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Four-storey experimental block for public housing

J. S. Sharma, B. K. Jindal and Suresh Chand

The Central Building Research Institute, Roorkee, was approached by the Roorkee Municipal Board for designing and planning four-storey residential blocks they proposed to build, and also for guidance during their construction. The Institute used the opportunity to incorporate in their design a number of proven new construction techniques. For experimental purposes, a block with access staircase was first built, for which a grant-in-aid was obtained from the experimental housing assessment committee of the National Buildings Organisation, New Delhi. The paper describes the planning and the new techniques employed in the construction. The economies achieved in the materials used and the cost of construction, are also discussed.

The municipal board, Roorkee, had earlier constructed single- and double-storey residential buildings for middle- and low- income groups. In view of the increase in the cost of land and the shortage of readily available land near the main market and offices, the board desired to construct four-storey housing blocks. Since the board had no experience in multi-storey construction, the Central Building Research Institute, Roorkee, was asked to provide the necessary design and offer guidance in the construction of the blocks. The Institute did the planning and provided the design and took the opportunity to incorporate laboratory-proven new construction techniques in the design, thereby obtaining a field trial for these techniques. A grant-in-aid was obtained for one block from the experimental housing assessment committee of the National Buildings Organisation, New Delhi. The work was awarded by the municipal board, on an item-rate contract, to a local contractor after due publicity in the local press.

Planning

A twin-block grouping, four-storeys high, with each block having sixteen units connected by a common staircase, and a separate bicycle parking area at ground level was planned, *Fig* 1. The front elevation is shown in *Fig* 2 and the floor area details for each unit are given in *Table* 1.

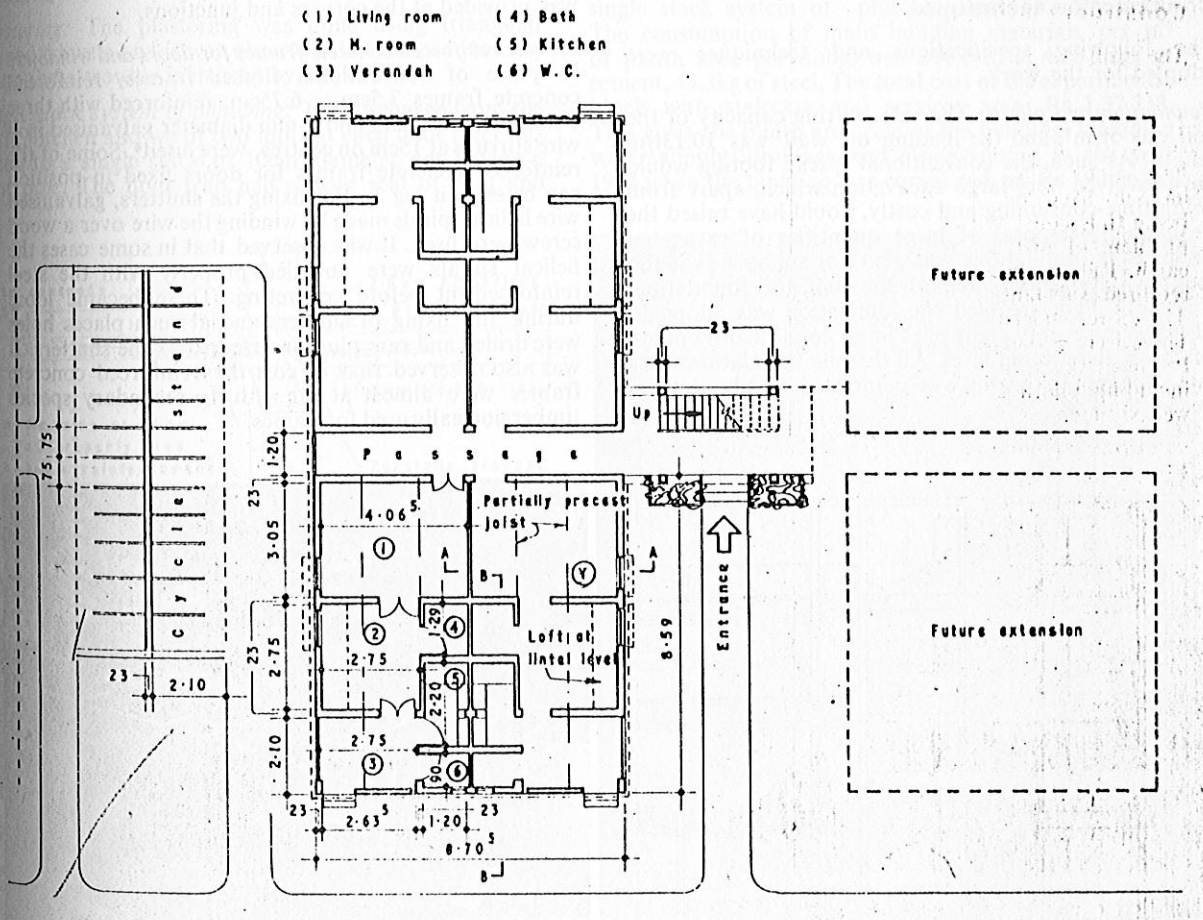

Fig 1 Key plan of housing block

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TABLE 1 Floor area details per unit

Item	*Length*, m	*Breadth*, m	*Area*, m^2
Living room	4.07	3.05	12.41
Multi-purpose room	2.75	2.75	7.56
Kitchenette	2.20	1.20	2.64
Verandah	2.75	2.10	5.78
Bath	1.29	1.20	1.55
WC	1.2	0.9	1.08
Total area	—	—	31.02

The plinth area of each dwelling unit is 37.40m^2, and this shows that the wall area in this planning arrangement is only 17.36 per cent. The multi-purpose room has a loft, 1.65 m^2 in area at lintel level for storage purposes. The passage area per unit at each floor works out to 2.57m^2. The plinth area of the staircase which serves eight units at each floor is 15.7m^2. The total external circulation area per unit works out to only 4.11m^2. The staircase is a single-flight one, and it stops at the third-floor level. Access to the terrace for maintenance is provided by a steel ladder from the passage balcony.

Construction techniques

The following specifications and techniques were adopted for the work.

Foundation and plinth: The safe bearing capacity of the soil was 5t/m^2, and the loading on wall was 10.13t/m length. As such, the conventional spread footing would have involved very large excavation which, apart from being time-consuming and costly, would have raised the problem of disposal of large quantities of excavated earth. Raft foundations was also not suitable as it too required substantial area of the unit for foundation. Therefore, under-reamed pile foundation was adopted[1]. There were seventy-eight piles in all connected by plinth beams at the ground level. All the pile foundation work including plinth beams was completed in about three weeks' time.

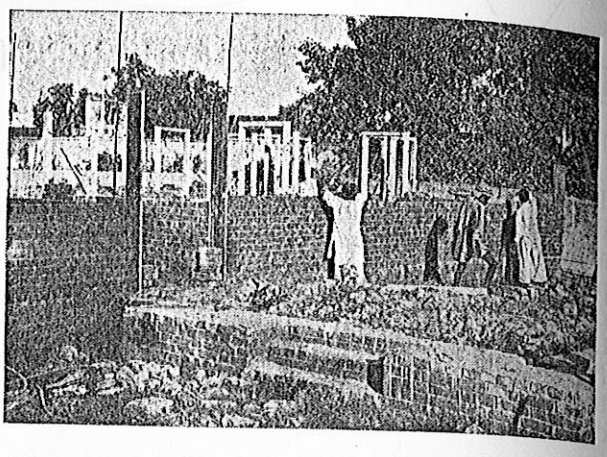

Fig 3 Improved method of bricklaying using end frames and string holders

Walls: The bricks available at Roorkee had a compressive strength of over 100kg/cm^2 hence single-brick thick load bearing walls built in 1 : 6 cement mortar was adopted[2]. The party walls which also shared part of the floor and roof load were half-brick thick built in 1 : 4 cement mortar. The improved method of bricklaying in which end frames and string holders were used was also adopted for the walling, *Fig* 3[3]. It was observed that the quality of the work was good, and there was also an increase in the bricklayer's productivity by 28 per cent. Vertical reinforcement for anti-seismic purposes was provided at the corners and junctions.

Precast reinforced concrete frames for doors and windows: In place of conventional timber frames, reinforced concrete frames 7.5cm × 6.75cm, reinforced with three 6-mm diameter bars and 3-mm diameter galvanised iron wire stirrups at 15cm on centres, were used[4]. Some of the reinforced concrete frames for doors fixed in position can be seen in *Fig* 3. For fixing the shutters, galvanised wire helical spirals made by winding the wire over a wood screw were used. It was observed that in some cases the helical spirals were not tied properly with the steel reinforcement before concreting. These became loose during the fixing of shutters and at such places holes were drilled and raw plugs inserted to fix the shutters. It was also observed that in cost the reinforced concrete frames were almost at par with the secondary species timber normally used for frames.

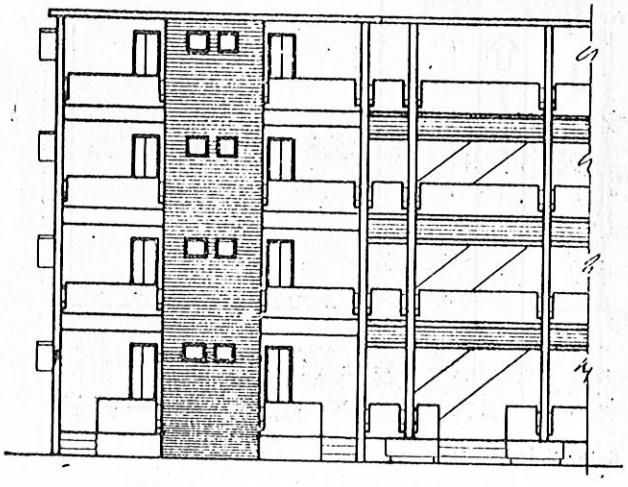

Fig 2 Front elevation

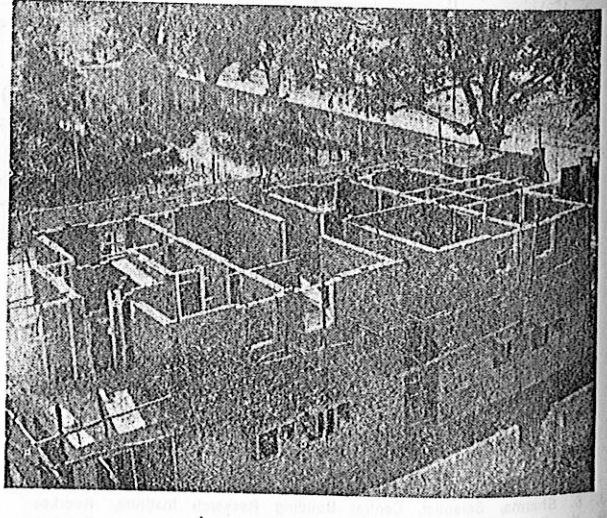

Fig 4 A view of the block during construction

Thin precast lintels: All lintels were precast and 7.5cm thick with two 10-mm diameter bars placed at centre, and 6-mm diameter spacer bars at 20cm on centres[5]. For the exterior windows and vertical louvers, the lintels were cast with projection; precast reinforced concrete beams 7.5cm × 7.5cm and 75cm long were precast and embedded in the masonry. The gap between the projecting beam and sunshade was filled with brick-on-edge and plastered, *Fig* 4.

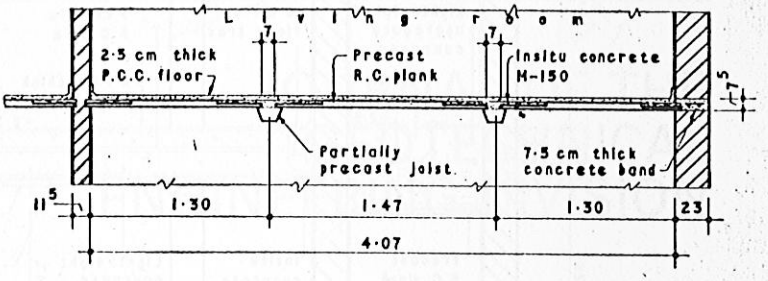

Fig 6 Section at AA

Floor and roof: The intermediate floors and the roof were provided with precast reinforced concrete planks resting on partially precast beam, *Figs* 5| and 6[6]. The reinforced planks were 0.40m × 1.2m, and partly 5cm and partly 2.5cm, thick with three bars of 6-mm diameter as main reinforcement. The planks weighed 60kg each and were handled and transported by a single man, and sometimes by two men right up-to the roof. Reinforced concrete bands at floors and roof were provided for anti-seismic purposes. Fan hooks were provided in between the planks but before laying in situ concrete in the haunches. The partially precast beams were supported at middle by a prop, having a wooden plank of 40cm braced on either side before placing the planks, *Fig* 7. After filling of the haunch and setting of the concrete, the joists act as a T-beam. The props were removed from below the beams in all floors only after the in-situ concrete had been laid in the haunches of the roof and after it had been cured for ten days.

Plastering: The plastering was done using triangular shaped trowels and it was observed that the productivity using these trowels increased by 18 per cent[7].

Single stack system of plumbing: The discharge from the bath, kitchen and wc of two units at each floor level was taken to a single stack of 10cm diameter not having a vent pipe. The floor trap had a deep seal of 5cm and the pipe drainage was accommodated by sinking the bath, kitchen and wc floors, *Fig* 8.

Cost economics

A comparison of the material used and cost for the under-reamed piles with plinth beams versus the conventional spread footing is given in *Table* 2. It can be seen that there was a saving of 36.2 per cent in the cost of foundation.

The comparison of the amount of materials required for conventional techniques and for the new techniques and the cost comparison for the superstructure is given in *Table* 3. It can be seen that there is a saving of over 20 per cent in the requirements of the major building materials, aside from an overall saving in cost of 18.6 per cent.

The saving in building drainage by the adoption of single stack system of plumbing was 36.6 per cent. The consumption of main building materials per m² of plinth area per house was 244 bricks, 4.68 bags of cement, 43.3kg of steel. The total cost of the experimental block with staircase and services was Rs 1,37,718. This gives the plinth area rate of the building, including water supply, drainage and electrification in the year 1973 when the building was completed, as Rs 192.66/m².

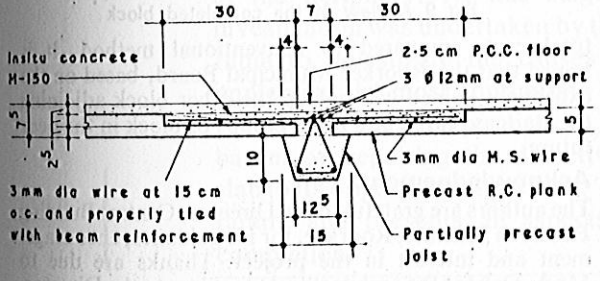

Fig 5 Detail at Y

TABLE 2 Comparison of materials and cost in foundation and plinth

Item	*Conventional spread footing*	*Under-reamed piles*	*Saving,* per cent
Bricks, 1000	80.5	8.5	89.3
Cement, bags	498.0	253.0	49.2
Steel, t.	—	1.98	—
Coarse aggregate, m³	75.5	34.72	54.0
Fine aggregate, m³	140.2	80.0	42.8
Cost, Rs	23,980.15	15,290.23	36.2

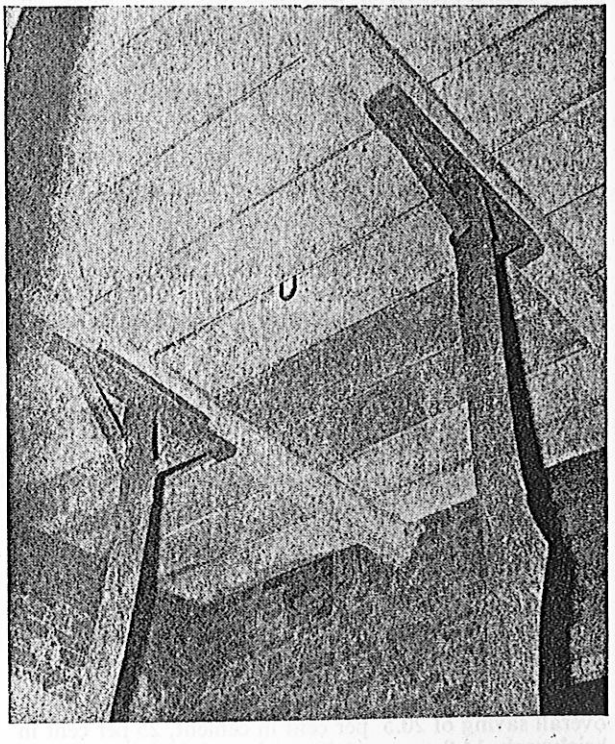

Fig 7 Prop with wooden plank for supporting partially precast joist

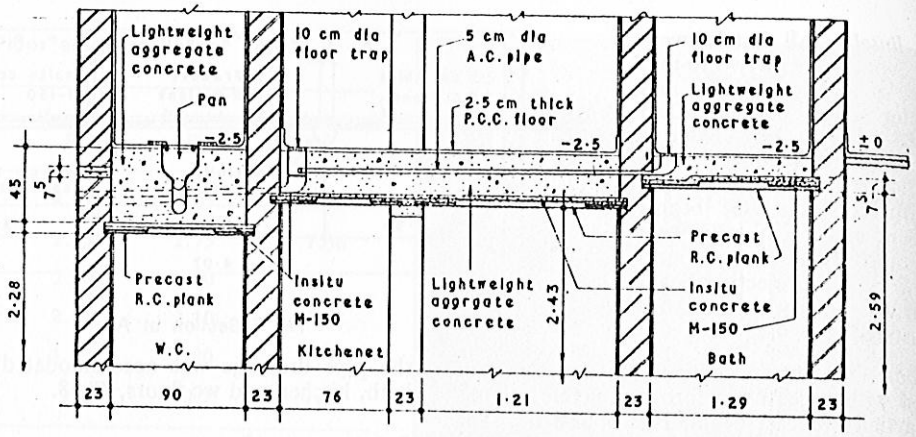

Fig 8 Section at BB

only. The normal rate for conventional buildings in the same year was Rs 245/m². It shows that the adoption of CBRI techniques has resulted in a saving of 19.1 per cent in overall cost. In fact, the saving is actually more than this since the cost of the staircase will be shared by the next sixteen units when built.

The percentage break-up of the cost in different building elements was: foundation and plinth 9.3 per cent; walling including lintels, etc., 23.5 per cent; joinery 12.3 per cent; roofing 16.5 per cent; flooring 4.0 per cent; finishing 6.6 per cent; earthquake resistant provisions 3.6 per cent; staircase 7.2 per cent; water supply 6.2 per cent; sanitation 5.5 per cent; and electrification 5.3 per cent.

TABLE 3 Comparison of materials and cost in superstructure

Items	*Conventional specifications*	*New techniques*	*Saving,* per cent
Bricks, 1000	150.50	113.74	24.5
Cement, bags	1437.00	1126.00	21.7
Steel, t	9.55	7.27	23.4
Coarse aggregate, m³	127.5	90.0	29.4
Fine aggregate, m³	193.8	145.1	25.2
Building cost, Rs	1,127,40.74	91,806.29	18.6

Conclusions

Apart from a compact plan with minimum frontage and circulation area, the new construction techniques adopted were under-reamed piles with grid beams, single-brick thick load bearing walls, party wall only half-brick self-loading, and partly sharing floor/roof load, improved method of bricklaying, thin precast lintels, precast reinforced concrete frames for doors and windows, precast reinforced concrete planks and partially precast beams for floors and roof, improved method of plastering and single stack system of plumbing. A demonstration of the new techniques were given to the building contractors before submission of tenders and it was seen that fairly reasonable rates were tendered. The skilled workers quickly picked up the new techniques after a week's training on site which was provided by the Institute during the initial period of work.

This experimental building is the first four-storey residential building built by a public agency in the area from Meerut to Dehradun, and has aroused great interest in various housing agencies, *Fig* 9. The techniques adopted performed well and resulted in an overall saving of 20.5 per cent in cement, 25 per cent in brickwork, 14.8 per cent in steel, and 19.1 per cent in total cost, compared to conventional method. It is hoped that the Roorkee Municipal Board, based on the experience gained will put up the other block adjoining the staircase early, and more groups of block in the near future.

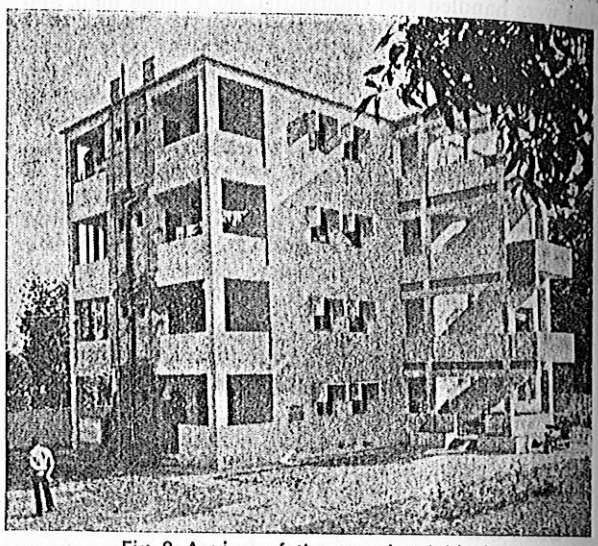

Fig 9 A view of the completed block

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