CHAPTER 5

EXPERIMENTAL INVESTIGATION -‘2D’ FRAME

5.1 GENERAL

The experimental investigation consists of testing two numbers of a reduced scale model of two-storey, two-bay reinforced concrete frame in ‘2D’. In frame (1) brick masonry infill was provided partially and in frame (2), brick masonry inserts were provided. The frames were cast in the laboratory with quality raw materials as per codal provisions. Sufficient care was taken to ensure quality control and frames were cured. The details of the frame model, reinforcement details, casting, curing and construction of infill with brick masonry and masonry insert in ’2D’ frames are presented in this chapter.

5.2 DETAILS OF '2D' MODEL FRAME

Test models were fabricated to a reduced scale following the laws of similitude by scaling down the geometric and material properties of the prototype for frame (1) and frame (2). The geometry of frame models are shown in Figure 5.1. Foundation portion of the frame was made between the loading frame columns, so as to cater to the lateral loading of the frames as a vertical cantilever.
5.3 MATERIALS USED

Ordinary Portland Cement conforming to IS: 269-1976 was used for concrete. Well-graded, crushed and uniform size hard blue granite metal of 6mm down size was used as coarse aggregate. Well graded sand was used as fine aggregate. Potable water was used for concreting, construction of brickwork and curing of the specimen. The reinforcement grill works was prepared using high yield strength deformed bars of various sizes of Fe 415 grade for flexural reinforcement and Fe 250 as shear reinforcement. To provide cover to the reinforcement, precast cover blocks of 13mm thick were used for columns and 8mm for beams. Good quality, burnt clay bricks of size 77x33x25mm were made and used as infill in the frames. Concrete mix of 1:2:4 (volumetric mix) was used for beams and columns.

5.4 CONSTRUCTION OF TEST FRAMES

5.4.1 Reinforcement Details

The dimensions of the beams and columns with reinforcement details are shown in Figure 5.2. Four numbers of 10mm diameter High Yield
Strength Deformed (HYS) bars were provided for columns. Two numbers of 10mm diameter HYS bars were provided both at top and bottom for beams. The transverse reinforcement were in the form of closed rectangular two-legged stirrups of 4mm diameter mild steel bars, provided at 100mm c/c near the ends of the beams whereas in the middle portion of the beams, the spacing adopted was 150mm c/c. For the column, the spacing of ties was 100mm c/c. At the base, to ensure fixity, the column reinforcement was taken in footing to achieve adequate anchorage length. Similarly the beam rods were bent to the required development length and inserted into the column reinforcement grill. The reinforcement detailing was adopted according to IS: 456 and SP-34. The reinforcement grill for the RC frame is shown in Figure 5.3.

![Figure 5.3](image.png)

**Figure 5.2** Dimensions of the beams and columns with reinforcement details
5.4.2 Formwork Details

Formwork for frame (1) was done using plywood/planks and carried out in stages. First foundation was cast, followed by column upto first storey and later with tie beams and second storey columns and the finally top tie beams. Second frame was also cast similar to frame (1). Proper care was taken at the junctions of beams and columns, to ensure proper compaction. The formwork carried out for casting the frame is shown in Figure 5.4.
Both frames were cast between the loading frame columns. Sufficient precautions were taken at every stage of concreting. For mixing of concrete an electrically operated concrete mixer was used and the concrete was placed immediately after mixing. A needle vibrator was used for compaction of concrete. Proper care was taken so that the concrete would be free of honeycomb. The casting was done at various stages as per the approved construction methodology and is shown in Figure 5.5 (a), 5.5 (b) and 5.5 (c).
Figure 5.5(a) Casting of foundation block

Figure 5.5(b) Casting upto first storey

Figure 5.5(c) Casting upto second storey
A slump of concrete was measured to check the workability (Figure 5.6). Specimen such as cubes and cylinders were cast for all the mixes. The frames were covered with gunny bags and were kept moist by periodical sprinkling of water for a period of 21 days from the day of casting. The companion specimens were also cured for the same period as that of the frames (Figure 5.7).

![Figure 5.6 Slump test](image)

5.4.4 Completion of Curing Work for Frame (1) and Frame (2)

The gunny bags were removed after curing the frames (1) and (2) for 21 days and cleaned. To ensure proper bonding roughening of the surface was made wherever the brickwork would be touching the columns and beams to ensure proper bonding (Figure 5.8).

![Figure 5.7 Casting of companion specimen – cubes](image)
5.4.5 Construction of Brick Infill

Brickwork construction was carried out after the frames were completed and prepared. The size of the brick masonry used was 77x33x25mm conforming to the similitude law (Figure 5.9). For infilling the frame with brick masonry, cement mortar 1:5 with a water cement ratio of 0.5 was used. In the frame (1), the panel size at the bottom storey of the infilled specimen was 1000mm x 900mm. In the frame (2), the dimensions of inserts are 450mm x 350mm. The thickness of the brick masonry panel was 70mm. The curing for brickwork was done for 7 days (Figures 5.10 and 5.11).
5.4.6 COMPLETION OF TEST FRAMES

The frames were ready after stipulated period of curing. Concrete elements were marked white and brick masonry was marked red and mortar joints were marked white for better clarity. Both frames were ready for testing as shown in Figures 5.12 and 5.13.
Figure 5.12 Frame (1) with partial infill with opening

Figure 5.13 Frame (2) with partial infill and opening with insert
5.5 TESTING OF COMPANION SPECIMEN

The concrete cubes were tested for the 7\textsuperscript{th} and 28\textsuperscript{th} day’s strength as per IS 516 – 1964. The concrete cylinders were tested under compression. From the flexure test results, stress – strain diagram for the concrete was obtained and this diagram was used to find the modulus of elasticity of the concrete. To study the properties of the brick wall, 155mm x 80mm x 155mm size prisms as recommended by IS 1905 – 1980, were prepared using the same cement mortar mix used for the construction of brick infill tested. The test was carried out upto the final failure of the specimen. The result obtained were used to plot the stress – strain diagram, from which modules of elasticity of brick masonry were obtained (Table 5.1 and Figure 5.14). The testing of the companion specimen is shown in Figure 5.15 (a), 5.15 (b) and 5.15 (c).

Table 5.1 Stress, strain and modulus of elasticity (E) values

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<th>Dimensions (mm)</th>
<th>80 x 155</th>
<th>Original length=155mm</th>
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<tr>
<td>Area=12400mm\textsuperscript{2}</td>
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<td></td>
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<tr>
<td>Load (kN)</td>
<td>Deflection (mm)</td>
<td>Stress (N/mm\textsuperscript{2})</td>
</tr>
<tr>
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<td>0.02</td>
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</tr>
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<td>8</td>
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<td>0.38</td>
<td>4.35</td>
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Figure 5.14 Stress Vs strain curve for brick prism

Figure 5.15(a) Testing of Cube for compressing strength

Figure 5.15(b) Testing of cylinder for split tensile strength
5.6 TEST SETUP AND TESTING PROCEDURE

5.6.1 Test Setup

Test frame set up available in the Structural Engineering laboratory is shown in Figure 5.16. A schematic diagram of the test frame is also shown in Figure 5.17. Two numbers of the two storey, two-bay RC frame with partial infill in the bottom storey and complete infill in the top storey (frame (1) - without insert and frame (2) - with insert) were ready for test under a lateral loading. The whole arrangement of test set-up is shown in Figure 5.18. It consists of the following arrangements.

- Loading arrangement
- Instrumentation for measuring deflections
Figure 5.16 Test frame setup

Figure 5.17 Schematic diagram of test frame
5.6.2  Loading Arrangement

Load point were located at the first storey and second storey levels in line with the beams. The reaction frame, which is used for loading arrangements, was rigidly fixed to the test floor. Jacks of 500 kN in capacity at the top level and 100 kN at the middle levels were used. Pressure gauges were used to measure the applied load. Two numbers of hand-operated oil pumps were used for the application of load through jacks. Loading jack arrangements are shown in the Figure 5.19.

Figure 5.18 Frames in position and ready for testing

Figure 5.19 Loading jack arrangements in frame (1) and frame (2)
5.6.2.1 Instruments for measuring deflection

LVDT (Linear Variable Differential Transformer) of least count 0.01mm was used for measuring deflections at the top storey as shown in Figure 5.20. The test set up of LVDT arrangement is shown in Figure 5.20.

![Figure 5.20 Closer view of LVDT (to measure nodal displacement)](image)

5.6.3 Testing of Frames

The effectiveness of instrumentation set up and the loading were checked in the beginning by loading and unloading the frame with small loads (in the order of 1.0 kN at the two load points) till all the readings were repeatable. The frame was subjected to unidirectional lateral loading. Lumped mass distribution was calculated and unidirectional lateral loads were applied accordingly. Frame (1) was tested for first increment of 10 kN base shear for each cycle and was then released to zero after each cycle. The deflections at top storey levels were measured at each increment and decrement of the load. The formation and propagation of cracks, hinge formation and failure pattern were recorded. This procedure was repeated for frame (2) with masonry insert. Testing of frame (1) and (2) is shown in Figure 5.21.
Figure 5.21 Testing of frame (1) and (2)