IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)
e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 12, Issue 4 Ver. V (Jul. - Aug. 2015), PP 04-08
www.iosrjournals.org

Seismic Performance of Partial Capacity Designed RC Framed Structure

Yashvanth M H[1], A R Pradeep[2], Dr.Mahadev M Achar[3]
[1]*PG Student, Dept of Civil Engg, SSIT Tumkur, India*
[2]*Asst Professor, Dept of Civil Engg, SSIT Tumkur, India*
[2]*Associate Vice President, IIIE Ltd, Bangalore, India*

Abstract:*Partial capacity design method is one of the performance based design approach derived from capacity design method. In partial capacity design method selected columns are designed to remain as elastic during the severe earthquake which is achieved by designing them to the higher seismic load by using magnification factor formula. Plastic hinges are allowed to form only in the expected locations so as to attain the safe collapse mechanism. In the present study, a new magnification factor formula is used for partial capacity design method and partial capacity design method uses the overstrength present in the frames unlike assuming the overstrength to columns as in case of capacity design method. The frames with 3 and 5 storeys with 3, 5 and 7 bays of equal bay width in 2D are selected to study the partial capacity design method. The frames are designed according to the IS 456 and using the magnification formula. To study the seismic performance of frames nonlinear static pushover analysis is performed and the collapse mechanism is obtained as expected. From the study it is found that the resistance of the frames to the severe earthquake depends on selection of size of the frame sections.*
Keyword: *partial capacity design, overstrength factor, magnification factor, pushover analysis, performance point, collapse mechanism.*

I. Introduction

The concept of partial capacity design method is derived from the ideas of capacity design (CD) method.The method is first introduced by Muljati and Lumantarna in Indonesia. The method involves designing of interior columns and beams for nominal seismic load and exterior columns for higher seismic load that is exterior columns are designed as elastic, interior columns are designed as plastic as shown in fig. 1. To design the frames for higher seismic load a new magnification factor formula is used.Previously work on PCD has been carried out in Indonesia, only the square columns are adopted for the study. The study on the parameters such as overstrength factor, variation in interior and exterior column sizes, reduction in column sizes in the upper stories etc. have been taken up. It is found that no such study/research is conducted in India.

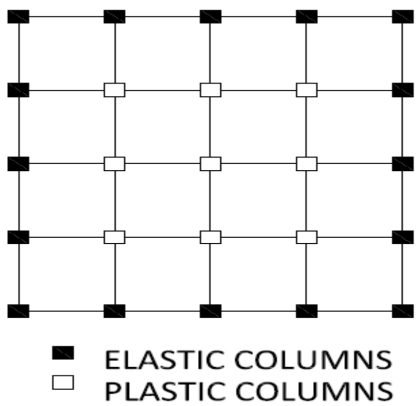

Fig. 1 Plan View of PCD

In the present study 2D building frames of 3 and 5 storeys with 3, 5 and 7 bays are modelled in SAP software to know the behaviour of PCD method. The frames are designed in accordance to the Indian seismic code IS:1893-2002 (Part1). The hinge pattern shown in fig. 2 is assumed as the safe collapse mechanism.

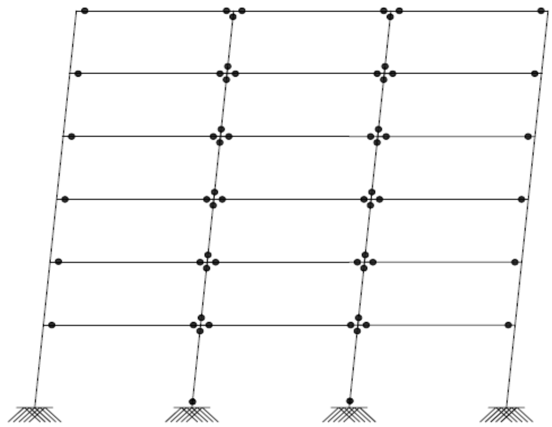

Fig.2 Assumed Collapse Mechanism for PCD

II. Magnification Factor Formula

For defining magnification factor, the maximum considered earthquake is used as target base shear;design basis earthquake is used as nominal base shear which are defined in IS1893, the term overstrength factor is determined by pushover analysis.

$$MF = \frac{V_B^T - R_s n_{in} S_{in}^N}{n_{ex} S_{ex}^N}$$

Where

V^T_B = target base shear $= \frac{ZISa}{Rg} W$

R_s = overstrength factor $= \frac{V_o}{V_B^N}$

V_o = base shear at which first plastic hinge is formed

n_{in}, n_{ex} = number of interior and exterior columns

S^N_{in} = base shear in the interior columns due to nominal seismic load

S^T_{ex} = base shear in the exterior columns due to target base shear

V^N_B = nominal base shear $= \frac{ZISa}{2Rg} W$

Table I
Description of the Frames

Name of the frame	Number of stories	Number of bays	Interior columns (mm)	Exterior columns (mm)	Beams (mm)
PCD 3-3-1	3	3	300X450	500X500	300x500
PCD 3-5-1	3	5			
PCD 3-7-1	3	7			
PCD 3-3-2	3	3	450X300		
PCD 3-5-2	3	5			
PCD 3-7-2	3	7			
PCD 5-3-1	5	3	300X500	550X550	300X600
PCD 5-5-1	5	5			
PCD 5-7-1	5	7			
PCD 5-3-2	5	3	500X300		
PCD 5-5-2	5	5			
PCD 5-7-2	5	7			
Grade of concrete = M30		Grade of steel = Fe500		Storey height =3.2m	
Floor finish = 1kN/m^2		Live load = 2.5kN/m^2		Slab thickness = 120mm	
Type of soil = medium		Seismic zone = zone IV		Isolated footing	

III. Description Of The Models

The nomenclature of the frames and the details of the models considered to study PCD are given in table I. The view of model PCD 5-5-1 is shown in Fig. 3.

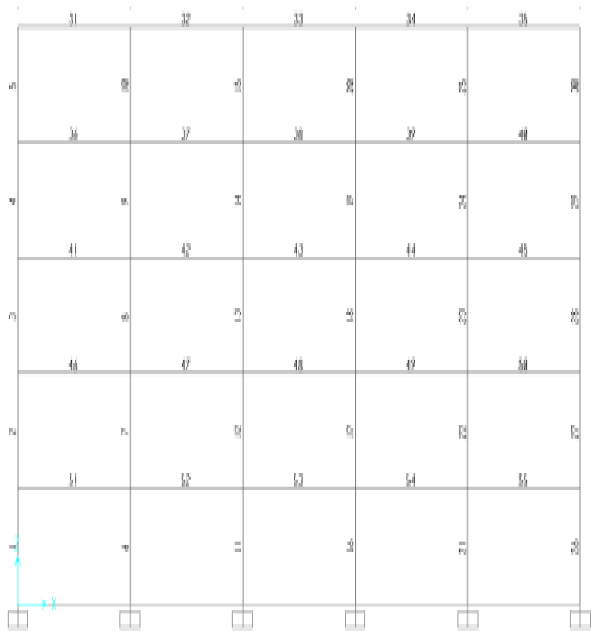

Fig.3 Model of PCD 5-5-1 and PCD 5-5-2

The frames are analysed by equivalent static analysis and designed to combination of in table 1.2DL+1.2LL±1.2EL where EL is the earthquake load. The dead and live loads applied on the frames are given in table II.

Table II
Loads Applied On The Frames

3 Storey Frames	
Dead load on floor beams	33.5 kN/m
Live load on floor beams	12.5 kN/m
Point load on columns at floor (dead load)	86.25 kN
Dead load on roof beams	20 kN/m
Live load on roof beams	12.5 kN/m
Point load on columns at roof (dead load)	18.75 kN
5 Storey Frames	
Dead load on floor beams	33 kN/m
Live load on floor beams	12.5 kN/m
Point load on columns at floor (dead load)	87.5 kN
Dead load on roof beams	20 kN/m
Live load on roof beams	12.5 kN/m
Point load on columns at roof (dead load)	22.5 kN

IV. Methodology

After designing the frame, reinforcement is provided as required, pushover analysis is performed for combination of 1.2DL+1.2LL±1.2EL to calculate the overstrength and magnification factor and external columns are redesigned to the combination of 1.2DL+1.2LL±(MF)EL. Then pushover analysis is performed to 1DL+0.25LL and gradually increasing lateral load up to the failure to evaluate the seismic performance of the frames.

V. Results

After performing the pushover analysis to the frames designed by partial capacity design method, the collapse mechanism is obtained as shown in Fig. 4 and 5 for frame PCD 5-5-1 and PCD 5-5-2. The obtained collapse mechanism shows that the assumed collapse mechanism can be obtained by partial capacity design method. The overstrength and magnification factor calculated for the frames is shown in table III. The table also shows the values of base shear resisted by the frames at the stage of collapse mechanism.

Table III
Overstrength and Magnification Factor for Frames

Name of the frame	Overstrength factor	Magnification factor	Resisting base shear (kN)
PCD 3-3-1	1.23	2.6	526.79
PCD 3-3-2	1.24	2.35	496.13
PCD 3-5-1	1.11	3.34	845.66
PCD 3-5-2	1.13	2.77	746.93
PCD 3-7-1	1.21	3.77	1132.67
PCD 3-7-2	1.21	3	996.1
PCD 5-3-1	1.14	2.63	660.62
PCD 5-3-2	1.05	2.37	623.48
PCD 5-5-1	1.21	3.17	1059.29
PCD 5-5-2	1.03	2.71	1012.32
PCD 5-7-1	1.15	3.87	1425.55
PCD 5-7-2	1.03	3.01	1373.76

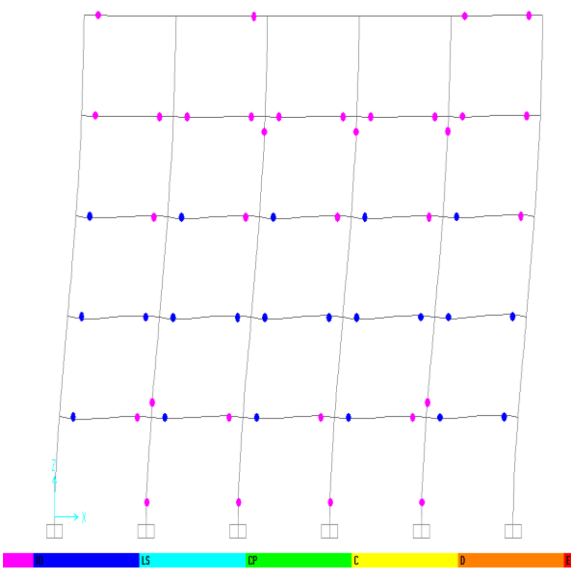

Fig. 4 Collapse Mechanism for PCD5-5-1

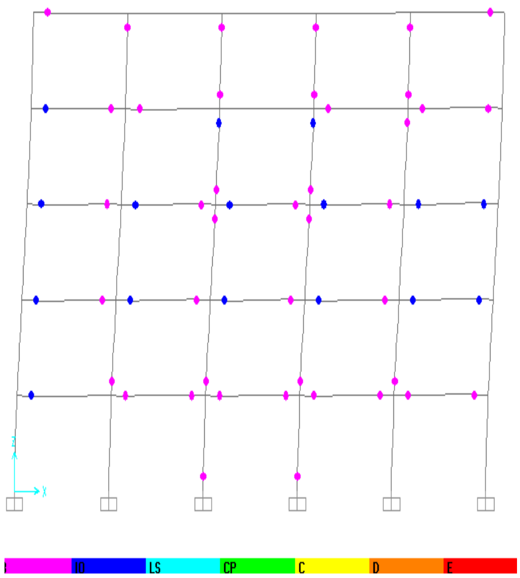

Fig. 5 Collapse mechanism for PCD 5-5-2

VI. CONCLUSION

1. The overstrength factor of the frames is found to be depending on the cross-sectional area of the frame elements and percentage of reinforcement area in the frame elements. For a particular cross-sectional area of the beam or column the overstrength factor increases with increase in percentage of reinforcement area.
2. The magnification factor depends on the overstrength factor and orientation of the interior columns. The value of magnification factor will be more for the frames with depth of columns along the direction of the frame when compared with depth of columns perpendicular to the direction of the frame also The magnification factor is found to be largely depends on the orientation of the columns than that of the overstrength factor
3. The frames PCD 3-3-1, PCD 3-5-1, PCD 3-7-1 are capable of resisting base shear even more than that caused by MCE. This is because the cross-sectional area of the frame elements is more than the required which becomes uneconomic.
4. The effective time period for the frames during DBE and MCE are more than the actual time period. This indicates that the frames are entering the plastic stage even for nominal earthquake. The frames can be designed as perfectly elastic by designing the frame elements to the different load combinations.
5. The selection of size of exterior columns requires should be done carefully, after the application of the magnification factor the percentage of reinforcement in the columns may exceed 6%. This requires to increase the dimensions of the exterior columns and to repeat the procedure from the beginning; also the square columns must be selected for exterior columns to get the assumed collapse mechanism.

References

[1]. Armagan Korkmaz1, Mustafa Duzgun2 (2006), "Evaluation Of Different Types Of Pushover Analyses For R\C Frame Structures", Joint International Conference on Computing and Decision Making in Civil and Building Engineering June 14-16, 2006 - Montréal, Canada

[2]. I Muljati, B. Lumantarna (2011), "The Use of Magnification Factor Formula in Partial Capacity Design Method for Fully Ductile Moment Resisting Frames",Procedia Engineering 14 (2011) 220–226

[3]. N.K. Manjula1, Praveen Nagarajan2, T.M. Madhavan Pillai3 (2013), "A Comparison of Basic Pushover Methods", International Refereed Journal of Engineering and Science (IRJES) Volume 2, Issue 5(May 2013), PP. 14-19

[4]. Branci Taïeb1, Bourada Sofiane2 (2014), "Accounting for ductility and overstrength in seismic design of reinforced concrete structures", Proceedings of the 9th International Conference on Structural Dynamics, EURODYN 2014 Porto, Portugal, 30 June - 2 July 2014

[5]. IS: 1893-2002 (Part 1), Indian Standard Criteria for Earthquake Resistant Design of Structures, fifth revision, Bureau of Indian Standards, New Delhi.

[6]. Applied Technology Council, ATC-40, (1996), 'Seismic Evaluation and Retrofit of Concrete Buildings', Vol. 1, Applied Technology Council, Redwood City, California.

[7]. IS 456 : 2000 Indian Standard plain and reinforced concrete code of practice (fourth revision)Bureau of Indian standards New Delhi