Comparative Study for Seismic Performance of Ductile and Non Ductile RC Frames

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Abstract— Ductility plays an important role in structures subjected to earthquake loads. As structures are not designed for full amount of forces induced under seismic events, the structure is expected to undergo nonlinear deformations. In case of reinforced concrete buildings, ductility safeguards building against dangerous brittle failure. The effect of ductile detailing on seismic performance of reinforced concrete building is studied in present study. For this three different type of frames are employed. The analysis is carried out using non-linear static procedure. The pushover curve and storey displacement results show that reinforced concrete frames with ductile detailing show better performance in non-linear regiong.

Key words: Ductile Frame, Non-Ductile Frame, Non-Linear Static Analysis, Reinforced Concrete, Seismic Performance

I. INTRODUCTION

Concrete in itself is a brittle material and hence is badly damaged under earthquake loads. However, concrete reinforced with steel shows considerable ductility. The ductility of reinforced concrete depends on amount of detailing.

The aim of structural design is that the structure should remain elastic under given load. For dead load and imposed load, the structure can be designed for their full magnitude. However, the building structure cannot be designed for full magnitude of earthquake as it will lead to highly uneconomical design.

The building structure are therefore expected to undergo inelastic deformations under earthquake. The lack of ductility in frame will lead to sudden brittle failure which is undesirable. Hence, the earthquake resistance of a building is dependent on amount of ductility incorporated.

Proper detailing of reinforcement of reinforced concrete members leads to increase in ductility and reduces the inelastic damage.

The seismic performance of ductile and non-ductile frame is compared for three frames - which have different configurations. The non-linear static analysis is performed to better assess the seismic performance.

II. DETAILS OF BUILDING FRAMES

Three different frame are employed in present study for comparison of seismic performance as given below. Each of these are first modelled as non-ductile and then as ductile by employing the detailing as per IS 13920:1993 [1]. The designation of frames is as follows.

- Model I - Frame having 6 storeys and 6 bays
- Model II - Frame having 6 storeys and 3 bays
- Model III - Frame having 9 storeys and 3 bays

The storey height and bay width of all frames are kept as 3 m. The geometric details of these are given in Fig. 1, Fig. 2, Fig. 3 All frames are of reinforced concrete with M20 concrete and Fe415 reinforcing steel. The frames are designed as per IS 456:2000 [2].

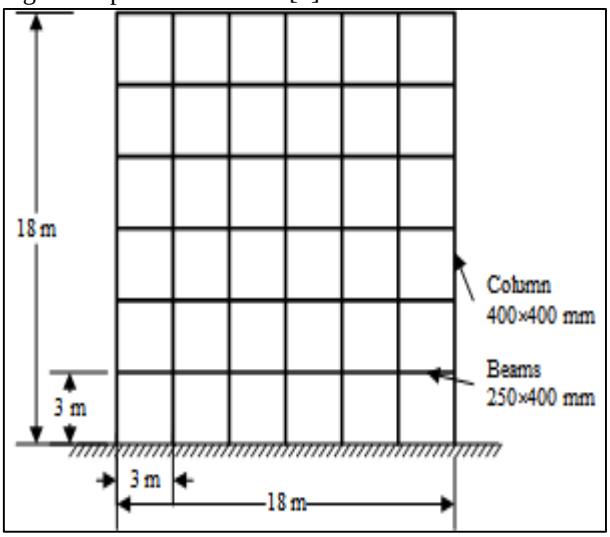

Fig. 1: Geometric details of Model I

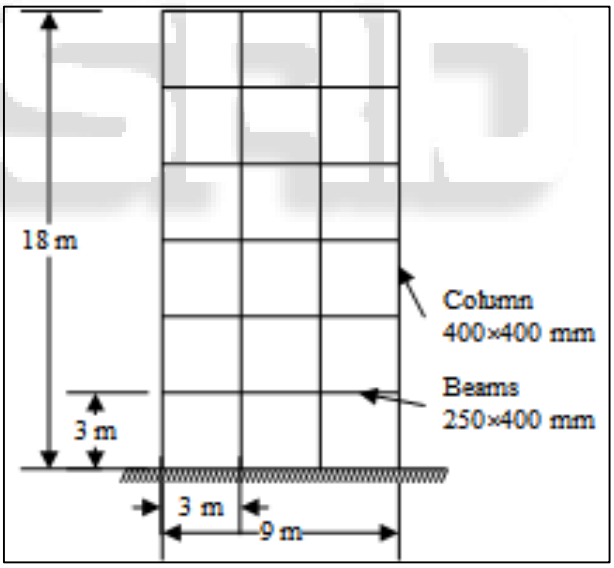

Fig. 2: Geometric details of Model II

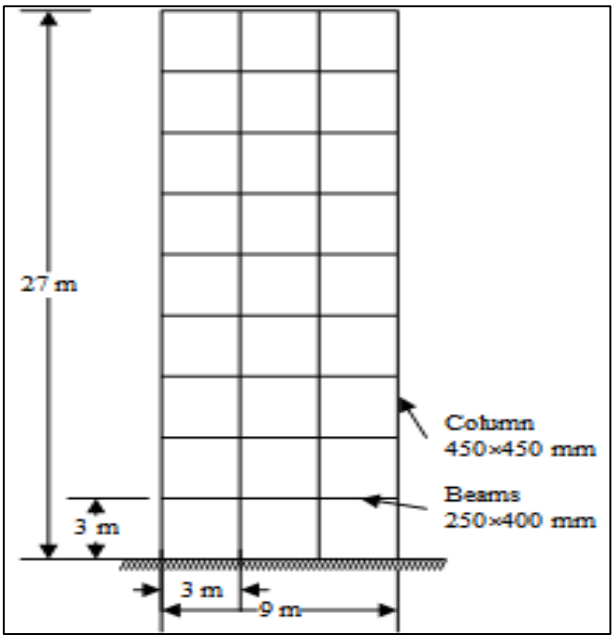

Fig. 3: Geometric details of Model III

III. Analysis Procedure

The frames are analysed using non-linear static procedure of FEMA 440 [3]. Firstly, the pushover curve is obtained by analyzing the frames in ETABS [4]. The performance of building under the response spectrum earthquake from IS 1893:2002 [5] is then evaluated. For this, the pushover curve and response spectrum are converted in acceleration displacement response spectrum form. The method of conversion is given in ATC-40 [6].

The response spectrum used for this purpose is given in Fig. 4 which corresponds to zone V medium soil with importance factor as unity.

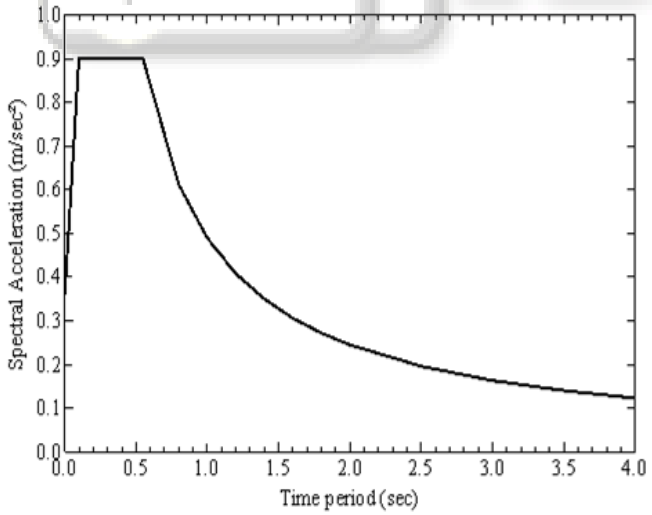

Fig. 4: Response spectrum from IS 1893:2002 [5] for zone V medium soil

IV. Results and Discussions

A. Pushover Analysis Results

The pushover curves for frames are given in Fig. 5, Fig. 6 and Fig. 7. These curves clearly show that non-linear behavior is significantly affected with incorporation of ductile detailing.

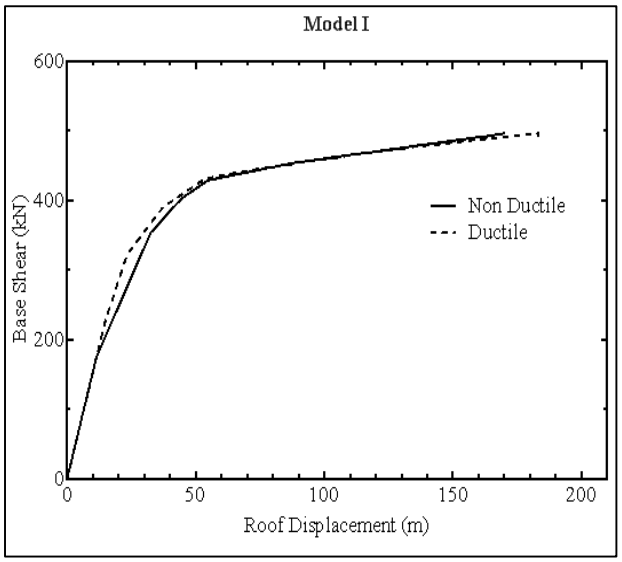

Fig. 5: Pushover curve for Model I

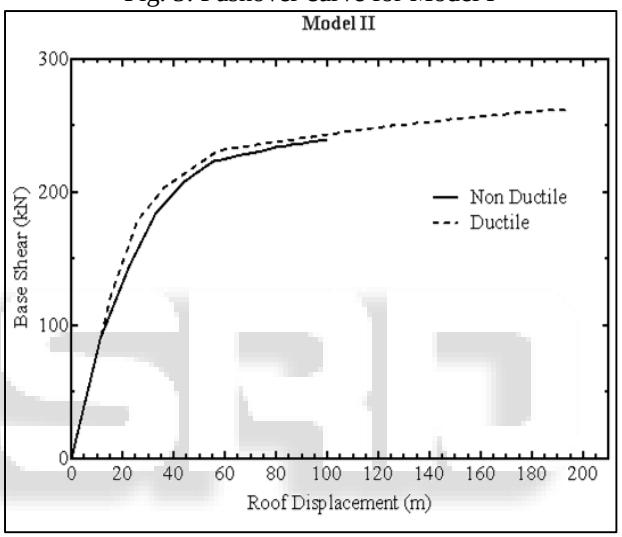

Fig. 6: Pushover curve for Model II

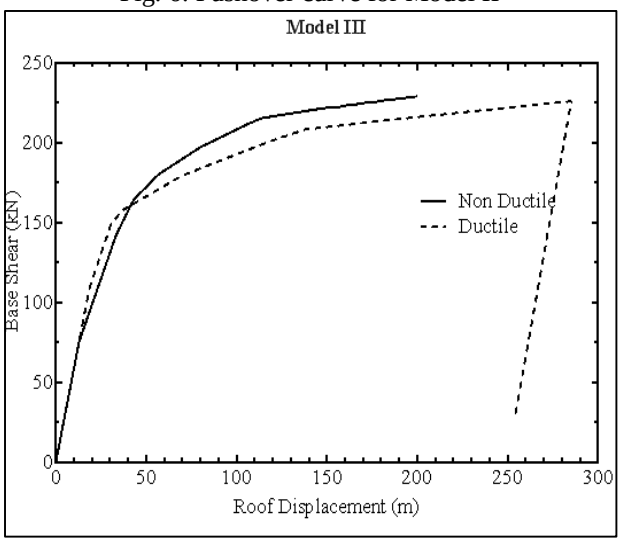

Fig. 7: Pushover curve for Model III

B. Storey Displacement

The storey displacement for each frame is evaluated at performance point calculated by procedures of FEMA 440 [3].

The storey displacement plots corresponding to maximum lateral displacement are shown in Fig. 8, Fig. 9 and Fig. 10.

It is observed that frames with proper ductile detailing have enhanced capacity to undergo displacement.

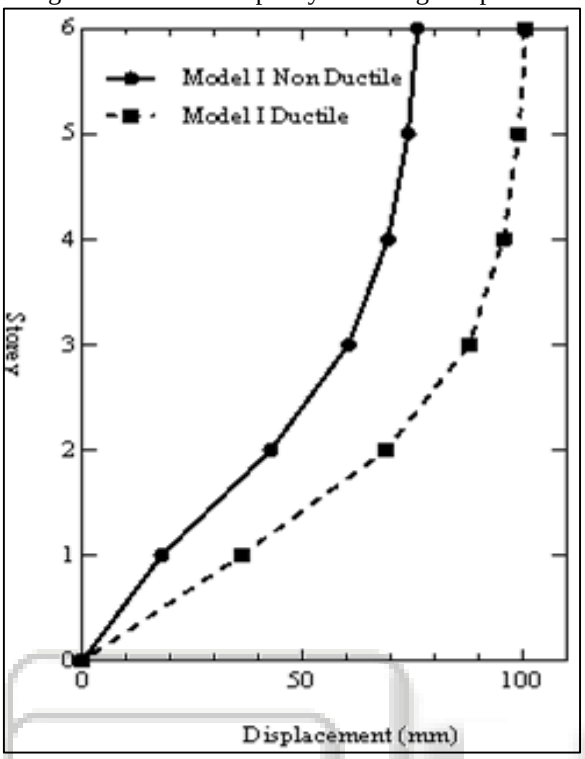

Fig. 8: Storey displacement plot for Model I

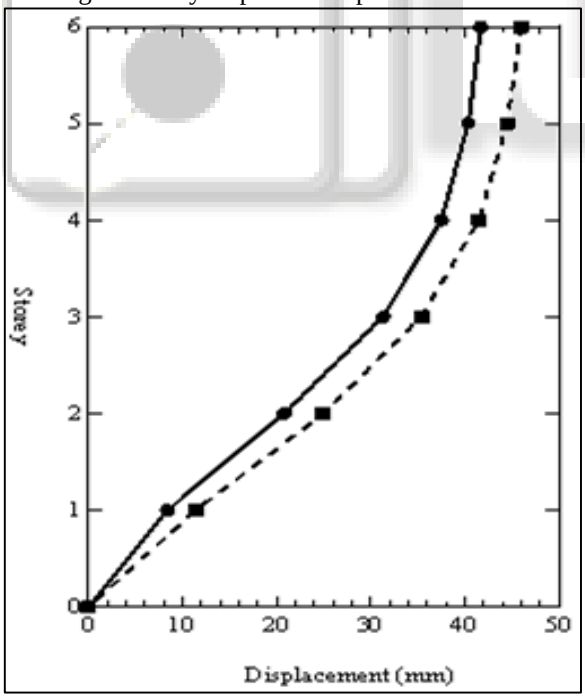

Fig. 9: Storey displacement plot for Model II

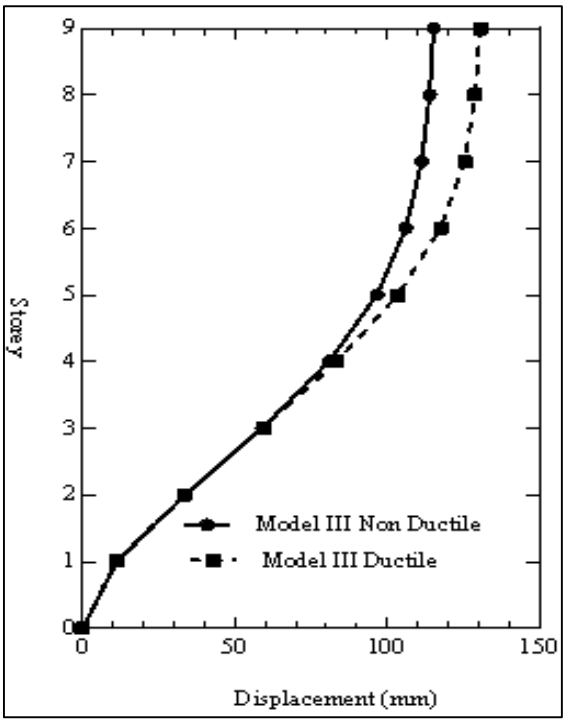

Fig. 10: Storey displacement plot for Model III

V. CONCLUSIONS

The seismic performance of three different reinforced concrete frame with and without ductile detailing is assessed using non-linear static procedure. The pushover curves and storey displacement plots show that capacity of reinforced concrete frame is enhanced with incorporation of ductile detailing.

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