

IRRIGATION RESEARCH IN INDIA.

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IN

INDIA



**Model studies of the Spillway of the Bhakra Dam
Shooting bucket in operation**

CENTRAL BOARD OF IRRIGATION

Popular Series

Second Edition

Leaflet No. 2

FOREWORD TO THE SECOND EDITION

The first edition of this leaflet was published in 1947 and was got out hurriedly with the information available in the office of the Board. Since then an appreciable amount of research in canal and river engineering and other allied subjects has been carried out at the Research Stations in India and outstanding advances made in many directions connected with development of river valley schemes.

An attempt has been made in this revised edition to acquaint the reader with the up-to-date development of irrigation research in India and the achievements of her engineers and other research workers in this field. Some information of interest relating to corresponding research carried out in other countries has also been added.

Crores of rupees are being spent on new irrigation and multi-purpose projects so essential for development of our country and the importance of research work for efficient and economic execution of these projects cannot be over-emphasized. It is hoped that the information contained in this leaflet will result in a better appreciation than here-to-fore, of the research work being done in India in connection with the conservation and utilisation of India's water resources and of the usefulness of the comparatively small expenditure being incurred on this important aid to engineering construction.

S. L. MALHOTRA,
Secretary.

KENNEDY HOUSE,
SIMLA,
October 1, 1950.

FOREWORD TO THE FIRST EDITION

In this leaflet, an attempt has been made to acquaint the readers with what is being done in connection with irrigation research in India. Details of the highly technical work may not interest all, but a general knowledge of what has been achieved in the country and what is being done for the optimum utilisation and conservation of the water resources of the country should, no doubt, be available to every citizen.

Details about individual experiments or of work done on different subjects are available in the office of the Secretary, Central Board of Irrigation and the undersigned will be only too glad to furnish further information to those who feel interested.

N. D. GULHATI,
Secretary.

KENNEDY HOUSE,
SIMLA,
5th January, 1947.

IRRIGATION RESEARCH IN INDIA

THE NEED FOR RESEARCH

“Nature to be commanded must be obeyed”. To construct works, “all that man can do is to put together or to put as under natural bodies. The rest is done by nature working within”. “Human knowledge and human power meet in one; for where the cause is not known, the effect cannot be produced. Nature to be commanded must be obeyed; and that which in contemplation is as the cause is in operation as the rule”. These are words of Francis Bacon who “elaborated the basic philosophy of modern science; test every thing by experiment, accept nothing that cannot be corroborated by experience”.

To harness the forces of nature for the benefit of mankind, it is evidently essential that the manifestations of nature must be studied and examined in all their implications. Research is the modern method of probing into the mysteries of Nature and unfolding them. The word “Research” has been derived from two Latin words ‘*re*’ meaning again, and ‘*circare*’, to go round. Research, therefore, literally means going around in circles and connotes continuity. Scientific approach and critical analysis of specific problems lead to basic research; and the achievements of basic research, in turn, open the vista of new specific problems. Thus the unending cycle of research continues inviting endless effort.

Research is playing a very important role in the present age in all spheres of man’s activities. For example, the development of penicillin and the benefits which it has brought to mankind can hardly be over-stressed. The atomic energy, it is said, if used as a creative power, can work wonders in every walk of life; the greatest handicap to aviation—the weight of fuel, will disappear, as a pound of atomic energy is equivalent to 10 million pounds of petrol. Scientists can plan a trip to the moon and think of achievements considered impossibilities some time back. Research is endless and a research worker has always been described as a learner.

It has been aptly remarked that “The Irrigation Engineer serves a hard and unforgiving mistress and water will seldom forgive any small miscalculation or mistake in the design or construction of works”. Irrigation problems are complex and most of them are not susceptible to correct mathematical treatment. It is only through model experiments and research that the improvements in the existing works, safe and economical design and construction of new works, and furtherance of knowledge on various aspects of irrigation science can be effected. To build weirs, dams, embankments, bridges, falls, silt excluding devices and other hydraulic structures, the engineer is increasingly dependent upon the conclusions drawn from experimental investigations.

In fact research of this nature has become almost a branch of engineering itself and it is considered fool-hardy to embark on any major project without its aid.

ECONOMY EFFECTED BY RESEARCH

It is perhaps not generally known that research pays heavy dividends. A small improvement in a particular device may result in huge savings. It has been estimated ⁽¹⁾ that the gas filled lamp, developed by Langmuir, represents an annual saving in the domestic lighting in Britain alone of 50 million pounds. The improvement in the efficiency of the petrol engine due to lead ethyl saves over 2,000 million gallons of petrol a year. The use of accelerators for vulcanizing rubber has saved capital outlay on moulds estimated at 16 million pounds. Research on motor tyres has increased their average life from 3,000 miles to over 20,000 miles.

What irrigation research has meant to India can be gauged from the fact that the estimated savings by research carried out at Poona in connection with the Sukkur Barrage and Canal construction (now in Pakistan) exceeded Rs. 60 *lakhs* and that on the Deccan Canals exceeded Rs. 40 *lakhs*. Considerable savings have been made on the design of individual works as a result of model experiments. The original design of silt excluder at Tajewala contemplated the construction of a shingle and silt ejector in the head reach of the Western Yamuna Canal. Model experiments showed that a simple and efficient type of excluder consisting of only two tunnels could be constructed in the river in front of the Head Regulator. This resulted in a saving of approximately Rs. 5 *lakhs*.

In U.S.A. ⁽²⁾ the research laboratories of the Bureau of Reclamation showed a direct monetary saving of \$20 millions during the 17 years of the laboratories' operations. Some of these savings came in big lumps. A less conservative design of the Grand Coulee Spillway made possible by laboratory studies saved five million dollars and the decision to leave a portion of the Friant-Kern Canal unlined, made possible by geological studies, saved two million dollars. It is stated that in connection with the selection, utilization and control of concrete materials alone, the Bureau of Reclamation has obtained concrete of the required quality with at least one-tenth of a barrel less cement per cubic yard. During the laboratories' period of existence, this represents a saving on 30 million cubic yards of concrete placed during that period, of \$6.75 million.

In addition to direct monetary savings on works, other benefits of research include the adoption of improved methods and technique

⁽¹⁾ Hellstrom, J. Edwin "Record and Research in Engineering and Industrial Science."

⁽²⁾ Blank, F. Robert, "Tool for better Engineering, Engineering News Record, September 18, 1947."

on new projects, more efficient, more durable and safer structures and the general advancement of engineering and scientific knowledge for the good of the world at large.

HYDRAULIC RESEARCH IN OTHER COUNTRIES

Before describing the work done in India in the field of irrigation (including hydraulic) research, it would be interesting to refer briefly to what is being done in other countries in this respect.

UNITED STATES OF AMERICA

U.S.A. has over one hundred hydraulic laboratories out of which 62 belong to universities and colleges, 36 are owned by the Government and 7 by private firms. The Federal Government Departments which carry out research include the Bureau of Reclamation and Corps of Engineers and Independent Federal Agencies like the T.V.A.

The Bureau of Reclamation has its research and Geology Division at Denver. The achievements of the Bureau in the laboratory include development of more durable concrete, better cement, improved paints, new technique of testing materials and cavitation free hydraulic structures. The expenditure of the Research and Geology Division in the fiscal year 1949 approximated \$1,350,000. The Bureau also undertakes design and model experiments on behalf of other foreign governments. A large number of engineers and students from several countries are trained at the Bureau.

The Corps of Engineers has seven research stations, the biggest being the Waterways Experiment Station Vicksburg which has made numerous contributions to the knowledge of hydraulic engineering.

The Tennessee Valley Authority has its laboratories at Knoxville where experiments are carried out as an aid to the design and construction of new works and improvements of existing ones.

The Universities in U.S.A. are mainly concentrating on basic research, while the objective of the design organisations is applied research.

FRANCE

The most important Hydraulic Laboratory in France is at Grenoble owned by the *Ateliers Neyret-Beylier and Piccard-Pictet*, staffed with some eighty fully qualified engineers of whom 12 work in the library alone for reference work. This laboratory which has an annual expenditure of about Rs. 23,00,000, is run on commercial lines and undertakes experiments on behalf of various organisations. An im-

portant feature of this laboratory is that in all research of an applied nature, a provision to the extent of 10 per cent of the cost is made for fundamental research which sum is placed at the disposal of the Director. The Central National de la Recherche Scientifique (CNRS) established in 1936, co-ordinates the research work, pure as well as applied, of all organisations in France. Among the other important hydraulic laboratories in France are Laboratoire Central d'Hydraulique, Electricite de France, Service des Etudes et Resherches Hydrauliques Institute de Mecanique des Fluides des Toulouse.

UNITED KINGDOM

Hydraulic Research has mainly been carried out in Universities and Colleges. The more important Laboratories include Hawksley Hydraulic Laboratories of the City and Guilds Engineering College and Whitworth Engineering Laboratories. Recently a Hydraulic Research Station has been started under the auspices of the Department of Scientific and Industrial Research, under Sir Claude Inglis, the late Director of Poona Station in India.

OTHER COUNTRIES

Hydraulic research in most countries is carried out either by the Universities, Colleges, and State Departments or by individuals and industries. The number of hydraulic laboratories in other countries that report their activities for publication in the Bulletin issued by the International Association for Hydraulic Research are :

Belgium—4, Denmark—2, Hungary—1, Ceylon—1, Pakistan—2, Indonesia—1, Italy—3, Norway—1, Palestine—1, Holland—2, Portugal—2, Syria—1, Switzerland—2, Sweden—6, Czechoslovakia—2, and Tunis—1. The number in Russia and Germany, though not known, is appreciable.

GROWTH OF IRRIGATION RESEARCH IN INDIA

Irrigation has been practised in India since times immemorial, and works built many centuries ago bear witness to the acumen of the ancient people of the land. Especially the irrigation works built during the last one hundred and fifty years, have advanced the Irrigation Science in India to a high degree of perfection. The total area irrigated annually in India now exceeds 50 million acres, and is greater than that in any other country of the World. It was but natural therefore, that the extensive works built in recent times should have led to considerable growth of technique and knowledge on the subject. The development of irrigation technique and connected research may be split into two parts :

1. *Ad-hoc* Research.
2. Organised Research.

AD-HOC RESEARCH

The great irrigation works that were constructed in India in the nineteenth century were designed when the Science of Hydraulics and Irrigation Engineering was in its infancy. Mistakes were made and had to be corrected over a long period of trial and error. Some of the works as designed could not withstand the destructive action of flowing waters, and the damage done had to be repaired, year after year, on improved lines. Problems as they arose were overcome by dogged persistence and shrewd commonsense which had to be substituted for correct scientific knowledge.

Irrigation Research in India had humble beginnings. Individual officers interested in the development of the subject and anxious to solve correctly the problems with which they were faced THOUGHT, OBSERVED AND CONCLUDED. Roorkee Professional Papers on Indian Engineering (1863—1886) and the proceedings of engineering associations in the country give sufficient evidence of the keen interest taken by some engineer officers in developing, as best as could be done without the aid of modern research technique, the theory of flow of water in artificial earthen channels, measures for the improved distribution of water and the design of hydraulic structures.

The construction over a hundred years ago, of the Solani Aqueduct of the Ganga Canal and the 35 feet high embankments on both sides of the Aqueduct, are examples of technique which rank with modern developments. The Ogee type fall originated on the same canal and in 1864 were initiated fundamental ideas on the causes of silting and scouring. Practical tables of mean velocities and depths were evolved for Northern Indian Channels. The importance of these tables can be judged from the fact that the velocities given therein differ but slightly from the safe limiting velocities advocated by Kennedy many years after.

Cunningham (1874—1879) did valuable work in connection with methods of measuring discharges, and determining velocities. Other works of Cunningham include investigation of "Stability and strength of masonry well foundations in quick sand". Further developments of the time include 'Action of falling water', 'Irrigation duty of water and the principles on which its increase depends' and 'Percolation of water through sands'. Experiments on the training of rivers by means of embankments with a system of groynes placed at right angles to them and projecting in the river were also conducted about 1880.

In the closing years of the nineteenth century, the work of Colonel Clibborn consisting of experiments on percolation through sand was of an outstanding importance. He established that the upthrust on the downstream floors of weirs on sandy foundations varied with the hydraulic gradient. His other contributions include investigation on sub-soil waters/ He found that the replenishment of ground water in the Gangetic Plains was mainly due to rainfall in the area and other local causes and that the velocity of flow in the ground water was so low that heavy rainfall on distant areas in the Himalayan foothills had little effect. He worked out that the velocity of ground water was of the order of one mile per year.

✓ In 1895 Kennedy propounded his classical equations connecting depth and velocity in a channel as a result of his experiments on the Upper Bari Doab Canal in the Punjab. Experiments were carried out in Madras on determination of duty and coefficient of discharge for weirs, *anicuts* and sluices /

The rapid extension of irrigation early in the twentieth century brought with it a host of connected problems on more economical design of hydraulic works, silting of channels, equitable distribution of water, weed growth, efficient drainage of irrigated tracts, waterlogging etc. Individual officers pondered over these problems as they arose, and developed new methods and devices which were tried in the field. Several new types of outlets were invented. The theory of Kennedy regarding design of channels was developed further. The design of hydraulic structures, big and small, underwent gradual evolution. ✓ The proceedings of the Institution of Engineers (India), the Punjab Engineering Congress and other local engineering organisations provide sufficient evidence of the keen interest taken by successive generations of irrigation engineers in advancing knowledge on the science of irrigation. As the problems multiplied it became imperative to establish regular research stations in the country as an aid to the engineer for the maintenance, design and construction of irrigation works. /

✓ ORGANISED RESEARCH

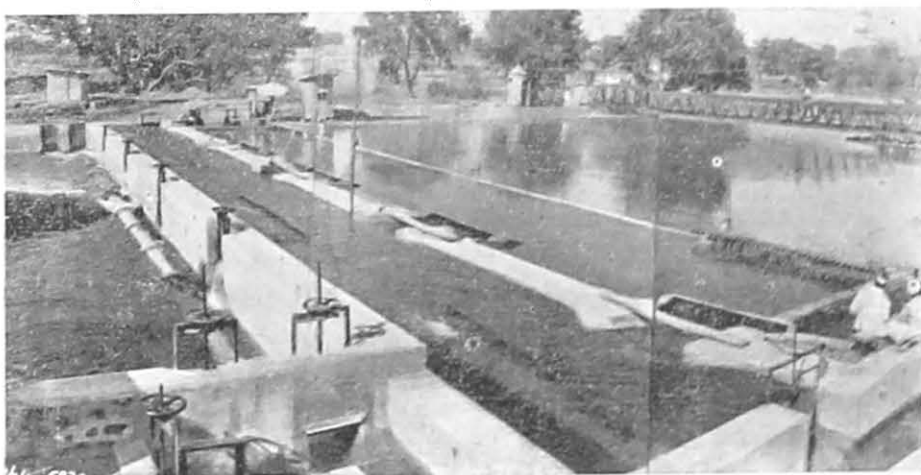
Experimental research in India, in connection with irrigation, is of a recent origin. The first in the field was Bombay, where a special Research Division was created in 1916 by the Bombay Public Works Department, to carry out research into local problems on land drainage and reclamation. Subsequently in 1920, a hydrodynamic research station was opened on a small distributary near Poona. By 1925, the activities of the Research Station developed enormously and the water

supply available for model work was found inadequate. The Station was, therefore, shifted to Khadakvasla below the Khadakvasla Dam where ideal conditions for constructing a hydrodynamic station existed. This station was taken over by the Central Government in 1937 with a view to extending its facilities to all parts of the country. Bombay, however, continued to maintain a separate research station where, *inter alia*, local problems on irrigation continue to be studied.

After 1945 the activities of the Central Research Station at Khadakvasla increased manifold as many projects were taken in hand in various parts of the country and more and more problems were referred to it. In order to cope with the increased research work, the station was reorganised in 1947 and renamed Central Waterpower, Irrigation and Navigation Research Station (CWINRS) to include the following nine sections :—

- (i) River and Canal Hydraulics, (ii) Navigation (iii) Soil and Soil Mechanics, (iv) Concrete and Materials of Construction, (v) Mathematics, (vi) Statistics, (vii) Physics, (viii) Chemistry and (ix) Hydraulic Machinery.

During the last 33 years of its existence, over 1,500 experiments have been carried out relating to river training, design of channels and hydraulic works, navigation, soil and agricultural problems.



CWINRS—A view of the Hoogly Estuary Tidal Model

After Bombay the next in the field was Punjab where the menace of waterlogging and deterioration of land by salts, developed to an alarming degree. Investigations were started in 1925 and gradually a hydraulic laboratory was established at Lahore which developed into one of the finest Research Institutions in the World with a large field station at Malikpore near Pathankot. The partition of the Punjab in 1947 left East Punjab with no research station except for the field Research Station at Malikpore. No time was, however, lost in setting up a new Research Institute with headquarters at Amritsar. During its short life of three years the new Institute has developed considerably and it will not be long before it reaches the same standard as the Lahore Institute. The Institute is concentrating on the problems relating to Bhakra-Nangal Project and on other new schemes and existing works.

Irrigation Research Station in Uttar Pradesh was established in 1930 at Lucknow and subsequently shifted to Roorkee with a field station 10 miles away at Bahadarabad. A large amount of work has been done at this station on various problems including calibration of flumes and falls, study of non-silting distributary heads, fluming of structures, water requirements of crops, earth dam construction, river training, and sub-soil supplies available in different doabs in the western districts of Uttar Pradesh.

In 1931, THE CENTRAL BOARD OF IRRIGATION was set up to co-ordinate research work in the counting and an impetus was given to irrigation research by the annual meetings of research officers and chief engineers in which the research work carried out during the year is discussed, knowledge and information pooled and further programme chalked out. Extracts from research reports of Irrigation Research Stations, other papers and discussions are published in the Annual Report (Technical) of the Board. The Board maintains one of the finest libraries on irrigation, hydro-electric and other subjects where enquiries from engineers in India and abroad are dealt with. The Board also publishes a two-monthly Journal, Monthly Abstracts of the literature received in the Library, Popular series Leaflets and treatises on various technical subjects.

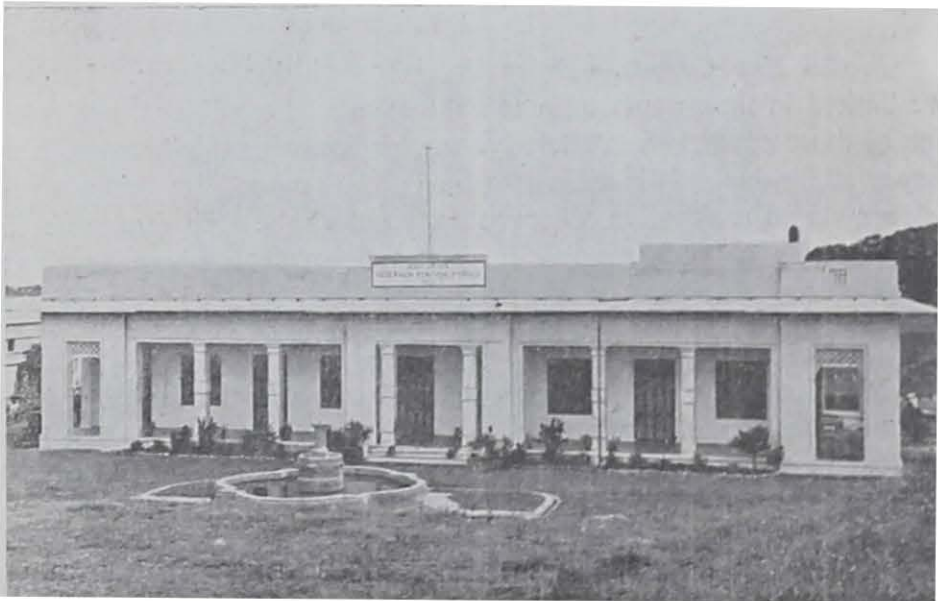
THE RIVER RESEARCH INSTITUTE, WEST BENGAL was set up in 1943 and comprises River Model Station at Galsi, Tidal model Station at Belgharia, Soil Mechanics Laboratory at Russa and

Statistical Laboratory at Anderson House, Alipore. It has got a number of hydrological river gauging stations under its control in the Damodar, Mor, Selye, Cossye and Darkeswar Valleys and also in connection with the Ganga Barrage Scheme.

✓ THE KRISHNARAJASAGAR RESEARCH STATION in Mysore was established in 1945 immediately below the Krishnarajasagar Dam on the Cauvery. Important experiments on various aspects of the design of the volute siphon continue to be conducted at this Station in addition to other hydraulic experiments.

✓ THE HYDERABAD ENGINEERING RESEARCH DEPARTMENT was started in October, 1945 to study the engineering problems of the State relating to irrigation, roads, buildings and housing.

✓ THE IRRIGATION RESEARCH STATION POONDI (MADRAS) was set up in 1945 and carries out investigations with the aid of hydraulic models relating to problems on hydraulic structures, river training, flood control *etc.*



A view of the Irrigation Research Station Poondi.

✓ THE SOIL ENGINEERING RESEARCH STATION, CHEPAUK (MADRAS) is engaged in conducting soil tests on material to be used in different engineering structures and in foundations. The

Laboratory has also been developed as a standard laboratory for testing engineering materials such as lime, cement, *surkhi*, aggregate for concrete *etc.*, especially as regards their physical and chemical properties. The Laboratory is also engaged in conducting detailed soil surveys and preliminary geological surveys of dam sites under contemplation.

✓ THE CONCRETE LABORATORY, CHEPAUK (MADRAS) is equipped for carrying out tests on the various properties of cement and concrete, in connection with modern methods of construction.

The Hiraikud Research Station has recently been established at the site of the Hiraikud Dam at Sambalpur (Orissa) to deal with all local problems arising during the construction of the dam.

PRESENT ACTIVITIES

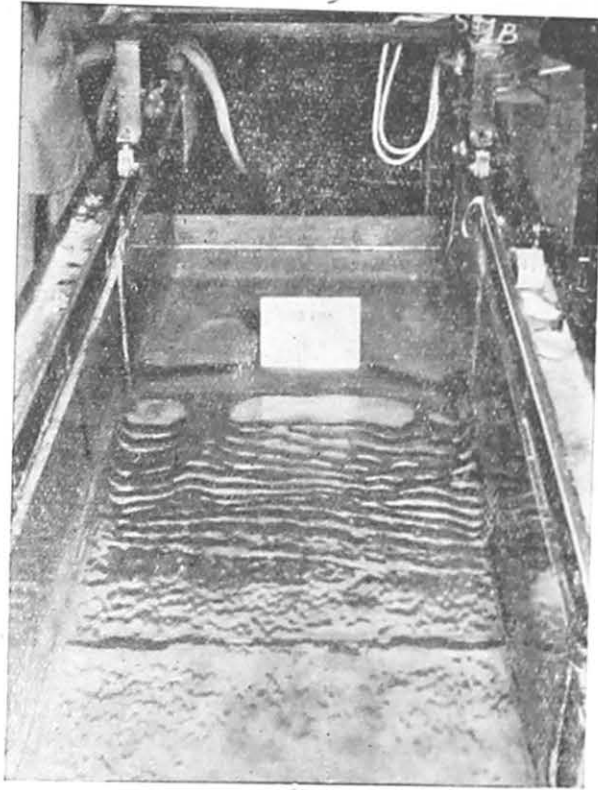
Among the numerous problems which are referred to the Irrigation Research Stations in the country, the following may be mentioned :

Model Experiments.—Hydraulics is an elusive science. Its laws are limited in their application to definite sets of conditions, and when one of those conditions is altered, a law perfectly good otherwise, is no longer applicable. It is difficult to avoid the tendency to apply a rule or formula to a situation where it does not apply. To overcome the consequences of such tendencies, hydraulic structures are first examined on models where an attempt is made, as best as possible, to simulate conditions that exist in the original or the prototype.

Model experiments are thus employed to verify the design of large structures and these experiments give such useful indications that have resulted in the past in considerable savings as compared to the small sums spent on the model experiments.

Model experiments are particularly useful for river protection works. The laws relating to the behaviour of rivers under different conditions are so little known, that the only possible method of tackling river problems is by recourse to these experiments, and their application even, is limited by the extent to which it is possible to simulate the natural conditions on the models.

Silt Investigations—Silt or detritus in flowing water is at once the bane and blessing of the canal engineer and plays a very important part in his every day work. Silting and scouring of irrigation channels, silting of reservoirs, and meandering of rivers are some of the manifestations of the silt problem with which the irrigation engineer is directly concerned and a considerable amount of research is carried out on the analysis of silt, the capacity of different kinds of channels to carry varying silt loads and the effect of silt on the behaviour of rivers.

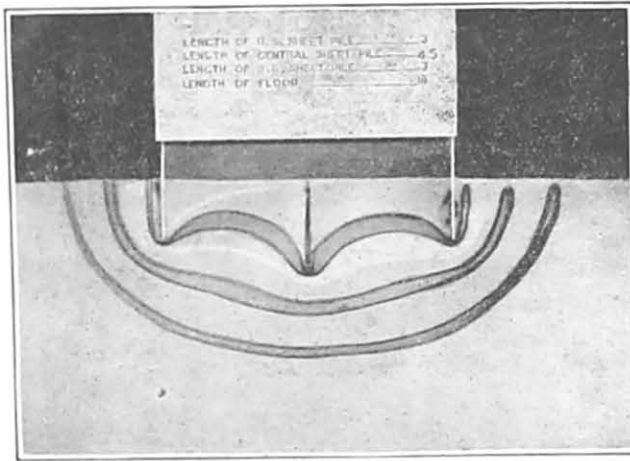


Model experiments on silt-exclusion

Design of channels—The determination of the most economical size and shape of earthen channels for carrying irrigation supplies charged with different silt loads is another problem that constantly engages the attention of the research stations.

Works on sandy foundations—Good rock and strong foundations are not always available for all massive structures. Many of the large irrigation structures particularly in the plains of Northern India have to be built on sandy foundations liable to scour and permeable to the

flow of water. Not an inconsiderable time of the research stations is devoted to basic research in connection with the design of such structures and to the study by model experiments of measures proposed for the safety of existing works on rivers and canals.



Lines of sub-soil flow under a weir on account of hydraulic head as seen in a model

Soil Science—Soil science is now engaging close attention of irrigation research stations, from the agricultural aspect, for the reclamation of salt lands, in connection with the rise of water table, for determining the bearing capacity in connection with foundation loads, for the consolidation of earth dams and embankments and for compaction of subgrade under lining of channels.

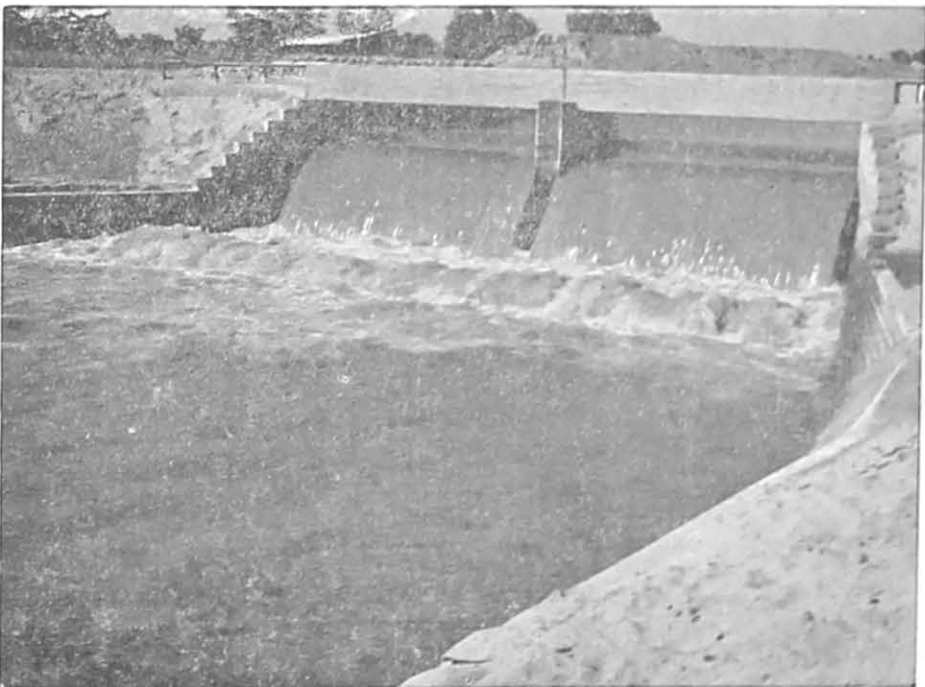
There are many other activities of the research stations, and the exhaustive list of subjects for research prepared by the Central Board of Irrigation includes various aspects of hydraulics, hydraulic machinery, hydraulic structures, river training, silting of reservoirs, water-logging, navigation, soils, cements, materials of construction, applied physics, photoelastic studies, physical chemistry, higher mathematics, statistics and agriculture, including water requirements of crops.

SOME ACHIEVEMENTS

The reader would, no doubt, like to know some of the outstanding achievements of irrigation research carried out in India whether as a result of experimental investigations in the research institutes or by individual officers who have made special observations and investigations on specific problems



Inglis type fall



C.D.O. Type fall

One of the first problems on which a solution was furnished was the design of earthen irrigation channels. Since 1895 when Kennedy propounded his empirical equation connecting velocity and depth, this subject has been engaging the closest attention of engineers in India and abroad. The latest in India are the attempts of Lacey who made further studies on the subject and published new formulae for design of stable channels in alluvium. Though finality has not been reached as yet, it is possible to design channels with some confidence which would neither silt nor scour.

Another problem on which India has made a very valuable, original and conspicuous contribution is the latest theory on sub-soil flow, propounded by Khosla for the safe design of hydraulic structures on sandy or permeable foundations which is contained in the World renowned Publication No. 12 of the Central Board of Irrigation. India gave the World the initial and later the final theory of the design of such structures.

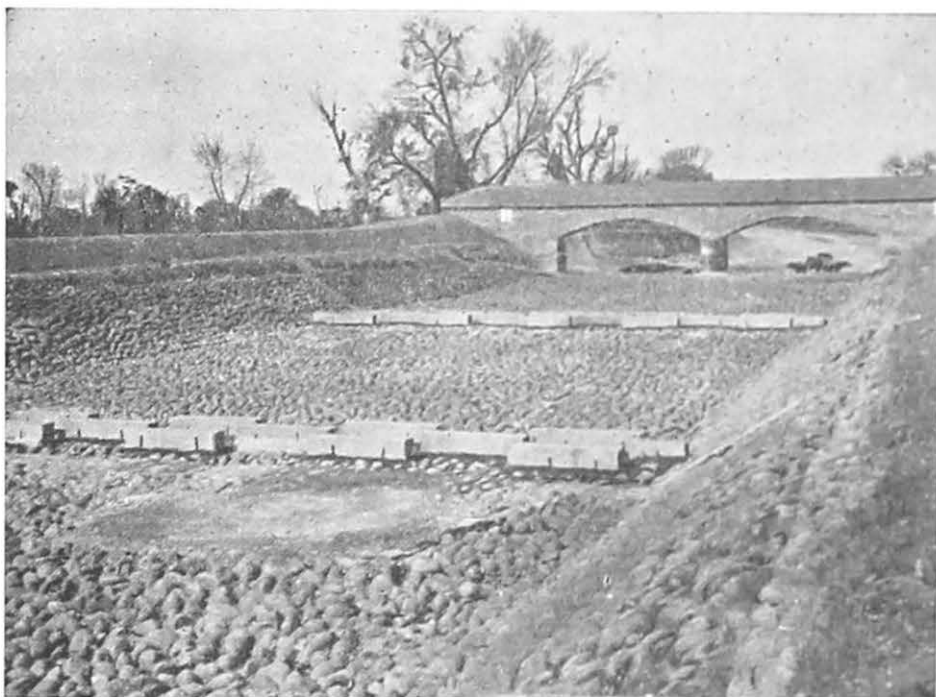
Four designs of canal falls have been developed and are extensively adopted on irrigation canals all over the country. These are, Montagu, Inglis, Sarda and C.D.O. Punjab types.



Montague Type Fall

Dissipation of energy of falling water below hydraulic structures constructed on sand or gravel foundations is one of the complex pro-

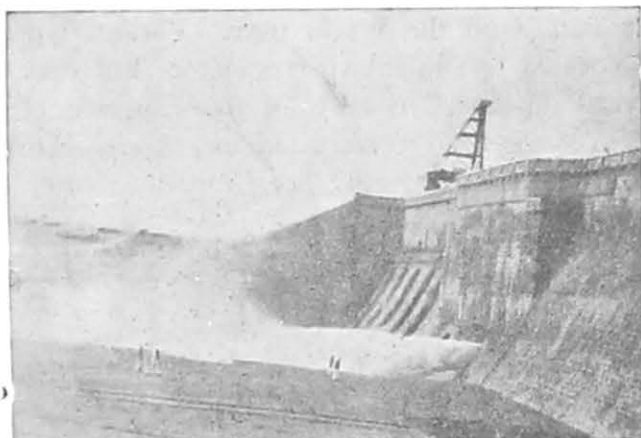
blems in hydraulic engineering and has been the subject of investigation by hydraulicians all the World over. Various types of devices have been advocated by different investigators but one of the most successful devices developed consists of the staggered blocks. These staggered blocks have been constructed extensively below works on rivers and canals in India and have been very successful.



A downstream view of the Islampur Feeder, showing rows of staggered blocks (U.B.D.C.)

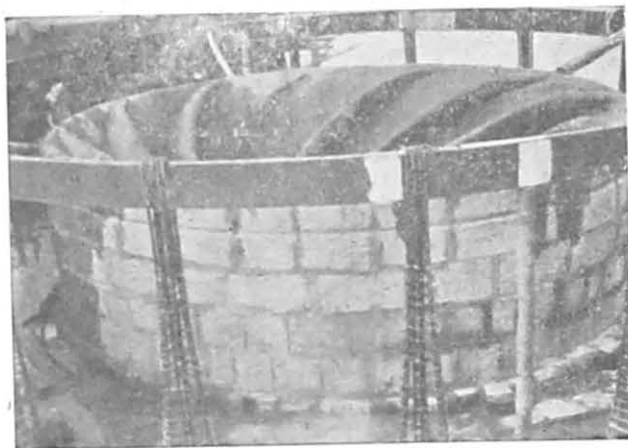
The devices for exclusion of detritus from entering the canals and further its ejection from the canals have mainly been developed in India and particularly in the Punjab. Most efficient and effective designs of silt excluders and ejectors have been developed, constructed and tried with success on some of the canals which suffered from silt trouble.

The problem of training of rivers in India has engaged the closest attention of the engineers and various types of training works depending upon local conditions have been evolved and comprise pitched islands, different types of groynes—permeable, impermeable, attracting, repelling *etc.* These devices have evoked considerable interest in other countries.



Marconahally Volute Siphon in action

More recently Shri Ganesh Iyer, Director, Mysore Station has evolved a new type of siphon known as Volute Siphon, for the automatic release of flood surplus water from storage reservoirs. This new device is still under perfection and may revolutionise the present conception of the design of spillways for storage reservoirs. Research



Volutes on the bell-mouth of the Marconahally Siphon

workers all over the country are busy tackling the local problems and devising equipment and apparatus to meet their requirements. Mention may be made of efforts to invent suitable types of current meters, silt samplers and soil mechanics equipment.

The use of *kankar* lime and *surkhi* indigenous materials to replace cement, which is in short supply is being developed in the construction of hydraulic structures. *Surkhi* reduces the heat of hydration. The Krishnarajasagar and many other dams in the South have been built with this mortar.

Many outstanding contributions have been made by India to the design of canal structures of all kinds and of these perhaps the most important is the automatic (without manual control) and equitable distribution of water on a scale not known elsewhere in the world. The use of cement soil blocks as protection works is a recent advancement, which has possibly a good future.

In all directions, new methods, new apparatus and new equipment are being devised for use in experimental research and in the field, and the research organizations are justifying their existence and demand for further expansion. The following extracts from an issue of "Engineering" a weekly Journal of London, show the opinion of the foreigners regarding the irrigation research being done in India :

"The irrigation engineers of India are making a strong bid for pre-eminence in the field of river and canal engineering, and it seems that Vicksburg, Delft and Manchester will have to look to their laurels; the latest (tenth) annual technical report of the Central Board of Irrigation, covering the year 1944 and published in Simla in August 1945 (though it has reached us only within the past month), displays a picture of organised research which is almost as admirable as the joint work of the American, British and Canadian men of science in their successful production of the atomic bomb.

"Great emphasis is placed on the use of models and the comparison of these models with their natural prototypes, but much attention is given also to the comparison of rivers of various sizes, the accumulation of hydraulic data of all kinds, and the diligent pursuit of valid generalisations.

The wide meteorological variations in India, the enormous falls of the major rivers, the extensive demands of irrigation, the extent to which large streams can meander and even change course and the geological diversity make that country a perfect site for hydraulic investigation. It is highly gratifying to see that every advantage is being taken of the opportunities afforded".

✓ FINANCING OF RESEARCH

The Irrigation Research Stations in India are solely financed from Government funds, and the total annual expenditure at present is between rupees 20 to 30 lakhs. The modern is an era of specialization by research and the Governments in India are fully alive to the importance of research for the optimum utilization of the natural resources of the country. It cannot, however, be denied that at times Governments have to tide over economic crisis by curtailing expenditure all round. At such times, the axe is likely to fall on such of the activities of research which cannot be justified as of immediate importance. This is liable to break the continuity, which is so essential for research work.

Again, individual officers or politicians who have to carry out the policy of the Government are unfortunately liable to overlook the importance of research work in national development and apply the axe unproportionately. It is, therefore, in the interest of research and of the country that separate non-lapseable research funds should be created as early as possible and research placed on sounder footings, immune from general cuts. In view of the importance, since 1948 the question of creating such research funds in each state has been under the active consideration of the Central Board of Irrigation, and information regarding financing of research in different countries has been collected. It is proposed to recommend that a percentage cess be levied on all capital and maintenance expenditure on irrigation and hydel works and to fund it for research connected with irrigation, flood control and water power developments *etc.*

✓ A FEW SUGGESTIONS

Projects worth *crores* of rupees are under construction, investigation or contemplation. The investigations and model experiments in connection with them have and will still further increase the activities of research stations. Many more new research stations may have to be established. Keeping this in view it is essential to train the personnel ahead of requirements and it is hoped that the departments concerned will keep this in view. Needless to stress that all research stations should be well equipped and adequately staffed.

✓ At present most of the research work carried out in our research stations is of an applied nature and there is little scope for basic research. As is the practice in other countries basic and applied research should go side by side, so as to derive maximum benefit from both. It is, therefore, recommended that the annual budgets for the research stations should include adequate provisions for basic research.

✓ In other countries most of the basic research is done in Universities and Colleges, while in India, engineering research is prominent and conspicuous by its utter absence from educational institutions.

✓ It is essential that Universities and Colleges be encouraged and provided with facilities for this type of research and the professors should associate senior students in the research work. It will indeed be very helpful in advancing research and producing research workers if in future irrigation research stations are located at the seat of Universities and Engineering Colleges.

✓ Many of our bright youngmen prefer to join administrative departments rather than research organisations. The reasons for this outlook are not far to seek. The status, pay *etc.* of the research workers require to be much improved and brought at par with other professions before suitable talent can be attracted to this line. Research requires peaceful mind. A research worker who is always worried about his financial liabilities cannot perform his duties efficiently. The crux of the problem is that it is essential that something must be done to improve the status of the research workers, and to provide them with better pays and amenities of life. Further, facilities should be there for every capable research worker to rise to the highest rung of the ladder in his line.

✓ CONCLUSIONS

The reader will appreciate that our contribution to the advancement of irrigation science is well known all the World over and in view of the importance of irrigation works to our country we must continue efforts in research with renewed vigour. This is possible only with sound finances, and efficient and willing personnel for research and co-ordination with institutions for technical education.