



**ADVANCE REPORT OF THE
SELECTED BUILDINGS PROJECTS
TEAM**

ON

**THE HEAVY ELECTRICAL PROJECT, BHOPAL
THE FERTILIZER PROJECT, NANGAL**

COMMITTEE ON PLAN PROJECTS

NEW DELHI

APRIL, 1958



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NEW DELHI**

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Composition of the Committee on Plan Projects for Public Works and Buildings Sector of the Second Five Year Plan

Chairman

Shri Govind Ballabh Pant, Union Minister for Home Affairs.

Members

Shri V. T. Krishnamachari, Deputy Chairman, Planning Commission.

Shri Morarji Desai, Union Minister for Finance.

Shri Gulzarilal Nanda, Union Minister for Planning, Labour and Employment.

Shri K. C. Reddy, Union Minister for Works, Housing, and Supply.

Shri N. Sanjiva Reddy, Chief Minister, Andhra.

Dr. B. C. Roy, Chief Minister, West Bengal.

Secretary

Shri Indarjit Singh, Joint Secretary (Economy), Union Ministry of Finance.

Composition of the Team for Selected Buildings Projects

Leader

Shri S. K. Patil, Union Minister for Transport and Communications.

Members

Shri Sarup Singh, I.S.E. (Retd), formerly Director, National Buildings Organisation.

Dr. Eng. A. Carbone, MIABSE, Consulting Engineer, Calcutta.

Shri C. P. Malik, Director, National Buildings Organisation. (*ex-officio*)

Secretary

Shri T. S. Vedagiri.

General H. Williams, Director, Central Building Research Institute, Roorkee, has also kindly agreed to attend meetings of the Team and the Panels as and when he can spare time. He has, however, placed the facilities of the Central Building Research Institute at the disposal of the Team.



**Minister of
Transport & Communications
India**

New Delhi, April 16, 1958

My dear Pantji,

I forward herewith an advance report of the Panel for factory buildings. You will be glad to find that the major conclusions of the Panel have been accepted by the authorities concerned. The Team has also been requested to help the authorities of the Heavy Electrical Project at Bhopal in evolving a suitable design for future phases of construction.

The Team for Selected Buildings Projects was closely associated with the work of the Panel. It has reviewed the report and is in agreement with it.

With regard to the industrial estate, the Team is considering the formulation of standard patterns of designs and specifications which will help in the speedy and economical execution of such schemes. Full particulars of these will be given in the final report of the Team in respect of factory buildings and industrial estates.

I take this opportunity of thanking the various Project Authorities for their cooperation in supplying the information required by the Team and for the facilities that they have accorded for on the spot studies.

Yours sincerely,

S. K. PATIL.

**Shri Govind Ballabh Pant,
Chairman, Committee on Plan Projects &
Minister for Home Affairs, Government of India,
New Delhi.**

Advance Report of the Selected Buildings Projects Team on
(1) The Heavy Electrical Project, Bhopal; and
(2) The Fertiliser Project, Nangal.

CONTENTS

REPORT	Page
1. Background	1
2. Heavy Electricals Project, Bhopal—Observations and Conclusions	3
3. Fertiliser Project, Nangal—Observations and Conclusions	5
APPENDICES	
I. Heavy Electrical Project, Bhopal, Conclusions of the Sub Committee on the scope of economy that could be effected in the various items of work	8
II. Heavy Electrical Project Bhopal, Minutes of the meeting held in the room of Shri Indarjit Singh Secretary, Committee on Plan Projects on 22nd March, 1958	12
III. Heavy Electrical Project, Bhopal—Effects of conclusions on cost and materials	14
IV. Fertiliser factory, Nangal. Statement showing saving in cost and materials	15
V. Heavy Electrical Project, Bhopal. Note on alternative design.	16

**ADVANCE REPORT OF THE BUILDINGS PROJECTS
TEAM ON THE HEAVY ELECTRICAL PROJECT
AT BHOPAL AND THE FERTILISER
PROJECT AT NANGAL.**

Background

1.1 The Buildings Projects Team in its meeting on the 29th March, 1957 decided to take up factory construction as one of the items for detailed study. A Panel composed of the following was set up for this purpose:

1. Dr. Eng. A. Carbone, Consulting Engineer, Calcutta.—*Chairman.*

Members

2. Sardar Sarup Singh, ISE (Retd) Member—Chief Engineer, Buildings Projects Team.
3. Shri N. S. Mankekar, Chief Adviser of Factories, Ministry of Labour.
4. Shri H. D. Avasthy, Director (Civil Engineering) Railway Board.
5. Shri O. Muthachan, Superintending Engineer, C.P.W.D.
6. Prof. G. S. Ramaswamy, Asstt. Director, C.B.R.I., Roorkee.
7. Shri T. S. Vedagiri, Secretary, Buildings Projects Team.—*Member-Secretary.*

1.1.2 The Team also decided that the Panel should take up evaluation of some of the factory buildings which have been completed and some others which are in the process of planning and execution.

1.2 The Panel issued a questionnaire to authorities in-charge of various factories in order to collect information on the type of structure adopted, cost of construction, consumption of essential materials like steel and cement etc. The information received from the Heavy Electrical Project at Bhopal showed steel consumption at 31.3 lbs. per sft. of factory area. This obviously is a very high figure. In the meeting held on the 15th January, the Panel set up a Sub-Committee consisting of Dr. Carbone, Sardar Sarup Singh, Shri N. S. Mankekar and Shri T. S. Vedagiri for discussing the case with the Project Authorities and collecting more information necessary for further study.

1.2.2 The Sub-Committee met the Project Authorities at Bhopal on the 16th January, and from the information gathered the Sub-Committee came to the conclusion that considerable economies could be achieved by a functional approach in laying down specifications for the building and by redesigning the structure according to the latest techniques. Appendix I gives in a tabular form the conclusions of the Sub-Committee and the scope of economy that could be effected in the various items of construction without affecting the utility value of the building.

1.2.3 The Report of the Sub-Committee was considered by the Panel in its meeting on the 23rd January, and a note containing the observations of the Panel was sent to the Ministry of Commerce & Industry. A meeting to consider this note in detail was convened by Shri L. K. Jha, ICS, Special Secretary, Ministry of Commerce & Industry on the 1st February, 1958. This was followed by further discussions with the consultants and the Managing Director of the factory. Final decisions were arrived at in the meeting held on the 22nd March. A copy of the minutes of this meeting is attached as Appendix II of this report.

1.2.4 A brief survey of the items taken up by the Panel and the conclusions arrived at are given in para 2. The impact of the agreed modifications on the cost and consumption of materials is given in Appendix III. Briefly it may be stated that there would be a saving of about Rs. 42 lakhs in cost, 2,240 tons in structural steel and 2,720 tons in cement in the first phase of construction. The saving in phase II would be of a much larger order.

1.3 While the Panel was examining the Bhopal Project, the Finance Ministry requested that the plans and estimates of Nangal Fertiliser Project should also be taken up for study. Relevant papers were collected on 1st February, 1958 and the Panel had the opportunity of consulting Prof. Nervi, a great Italian Structural Engineer, who happened to be in India at that time.

1.3.2 The preliminary observations of the Panel were sent to the Project Authorities on the 14th March, and the Panel had discussions with them on the 21st March, 1958. The observations and conclusions in this respect are given in para 3 of the report. The figures of saving in cost and materials is given in Appendix IV.

2.0 Heavy Electrical Project at Bhopal—Observations and Conclusions.

2.1 The Heavy Electrical Project at Bhopal is intended for the production of transformers, A.C. and D.C. rotating machinery etc. The Project will be executed in two phases. The construction of phase I is scheduled to start shortly. On an examination of the outline plans and specifications the Panel thought that certain rationalization of the specifications and redesigning of the structure would lead to considerable economy in cost and material. The items taken up by the Panel and the conclusions arrived at are given in the following paragraphs.

Double roofing.

2.2 The specifications provided a double layer of roofing with a space of 12" in-between for purpose of insulation and ventilation. The Panel considered that with roof heights ranging between 40—60', the effect of double roofing at working level would be negligible, and that the same effect of ventilation could be had with suitable exhaust fans. The suggestion of the Panel was accepted by the Project Authorities, but they wanted that the sheeting should be of aluminium instead of Asbestos cement. The additional cost not being high, it was considered worthwhile to adopt aluminium covering.

Height of workshops.

2.3. Out of a total factory area of 14 lakhs sft. over 4½ lakhs sft. had been provided with roofs at a height of 50' or above. This was considered expensive and the Panel desired that the height should be based upon the actual requirements of manufacturing operations to be performed in each shed. The plan showing the lay out of the machinery was, unfortunately, not available in India. The Consultants, however agreed to reduction in heights of the Maintenance Shops and Foundry Block. The Managing Director undertook to study the problem further and effect such reductions as possible.

Jib cranes.

2.4 According to the outline plan specifications all columns placed 50' apart and numbering about 850 in all are to be designed for taking up jib cranes, of 25 to 30'

length with a lifting capacity of 2 tons. It was explained that, in the absence of a detailed study of the location where jib cranes would operate, maximum flexibility had been provided to cover all eventualities. In the absence of detailed lay-out of machinery and flow-sheets, it was not possible to determine the columns that would be required to take up the jib cranes. It was therefore suggested that the columns should be designed only for the immediate loading. The jib cranes wherever required could be installed later by strengthening the columns by welding suitable stiffeners. The foundations have, however, to be designed in all cases to take up the load of the jib cranes. In the absence of complete data, this was considered to be the best solution, and was agreed to.

Loading standards.

2.5 The specifications mentioned that the loading standards would be according to the B.S.S: 449 of 1948. The Panel was of the opinion that it was not necessary to adopt the British standard when corresponding Indian Standards Code was available. Further, by the adoption of Indian Standard there can be saving in steel as conditions of loading here are quite different from those in England. This suggestion was accepted by the Project Authorities.

Redesign of racker girders.

2.6 The Panel suggested that the rackers could be of a different design. The Project Authorities doubted that it may lead to trouble in carrying the service pipes. Finally, however, it was agreed that the Project Authorities could induce the successful tenderer to adopt the racker design suggested by the Panel.

Adoption of welded construction.

2.7 The Panel was of the opinion that the roof members could be welded as it would lead to considerable economy in steel. The Managing Director agreed to discuss this matter with the successful tenderer and induce him to adopt welding to the maximum extent possible.

Thickness of flooring.

2.8 The Panel considered that a uniform thickness of 8" for the floor was not necessary and most of the requirements could be met by a thickness of 4". The thickness may vary to suit the nature of loading and the usage. The principle was accepted and the Project Authorities agreed to consult the Road Research Laboratory at Delhi.

Canteen building.

2.9 The original proposal was to construct the canteen buildings also in steel. This appeared to be entirely unnecessary. The Panel suggested the adoption of shell roofing if clear space uninterrupted by pillars was required. The Panel's recommendations were accepted.

Bracing of trusses.

2.10 The Panel was of the opinion that there was a general tendency to provide for heavy bracings for the roof members and suggested that a scientific design of braces would reduce the steel consumption considerably. The Project Authorities agreed to take this up with the successful tenderer.

Redesigning of phase I.

2.11 The workshops included in phase I are all proposed to be of riveted construction. The Panel felt that by the adoption of advance techniques of designing such as indeterminate frame analysis or by adoption of concrete structure with shell roofing, there could be considerable economy in cost as well as in materials. The brief note prepared by the Panel in this connection which is applicable to both phases I and II is given in Appendix V. During discussions, however, it was found that it would not be advisable to go in for redesigning for phase I due to limitation of time. The Project Authorities, however, agreed to adopt the Panel's suggestion for the future phases, and requested the Panel to assist them in evolving an economical design for phase II.

3.0 Fertiliser Project at Nangal—Observations and Conclusions.

3.1 The factory can be divided into 3 major units:

- (a) Silos.
- (b) Electrolysis and rectifier plant.
- (c) Ammonia and other allied plants.

From a purely technical point, items (a) & (b) deserve greater attention as the structures are large and cost about Rs. 1.5 crores.

Silos.

3.2.1 The proposal of the Project Authorities was to construct two longitudinal silos of the parabolic type with 30 ft. high retaining walls on either side. The structure as shown in the plan was not economical. Prof. Nervi was also of the same opinion. The keynote in the design of structures for storage, according to Prof. Nervi is "to cover the heap and not to contain it". This can be achieved by adjusting the profile of the structure to suit the angle of repose of the material inside.

3.2.2 Several alternatives are possible, both in cast-in-situ construction and prefabricated construction. Prof. Nervi suggested that an inverted catenary with a springing angle almost equal to the angle of repose of the contained material and with external ribs would be more ideal. The shell in the form of inverted catenary will have the least stresses. The external ribs will provide for the wind and other horizontal forces. The provision of ribs on external side has also a further advantage that the shuttering inside can be bodily moved along the length of silos reducing thereby the time required for lowering and re-erecting the Centering.

3.2.3 Another alternative suggested by the Panel was a combination of precast and cast-in-situ construction wherein the ribs will be cast in place and filling in between would be of prefabricated elements, joined by subsidiary ribs which could be cast in place. The alternative solution would be about 30% cheaper than the proposed one and the saving in cement and steel would also be in the order of 40%.

3.2.4. The Project Authorities agreed to the principles suggested by the Panel. But they stated that they had to withdraw the tender notice for silos as their consultants in France had in the meanwhile changed the basis of design. They, however, agreed to communicate to the Consultants in France all the suggestions of the Panel in this regard.

3.2.5 The Team would be interested to examine the final designs.

Electrolysis plant.

3.3.1 The Project Authorities have proposed a flat roof of RCC beam and slabs for the electrolysis building. Though some portions of this building, from functional necessity had to have flat roofs, the Panel thought that for

other portions a barrel shell roof could have been advantageously adopted. The building is about 800 ft. in length and would have been ideal for adoption, of shell roofing with the help of moving centering, which could have resulted in a saving of about 30% in financial cost. The Project Authorities could not adopt the suggestion of the Panel as that would mean delay in the execution of the Project. It was, however, agreed by the Project Authorities that the suggestions of the Panel would be kept in mind while designing other structures for the rectifier and fertiliser group of plants.

Appendix I

HEAVY ELECTRICAL PROJECT, BHOPAL

Serial No.	Items	Views of the Project Authorities	Views of the Panel	Effect on cost and consumption of materials
1	2	3	4	5
1	Double sheeting for roof.	Helps in heat insulation and provides for induced ventilation. The extra cost is a small portion of the cost of the Project.	With heights of 30' to 75' the insulating effect of the double sheeting is insignificant. Ventilation can be had through louvres.	The area of Factory is about 14 lakhs sft. The area of sheeting will be 15 lakhs sft. Taking cost of Asbestos sheeting and purlins clamps etc., as Re. 1/- per sft., the saving if double sheeting is not done is Rs. 15 lakhs. This apart saving in structural steel in purlins will be about 600 tons (Taking purlin to be 1 lb. per sft. of covered area). If all corrugated sheets are to be used the saving in cost will be much more.
2	Heights of buildings, 4,48,000 sq. ft. of workshops have a ht. of 50 ft. upto crane rail.	This is necessary from future functional requirements.	If layout plan is available only some portions need be of 50 ft. height. Others can be 30 ft.	Assuming 1/2 of this area can be reduced to 30 ft. height, the saving in steel will be about 150 tons and saving in cost will be Rs. 12.25 lakhs.

3 Jib cranes about
850

All columns at 50 ft. c/c have a jib crane. The central columns have two such cranes one for each bay. Necessary from point of view of flexibility, only same cranes will be actually put but columns designed to take a crane at any time.

This is too much. With a layout diagram and a properly prepared flow chart it is possible to decide which of the columns must be designed for jib cranes. Saving thus effected will be quite considerable.

There are 492 columns. Even if 100 of these are designed to take jib cranes which itself is on the high side, the remaining 392 will be of simple design which can be about 1/2 of the present section. Assuming all columns to be only 30 ft. to gantry level the saving in steel will be about 400 tons, cost reduction will be Rs. 6 lakhs. Besides this, reduction in foundation cost is there due to reduced load and bending moment.

4 Design of trusses
total area 14 lakhs
sft.

All trusses are of the north light type including rackers. The live load is taken as 15 lbs/sqft. apart from wind and other dead loads.

15 lbs. sq.ft. is too heavy. The rackers can be designed differently as lighter trusses.

Assuming we save 1 lb.sq ft. in the racker it comes to 1/2lb. per sqft. distributed all over as there are equal number almost of rackers and girders. The saving in steel will be about 300 tons and cost reduction will be Rs. 4.5 lakhs.

5 Welding (total area
14 lakhs sft.)

Gantry girders may be welded. All other structures to be riveted only.

It is better to rivet the gantry girders and weld the entire roof structure and columns.

Even if trusses alone are welded the saving in steel will be 15% after accounting for the extra cost of fabrication. This comes to saving of 1 lb/sqft or 600 tons. The saving in cost will be Rs. 9 lakhs. Due to reduction in weight by all those framings, saving will accrue in foundations which has not been mentioned.

1

2

3

4

5

6 Flooring Area.
14 lakhs sqft.

8" cement concrete reinforced
wherever necessary.

This is too thick. C.R.R. I. to be consulted. Most of the flooring need be only 4" thick, locally increased thickness can be adopted. This can be fixed from the layout & flow diagrams.

Even assuming the thickness to be 5" there is a 3" saving in thickness i.e., at -/8/- per sqft. saving in cost will be Rs. 7 lakhs] for the factory & saving in cement about 3000 tons.

7 Canteen building
Area. 64,000 sqft.

This is also of steel construction.

This is unnecessary, concrete construction is better.

Saving in steel will be 240 tons. Extra cement required will be 280 tons. We assume there will be no financial saving.

Appendix I—(contd).
HEAVY ELECTRICAL PROJECT, BHOPAL
Abstract of Saving in Materials & Cost

Items	Saving in Steel (Tons)	Saving in Cement (Tons)	Saving in Cost (Rs. lakhs)
1.	600	..	15
2.	150	..	12.25
3.	400	..	6
4.	300	..	4.50
5.	600	..	9
6.	..	3000	7
7.	240	—280	..
TOTAL	2290	2720	43.75*

*If saving in foundation at 4 annas per sq. ft. is considered, it will result in a further saving of Rs. 3.5 lakhs.

Appendix II

MINUTES OF THE MEETING HELD IN THE ROOM OF SHRI INDARJIT SINGH ON 22ND MARCH, 1958 IN CONNECTION WITH HEAVY ELECTRICAL PROJECT, BHOPAL.

Present:

Shri Indarjit Singh, Secretary, C.O.P.P.

Shri Sarup Singh, Member-Chief Engineer, B. P. Team.

Shri N. S. Mankekar, Member, Factory Panel.

Shri S. Sarangpani, Managing Director, H.E.P.L.

Shri K. N. Shenoy, Dy. Secretary, C. & I. Ministry.

Shri T. S. Vedagiri, Secretary, B. P. Team.

The case of the design of the workshop buildings for the Heavy Electrical Industries to be set up at Bhopal was further discussed. The decisions are recorded below:

Roofing: The principle of single roofing has already been accepted. The Managing Director's suggestion to cover the roofing with aluminium sheets instead of A. C. sheets was agreed to. It is understood that the roof members will be accordingly redesigned to allow for the reduced load. The ISI code would be adopted.

Height of roof: The Panel's suggestion for reducing the height of the roof of the maintenance and foundry blocks has already been accepted. The Panel, however, still feels that there is ample scope for reducing the height of the roofs of other buildings. The area of the factory with 50ft. height is very substantial.

The Managing Director agreed to examine the functional requirements of the buildings and affect reduction wherever feasible.

Jib cranes: It was accepted that the best solution would be to determine in advance the exact position where the jib cranes would be required. If this is not possible at this stage, it was agreed that the foundations of all columns may be designed to take up the load that will be imposed by the jib cranes. For the time being, however, the

columns would be designed to take up the load of the roofing and the gantry cranes only. Subsequently, wherever the necessity for jib cranes is felt, columns will be strengthened by welding additional members or otherwise as may be found suitable. This would materially reduce the quantity of steel at the initial stages. In any case, overall economy in steel is assured.

Redesigning of phase I: The Managing Director explained that it was his proposal to *adhere* to the original target dates fixed for production operations, by overcoming the apprehended delay in the completion of the training programme. The time, therefore, available for construction of phase I is very limited. Tenders have been called for, and it is desirable that the work is taken in hand without delay.

The Managing Director further informed the meeting that one of the tenderers had already suggested welding of the gantry cranes, and he would see to it that this is extended to the maximum extent possible with a view to secure economy in steel.

In view of the circumstances, the question of redesigning of the factory buildings coming under phase I was not pressed, and the matter was left entirely to the discretion of the General Manager.

Stores for raw material and finished products: The Panel has pointed out the absence of the building for stores. The Managing Director explained that the Nissen huts already put up for construction operations could be used as stores godowns, after completion of the construction. Anyhow, he decided to look into this matter further.

Alternative designs for phases II & III: As a result of the study of the existing designs and the quantity for steel required, the Panel's views are that very considerable economy both in cost and consumption of steel can be effected either by adopting a structure with reinforced concrete columns and shell roofing or a steel structure designed on the basis of indeterminate frame analysis.

The Managing Director stated that he would be too glad to adopt the suggestions of the Panel for future construction, but since they had no organisation for structural designs, they would request the Buildings Projects Team to get the designs prepared.

Appendix III

HEAVY ELECTRICAL PROJECT LTD., BHOPAL—EFFECTS OF CONCLUSIONS ON COST AND MATERIALS

Item	Conclusions	Saving in cost (Rs. lakhs)	Saving in steel (Tons)	Saving in cement (Tons)	Remarks
1. Roofing	To adopt single sheeted roof with aluminium sheets.	13	700*	..	*The saving here is more than shown in Appendix I owing to saving in purlins because of aluminium sheeting.
2. Height of buildings.	Only maintenance and foundry blocks have been reduced in height.	1	50	..	
3. Jib cranes.	Suggestions of the Panel will be incorporated as detailed in the report	5	300	..	There will be saving both in Steel & Cement, but this cannot be worked in the absence of detailed designs.
4. Redesign of trusses and racker		6	350	..	
5. Welding		9	600	..	
6. Flooring		7	..	3000	
7. Canteen building		..	240	-280	
8. Saving in foundation		1	
TOTAL		41	2240	2720	
Redesigning of phase II		90	8000		Indeterminate frame analysis will form the basis of design.

Appendix IV

NANGAL FERTILISER PROJECT—EFFECTS OF CONCLUSIONS ON COST AND MATERIALS

Items	Conclusions	Saving in cost	Saving in steel	Saving in cement	Remarks
1. Silos	As detailed in report .	Rs. 25 lakhs	1500 Tons.	3000 Tons.	This is in comparison with an approximate estimate prepared for silos by the Project Authorities.
	TOTAL	Rs. 25 lakhs.	1500 Tons.	3000 Tons.	

Appendix V

HEAVY ELECTRICAL PROJECT AT BHOPAL—DETAILS OF ALTERNATIVE DESIGN IN STEEL.

During the discussions at Bhopal, the Team suggested that there could be 3 alternative methods of design which can lead to saving in cost and quantity of steel, namely:

- (a) design in reinforced concrete;
- (b) composite design with RCC pillars and shell roof and steel columns for gantries; and
- (c) design in steel adopting statically indeterminate structure.

The Team has further studied this problem and has come to the conclusion that alternative (b) would not be so economical in comparison with (a) or (c). Preliminary details therefore have been worked out for alternative (a) and (c). Alternative (c) is discussed in the following paras. Details of alternative (a) are given in note on page 18.

Alternative (c)

The proposed design for the Bhopal factory envisages the usual riveted steel construction. This method is obsolete and usually uneconomical. With the advent of welding, it is possible to ensure rigidity in the structure and thereby reduce the quantity of materials required. This method of design is nothing new. Full details are available in Steel Designers Manual which has been compiled by the British Iron & Steel Federation.

The adoption of statically indeterminate frame structure will not obviously in any way affect the lay out of the factory. The module shown in the lay-out plan can be adhered to.

For reducing the weight of gantry girders, it is however desirable to add an intermediate support, thereby reducing the span of the girder to 25'.

By redesigning the structure, as an indeterminate frame, there shall be a saving of the order of 4,000 tons of structural steel in phase I and about 8,000 tons in phase II. The economy that can be effected in the financial cost can be placed at Rs. 45 lakhs and Rs. 90 lakhs respectively for phases I and II.

The redesigning on the basis of indeterminate frame structure however will take sometime but it is understood that even the detailed designs on the basis of conventional practice have not yet been taken up. The extra time, therefore, that may be necessary for designing on the basis of indeterminate analysis will not be appropriate. It may, however, be argued that more time will be necessary for reinviting the tenders. But this can be offset by properly coordinating the planning, procurement of steel, tender enquiry etc. It should also be understood that the total time for fabrication and direction will be considerably reduced as the quantity of steel to be used according to indeterminate analysis will be less by 30 to 40 per cent.

The design can be divided into two stages. The first stage will comprise such information that may be necessary to call for tenders and arrange for the procurement of steel. In the second stage, complete details may be given for fabrication and direction, step by step. Stage I for phase I may take 4 months and stage II may take 2 to 3 months more. For phase II, the corresponding period will be 8 months and three months. It may also be noted that the time for tendering can be conveniently reduced to 4 weeks or so in this case as the tenderers are not to prepare any design of their own. If it is decided to adopt our suggestion for phase I, it is possible to go for tenders after 4 months and start work at the beginning of the 7th month.

While on this subject, the Team also likes to suggest that splitting of the work envisaged even in stage I into two or three parts would be more economical and advantageous in the long run, if tender is open to all fabricators with workshop facilities. In this case, tenders can be invited for block 4 at the end of the second month, for block 3 at the end of 4th month and for the maintenance block at the end of 5th month. Work on these blocks can be taken up at the end of the 4th month, 6th and 7th month respectively. This enables work to be put through at a quicker pace and may also result in lower tendering.

ALTERNATIVE DESIGN IN REINFORCED CONCRETE FOR THE BHOPAL FACTORY.

Reinforced concrete has been acknowledged since the War as the material which is most successfully meeting the needs of factory construction. Great Britain has adopted the structural concrete for all its post-war factory construction. The advantages of structural concrete for factory construction are well brought out in the publication of the Cement & Concrete Association entitled "Single Storeyed Industrial Buildings". Details of a number of factories in England constructed with reinforced concrete are available in this publication. The usual objection raised against concrete construction, namely, the lack of flexibility does not hold good any longer. In Italy and all over European countries structural concrete is the medium for factory construction.

The required amenability for service installations in concrete construction can be obtained with the help of rivet guns and other such device. Prof. Nervi while he was in India has explained to gatherings of engineers his method of speedy factory construction with reinforced concrete. He was of the firm view that for conditions in India reinforced concrete is the ideal solution for factory construction and for other long span structures.

The proposal is to have a RCC structure with shell type roof adopting the same module as shown in the layout plans of the consultants. The column may consist of 4 RCC pillars properly braced together. This arrangement in addition to its structural advantage also enables the service pipes to be taken through the columns.

It is needless to say that the construction as suggested above will not require any structural steel except for the gantry girders. It is possible to have the gantry girders also in RCC either ordinary or prestressed. This is a matter for consideration of the Project Authorities.

The RCC construction will require 8—9 lbs. per sft. of mild steel per sft. of factory area excluding gantry girders. The cement consumption for the foundation, columns and roofing will be 30 cwt for 100 sft. of factory area. The cost of construction of the framework i.e. foundation, column and the roofing will be about Rs. 8—10 per sft. of factory area. The saving in financial cost, therefore, in phase I

will be Rs. 50 lakhs. The savings in structural steel would be of the order of 6,000 tons in phase I. The RCC construction, however, will require more cement than the all steel construction. But this will not be a great problem as the cement position in the country is progressively improving.