhale Institute on "The Problems presented by an investigation of the economic effects of large Irrigation and Power Projects and the possible ways of dealing with them" was very important. The Gokhale Institute had carried out survey on one of the canals which had been in operation for about 20 years. He said that only a short while ago Shri Handa had also made a reference to this paper of the Gokhale Institute. The Gokhale Institute had given these findings after a complete survey. SHRI M.L. CHAMPHEKAR said, however, that the report which they had published as one of their publications was not very lucid and he himself had to study the report at least 10 times before he could make head or tail of it. The report contained valuable information, and after studying that report very carefully he was able to forecast the

results of other projects as to what would be the picture of the region 20 or 30 years hence. Many methods were given in the paper of Gokhale Institute.

SHRI M.L. CHAMPHEKAR said that Shri Kanwar Sain had described certain financial tests which the Government should apply before deciding to take up new projects for execution. The remunerative projects should show a fair return after 20 or 30 years.

Earlier projects which were executed under favourable conditions easily satisfied these conditions. But the projects now being undertaken are not under such favourable conditions and it is difficult to satisfy the financial tests to get those projects through. Increased revenue could be obtained by introducing betterment levy and also by the sale of waste crown lands prices of which had also gone very high. But, he said, that crown lands were only available in Punjab. All land in Bombay was occupied and owned by somebody or other. One phenomena which was observed in the areas in which irrigation had been introduced and had been in operation for sometime, was, that prices of land had appreciated very much and specially so during the two world wars.

The Bombay Government was one of the earliest State Governments which had taken some concrete steps in regard to betterment levy and passed the legislation in 1950 providing for the recovery of betterment levy. But after passing the legislation, they were faced with the difficulty of devising a proper method for recovery of betterment levy. The legislation was a hurried one and was passed without full consultation, and he as Chief Engineer was only half consulted. In this legislation, it was provided, that the betterment levy should be equal to half the appreciated value of the land which occurred during the period between commencement and completion of the project. Supposing a project had been under execution for 5 years, half of the appreciation which occurred during those 5 years, would be recovered from the cultivators. In the paper of Gokhale Institute it would be seen that an irrigation project did not begin yielding results during the construction and it was only after the construction, when cultivators began to reap benefits that the prices of land began increasing. Till the water came into their fields and they had used it for 4, 5, or 10 years, the prices of land would not go up. So really it so happens that during the period of construction the prices of the land do not increase appreciably and when the question of levying this betterment tax comes in, it will be seen that practically no levy can

be realised. Prices of land will not increase to any considerable extent. It was therefore necessary that this legislation should be changed to suit the conditions and circumstances but the Government was not prepared to do so. But it was his conviction that sooner or later they were bound to change it and accept his suggestions.

If this betterment levy could not be worked out successfully and if he criticised a thing which had been done by his Government, people would ask for the solution from him. One solution which Mr. Hiranandani had suggested was that the betterment levy should be based on the increased yield that the cultivators were going to get. That was quite correct to a certain extent. But it defeated the very object for which the betterment levy was proposed, that is, for financing the capital cost of the project. The idea of betterment levy was to get more capital for starting new projects. The cultivators were not so rich as to give money in lump sum so that the same could be utilised for the construction of projects ; nor could they give money just after the completion in lump sum. So that would mean that they could be expected to pay betterment levy only in instalments spread over, say, 20 to 30 years. Therefore it would be much better to do away with all these betterment levies or cesses and it would suffice that the water-rate should be suitably increased from time to time. After all the farmers were expected to pay the economic rate. In most of the Provinces and even in his own Province there had been no increase in water-rates till recently, in spite of the fact that the prices of other commodities and every other utility articles had gone up to 4 to 5 times. It was only logical that the water-rate should be brought up to that extent at least.

SHRI G.L. NANDA said that this was a very important question which had been touched. It was of practical interest here for us and for the States. He would like to have some light thrown on this aspect. He wanted to know if it was possible to take a part of the land as betterment levy in kind, provided the holdings were sufficiently big. Considering the fact that development would take a period of time it was obvious that in the course of four or five years the full increment in value would not become visible, although it was not necessarily so. Speculative transactions take place and it was quite possible that in anticipation of the increased value later on the prices might rise even during the first four or five year period. He had known instances where prices had risen as soon as people came to know that a project was going to be constructed. Supposing a decision was taken not to have a project there, some people would

then suffer. It might be easier to take a part of the land as betterment in kind. He would like to know if any one had some experience bearing on the question or had any ideas on the subject. Secondly he failed to understand the question of commuting the betterment levy in water rate itself. If an economic rate was charged from the farmer all values were included. It would be really a business transaction. But the question for consideration was that for various reasons it might not be possible to get the rates increased immediately. The rates if they were to be increased should be increased from the very start otherwise if the land was resold the purchaser would have to pay higher rates. He had made these observations so that speakers may throw some further light on these aspects.

SHRI U.J. BHATT said that he was working in a small State of Saurashtra which comprised of two hundred and some odd States and Estates. It has an area of 20,000 sq. miles. While building up its economy, this small State had very rightly given highest priority to the development schemes of harnessing and conserving every drop of water that falls during monsoon. In the Five Year Plan 15 schemes had been provided. Except two of these, all could be classified as medium minor irrigation schemes, costing between Rs. 50 lakhs and Rs. 1 crore. Two schemes would cost between Rs. 4 to 5 crores each. Seven of these schemes had already been completed and six would be completed before the next monsoon. Only two would be carried over beyond the year 1954-55, thus fulfilling the task scheduled for the first Five Year Plan well before the end of the period. As a result the Planning Commission has permitted the starting of about five schemes contemplated for the second Five Year Plan during the first plan period.

“Actual experience had revealed that his expectations had been exceeded so far as direct returns were concerned. In these schemes while costs could be ascertained with fair degree of accuracy, it was not so as regards the benefits - particularly the indirect benefits, as this would take a long time - a period of 25 to 30 years before this could be assessed with reasonable accuracy. However, one could see indirect benefits in the form of assured drinking water supply. This small State had the calamity of two consecutive famines or scanty rainfall years and it was a task to supply drinking water to one fifth of its total villages. At this time where the medium minor schemes were completed, the drinking water supply was assured through the wells in the command area. This benefit was, of course, not taken into account for the schemes which were primarily meant for irrigation only.

“Another point which he wanted to emphasize was that the direct financial return should not be taken as a criterion for deciding the priority of projects, as this was misleading in so far as these were not modified with the change in prices, mostly rise in prices. For the balanced development of the State, the overall return from all projects should be a criterion and not the return figure for the individual projects. For instance, in Saurashtra in the southwest in a division called Sorath, there is rich soil, with rainfall of 30 to 35 inches, and some perennial streams. This rainfall decreased to 24 and even to 16 inches within a distance of 150 miles, towards the northeast which had only flashy rivers. The schemes in the southwest would certainly give greater return per acre of area irrigated, than the area in northeast known as Zalawad. Question was how Saurashtra would programme its development, whether by developing rich southwest or by bringing up the economic level of comparatively poor northeast. Saurashtra had, without hesitation, decided to give highest priority to the comparatively backward area of northeast and the House would be glad to know that one of the first scheme provided in the plan had been completed in this area, which would irrigate 27,000 acres of land from this October. If this had not been adopted, there would be let into the vicious circle of rich becoming richer and the poor becoming poorer which must be avoided by balanced development and benefits for all. What was true of a State was more true of a region. What was true of a region was more so about a nation and this seemed to have been accepted that the undeveloped countries should receive priority in contra-distinction to well developed ones, otherwise all the United Nations Organization would be besides the point.

There was also the difference between the direct and indirect benefits in the developed and undeveloped areas. Both the direct and indirect advantages would be higher in the undeveloped area than in the developed area. He said that the ratio between indirect and direct benefits would be also much higher in the case of undeveloped than in the developed areas. If indirect benefits were three to four times those of the direct benefits in the developed areas, it would be of the order of eight to ten times in the undeveloped areas.

He said that if only the yardstick of direct benefits was to be adopted for selecting the projects, this should be on a different scale for major, medium and minor projects and also different in the developed and undeveloped. Engineers should have the courage of

conviction to reduce the arbitrary yardstick of 4% return to 2% for medium schemes and even 1% for the minor schemes, as these entailed a higher proportion of indirect benefits.

SHRI A.C. MITRA said that, in the Uttar Pradesh, it would be inadvisable to levy a lump sum betterment levy in advance of the construction of an Irrigation project. Where there were large areas of uncultivated land owned by the State or big landlords, which could not be cultivated without artificial irrigation such land could be sold at a high price when irrigation facilities were introduced. In such cases, a reasonable proportion of the sale price of the increased value of the land could be levied by the State in advance and utilised for meeting capital expenditure that was to be incurred on the construction of the irrigation works in question. Where, however, due to pressure of population, the entire cultivable area is already under the plough and where holdings are so small as to be hardly sufficient for the needs of each holder, the cultivator could not be in a position to pay any betterment charges until the benefits actually accrued. Even then they could only pay such charges in a large number of annual instalments and not in a lump sum. If, as the result of introduction of irrigation facilities a large fee were to be demanded of him in advance, he could not possibly find the money except by selling a part of his already uneconomic holding to a capitalist. This would defeat the very purpose for which the 5-year plan of development had been launched viz, the improvement of the living standards of the tillers of the soil who form the major part of the population of India.

It was, therefore, obvious that any charge for the betterment of land by the introduction of irrigation facilities must, in the conditions prevailing in the greater parts of Uttar Pradesh, be charged in small annual instalments not exceeding a reasonable proportion of the value of the additional annual benefits derived by the cultivator due to the introduction of irrigation. This could be done, either in the shape of a permanent irrigation cess on the entire cultivated area within the command of the new irrigation works, or in the shape of an annual levy for a fixed period of years, say 20 to 30 years, which would amortise the capital expenditure on the work by the end of this period. In either case, the amounts levied would not be available to meet, either partially or wholly, the capital expenditure required for the particular irrigation work, but it would be utilised to meet the capital expenditure on future programmes. This was

the reason why in the Uttar Pradesh it was not proposed to introduce any betterment levy for the present. Similar conditions would probably be found to prevail in many other States and these points would need careful consideration before embarking on costly projects on the assumption that a large proportion of the capital expenditure could be found by the imposition of a betterment levy.

Another method by which the cultivators, the value of whose lands would appreciate greatly by the construction of State Irrigation Works, could be made to pay a suitable proportion thereof to the State would be to levy a high water rate on the crops actually irrigated each season. This method could be applied without difficulty in arid tracts where no crops whatsoever could be grown without irrigation. But, where some crops could be grown even without irrigation in years of normal rainfall, the levy of a very high crop-acre water rate would result in the cultivators delaying irrigation in the hope that rain would fall and they would go on waiting until at the last moment when the rain did not fall, every body would try to take water at the same time and the canal could not be able to supply the required water. This would not only result in loss of yield of crops but also in loss of irrigation revenues.

SHRI A.C. MITRA, therefore, suggested that the charge for irrigation from State works should consist of two parts, one being the crop-acre water rate to be charged on the fields actually irrigated each season, and the other a fixed charge leviable each season on all the fields within the commanded area of outlets of each State irrigation work, irrespective of whether these are irrigated in the particular season or not. With this method of charging, the crop-acre water rate could be kept low enough to obviate the risk of cultivators trying to postpone irrigation until the last moment whilst the fixed charge would ensure that there would be reasonable return from the project even in years of good rainfall, without putting excessive burden on the cultivators.

DR. K. L. RAO suggesting certain measures for economical planning, design and execution of projects, said that it might be that economy for individual items might be small but when these small economies were added up they will be found to result in considerable economies extending to *crores* of rupees in case of present day multi-purpose projects. It was therefore necessary to consider in detail, the various alternatives of each item.

He said he had indicated in his paper how the utilisation of earth dams, in greater measure, could affect large economies. The Lower Bhavani Dam was Originally intended to be made mostly of masonry and to a limited extent of earth. In actual designs, however, this was reversed and considerable economy in cost effected. But even then, the height of the earth dam was limited only to 90 ft. as the Chief Engineer did not want to have a higher earthen dam. Otherwise if a free choice were given to him he would have put earthen dam in the river section also and that would have meant further an earthen dam of 100 ft. to 120 ft. height. This would have considerably reduced the cost of the dam. There were great possibilities of economies in earth dams. In the case of Tansa Dam, it was suggested that strengthening by earth behind the dam would be sufficient and economical.

He added that he was of opinion that in the Koyna Dam they would be able to save appreciable money by adopting an earth dam instead of a concrete dam as at present thought of. Similarly masonry dams gave a reduction in cost of the order of 1/3 as compared with concrete dams. It was argued that masonry dams were not as tight as concrete dams. The relative impermeability and soundness of the structure depended on workmanship and not on the masonry or concrete that was used. Wherever the lime *surkhi* was available, it would be cheaper to use mortar of this material rather than of cement.

DR. K. L. RAO said that considerable saving could be obtained by having careful and complete designs before starting a work. He illustrated this by saying that one Chief Engineer of a State had called for tenders for a gate with very few specification drawings. At the same time he requested the Central Water and Power Commission for preparing the detailed designs and Shri Kanwar Sain, Chairman, Central Water and Power Commission, supplied the design for the gates in only a month's time. Quotations were called again and it was found that bid amounts were only 1/3rd of what they were quoted originally. This would show at once how detailed designs could result in great economies. It was regretted that even now many structures in the country were being built without finalising the designs.

It was interesting to observe, he said, that the rate of construction of masonry dams was substantially the same everywhere in India. Thus the rate for masonry at Lower Bhavani was almost the same as at Mayurakshi Project which is situated thousands of miles away.

In the case of cement, concrete and earth work by machinery, however, considerable differences were reported in the various parts of the country. Thus the Bhakra rate was less than 100 rupees per hundred cft. including cooling of concrete while for the same type of work more than Rs. 200/- was the prevalent rate at Vaitarna. This great divergence in cost of cement concrete was in his opinion, an indication that the Indian Engineers and constructors were not fully experienced in handling of these materials. In times to come it should be possible to attain a more uniform type of rates.

As regards Rawhouser's remarks on the stage construction, DR. K.L. RAO said that Mr. Rawhouser was referring only to the unscientific phasing of schemes. Scientific phasings was recognised and would definitely result in proper and economical allocation of country's resources. He quoted the example of Lakkavali Project. The cost of the complete project was Rs. 20 crores and the Government found it difficult to find all this money. It was more so when the amount was large. But by postponing construction of a few parts and phasing the project, the cost of the first phase was cut down to Rs. 10 crores. Construction of this phase would be sufficient to supply irrigation water for a *lakh* of acres in scarcity areas. When more finance were available, it would be possible to continue the construction and attain full benefits. He suggested that a committee might be formed to find out the rate of development in the various regions of the country. Naturally where there was already much irrigation, the rate of further development would be less as in the case of Cauvery areas but in other parts of the country where the irrigation was scanty, the development would be much more rapid in the beginning. It was necessary to have a picture of the rate of development of both power and irrigation facilities in the various zones of the country to plan a correct phasing of each project.

DR. K.L. RAO observed that in the olden times 1/10th of land (Dasa Bhindu Manyam) under projects was left apart as a gift to the engineers and others who participated in the construction of the projects. He felt that this method might be revived and the payments of some part of the salaries of the staff engaged on the work might be deferred and in lieu of this they might be provided with amenities like scholarship for their children, etc., in the future from the yield of the allotted land.

SHRI GULZARI LAL NANDA said that there was valuable material which the contributors had brought into these papers. He

wanted the engineers to concentrate attention on practical aspects which would help in dealing with these matters at administrative and technical levels. The questions were of such great importance that speakers could easily talk about them for hours, but the time was limited and the House would agree that some means should be found of not leaving this discussion in a diffused state, to a conclusion. Some conclusions should emerge out of these. Previously land for land was not given but now there was Bhoomidari movement and land for land might be possible. Another way possible for recovering full amount of betterment levy was by deferred payments. While there were certain theoretical matters regarding which the administration would not care much as they might be resolved in a course of centuries, there were other matters of practical importance such as betterment levy, etc., which should be tackled immediately. There were States which would not agree to the levy of betterment tax. Bombay Government has passed legislation, but what concrete shape it will take is not certain. The Planning Commission was writing to the States and asking them to agree to legislation for imposing betterment levy on certain principles and those principles should be such as were able to command a general acceptance. So this was a matter of immediate practical importance. Similarly was the question of costs. He would like the projects to be examined in the light of these discussions. For example Hirakud Costs and the Bhakra Nangal Costs should be examined in the light of these discussions, and it should be seen if these tests had any relation with the actual conditions. Certain tests emerged as a result of these discussions and as a result of this common thinking. The point to consider was whether this pooled knowledge would take us to a certain direction in which it could be used and utilised for purpose of reducing existing costs. He said that he would like to make the outcome of these discussions more purposeful. He did not like therefore that speakers should make any general remarks at any stage because the general ground had been covered already. His mind was full of questions and problems which concerned the common man every day. He was not present at the time of discussion on flood control. He was very deeply interested in that question. It affected the lives of *lakhs* and *lakhs* of people in this country and there appeared to be serious difficulties in dealing effectively with the problem of flood control. The engineers have to take counsel together on this problem. These were problems of a varied nature. The flood problem was different in different areas. In Assam it was of one type and as in Bihar it was of a different character and so in other parts. Money had to be spent

on flood control. The best use of the money should be made and it should be seen that expenditure brought best results and brought relief to millions of people. That was only a side remark. That was one problem which was of immediate and urgent nature, on which he had hoped some contribution might have been made during these deliberations here and led to useful results. Reverting to the discussions on costs and benefits and the things which arose out of that he said that two questions were before his mind. It might be thought that all this discussion on costs in relation to benefits was primarily useful for the purpose of establishing priorities. This might have been of academic character so far as the existing project. This question of methods of deciding priorities was however of practical interest because Planning Commission was going to prepare the second Five Year Plan. The Planning of first Five Year Plan partly proceeded side by side with the execution of the plan. Second Five Year Plan should be planned in advance and therefore all these things would be of very great practical importance. There were regional grievance complaints of neglect of areas. It had to be seen that everybody was satisfied to the extent possible and when it was not going to be possible to satisfy everybody it would be better to tell them why more could not be done. It was better to tell them that due to the limitations of resources or other reasons it was not possible to do more. In this context the question of benefits in relation to costs was important. Raising of standard and developing of economic resources was the aim before the country. At the same time it was not correct to neglect financial considerations. There was a stage when the emphasis was on securing increased food supply in the quickest time and therefore those schemes which could yield these benefits in the shortest possible time were sanctioned. But now other considerations have also come into play. The question of employment and the question of regional needs and social considerations generally have to be borne in mind. Another factor was how it was possible to reduce the cost of the projects and if more thought was given to this thing, it might be possible to achieve better results.

He emphasised that machinery would be used more and more in the country. But every additional use of machinery should have its justification, having regard to the available man power. If the use of machinery gave much bigger results than the machinery might be used but if it was only a marginal advantage then man power may be preferred. Economical considerations were important but social considerations were equally important in the long run. So the question

of costs had got to be interlinked with other considerations such as employment. It should be seen that projects should be made use of for mitigating unemployment. Employment was of very great consideration to the Administrators. In reducing the cost there were difficulties. These were therefore the big responsibility of the Engineers. They had to face these difficulties and solve them with the resources available to them. Sometimes they had to take risks. Sometime they made mistakes. But it was possible that by greater attention to both details as well as to larger matters of organisation costs could be reduced by utilizing the best experience by more efficient use of man power and better use of machinery. The training of the workers at the lowest level should receive more attention.

Training of technicians was very important but the training at the lower level was equally important if not more. Foreign advice was necessary sometime but it should not be resorted to unnecessarily. At the second level the deficit was very large indeed. Technical training was very necessary. Adequate facilities in training were not available or were not sufficient. If unsound technicians were employed then the results would not be good, and the work would not be satisfactory. But the third level training was more important *i.e.*, labour should have sound training. It was his opinion that good results were not being obtained from labour and neither any attempt was being made to improve their worth. If attempt was made it would go a long way in reducing the cost. Best use of machinery should be made of. The maintenance was not good. A committee was being appointed which would see to the needs of the machinery and would evolve some kind of standards for its maintenance *etc.* He hoped that would be done soon and that might be useful to the various projects. So these were the main questions *i.e.* of personnel and equipment. As stated previously the economical use of the machinery was very important; equally important was the use of other materials. The impression that had been left on his mind after a fairly close contact with some of the projects, and he knew enough about Hirakud and about Bhakra Nangal and the impression persistent in his mind was that these projects were started in a mighty rush. There was a sense of emergency. Improvisations were made. The refined preparations which were necessary for the purpose of obtaining the best results were not attended to. The sense of emergency should be there but it should be more in terms of results and in terms of reducing the cost. This was particularly necessary now. Co-ordination was lacking, this was the impression.

he had got. In view of the next Five Year Plan, preparation had to be adequate and for that purpose there had to be enough data. Hydrology and other sciences should be brought into service to a greater extent. Some data about certain rivers had been collected but full data was not available. All these things would have to be attended to.

He had an impression that it was an inconclusive discussion and this should be pursued and brought to a logical conclusion. The prices of lands did not rise only because certain dams were going to be constructed but they rose from other considerations.

SHRI M.G. HIRANANDANI while introducing his paper on levy of water rates and betterment charges in River Valley Projects stated that his paper had been written with reference to the areas in Sambalpur District which were being irrigated by the Hirakud Canals. In his note a method had been suggested according to which water rates and betterment charges could be calculated in case of an irrigation project. It had been proposed that the levy of water rate plus betterment charge should not exceed half the net additional profit, that would accrue to farmers on account of the construction of an irrigation project. This suggestion had been made by the Mazumdar Committee appointed by the Government of India while revising the estimates of the Hirakud Dam Project.

In order to work out the net benefit accruing to a farmer, the cost of agricultural operations including the Improvements on different types of land in the Sambalpur District had been worked out in great detail. The gross revenue from the sale of produce minus the cost of agricultural operations including the cost of permanent improvements, etc. gave the net profit to a cultivator. The water rate and the annual instalment of betterment levy was to be limited to 50 per cent of that profit.

In the past recovery of betterment charges had been linked with increase in the value of land due to the introduction of irrigation supplies. The State of Bombay which was the first to enact a legislation for recovery of betterment charges, which were based on the increase in the sale price of land, had not found it possible to put this into practice as on completion of certain irrigation projects the anticipated increase in the value of land had not actually occurred.

The Punjab which had also enacted a legislation for recovery of betterment charges, had also found it difficult to link the betterment charges with increase in the price of land and had therefore

suggested the fixation of recovery of betterment charges on the next assets accruing to a cultivator and multiplying that figure by 30. These "net assets" which had been explained in the paper were in other words the net profit on which the betterment levy charges are now suggested to be recovered.

It was brought out by Shri Hiranandani that since 1952 when *Zimindari* Abolition Act came into force in the Orissa State, the price of the land had registered a fall of 25 per cent in the Cuttack District and 10 per cent in the Puri District. This fall in the price of agricultural land may have been due to a number of factors. There is a feeling that due to the Bhoodan movement where people make voluntary gifts of land which is again distributed among the landless labourers, the big land holder will have to ultimately part with surplus land. More land is therefore available for sale in the market than before.

If, therefore, at the completion of a project it is found that land values have actually depreciated for any reason, it would be difficult to effect its recovery. It would, therefore, be safer in the interest of the financial success of the project to fix the betterment levy on the net profits as it can be easily established that the net return to a farmer on account of assured and permanent supply will always be more than when his cultivation is subject to the vagaries of rainfall.

THE HON'BLE MINISTER FOR IRRIGATION AND POWER during the debate on betterment levy charges, had made a suggestion that betterment charge, instead of being collected in cash, may be recovered in kind. It was explained by Shri Hiranandani that during the post independence period which had witnessed a radical change in the tenancy legislation, the tendency was towards smaller holdings. The Bhoodan movement was a typical example where land distribution was made in one or two acre plots.

Where as, therefore, it would have been easier for a large land-holder to part with a part of his land towards payment in kind towards betterment levy, the recovery of betterment charge in kind in the case of small land-holders would lead to further division of an already small holding which would prove uneconomic. Another handicap towards the recovery of betterment levy in kind was the natural objection of a land-holder (particularly a small one) to part with his land. A suggestion for the recovery of betterment levy in kind had been made in the case of Tungabhadra

Project but this has not materialised so far, probably due to the reasons mentioned above. It would, therefore, be best under the circumstances to recover betterment levy in cash instead of in kind.

SHRI CHAMPHEKAR, Chief Engineer, Bombay, during the discussion on the above subject, while agreeing that the recovery of betterment levy should be based on the net profit from cultivation, suggested that the word "betterment levy" should now be abolished as recovery of this charge was no longer proposed to be linked with the increase in the price of land. He was of the opinion that water rate may be increased by say 200 or 300 per cent, to make up for the recovery of betterment charges,

SHRI HIRANANDANI pointed out that while he agreed on principle with Mr. Champhekar that the word "betterment levy" may be abolished, there was likelihood of a strong opposition in the State legislatures to further increase in water rates which had only recently been increased in most of the States for example by 50 per cent. in Uttar Pradesh and about 100 per cent in Bombay. He, therefore, suggested that the betterment charges and water rates may be collected separately as at present and that the former may be levied as already suggested in the paper.

SHRI KANWAR SAIN said that he had been thinking that there should be differentiation between betterment levy and water rates. The former rate should fall on the owner of the land and the latter on the user of water. This had been tried on the Bikaner Canal by His Highness Sir Ganga Singh, Maharaja of Bikaner. He levied Nazrana from the land owners whose lands were commanded by the Canal at a flat rate of Rs. 50/- or 60/-, per acre of a culturable commanded area. Whatever was decided by the Revenue Officers, people paid it readily, in cash in instalments. Similarly on the Thal Project in West Punjab an Act was passed in 1902, that 3/4th of the land would go to Government. Subsequently that Act was repealed and then a fee of Rs. 30/- per acre like Nazrana was fixed by legislature. Later on after partition, he understood that people were not able to pay their dues and the Government had decided to take some part of the land from the land owners. He also understood that this had proved to be a great success. He referred to Columbia Basin in U. S. A., where a special Act was passed by which all land above a certain area was to be sold at a certain price fixed by Government. Government sold it at higher price and the

profits were credited to the project. If the land holdings were very big, the owners would find it difficult to pay the betterment levy in cash. In that case, an option should be given to them to pay in kind. A very useful suggestion in this connection had been made by Shri A. C. Mitra and that suggestion if adopted would in his opinion achieve the same object. According to this suggestion, the charge per acre per year should be split into two parts. The owner whose land fell in the commanded area would have to pay in perpetuity a betterment levy and the cultivator would have to pay for the use of water. This was another possible alternative which required further exploration.

SHRI D. B. ANAND speaking on the item of economising of costs said that he had dealt with the various aspects of this subject in his paper. Therefore he would only mention the amplifications to that paper.

He stated that he had already made suggestions regarding the training of engineers after they have joined service. He would however like to add a few suggestions for the training of the budding engineers which would help a long way in his future work. Some of the suggestions he would like to make were as under :—

(i) Fellowships and post-graduate studies should be started in engineering colleges. This step would bring research into our universities which, as has been expressed alround, would be a very desirable thing.

(ii) A practice should be started whereby engineering students could work as technical aids during their vacations. This sub-professional training would democratise the outlook of the budding engineer and give him an opportunity to select the particular branch of engineering that might suit his natural bent of mind.

(iii) After recruitment, the young engineer should be put through a training school which could be run by each State or jointly by two or more States. This would be somewhat on the lines of the training schools run for the administrative and the police services. The school should cater for the needs of the officers' cadre as well as for overseers, the classes being joint for some of the subjects and separate for others. It can also train up mistries and works foremen. Courses should include departmental routine and accounts

The location of these schools should be in the vicinity of engineering colleges, and there should be free exchange of lectures between the two and use of each other's facilities.

(iv) There should be short refresher's courses for officers in the department, the lectures being delivered by senior staff on specialised subjects like dams, canal management; engineering economics, mechanisation, laboratory work *etc.* Lectures should also be arranged by other eminent engineers in the country and from aboard when the latter happen to visit India.

These courses should be attended by officers specially selected by Government each year. This step will help the officers keeping pace with the latest techniques and developments.

(v) The young engineers' training in the first 5 years should be specially planned so as to make him as useful to the Department as possible.

Shri Anand felt very certain that the adoption of these and similar suggestions will go a long way towards improving the quality of our engineering services.

The second point on which SHRI D.B. ANAND laid stress was the method of audit and accounts to be adopted on projects. He stated that big projects involved heavy expenditure which must need proper accounting and auditing. The technical staff would have their hands full and must be given audit and accounting staff to relieve them of as much avoidable accounts work as possible. This does not, however, mean that the technical staff can afford to be ignorant of the accounts rules and regulations. Such ignorance can only lead to costly day-to-day mistakes. The purpose of the audit and accounts help would be merely to relieve them of heavy routine, which is handled in a normal PWD Division. Of the various methods known, the one successfully employed at the Sukkur Barrage project appears to be the best.

SHRI D.B. ANAND said, that in that method, it was fully realised and accepted that in the final analysis, the responsibility for works is that of the engineers in-charge and that the function of the accounts is to lend as much support as possible towards the economical execution of work. Such a goal would need co operation and trust on both sides and a clear understanding of each other's functions. Without such co-operation, there would be endless trouble and friction. This branch of the staff attached to big projects will exercise the same functions as are being executed by the Accountants General and the Auditor General. The staff would, therefore, be headed by a Chief Accounts and Audit officer. SHRI D.B. ANAND

stated that he would, particularly, like to stress the need for a designation which aptly describes the functions so as to obviate misapprehensions regarding duties and powers.

SHRI D.B. ANAND further stated that while aiming at perfection, it must be realised that flexibility and relaxations of rules would be inevitable if economies and speed are to be achieved. This will also lead to the evolution of the accounts codes to fit the modern techniques of work. After all, the only aim of the codes is to assure the most economical use of funds towards satisfactory execution of works. And towards this end, rules and regulations must undergo change to suit new types and methods of works.

SHRI D.B. ANAND then referred to Dr. Rao's paper and endorsed the view of economising on the designs of projects. He stated that the earth dam would usually be cheaper on locations where it was technically feasible and where suitable soil was available in sufficient quantities. It was not however a general rule that the earth dam would be the best and the most economical at all sites.

Referring to the Koyna Project, Shri Anand stated that investigations had been made regarding the various alternatives for the dam e.g. earth, rock fill, masonry concrete, etc., etc.. He also stated that they had obtained experts' advice in the matter and that the decision was reached after sufficient investigations and for strong technical and other reasons. He would therefore like to assure the House that all precautions and steps were taken to ascertain the most suitable type of structure before a decision was reached.

SHRI C.L. HANDA said that the rate of concrete fixed at Bhakra took into account the conditions which were prevalent at Bhakra. Thus natural aggregate was available nearby and crushing did not require. Features like this had enabled the rate of concrete to be kept low.

In analysing the rate account had also been taken of the construction plant layout of the special equipment with which concrete is to be laid at Bhakra Dam. The rate of Rs. 100/- per hundred cft. can certainly be reviewed taking into account the actual cost of equipment and the depreciation thereon. But the reasons contributing to the lower rate is that Bhakra Dam is a very big single job of the concrete and the quantity to be executed is over 5 million cubic yards. The quarry from which aggregate was obtained did not need any blasting. The machinery at Bhakra was very well

co-ordinated. The Bhakra management had adopted all possible measures of economy. Cement was being used in bulk. The shuttering also was of the standard type. The cranes were well co-ordinated. Some of the structural work would be done at Amritsar at an economical rate. Since Bhakra Dam is a unique work involving high concrete dam construction, the engineers of the country can derive a lot of information for themselves by visiting the work and seeing how overall economy was being effected.

SHRI G. L. NANDA said that they were finding great difficulty in comparing rates. Engineers had not evolved a method of comparison. They should be armed with sufficient criteria and they should judge whether certain rate was economical or not. Much more work had to be done before comparison could be made. It was high time that final decision regarding machines and rates should be arrived at.

SHRI D. V. JOGLEKAR said that four papers were contributed by the Central Water and Power Research Station, Poona. Since the inception of the Research Station as far back as 1916 it has investigated numerous problems on irrigation, river training for safeguarding of bridges and protection to towns, navigability of channels and improvements to harbours and hydraulic structures. The application of results obtained from the various model studies has contributed 80 crores of rupees to the Exchequer as a result of direct savings effected by them. Besides these direct savings, innumerable indirect benefits have accrued therefrom but it is difficult to assess them in money value.

Paper contributed by Dr. Banerjee of the Station discusses the advantages and relative costs of geophysical investigations in engineering projects.

Paper by Shri Pant shows how the experimental stress analysis effects considerable savings in the structures and makes them safe.

Paper by Shri Gole discusses the methods of estimating benefits and cost and economics of inland navigation projects.

SHRI M. L. AGGARWAL said that his paper was the outcome of personal observations and laid stress on procedures which, though

generally known and accepted, did not always receive the attention that they deserved. It stressed the need of studying in advance the economics of execution through manual labour and through machinery and necessity of deciding at the planning stage on the mode of execution i.e. what portions should be executed through machinery and what portions through manual labour where both modes of execution were possible. The draw backs of framing an estimate without deciding on the mode of execution were stressed in the paper. It also pointed out the mistakes in framing estimates without taking into account the mode of execution.

The considerations which should govern the decision as to whether a work was to be executed through manual labour or machinery were mentioned. It had also been pointed out that though mechanisation need not necessarily be more economical than employment of manual labour in this country, the increasing magnitude and complexity of the present day engineering works made the increasing use of machinery unavoidable and as such stressed the need of equipping engineers to handle and operate these machinery economically and efficiently. For this there was need, not only for properly trained operators and mechanics, but also for properly trained engineering personnel who understood the performance and limitations of various types of machinery commonly used on our works. They should be able to allocate the right type of machine for the right job and direct its use in the right way. There might be occasions that the mode of execution of a job might have to be changed to a less satisfactory one in order to make use of machinery actually on hand instead of ordering a new one even though the existing machinery might not be best suited to yield economic results but when engineers had the choice to make selection there was no reason why correct selection should not be made for the job or jobs in hand.

The need of watching the output of machines and proper system of accounting for correct indication of the unit cost of out-turn was stressed. It had been pointed out that a proper comparison of working cost of machinery employed on different projects was necessary to ensure economic working of these machines and the pre-requisite of a proper comparison was a uniform basis of accounting for all the projects. Generally in this country no account was taken of the basic ownership cost of equipment in arriving at the unit cost of out-turn. This failure to take account of the hourly cost of ownership comp-

rising of depreciation, interest, taxes, insurance and storage was responsible for uneconomical and unmethodical methods of working of machines remaining undetected.

He said that the paper also stressed the need for proper incentive to operators for efficient and economical working of machinery through a proper planned system of bonuses. In fact the economies that could be effected by increasing the out-turn per hour through proper handling by operators of machinery and the great incentive to this proper handling that a proper system of bonus could give was not fully appreciated through our not evaluating the hourly cost of ownership which was a fixed charge.

The paper also stressed the need for having proper training centres for operators and mechanics and permitting recruitment of operators only through such centres.

SHRI G.L. NANDA said that this question of training the operators was really very important. He wanted to know if there was any school of training for such operators. He felt that there should be a training centre from where operators should be drawn. It would be no use picking up a man from here and a man from there and put him on the job. Such men might spoil the machinery. This was indeed a point worth considering.

SHRI A.S. KALHA speaking on the subject of "Different constructing agencies that could be employed on the River Valley Projects" said that there was a large variety of jobs on any irrigation project and there was room for all the different types of agencies. For example on distributary construction, there was room for small local contractors as well as for co-operative labour and construction societies. For canal construction both small local contractors as well as fairly big Indian Firms who could take big jobs on contract could be employed. Then there was the construction of dams wherein highly specialised talent was required.

There was a big controversy in connection with the construction agency to be employed for the construction of Bhakra Dam. It was argued that as the dam was to rest on very difficult geological strata, it was imperative that no mistakes be made that the work be organised on economical basis and carried to completion in the least possible time so as to save interest charges and derive early benefits. It was alleged that the required talent was not available in this country and

that the best talent was employed in foreign countries by construction firms whose business was based on technical ability of the superior personnel. In almost all cases the superior technical hands were partners in the concerns and were in any case, sharing large bonuses. On the other side it was said that for getting the work executed by foreign firms a big commission had to be paid as foreign firms would not take any fixed contract but would do the work on cost plus commission basis. In such cases incentive for cheaper work could only be the share on saving out of the target estimate. In the end it was decided that the work of the dam should be managed by Indian Engineers with the help of a few foreign experts and so the work was started accordingly. As this was the first big dam construction work in India, time alone would show the capabilities of this method,

In foreign countries big dams were almost always constructed through contractors but these contractors gave firm bids both as regards cost as well as the time. The contractors also used their own equipments for the construction work. None of the foreign contractors would be willing to do work in India on such conditions. They would not like to invest such huge sums in this country as were required for the construction plant.

The difficulties of departmental work aided by experts were due to the basic fact that such huge works could not be executed without team work. Also there would be no superior outside technical authority to check if there was any mistake until it was too late. The experts engaged like-wise had no financial stake in the execution of work and it was also difficult in many cases to maintain continuity. There were thus many complications, that could arise when the work was in a critical stage. If big Indian constructing firms could be had they would in his opinion be superior to departmental work in many respects.

Regarding canal construction, both small local contractors as well as fairly big Indian firms could be employed. In the case of small local contractors the whole responsibility for getting the work done economically, efficiently and within the time developed on the Sub-Divisional Officer and the Executive Engineer. The pivot of course was the Sub-Divisional Officer who selected a contractor for allotment of piece work, got the work executed according to specifications and then made the necessary payment. He also was responsible to see that the materials were obtained from the most economical sources. There was a certain bit of check exercised on the Sub-

Divisional Officer's work by the Executive Engineer and also by the Circle Officer when estimates came up for sanction. But in great rush the pivot for successful work by the small local contractors was still the Sub-Divisional Officer. Due to rapid expansion, the quality of the Sub-Divisional Officers had deteriorated to some extent and that was our present weakness.

To quote an example how saving could be effected by timely planning he mentioned the case of lined canal. It was extremely essential for successful compaction and for the work of the lining that water supply was available in early stages all along the canal. If this water supply was made available the brick kiln rates would drop substantially. If however somebody started brick kiln contracts to be let out before the water supply was available the rates would be abnormally high. This sort of planning had to be done in the case of small contractors by the Sub-Divisional Officer and the Executive Engineer.

In case, however, big constructing firms were employed to do the whole construction for specified reach of the canal, the contractor would think of these matters because it would effect him financially.

It would however be necessary to have all the designs of the works on the canal ready before the construction was started. This was not always the case. If the designs were prepared in time and planning was properly done it would result in a substantial saving in the cost.

For distributary construction, both the small local contractors and co-operative labour and construction societies were suitable. A big experiment of construction of distributaries through co-operative labour and construction societies had been tried in Hissar District during the last 2 years. At the present moment 63 co-operative labour and construction societies were doing work of Distributaries earthwork excavation. They had so far done 11.0 crores cft. earthwork at the cost of about Rs. 15,00,000/-.

In the first attempt the Co-operative Societies were formed by the Deputy Commissioner through the Tehsildars. The Tehsildars selected the Group Leader who collected the men around him and was responsible for the work. The whole system then devolved on the capability and reliability of the Group Leader. It was not a Co-operative system in the real sense of the term. Difficulties arose regarding the payment to the different workers and some Group Leaders mis-behaved.

The system became unpopular and further progress could not be had. The whole method was then reorganised on co-operative basis. Officers of the Co-operative *Panchayat*, Publicity and Employment Exchange Departments went around the villages and explained to the people the advantages of co-operative work. The villagers were invited to form Co-operative Societies by paying a nominal fee for membership. After the society was formed and registered, the members were asked to select their representative who was authorised to obtain the work order from the department. The work order was issued on the same basis as to any other contractor and at the same rates. As the society had no capital it was ensured that payments were made weekly and Red Tape was reduced to the very minimum. Tuesday of every week was fixed as Pay Day on which in many cases the Sub-Divisional Officer was present near the Treasury so that the representatives of the Societies could come to one place to receive their cheque and get it cashed and then go back the same day for distributing money to the workers. All the staff was made very alert so that there was no delay in giving "NISHANS" to the labour for starting work and also to control the quality as it progressed. This method proved successful and had engendered great deal of enthusiasm in the local labour in the canal construction. They were now partners in the set up. They knew the difficulties of the construction and it was felt by the villagers that if the work was not properly done by them the distributary would not work properly and they themselves would suffer in the end.

The work started really from February 1953 and during the last eight months the average labour strength had been about 4000 men. The maximum strength so far was in May 1953 when during one week it rose to 7616. It had varied due to seasonal agricultural requirements and also sometimes to inclemency of weather. The average monthly payments to these societies was of the order of Rs. 2 lakhs. If the work was not there, payment would otherwise have had to be made in the shape of famine relief.

SHRI M.L. MEHTA said, that Shri C.L. Handa had already mentioned that he was to speak on some adverse effects of the River Valley Projects. In the paper circulated, subjects, like the rise of sub-soil water-table, water-logging, land deterioration on account of the accumulation of sodium salts, the gradual decrease of fertility of the soil on account of the slow increase in alkalinity by the action of sodium salts, soil fatigue, existence of malaria, etc. have been dealt with.

One of the expert speakers has pointed out that at no stage should attempts be made to over-plan for, he said, with the newer knowledge and tools and implements that become available as a result of research, problems arising in future could be more easily solved later. Mr. Mehta said, he would like to assure the speaker and the whole House that the Government of India and State Governments were already working on that plan. According to the standards laid by Government, no notice is taken of deterioration until the damage exceeds 75%. In joint Punjab approximately 20% of the land under irrigation projects had already gone out of cultivation on account of water-logging and salt accumulation.

The Indian farmer being short of money had always been trying to get more and more production from the land without observing the rule of return. The result had been that the productivity of the land had decreased considerably. It would be well, if in planning the possible decline in the fertility of the land is taken into consideration so that this potential wealth is not lost for ever.

With regard to the question of betterment fee which the President had raised, he was of the view that it would probably be realised more conveniently in the form of land than in the form of cash. An added advantage would be that it would be realised all at once and not in instalments spread over a period of years which method of course is inconvenient both for the Government and the people.

Shri Kanwar Sain had already mentioned the Thal Development act of 1902. According to this Act, three-fourth of the land was to go to the Government. This could not happen as during the period the Act remained in force, construction of the Thal Canal was not undertaken. Later a new Thal Development Act had to be enacted, according to which the betterment charges were levied in a different form.

SHRI M.L. MEHTA quoted an instance of an advocate from Bhakhar, his clients found more convenient to pay his fee in the form of a small area of land than in the form of cash.

SHRI G.L. NANDA said that it was a matter for regret that much as he would like to hear the comments of several other friends who were also prepared to say something on the subject, but due to lack of time it would not be possible to accommodate them. Still

it was not correct to lose the advantage of whatever they had to make in addition, and he would request them to send the copies of their views on these discussions. He was sorry also that while all the engineers were here he had other engagement i.e. D.V.C. conference etc. He wished to make more contact with you and exchange views. Some of the engineers might be coming to this place on another occasion at a conference of engineers probably in the first week of December. The representatives from most of the States would be coming to that conference. There was a definite agenda about rates and costs. This subject would be discussed at close range at that time and perhaps advantage would be taken of your presence at that occasion. He suggested that before the discussion in the conference took place, material should be collected on the basis of which the discussions could proceed without any loss of time. The agenda should be circulated and the views of many engineers as possible could be obtained. He was sorry to point out that all efforts made in the past to bring into being here in this organisation some kind of data which would enable to compile workable basis for comparison of rates, had not borne fruit. It could not succeed because the necessary information asked for was not made available by the States and different projects. Well now still the co-operation of all the States and the engineers was very much needed in the discharge of duties of that Committee which would enable us to get those results. Now in this case a Committee was being appointed for outlining the procedure for the operation and maintenance of different machinery on various projects but that would not go into the question of rates, therefore another Committee would be appointed for that purpose. Something in the matter of training of workers had to be done at different levels and here again the co-operation of all of the engineers was required. Centre was asked to give advice and some time to send experts and on various occasions even to execute works. The centre should be properly staffed and equipped to discharge these functions satisfactorily and efficiently. Centre was experiencing difficulty in this respect. Some engineers were required in the States because they were useful to the States. When Centre asked for certain people from the States to come to the Centre they were not spared on the pleas that they were useful to the States themselves. These were some of the difficulties Centre was experiencing. In regard to many of them Centre required the co-operation of the engineers who were working at high administrative levels.

CONTRIBUTION

by

J. N. Mitra.

I wish to draw the attention of this House to two new measures adopted in Uttar Pradesh which are likely to reduce the costs of some of the smaller projects to be undertaken under the Five Year Plan. These are :—

(1) The employment of prisoners in jails for construction of earth dams. The idea originated with our Home Minister, Shri Sampurna Nand and two thousand prisoners were employed to do the earthwork on Chandraprabha Dam near Banaras. Special camp for the prisoners was prepared at the site of the dam and they worked on the construction of the dam for several months. The dam was completed last year. The same experiment is being tried on another earth dam 60 ft. high in Mirzapur District.

The second is employment of military units for some of the projects. The first such project on which military personnel were employed is construction of Lalitpur Dam which is 60 feet high earth dam. The army established a camp at the site of the dam and executed the work by mechanical equipment. This sort of work also provides a training for the military personnel. Recently for carrying out some urgent work in the Ganga Canal which is the most important canal in Uttar Pradesh, during a short closure of 10 days army units stationed at Roorkee were requested to carry out certain work with their ownmen and equipment. They have carried out work costing more than Rs. 60,000/- in the short period which it would have been very difficult if not impossible to do otherwise. This work was done as a part of the training of the personnel. There appear to be immense possibility in such co-operation between military personnel and the administrations carrying out civil works. Just as in the United States the army corps of engineers carry out a lot of civil work in connection with the development of country, similarly the army in India in peace time could help in our development programme to a great extent if some sort of understanding is arrived at between army and civil authorities.

CONTRIBUTION

On Relative cost and advantages of geophysical investigations in engineering projects.

by

S. L. Banerjee,

Research Officer, Central Water and Power Research Station, Poona.

INTRODUCTORY NOTE

In any major engineering project like a dam, weir or tunnel construction foundation studies, such as diamond drilling, pumping tests, geological survey, etc. costs about one per cent of the total cost of the Project. The comparative cheapness and quickness of the Geophysical method is however responsible for its use in the study of the subsurface particularly during the reconnaissance, site selection, and preliminary design and cost estimate stage of a project when merits of different potential sites are to be correctly assessed in a quick, cheap and yet dependable enough manner and the type of the structure best suited for the foundation has to be decided and a preliminary cost estimate made. Later, more comprehensive diamond drilling at the selected site might be necessary for the drawing up of the specific design and the final cost estimate.

The geophysical method most frequently employed at an engineering site is either the refraction seismic method or the electrical resistivity method of survey or both, if necessary. Usually occurring good contrast in acoustic velocities in the overburden and in the bed rock forms the basis for refraction seismic method and similarly a good contrast in their electrical resistivities would make electrical soundings for bed rock depth possible. The thickness of the overburden estimated by any of these geophysical methods is usually within $\pm 5\%$ of the correct value provided a single check bore has been utilised for the correlation purpose.

The average cost of a single bed rock depth estimation whether by seismic or by electrical method works out to be about Rs. 40/- as compared to an estimated cost of about Rs. 25/- per foot of core drilling in soft rock. Taking average depth of overburden encountered in a potential site of a river valley project to be about 50 ft., the

cost for a single geophysical depth estimation is about 1/30 the cost of a single bore hole and the time taken is 1/10 the time taken in a single bore hole at the usual rate of 15 ft. of drilling per day. This is because a small geophysical party consisting of a geophysicist, a technical assistant, a surveyor and a dozen helpers can finish on an average 3 depth estimates per day by either seismic or electrical method and the total cost of the party is Rs. 120/- per working day taking their usual pay, cost of transport, cost of explosives, etc. into account. For a project the duration of a geophysical survey varies from a fortnight to a month depending on the number of alternative alignments and the lengths of the alignments along which bed rock profiles are desired.

Figure 1 (of Paper III) of the detailed note shows the bed rock profile obtained from 15 electrical soundings across the river Tapi at the proposed dam site at Ukai. The result of 7 subsequent boreholes showing the depth of overburden is also given here and it shows a fair agreement with geophysical estimates. Similarly Figure 2 shows bed rock profile for Siwalik sand stones under a thousand feet wide terrace portion at Chatra Gorge in Nepal on the river Kosi and no bore hole results are yet available here.

CONTRIBUTION

by

S.N. Gupta.

Proper planning, evolving economical and sound designs, adopting cheap and speedy methods of construction in the execution of river valley projects both big and small are a common cry in the country today and the Irrigation Engineer is faced with the stupendous task of shouldering this burden and responsibility in a befitting manner. Although he can rightly be proud of his past achievements as a result of which numerous irrigation systems in the country came into existence and are functioning wonderfully well, yet much is required to be done to cope with the requirements of the present day undertakings. There are many a handicap in his way *viz.* lack of properly trained personnel both for the design office and the field, shortage of mechanical equipment and responsible staff to use and look after it and other day to day obstacles apart from administrative difficulties. The Research Worker comes to his help in the study of his designs in the right perspective with the aid of models and in the use of right type of materials as locally available during the course of construction. Models have come to be known as the real tool of the designer where he can see what cannot be arrived at otherwise. Nature in all its serenity presents very complex and intricate problems on which the design engineer with all the confidence at his command, feels diffident to lay hands upon but the science of model experimentation has gone a long way to solve his difficulties. The work which is undertaken at the eleven Research Stations under the control of the Centre and various State Governments bears a clear testimony of their utility in practically all the river valley schemes. Large savings have been effected by the use of designs adopted after model studies which, in turn, form a negligible fraction of the sum involved in a project. With all the modern literature available from the foreign countries our own in the domain of hydraulics, soil mechanics and materials testing and the knowledge derived from the existing designs of various hydraulic structures based on past experience,

there remain so many factors and aspects which vary with local conditions that it becomes difficult to adopt a particular design and these are better studied with models. Design of energy dissipation devices below spillways and power houses, design of spurs and guide *bunds* as a measure of river training for the protection of villages and checking out-flanking of works such as weirs, barrages and bridges are some of the specific cases which come under the above category. Likewise, the proper selection of the soil for an earth dam without the help of soils testing laboratory or the correct use of aggregates for a concrete or masonry dam are thrilling experiences of the past when very little was known of this science. Conditions are far different now as compared to those prevalent then and it would be most emphatically emphasised to associate the research worker more and more in the River Valley Projects in the larger interests of the country. In view of the important role these laboratories are being or will be called upon to play in the economical and sound execution of the river valley projects, we in Uttar Pradesh, propagate these views through films and exhibits to the common man so that he realises at all stages of a particular project what benefits are likely to accrue with this enterprise.

CONTRIBUTION

On Betterment Levy

by

A. K. Char.

The Hon'ble Minister for Irrigation and Power, Shri Gulzarf Lal Nanda while presiding over the Symposium held at New Delhi on the determination of costs and benefits of river valley projects wanted to know particularly what practices were in vogue regarding the betterment levy in the several States of the Union. A few members particularly from the Punjab and U. P. who took part in the Symposium expressed the view that the imposition of a betterment levy was not welcomed by the people in those States. I do not profess to know the conditions prevailing in these two States to offer any comments as to their unwillingness to bear the betterment levy. Coming as I do from Mysore State in South India this question of unwillingness to bear any charges due to betterment of the lands by the owners concerned caused me some surprise. But probably the people in these two States were accustomed to get the benefits of irrigation without paying any betterment levy so far, and naturally they would not like any new imposition like a betterment levy. Probably the Government concerned found the investment on works quite a paying proposition by itself without imposing betterment levy. But in the South where the country is rather cut up the areas that would be brought under irrigation being limited it was a very difficult proposition to make any major irrigation work pay its way. If the Government had to finance such works without the sharing of the part of the cost by the beneficiaries probably many works would not have come into existence. In Mysore particularly the betterment levy which is usually termed locally as "Contribution" has been in vogue since the late nineties.

The method of fixing the contribution to be paid depended upon several factors not the least of which was to make the project viable. People there, are accustomed to represent to Government voluntarily agreeing to pay any reasonable contribution which the Government would fix and request them to undertake certain irrigation works. The payment of these contribution has been in several ways.

Normally it is in cash. It is either paid in lump sum or in easy instalments. The amount fixed as contribution takes into account firstly the assessment on the dry land which is an index of the quality of land. It also takes into account the appreciated value of the land after irrigation is brought to them. They are normally payable after the water is made available for irrigating these lands. In fact this contribution does not become due during the first year of irrigation. It is generally payable in ten equal instalments. The payment of the first instalment is spread over a couple of years such that the land owner does not feel it a very heavy burden to start with in addition to converting his dry lands into wet. In fact the payment^t of this contribution of ten instalments is spread over twelve years. If some of the landholders had the wherewithal to pay the entire sum in one instalment a rebate of 10% is normally allowed. In some cases this payment in cash has also been converted into payment in land. Particularly under the fresh canal systems which were opened up consequent upon the construction of the Krishnarajasagar Reservoir when many people had to be displaced the Government were anxious to rehabilitate them on land. It was therefore decided that one-third of the area under holding in excess of three acres should be surrendered to Government in lieu of the cash contribution payable to Government. This system worked admirably and those who lost irrigated lands under the water spread of the lake got similar lands in exchange. This was possible because of certain procedure adopted by the Government while preparing projects. When the projects are investigated and are ready for sanction the whole matter is referred to the Revenue Department of the State suggesting that this project would be taken up provided the beneficiaries from this project are prepared to pay a certain amount of contribution towards the project in addition to the usual annual water rates. The project would be sanctioned only when the acceptance of the owners in writing is obtained on 80% of the holdings benefited by the scheme. The payment of this contribution was legally binding on the owners and could even be recovered as arrears of land revenues. In case large extents of land belonging to a particular person came under irrigation he had the option to surrender part of the land to Government in lieu of contribution. This has more or less become a routine matter in the South particularly in Mysore State. No difficulty has been experienced in working out these things.

This naturally shows that the people must realise the benefits of irrigation and the need for it. When people feel that something

is being thrust on them without their asking for it probably the reluctance to pay any betterment levy comes in.

The amount of contribution referred to has a bearing on the returns from the project. Indirectly it is also related to the appreciation of the value of land and approximates to anywhere between 40 to 50% of the appreciated value.

LIST OF PUBLICATIONS ISSUED BY THE CENTRAL BOARD
OF IRRIGATION AND POWER

(Publications marked with an asterisk are out of Stock).

*1. Digest of Technical Notes, 1931 (Reprint)

A summary of views of Chief Engineers on the following subjects :—

- (i) Waterlogging and Reclamation.
- (ii) Effect of deforestation and afforestation on river floods.
- (iii) Design of works on sand foundations.
- (iv) Fluming of canal works.
- (v) Regulation at canal headworks.
- (vi) Design of canal falls.

*2. Digest of Technical Notes, 1932.

A summary of views of Chief Engineers on the following subjects :—

- (i) Waterlogging.
- (ii) Design of works on sand foundations.
- (iii) Design of canal falls.
- (iv) Staunching of canals.

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