Concrete cube: shaped display hall

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Concrete Cube – Shaped Display Hall

Bâtiment d'exposition cubique en béton armé

Stahlbeton – Ausstellungshalle in Würfelfrom

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SUMMARY

This paper deals with various design and construction aspects of a Display Hall building in Bhopal, having intersecting hollow concrete cubes as its roofing system. The topmost point of the cube is 6 meter above floor level. Structural feasibility analysis, detailed design and specialist construction supervision have been undertaken by the authors.

RESUME

L'article traite de différents aspects du project et de la construction d'un bâtiment d'exposition à Bhopal, caractérisé par des cubes vides en béton formant son système de toiture. Le point le plus élevé du cube est à 6 mètres au-dessus du sol. L'analyse structurale et de faisabilité, le projet détaillé, et la supervision de la construction ont été entrepris par les auteurs.

ZUSAMMENFASSUNG

Der Beitrag behandelt verschiedene Entwurfs-und Baugesichtspunkte einer Ausstellungshalle in Bhopal. Ihr Dachtragsystem besteht aus sich überschneidenden, hohlen Betonwürfeln, deren höchster Punkt 6 Meter über dem Hallenboden liegt. Die Autoren waren mit der Machbarkeitsstudie, Konstruktion und Bauleitung der Spezialarbeiten beschäftigt.

1. INTRODUCTION

The Display Hall located at The Nehru Rose Garden, BHEL Township, Bhopal, India, was built in 1989. The plan of this building as envisaged by its architect is shown in Fig.1. This is generated by combining plans of three intersecting hollow cubes of

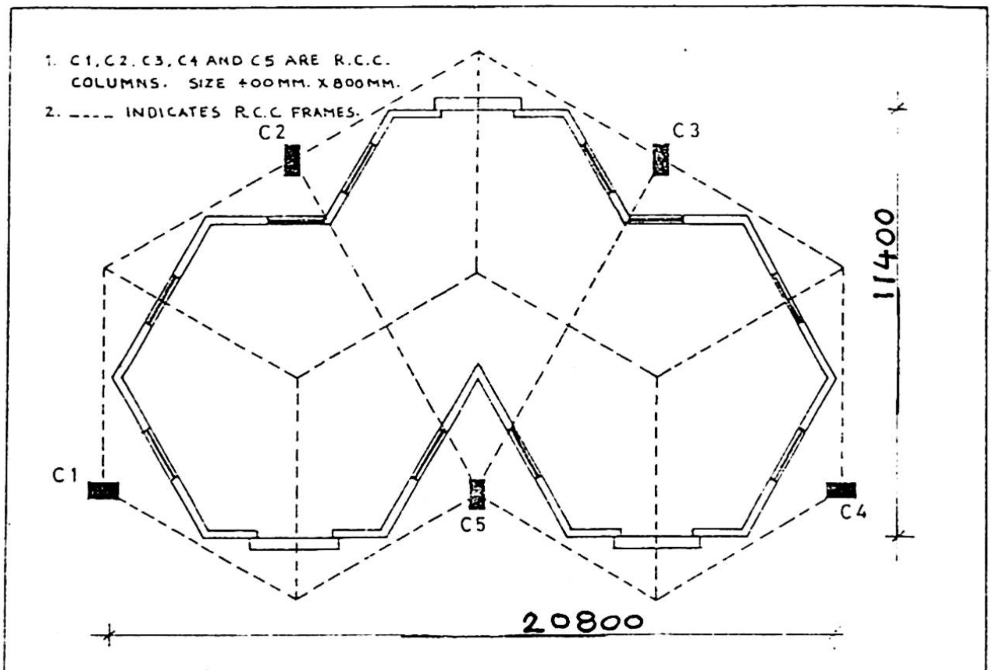

Fig.1 GROUND PLAN AND LOCATION OF COLUMNS DISPLAY HALL, NEHRU ROSE GARDEN BHEL, BHOPAL

reinforced concrete with overall plan dimensions of 11400x20800mm. The entire roof structure rests on five RCC columns, each size 400x800 mm shows as C_1 to C_5 resting on rectangular RCC footings on soft rock with SBC of 25 T/m^2. It is 1500 mm below the ground level. A hinge of size 250x650 mm, length being 500mm is provided at 1000mm above the base of the footing to facilitate hinge action. The topmost point of these intersecting hollow cubes shaped roof is at six meters above hall floor level as seen in Fig.2 & 3. The slopes of roof panels and supporting edge beams are of the order of 55° A cutout on top of each cube provide ingress of natural daylight.

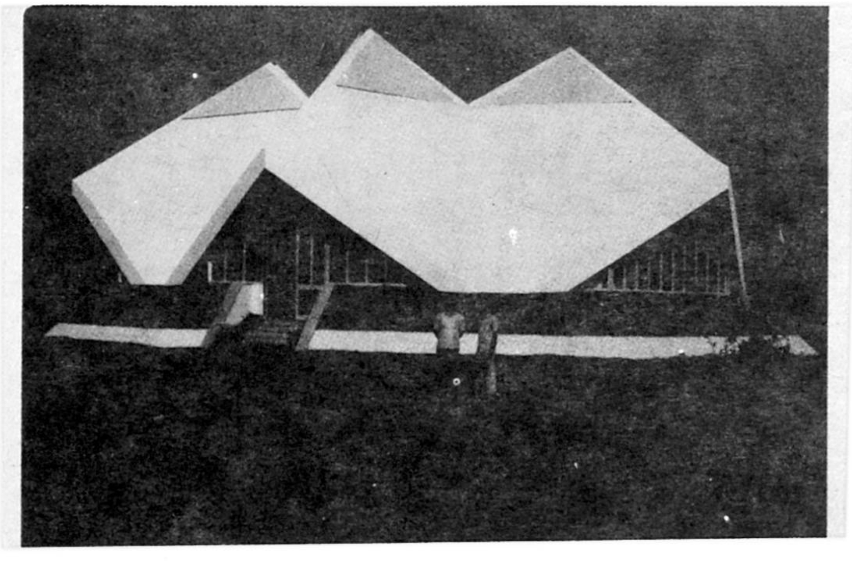

Fig.2 South side Elevation-Display Hall

2. INITIAL DESIGN CONSIDERATION OF STRUCTURAL SYSTEM

The project architects have visualised hollow concrete cohabit cubes consisting of solid slab panels supported on each of its edges by edge beams. These beams in turn rest on space frames as shown by broken line in Fig.1. These inclined slabs have 150mm thickness. These are designed as two-way slabs [1] and suitable reinforcement for restraining torsional effects at each corners is provided. The inclination of roof beams is also of similar order. They also serve forming for the openings for entry and exit of this pavillion as shown in Fig. 4.

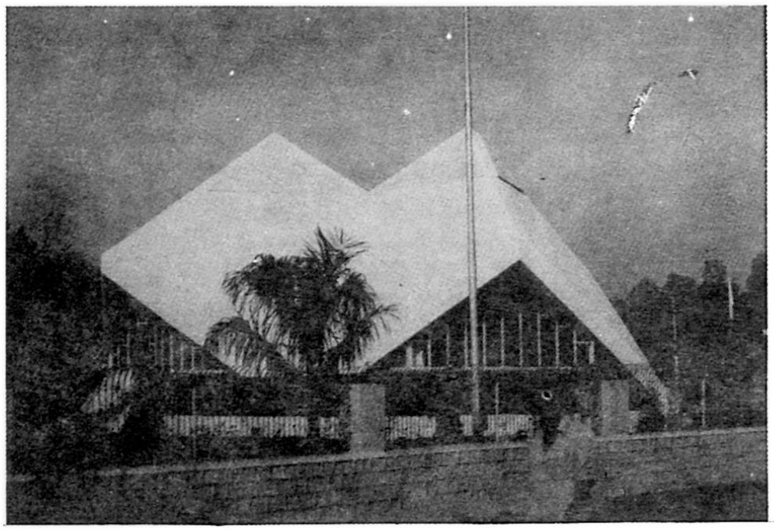

Fig.3 East Side Elevation of Building.

3. FINAL DESIGN CONSIDERATIONS

Some final design considerations in relation to the following elements are given below :

3.1 Composite Tie Beam

Seven steel-concrete composite tie beams were provided at plinth level to take up the horizontal reactions of the space frames at the foundation level in the form of three equilateral triangles. These consist of size 200x300 mm with 4 No ISA 50x50x6 mm suitably laced by 10 mm diameter links. These tie beams are connected to columns through bolted collars made out of 8 mm thich steel plate. The composite beam has to be envisaged to expedite the construction.

Fig.4 Details of Opening South Side, Display Hall Building.

3.2 Inclined Slab Panels and Supporting Space Frame

The type of structure as described above necessiates an integrated Finite Element analysis using the plate and beam elements in space. However due to the paucity of time, intitutive simplified elementwise analysis was undertaken like, roof as an inclined RCC slabs with appropriate edge conditions [2] and RCC space frames [3] supporting the inclined slabs and transferring the load to the foundations [4].

The inclined slabs were 150mm thick reinforced with 8mm diameter bars with 100mm centres bothways, suitably bentup and anchored. The Fig.5 shows details of this arrangement. The inclined roof beam members of the space frames were analysed and designed for combined effects of bending, shear, torsion and direct forces and thus adequately reinforced accordingly [5] M-20 (20 N/mm^2) Grade Concrete was used for roof slabs and supporting beams and columns. High strength deformed Bars Grade 415 were used as steel reinforcement of this structure as shown in Fig.6. below. This imparts adequate waterproofing property and gives enough durability to this structure.

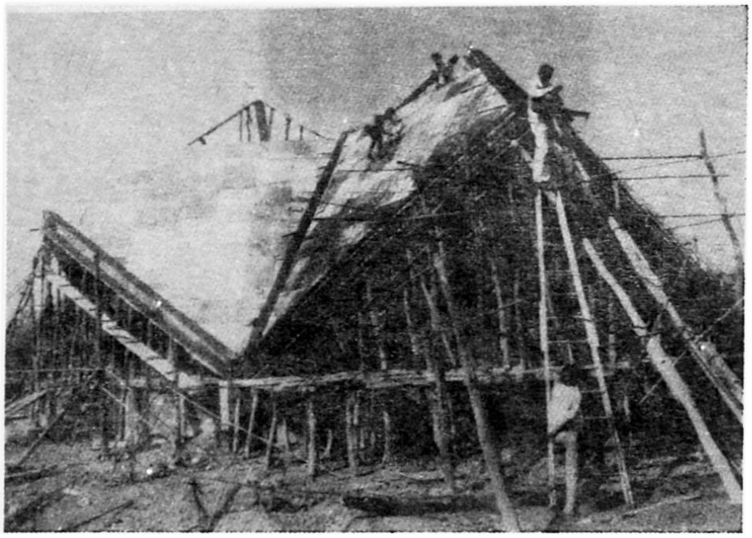

Fig.5 Details of slab reinforcement.

Fig.6 Details of Edge Frame Reinforcement.

4. SOME SIGNIFICANT DETAILS OF CONSTRUCTION PROCEDURE

Some typical and unique features of this type of construction adopted during construction of this Display Hall are discussed and highlighted below.

4.1 Detailing of Beams and Column Junction

The inclined space frames which constitute the most significant part of the structural system are very carefully detailed to ensure proper provision of torsional transverse stirrups, without causing excessive congestion for smooth ingress and compaction of concretemix in the forms to enable adequate compaction of concrete. The Fig.6 shows these details. Similarly the function involving sloping beam, edge beams and vertical columns are given due consideration in reinforcement detailing to achieve proper compaction of concrete. In view of the complex three dimensional geometry of this structrue the laps and anchorages for the reinforcement are carefully detailed [6]. Due care is taken to ensure proper cover to reinforcement in the various structural components of this building.

4.2 Care in Formwork and Usage of Double Shuttering

As the slopes of slabs and beams are steep, of the order of 55^{o}, therefore, extra precaution was needed to ensure correct level of formwork. It was suitabley braced to reduce risk of settlement during concreting operations. Smooth plywood double shuttering was employed to prevent flowing of mix and achieve proper compaction of concrete to resulting in dense and durable concrete mass with smooth surfaces.

5. CONCLUSION

Some of the important conclusions of this discussion are as follows :

- The envisaged form of this display hall incorporates the usual structural efficiency of **Shell Form** to a large extent with the added advantage of simplified formwork was required. The provision of sufficient openings and cutouts at top of cube shaped roof caters for allowing natural daylight, thus reducing energy requirement for lighting and cooling purposes of this building.

- The intitutive simple analysis taking advantage of continuity is in close proximity with the Finite element method of analysis and is less time consuming. It was also incorporating better feeling of behaviour of entire structural system.

- The form adopted for display hall at the Nehru Rose Garden, blended very well with its total environment and described very well the concept of form of a **Rose Bud**.

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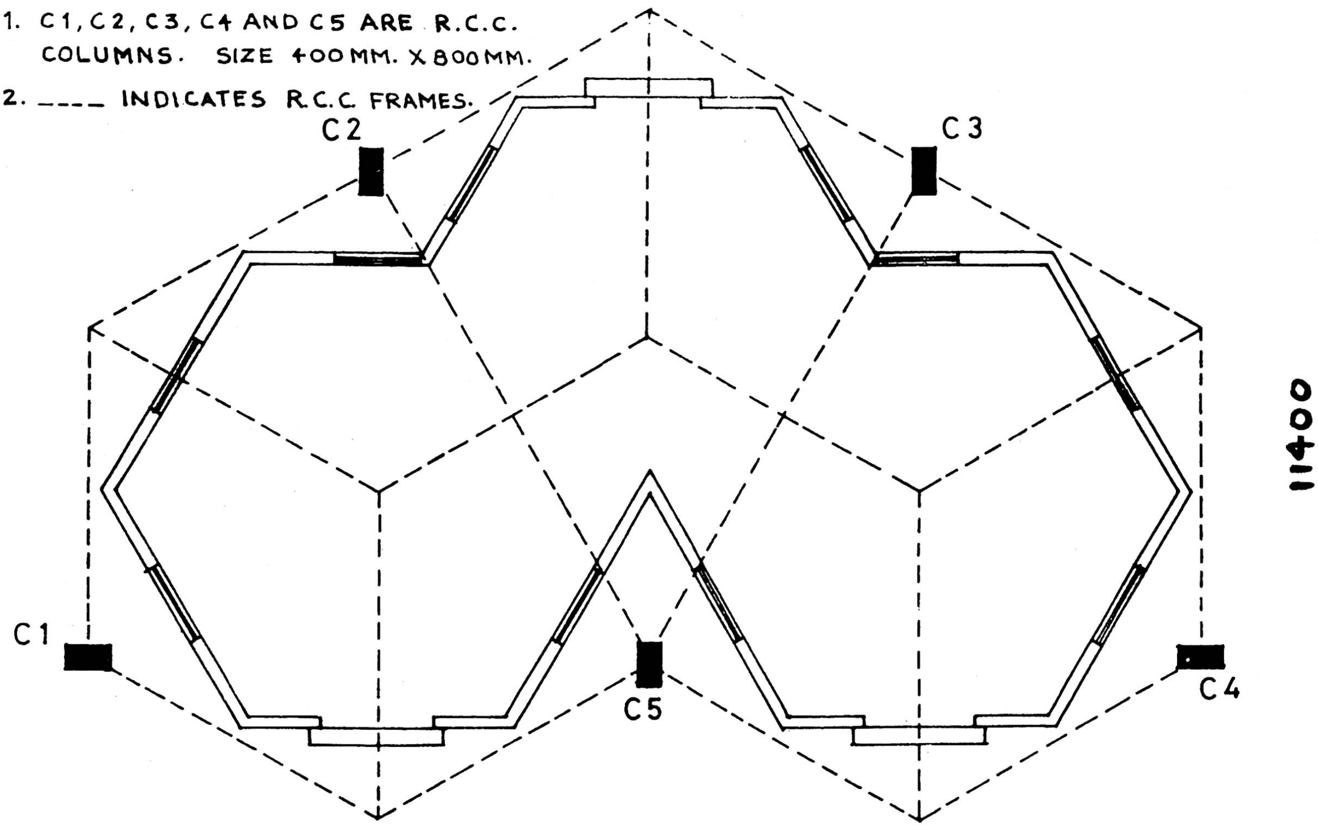

FIG. 1 GROUND PLAN AND LOCATION OF COLUMNS
DISPLAY HALL, NEHRU ROSE GARDEN BHEL, BHOPAL

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