Structural Design of Habitat '67

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The main purpose of Habitat '67 is to produce a low cost housing complex within a city and at the same time preserve the main characteristics of suburban living. Architecturally, the problem is not easy and requires ingenious and daring solutions. To make the architect's dream a reality, the structural engineers and precaster were hard pressed and had to come up with new techniques both in design and manufacturing.

The structure has 12 levels and is composed of clusters of house units or boxes piled one on top of the other, all leaning towards and partially, supported by the street girders at the 5th and the 9th levels.

The street girders are simply supported post-tensioned beams spanning between their supporting elements, i.e., escape stair shafts, cantilever girders and clusters of boxes propped by precast columns.

The whole structure rests on the cast-in-place concrete plaza structure. Garages are located below the plaza. The plaza structure is supported on expanded base concrete piles driven to rock, approximately 20 ft. below the pile caps.

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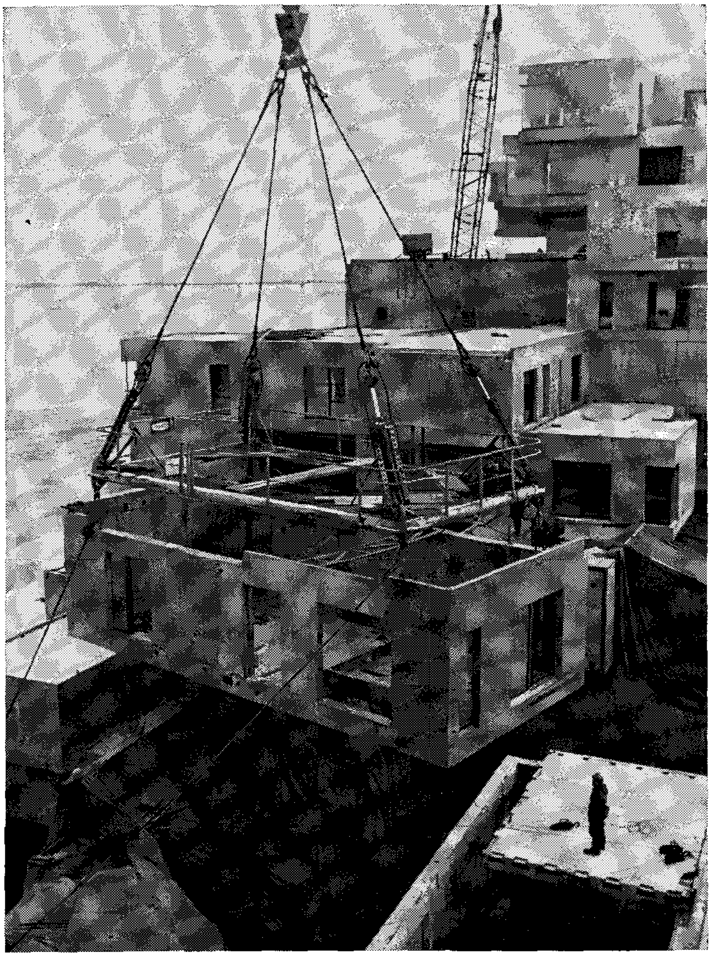
The main structural elements are house units, street girders, cantilever girders, escape stair and elevator shafts, various precast columns and the plaza structure.

House units or boxes, 354 of them, consist of 136 different modifications to the same basic size. The rest are mirrors or repeats of these. The boxes are 38 ft. 6 in. long, 17 ft. 6 in. wide, and 10 ft. high. Each box is a precast, steam cured concrete element reinforced for moments and shears. The walls are generally 5 in. thick and in special cases are increased to 12 in.

The walls are framed by top and bottom beams. Openings for doors and windows are between the beams. The stresses in the walls are determined from graphs based on Airy's stress function and developed by Dr. A. Komendant, structural consultant for Habitat '67. To counteract tension in the boxes or upper beams, post-tensioned Freyssinet cables or Stressteel rods were used.

The boxes were cast in two stages: first the floors and lower beams; then the walls and upper beams. The roofs were cast separately and bolted to the boxes after erection. Two boxes when joined together in one plane form an L-shaped unit. The connection is made with bolts

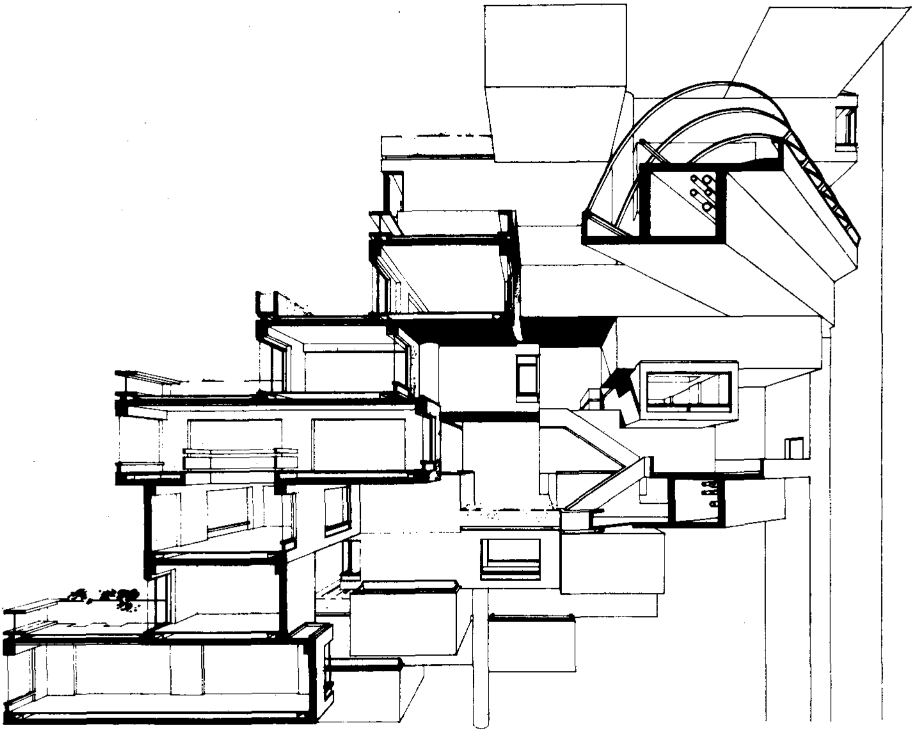


Erecting a House Unit

passing through top and bottom beams of the end walls of one box and side wall of the second box. Any relative movement between the walls of the boxes is cushioned by neoprene gaskets. The L-shaped units rest upon one another at bearing points where walls cross each other.

To simplify erection, the boxes are arranged so that the centre of gravity of each box is always within the points of support.

All bearing points are provided with steel plates and neoprene pads. The back end of each box is anchored to the box below by vertical Stressteel rods. The neoprene pads and the steel rods give flexibility to the structure required for energy absorption under earthquake and wind conditions. In addition, each



Typical Section

box is keyed into the box below and pins are also provided at the bearing points.

The top two clusters of boxes at levels 12, 11 and 10 are supported partly on 9th-level street girders and partly on 9th-level boxes. The 9th-level boxes distribute loads to the middle three clusters (levels 8,7 and 6) which are supported partly on 5th-level boxes and partly on 5th-level girders. The 5th-level boxes transmit loads onto four lower clusters (levels 4, 3 and 2) and these rest directly on the plaza level to which they are rigidly fixed.

The function of the street girders is to carry the vertical and horizontal loads from the box clusters, provide access to the house units (hence the name "street girders"), and to house mechanical services. There are 18 street girders divided into 11 different types varying in length from 27 ft. to 158 ft. They are cast in smaller pieces (a total of 69 pieces). The number of pieces into which each girder is subdivided is dictated by the lifting capacity of the equipment.

The long girders are assembled on scaffolding and the elements joined together transversally by Stressteel rods and weld plates and longitudinally by Freyssinet cables. All joints are filled with dry-packed concrete prior to post-tensioning. Camber and deflections of the girders are carefully controlled at all times during erection. The girders are keyed to the supporting elements. End bearings are of reinforced neoprene or Fabrika pads of varying thickness, which allow rotation and temperature movements at the bearings.

The cantilever girders form part of the elevator shafts and they are designed to receive street girder reactions, dead and live loads and torsional moments. Escape stairs are precast, post-tensioned concrete towers which carry vertical and horizontal girder reactions. They are cast in story-high elements which are joined at vertical and horizontal joints and post-tensioned vertically by Stressteel rods. The elevator shafts perform similar function to the escape stair towers and are manufactured and erected in the same way.

The 2nd-level boxes are set onto the plaza slab and are dry-packed to prevent any movement. Stressteel rods extend down to pile caps or wall footings to provide anchorage against uplifts under earthquake and wind loads.

Both static and dynamic analyses of the structure were carried out to determine the magnitude of seismic forces and the results compared and allowed for in the design.

Due to the severe architectural requirements of the job, and the necessity of keeping dead loads to a minimum, detailed studies of stress distributions in all structural elements were carried out using all available theoretical and experimental investigations supplemented by additional tests carried out by testing laboratories. These tests provided means for controlling the quality of materials used. The quality of workmanship was continuously controlled by an inspection staff.

Discussion of this paper is invited. Please forward your Discussion to PCI Headquarters before May 1 to permit publication in the August 1967 issue of the PCI JOURNAL.