



**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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*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.**

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## 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 sqft.

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 1/2 lb. 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 sqft.)

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.

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1

2

3

4

5

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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 sft. saving in cost will be Rs. 7 lakhs] for the factory & saving in cement about 3000 tons.

7 Canteen building  
Area. 64,000 sft.

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	..
<b>TOTAL</b>	<b>2290</b>	<b>2720</b>	<b>43.75*</b>

\*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.	41	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	..	..			
<b>TOTAL</b>		<b>41</b>	<b>2240</b>	<b>2720</b>			
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.