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Tours Scope à New Delhi, Inde

Scope-Türme bei Neu Delhi, Indien

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SUMMARY
This twenty two storeyed, high rise twin tower structure, nearing completion at Laxmi District Centre, Delhi, is a modern office complex for SCOPE. This imposing structure demonstrates the versatile utility of structural concrete in its various forms. Some of the salient features of construction include use of large diameter bored piles for foundations, large cast-in-situ reinforced concrete construction, raft, slipformed lift cores, precast flooring and pumping of concrete to various locations of this 110 m diameter building.

RÉSUMÉ
Il s'agit d'une tour jumelée de vingt-deux étages en voie d'achèvement à Laxmi, quartier central de Delhi, représentant un complexe de bureaux ultramodernes. Cet ouvrage imposant fournit la preuve de la diversité d'utilisation du béton structural sous ses formes les plus variées. L'article expose quelques unes des caractéristiques essentielles de cette construction, à savoir l'exécution de pieux forés à grand diamètre pour les fondations, le radier en béton armé coulé sur place, les cages d'ascenseurs réalisées en coffrage glissant, la préfabrication des planchers et le pompage du béton aux différents niveaux de ce bâtiment de 110 m de diamètre.

ZUSAMMENFASSUNG
Die sogenannten Scope-Türme, ein zweiundzwanzig Geschosse umfassender Bürokomplex im Laxmi-Distrikt-Zentrum, stehen kurz vor der Vollendung. Dieser eindrucksvolle Doppelturm führt den vielseitigen Nutzen von Konstruktionsbeton vor Augen: Grossbohrpfähle unter einem ausgedehnten Ortbetonträgerrost dienen als Fundament für die in Gleitbauweise hochgezogenen Liftschäfte. Neben einem Fertigteildeckensystem gelangte in dem grossen Gebäude von 110 Durchmesser auch Pumpbeton zum Einsatz.

1. GENERAL

The twin tower office complex for the Standing Conference of Public Enterprises, SCOPE, is nearing completion as a major facility of the district centre and shall house a number of public enterprises, including the Oil and Natural Gas Commission, ONGC.

The structure consists of two high rise curvilinear tower blocks, rising above a four storied circular podium block which includes two basements for car parking and a central mushroom. The podium flares outwards above the first floor level. The two towers rise above the circular podium and are of different heights, one having twenty two storeys and the other, seventeen. There is a provision for a heliport over the terrace. The 110 m diameter of the base of the structure gives an idea of its imposing size. The four storeyed circular podium block encompassing both the towers, flares outwards above the first floor level. With a total built up area of over 100,000 Sq.m. SCOPE Towers is to become a landmark on Delhi's skyline. (Ref. Fig.1, Fig.2, Fig.3).

2. STRUCTURAL ASPECTS

2.1 Analysis and Design

The tower structures which rise from the sprawling podium block are isolated from the low level structure through expansion joints. The method of analysis and detailing to arrive at the framing plans was finalised after considering a number of basic structural decisions affecting design and construction. These included precasting of typical floors above podium level to reduce elaborate in-situ staging and shuttering for slabs and to reduce the time cycle for the multistoreyed portion.

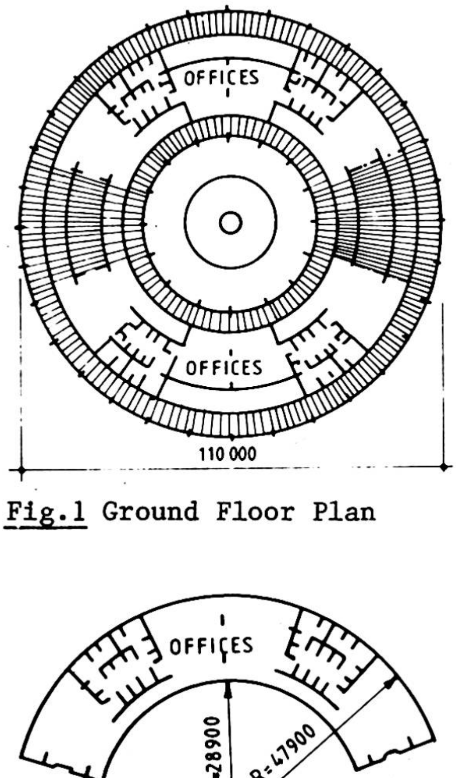

Fig.1 Ground Floor Plan

Installation of lifts takes considerable time and hence it was decided to slipform the four lift cores, so that the lift core and machine room could be in position much ahead of the other floors. Additionally, the

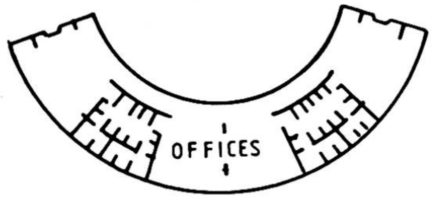

Fig.2 A typical floor plan

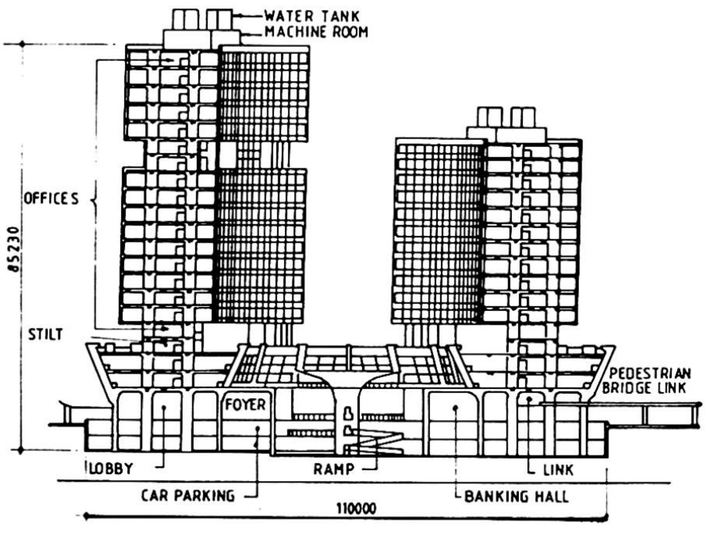

Fig.3 Sectional Elevation

machine room roof could be used for installing the cranes used for lifting precast elements and other construction materials. Expansion joints, construction joints and the sequence of construction especially to the large raft were also finalised.

The structural analysis for dead, live, wind and seismic loads was carried out by a three dimensional frame analysis, for the tower structure. The building was modelled as a space frame with degrees of freedom reduced by imposing the condition that the floor slabs were rigid in their own planes. The lift walls were considered as coupled shear walls. The program used was based on standard stiffness matrix method of frame analysis. Due to repetitive geometry of the building, the program generated data base on details of a typical floor. In addition to generation of element node relationship, co-ordinates, member types and sectional properties, the loading data was also generated from basic input information.

The structural analysis was carried out in two parts. The first part dealt with the dynamic analysis involving the computation of frequencies, mode shapes and earthquake forces on the basis of mode superposition method as per the recommendations of the Indian Standard IS:1893, criteria for Earthquake Resistant Design of Structures. Fig.4 shows the lumping of masses and Fig.5 the mode shapes. The second part deals with the analysis of the structure for dead and live loads in combination with seismic and wind loads, the latter being obtained from wind tunnel tests.

2.2 Wind Studies

To evaluate the wind pressure distribution on the two curved towers, wind tunnel testing was carried out during December 1985 at the Indian Institute of Technology, Delhi. This helped the scientific evaluation of the wind effects on the structure with the given shape, orientation, tower heights and relative disposition of the two tower blocks. The wind tunnel test was carried out on the structural model mounted on a turn table, in different orientations with respect to the direction of the wind. Contours of wind pressures over the surface of the structure were furnished by the Indian Institute of Technology, Delhi, for different directions of wind. Based on these data, wind pressures over the width and height of structure were evaluated and the wind loading considered suitably in the space frame analysis. Fig. 6 shows typical wind pressure contours on the structure. The wind pressure diagram adopted for analysis is shown in Fig. 7.

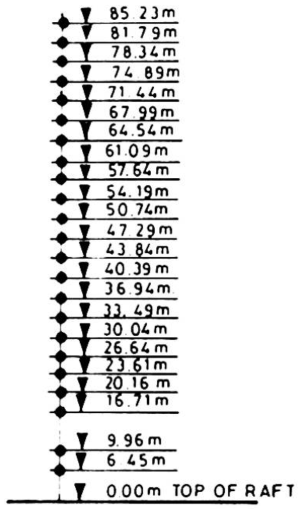

Fig.4 Mass lumping at floor levels for Dynamic Analysis

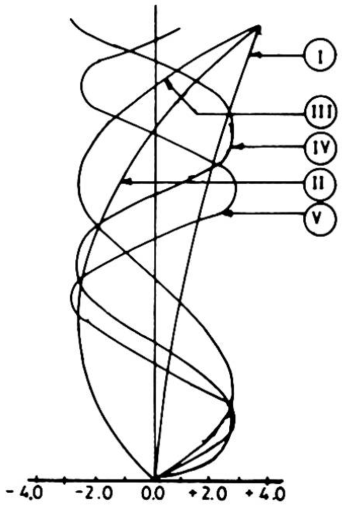

Fig.5 Mode Shape Diagram

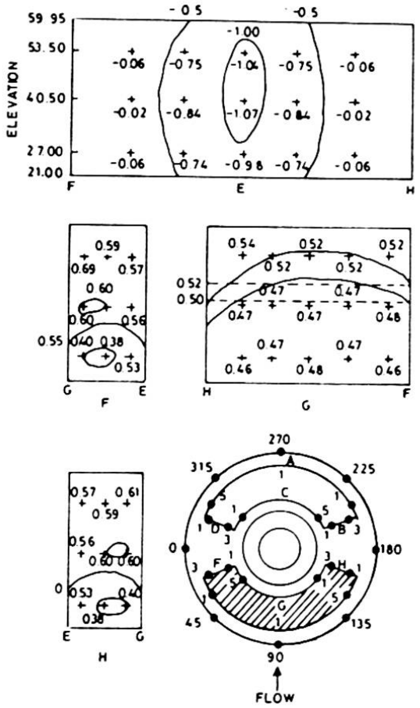

Fig.6 Contours of Pressure Coeffs. for 90° Orientation of Wind (Block II)

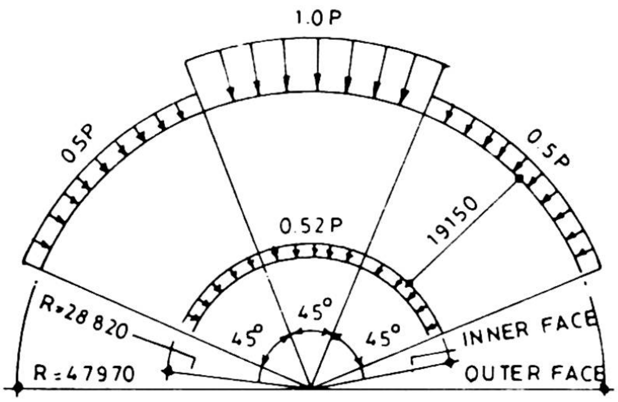

Fig.7 Wind Pressure Distribution Plan

While the global space frame analysis results were useful for evaluating moment, shear and torsion in the main framing elements for the various loading cases, under their various combinations with load factors; local grid and space frame analysis were carried out for determining forces in secondary members. The structural design of the members was carried out by the limit state design.

2.3 Foundations

The sub-soil at site is alluvial in nature upto 30 m below ground level. It was decided to adopt large diameter cast-in-situ bored piles going upto a depth of 20 m below the basement raft which is located at about 11 m below ground level. The pile diameters chosen were 1200mm, 700mm and 600mm. Though the maximum safe load capacity of 1200mm pile is 5500 kN, it was tested for a load of 14000 kN. The ground water table at site could rise upto 1.0 m below the ground level and hence the basement is subjected to a high water pressure. It was, therefore, necessary to provide piles for the entire base covering the towers and the low level structures. Fig.8 shows a typical arrangement of piles below a lift core. The piles are capped by a common circular base raft of about 110 m diameter, with thickness ranging from 0.9 m to 1.5 m. A tapered retaining wall with maximum thickness of 600 mm is provided all round the basement.

2.4 Superstructure

The structure is curved in plan and is framed by curved beams with large spans upto 180 m, heavy columns, lift cores and end shear walls. Each tower block comprises of two lift cores which are slipformed. During construction, two halves of each lift core were coupled by steel beams which were embedded later in a cast-in-situ 300mm thick diaphragm slab connecting both the halves. Floors upto mezzanine level are cast-in-situ. Above this level, precast elements are used and they are simply supported between circumferential cast-in-situ beams. The maximum length and weight of these elements are of the order of 7.0 m and 20 kN, respectively. A total of 18 types of elements of various sizes are used. Fig. 9 gives details of structural framing in a typical floor and Fig.10 shows the type of precast element used.

Another attractive feature of this office complex is a central mushroom shown in Fig.3. It is a centrally located structure with a 5.3 m diameter vertical shaft with an overall height of 19.0 m. It is topped by a doubly curved shaft of 100 mm thickness with a top diameter of 23.0 m. A three-dimensional analysis for the shaft was carried out by using SAP IV PROGRAM.

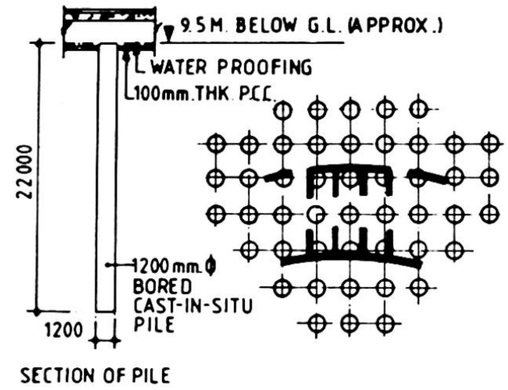

Fig.8 Typical arrangement of piles below lift core

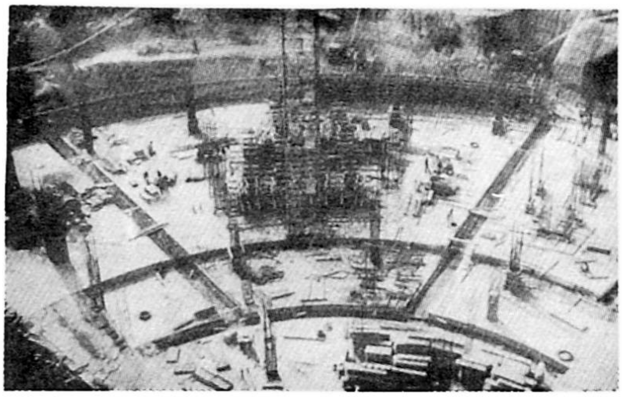

Fig.9 Base Raft with shrinkage gaps

3. CONSTRUCTION FEATURES

3.1 General

Even during the finalisation of structural framing, the following basic decisions emerged.

3.1.1 Precasting of floors was to be adopted to the maximum extent possible above the ground level. This would help in avoiding extensive in-situ staging and shuttering, and result in better quality control of the elements, and a faster rate of vertical construction.

3.1.2 The lift cores were slipformed in order to have the following facilities.

- Generally, the erection of lifts takes considerable time and becomes critical in the schedule. Hence, if the lift core is available ahead of rest of the structure, installation of lifts could begin in advance.

- The roof of lift cores could be used for installing cranes for lifting and installing precast elements and other lifting requirements.

3.1.3 A major construction consideration was the casting of the base raft with a thickness of 1.5 m under the tower portion and 0.9 m outside. Due to the pressure of the high water table it was decided that the 110 m diameter base of the structure will not have any expansion joints. However, circumferential and radial shrinkage gaps were provided at predetermined locations to facilitate casting of raft in segments and also to enable concrete to undergo shrinkage in smaller parts. The shrinkage gaps were concreted 28 days after adjacent parts of raft were cast. This helped in greatly reducing residual shrinkage strains in the concrete in the monolithic raft. The base of the raft and the sides of the basement retaining walls were waterproofed to withstand ground water pressure.

3.2 Concrete Pumping

Another interesting aspect of construction adopted by the contractors M/s. Larsen and Toubro was the use of pumped concrete in conjunction with a batching plant, for efficient production and delivery of concrete for this sprawling structure requiring large quantities of concrete at various locations and different heights. Pumped concrete was used for casting of the huge base raft (concrete quantity 13,000 Cu.m.) from lower basement floor upto a height of 50.0 m. To pump the concrete efficiently upto desired heights, additional

Fig.10 Slipformed Lift Cores

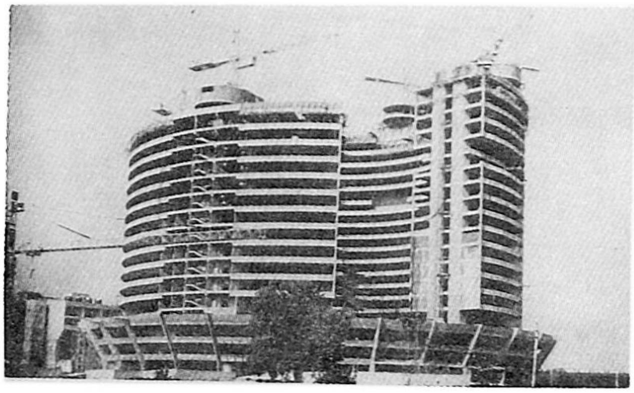

Fig.11 Building under Construction

pumps at intermediate levels were installed. To avoid choking of pipes and for transporting concrete without affecting the workability, higher slumps were used ranging from 75 mm to 110 mm. Superplasticizers were added to achieve the desired slumps without appreciably increasing the water cement ratio Concreting at higher elevations is proposed to be done with the help of buckets which will be lowered by four cranes mounted on top of the lift cores.

3.3 Slipforming

Slipforming of lift cores was a highly skilled job which required careful and proper planning, in view of the complex curved shape of the lift cores. Both the halves of the lift core were slipformed together and openings were left wherever necessary by assembling and inserting a wooden frame while slipforming. A check list was prepared to include complete details of reinforcement, pockets, openings and other embedments. The large size working platform was operated using a system of centrally controlled hydraulic jacks. Verticality of lift core was regularly checked by means of water level. Water level indicators were installed at various locations on slipforming platform to check any tilting. Concrete was taken upto the working platform by a bucket which moved inside the lift core and was operated by winches installed at the base raft level. Access to the platform was provided through a moving trolley. The normal rate of slipforming was 100 to 150 mm per hour. The lift core of about 85 m. height was complete in about a month's time.

In view of the decision to slipform the core, it was necessary to work out details of embedments in the walls of lift core, as these were to be kept for subsequent connection of members joining the lift core, perpendicular to the plane of slipforming. These embedments had to be fabricated before commencement of slipforming, kept in position precisely and securely and then concreting had to be done effectively around such embedments to avoid honeycombing.

3.4 Material Quantities

For a total built up area of about 100,000 Sq.m. the quantities of major construction materials are as follows:

Concrete of various grade	:	50,000 Cu.m.
High yield strength bar reinforcement	:	7,500 t
Number of piles: 1200 mm diameter	:	272 Nos.
700 mm diameter	:	109 Nos.
600 mm diameter	:	77 Nos.
Number of precast elements	:	6,000 approximately.