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Behavior of Single Bay Two Storeys RC Frame

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Abstract *-Multi-storeyed Reinforced Concrete (RC) framed structures are being constructed extensively in India of-late. The RC elements of the frame are generally designed to take up all the loads and masonry walls are often considered as non-structural filler materials. These RC framed structures suffer premature failures when subjected to lateral forces resulting due to cyclic load nature of seismic forces. This paper discusses about the behaviour of single bay two storied RC frame subjected to lateral loads. The paper also discusses on the aspects of ductility, stiffness degradation, and energy absorption and failure mechanisms of RC frame subjected to cyclic loading.*

Keywords:RCC Frame, Masonry infill, Stiffness degradation.

1. INTRODUCTION:

Multi-storeyed construction is a common sight in all urban centers. These multi-storeyed buildings perform well under vertical loads due to dead and live loads and hence do not pose much of a problem in designing for such loads. However, lateral loads which results due to earthquake, wind forces etc., is a matter of greater concern for which the structures need to be viewed with special considerations, since these lateral loads can produce critical stresses in the structure, or can setup undesirable vibrations, or undesirable displacements or a combination of above mentioned effects. A majority of multi-storeyed structures are being constructed with Reinforced Concrete (RC) frames. The masonry walls are constructed within the RC frames and its contribution against strength and stiffness is not considered. The designs of RC frames are performed such that the weight of masonry walls is considered as mass on the beams in addition to other loads during the analysis. Hence there is a need to understand the behaviour of RC framed structures subjected to cyclic loadings.

2. PRESENT INVESTIGATION:

In the present investigation a half scaled single bay two storied RC frame is considered. The columns are 150 X 100mm in cross section reinforced with four bars of 10mm HYSD bars with 6mm mild steel stirrups at 50mm centre to centre and beams are 100mm x 100mm in cross section reinforced with four bars of 8mm HYSD bars with 6mm mild steel stirrups at 50mm centre to centre. The reinforcement has been fabricated conforming to the IS 13920-1993

3. ESTIMATION OF FAILURE LOAD:

The dimensions of the RC members were small with congested reinforcement, and hence Self-Compacting Concrete was used to facilitate proper placement and compaction, without the need for vibration of concrete. Ordinary Portland cement (C53 grade), conforming to the requirements of IS- 12269, was used in the study. The Blaine fineness of the cement is 265 m^2/kg, Natural river sand (confirming to zone II) was used as fine aggregate and crushed granite stone was used as coarse aggregate. Maximum size of the aggregate was 12.5mm. The bulk specific gravities of the coarse aggregate and sand were 2.68 and 2.67 and their absorption values were 0.35 and 2 % respectively. Commercially available modified polycarboxylic ether based super plasticizer (GleniumB233) was used as chemical admixture. The product has specific gravity of 1.09 & solid contents not less than 30% by weight. For achieving grade 25, the water content 180lit/m^3 and water to cement ratio 0.45.For the mix proportion chosen, it was possible to achieve cube strength of 32.5 MPa.

4. EXPERIMENTAL PROCEEDINGS:

To ensure fixity of the frame at the base, foundation block was used which was anchored to the concrete base using 4 no's of anchor bolts of 40mm dia. The mass of the wall was replaced by stacking an equivalent amount of bricks on the beams. The model was tested under the 50ton loading frame for lateral loading. The loading was done using jacks with proving rings mounted at the storey levels and the drifts at the respective storey levels and the deflection of beams was noted. The Fig.1 shows the test setup wherein the model was subjected to lateral loading. Suitable lateral restraint arrangements with the help of steel pipes were made to prevent any out-of plane deformation of the frame. so that the RC frame is subjected to in-plane deformations only.

Fig.1 Test Setup

5. RESULTS AND DISCUSSIONS:

5.1 STOREY DRIFT:

The sequence of loading and the maximum load level reached in each cycle is shown in Chart 1. The frame was subjected to 5 cycles of loading and the ultimate load of 39 KN was reached in the 5th cycle. After the 5th cycle there was a drastic reduction of load associated with large drift values. Chart. 1 shows the storey drift at ultimate loads of each cycle.

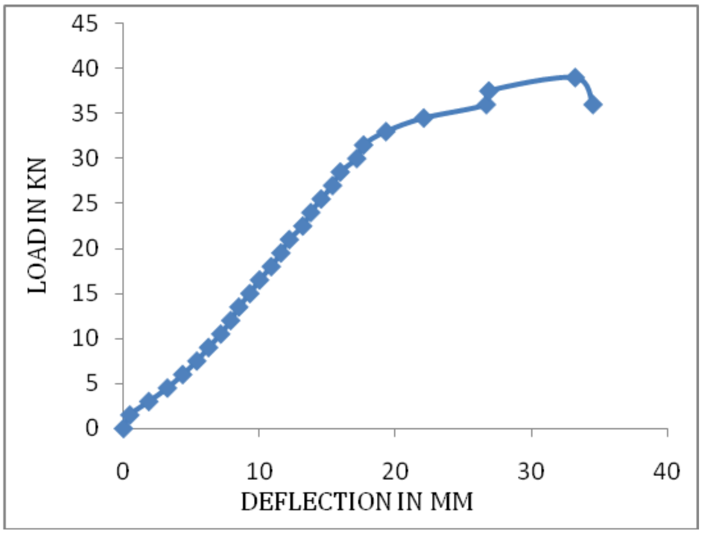

Chart1. Load vs. Storey Drift

5.2 STIFFNESS DEGRADATION:

Stiffness of the frame is defined as the bases hear required causing a unit drift at the top storey level. The initial stiffness of the frame was 6.35KN/mm in the first cycle. The stiffness degraded very steeply beyond the 5th cycle and the stiffness of the frame at the 5th cycle was 2.77KN/mm. Chart 2 shows the stiffness degradation of the frame corresponding to the loading cycles. There is a degradation of stiffness in the frame up to 56% at end of 5th cycle. Residual stiffness of 2.6KN/mm was noticed.

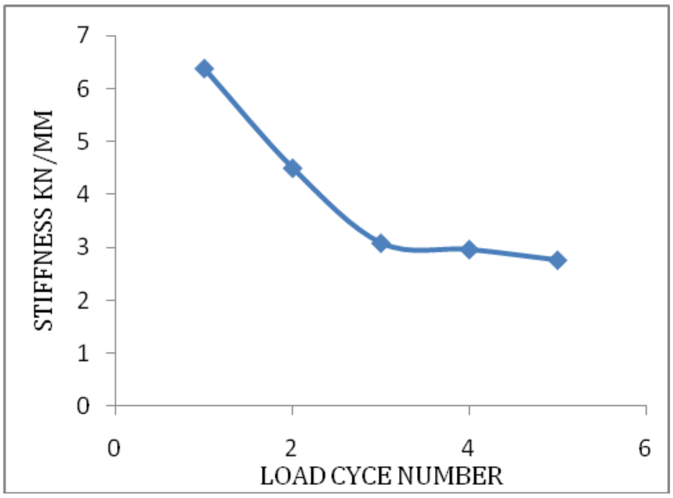

Chart2. Stiffness Degradation

5.3DUCTILITY:

Earthquakes imparts tremendous amount of lateral forces on the structures. Structures which has a high amount of deformable capacity and still retaining its vertical load carrying capacity is preferred so that the structure has the capacity to absorb considerable energy due to seismic activity. This property of the structure will prevent the total collapse of the structure. Hence resistance to seismic and lateral forces demands for higher energy absorption or ductility along with vertical load carrying capacity. Ductility factor with respect to the top storey drift of the proposed test models defined as the ratio of the maximum drift at any load level to the first yield drift. Thedrift of the top storey at the 8th cycle was taken as the first yield drift. Cumulative ductility up to any stage is defined as the sum of the ductility's at maximum load levels attained in each cycle up to the loadcycle considered. The storey drift and the corresponding load on the frame were subjected during testing and it can be seen that the frame yields at the 5^{th} cycle. Chart3 shows the cumulative ductility factor of the frame.

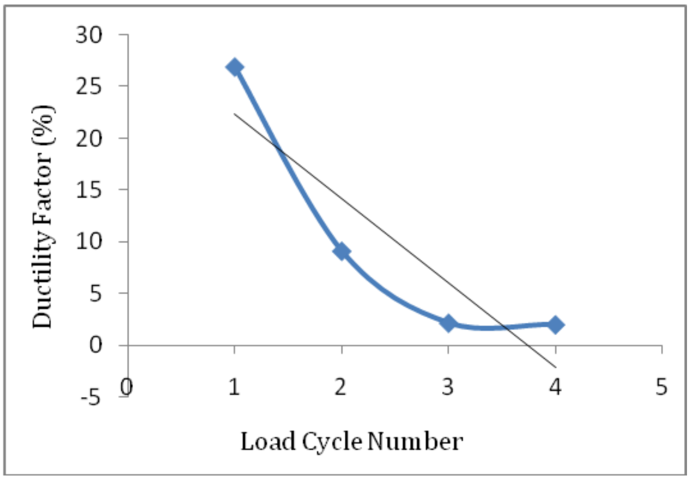

Chart3. Cumulative Ductility

5.4ENERGY DISSIPATION:

The energy dissipation capacity of the structure is the area under the load vs. storey drift diagram of each cycle which gives the energy absorbed by the structure. The cumulative energy absorbed has been calculated. The energy absorbed in the first cycle is 15.6 kN-mm while the cumulative energy dissipated at the failure stage (5th cycle) was 192kN-mm. and is shown in Chart 4.

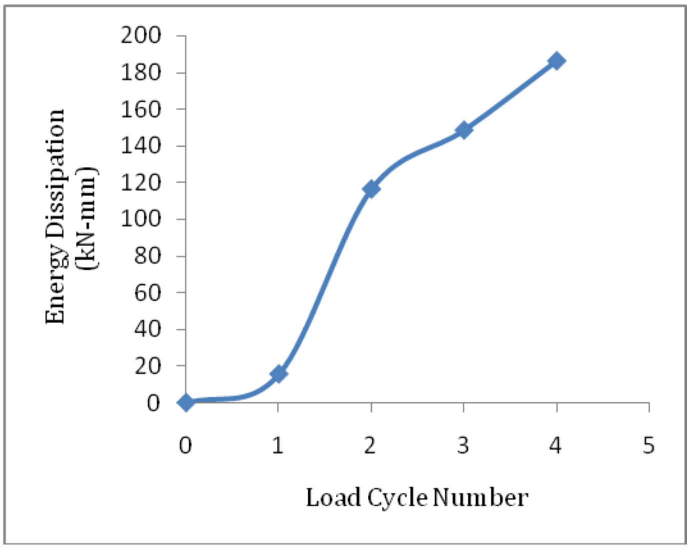

Chart4. Energy Dissipation

6. MODE OF FAILURE:

The first visible crack at the beam column junction of the storey1 developed midway during the third-fourth cycle. This corresponds to a base shear of about 7000N.This diagonal crack occurred exactly at the geometric mid-point of the beam column junction. Later the reversal of load leads to another crack at the same location. Thus a typical X – type crack was noticed. During the immediate next cycle, such cracks were noticed at either end of the 1st storey beam. During the fifth cycle, such plastic hinges had begun to form at all junctions; at the base, 1st and 2^{nd} storey level. During the last stages of loading, spalling of concrete was noticed. During this stage a few negative moment cracks were noticed at the top of the beams. It may be highlighted that it was possible to achieve a drift of more than 33 mm. Another interesting observation was that no horizontal shear cracks were noticed in columns.

7. CONCLUSIONS:

In the present experimental investigation to understand the lateral load responses of two storeyed RC frame Structure; a carefully designed experimental setup was developed. Based on the experiments, the following conclusions can be drawn;

i) The ultimate failure pattern was by way of development of typical X – type plastic hinges at beam-column junctions.

ii) The salient results are a) stiffness degradation, b) Ductility and c) Energy dissipation.

It may also be concluded that this experimental setup could be utilized for further experimental parameters involving partial and complete masonry in-fill.

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