Study on Seismic Behavior of RC Structures with Different Parameters of Haunched Beam

Jeethu Ponnachan
PG Scholar
Department of Civil Engineering
SAINTGITS College of Engineering, Pathamuttom
Kottayam, India

Vincy Koshy
Assistant Professor
Department of Civil Engineering
SAINTGITS College of Engineering, Pathamuttom
Kottayam, India

***Abstract*— Demand of haunch beam is high for column free spaces in a building. Haunch beams are those having thicker cross section at the supports when compared with its middle section. Haunches are generally provided at the bottom of the beam which requires no modification to the beam top flange thereby minimizing the need to remove or alter the floor slab. Rigid moment connections are established between the beams and columns by adequate haunch beam design. This study performs the analysis of Reinforced Concrete framed structures with Haunched beams. Many high-rise buildings have recently adopted the use of haunched beams. This paper emphasizes the effects of different configurations of Haunched beams on the seismic response of a structure and the main purpose is to carry out the non-linear static analysis on RC building frames of ten storey at seismic zones IV considering IS 1893 (Part 1): 2002 and compare the results of analysis (base shear and natural period, hinge formation pattern).**

Keywords*— Haunched beam, Pushover analysis, Performace point, Hinge pattern , Natural time period

I. INTRODUCTION

There is a greater demand for seismic evaluation and retrofitting of existing buildings due to the widespread damage to the structure caused due to earthquake. So the design should be done in such a way that they perform the function satisfactorily and economically. In a reinforced concrete building, loads acting on them are mainly carried and transferred by beams. When span increases as in case of soft storey structures, bending moment and shear force increases substantially at the center of the span and over the supports. Prismatic beams are uneconomical in such situations. In such cases, non-prismatic beams are the sufficient solution.
Haunched beams are most commonly used in bridge structures, portal frames, cantilever retaining walls etc where span is comparatively high. Cross-section of the beam can be made non-prismatic by varying its width, haunch depth, haunch length or by varying both haunch depth and length along their length. Haunched beams are used to make the efficient use of concrete and steel, to reduce the weight of the building, to increase the headroom, etc.

Pushover analysis is an approximation analysis method in which the structure is subjected to monotonically increment lateral forces is applied to the structure until a target displacement is achieved. In the proposed model, different parameters of haunched beams such as symmetric variation in haunch depth and haunch length are considered and non-linear static analysis like pushover analysis is done. Seismic performance are thus evaluated from its base shear displacement curve, performance point and hinge pattern..

I. CASE STUDY DETAILS

To evaluate the performance of haunched beams, a 10 storey RC structure are considered. It is consisting of four bays in both the directions. The spacing along X and Y directions is 8m and the story height of 3m is provided. The frame is located in seismic zone IV.

A. Design data

a) Live load : 3.0 kN/m² at each floors
: 1.5 kN/m² on terrace
b) Earthquake load : As per IS-1893 (Part 1)2002
c) Type of soil : Type II, Medium soil as per IS:1893
d) Storey height : 3m
e) Floors : G.F + 9 upper floors.
f) Walls : 230 mm thick brick masonry
g) Seismic zone : Zone IV

B. Building frame details

a) No. Bays along X direction : 4
b) No. Of bays along Y direction : 4
c) Spacing along X axis : 8m
d) Spacing along Y axis : 8m
e) Story height : 3m
f) No. Of floors : G + 9
g) Column sizes : 300mm x 450mm, 400mm x 900mm
h) Size of beam :
Width : 300mm
Haunch length and depth are varied Accordingly
i) Slab : 150mm thick

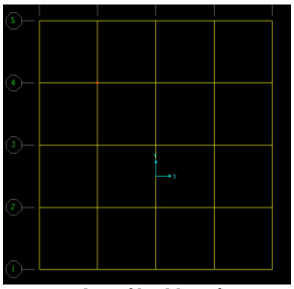


Fig. 1. Plan of building frame

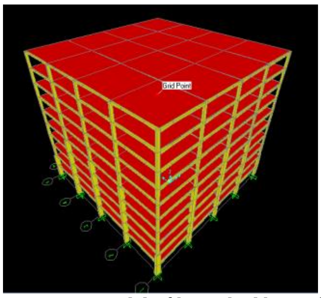


Fig. 2. 3D model of haunched beam frame

TABLE I. Details of symmetric variation in haunch depth

Si No.	**Model**	**Haunch length** *(mm)* *1/5th (clear span)*	**Size of haunched beam**		
			Depth at support (mm	*Depth at midsection (mm)*	*Width (mm)*
1.	A1	160	500	300	300
2.	A2	160	600	300	300
3.	A3	160	700	300	300
4.	A4	160	800	300	300
5.	A5	160	900	300	300

TABLE II. Details of symmetric variation in haunch length

Si No.	**Model**	**Haunch length** *(mm)*	**Size of haunched beam**		
			Depth at support (mm)	*Depth at midsection (mm)*	*Width (mm)*
1.	B1	150	500	300	300
2.	B2	200	500	300	300
3.	B3	250	500	300	300
4.	B4	300	500	300	300
5.	B5	350	500	300	300

III. RESULTS OBTAINED

C. Fundamental Time Period (sec.)

The natural period of a structure is its time period of undamped free vibration. It is the first modal time period of vibration. Variation of fundamental Time Period for various frames are shown in table V and VI.

TABLE III. Time period and mode shapes obtained from modal analysis for haunch depth variation

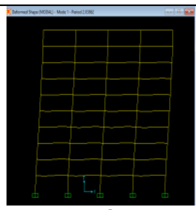
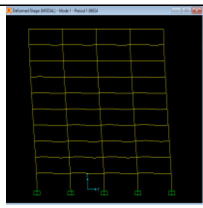
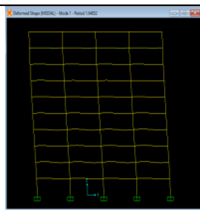
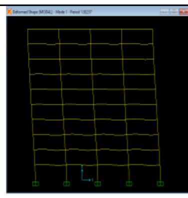
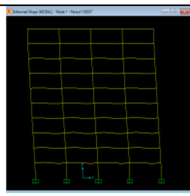
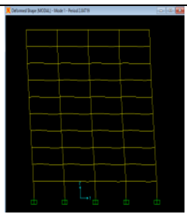
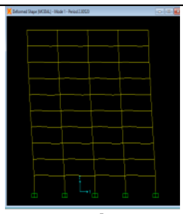
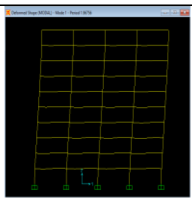
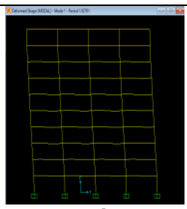
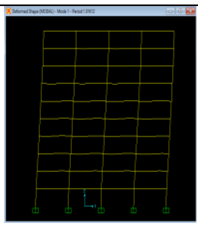
Si no	**Model**	**Time period(s)**	**Mode shape(mode 1)**
1.	A1	2.03862	 Y translation
2.	A2	1.98654	 Y translation
3.	A3	1.94852	 Y translation
4.	A4	1.92237	 Y translation
5.	A5	1.90557	 Y translation

TABLE VI. time period obtained from modal analysis for haunch length variation

Si no	model	Time period(s)	Mode shape(mode 1)
1.	B1	2.04719	 Y translation
2.	B2	2.00520	 Y translation
3.	B3	1.96756	 Y translation
4.	B4	1.92781	 Y translation
5.	B5	1.91612	 Y translation

D. Pushover analysis

To examine the performance point of the building frame in terms of base shear and displacement, non- linear static pushover analysis is performed on the above building frames. Various pushover cases such as push down, push X , push Y are considered during the analysis. The various load combinations are considered for this purpose. After pushover analysis, the demand curve and capacity curves are obtained and hence the performance point of the structure. The base shear for PUSH X load case and for PUSH Y at performance point for various configuration of haunched beam frames are listed in the table below:

TABLE VI. : Variation of Performance Point (X & Y Direction) for symmetric haunch depth variation

Si No.	Haunch depth (mm)	PUSH X		PUSH Y	
		Base shear (kN)	*Displacement (m)*	*Base shear (kN)*	*Displacement (m)*
1.	500	7032.57	0.146	6210.610	0.168
2.	600	7055.126	0.147	6210.554	0.169
3.	700	7092.122	0.146	6228.486	0.169
4.	800	7097.612	0.146	6246.416	0.171
5.	900	7117.88	0.146	6248.58	0.171

TABLE VII. : Variation of Performance Point (X & Y Direction) for symmetric haunch length variation

Si No.	Haunch length (mm)	PUSH X		PUSH Y	
		Base shear (kN)	*Displacement (m)*	*Base shear (kN)*	*Displacement (m)*
1.	150	7126.161	0.146	6294.716	0.171
2.	200	7253.889	0.142	6354.351	0.166
3.	250	7504.697	0.139	6523.756	0.162
4.	300	8411.802	0.138	7374.717	0.163
5.	350	9046.280	0.139	7746.39	0.165

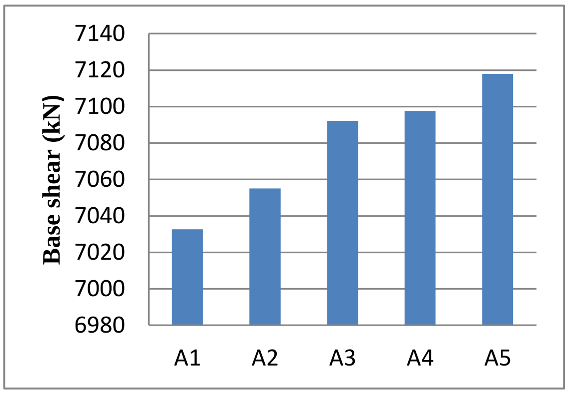


Fig. 3. Base shear variation for different haunch depth frames

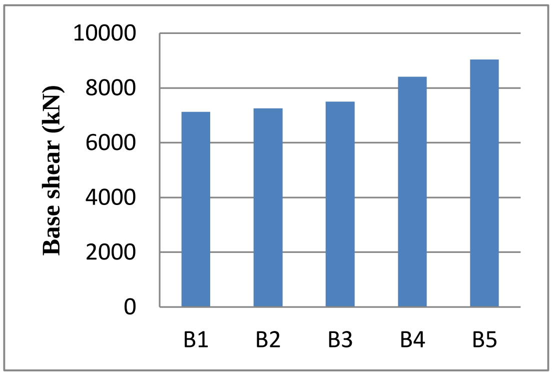


Fig. 4. Base shear variation for different haunch length frames

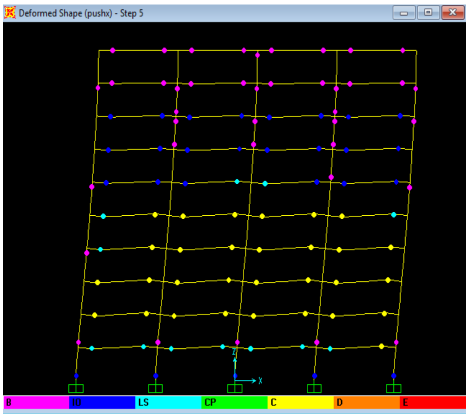


Fig. 5. Hinge pattern in X direction for frame with haunch depth of 500mm

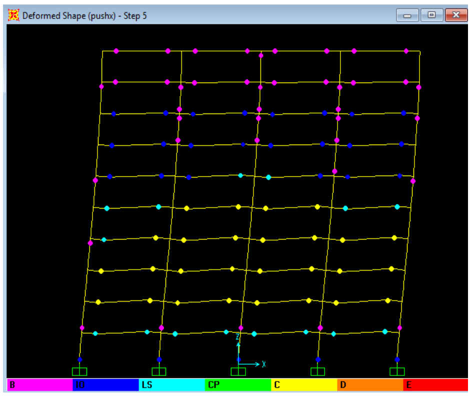


Fig. 6. Hinge pattern in X direction for frame with haunch depth of 600mm

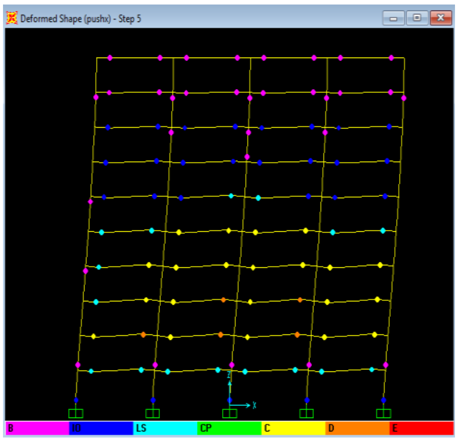


Fig. 7. Hinge pattern in X direction for frame with haunch depth of 700mm

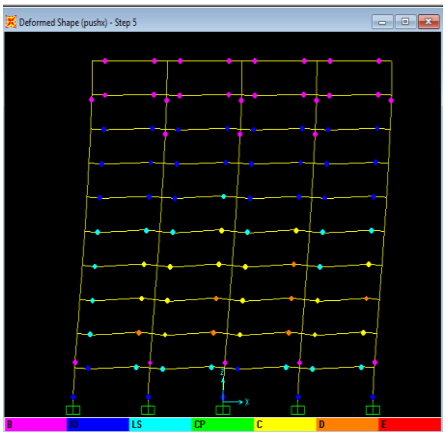


Fig. 8. Hinge pattern in X direction for frame with haunch depth of 800mm

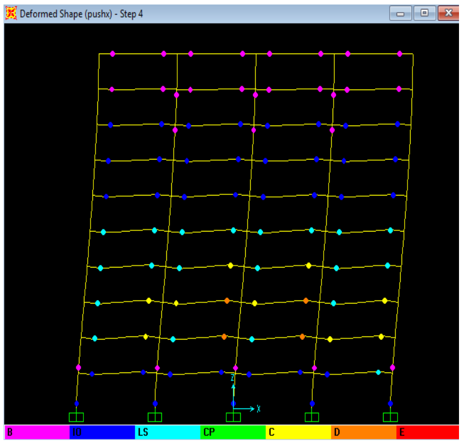


Fig. 9. Hinge pattern in X direction for frame with haunch depth of 900mm

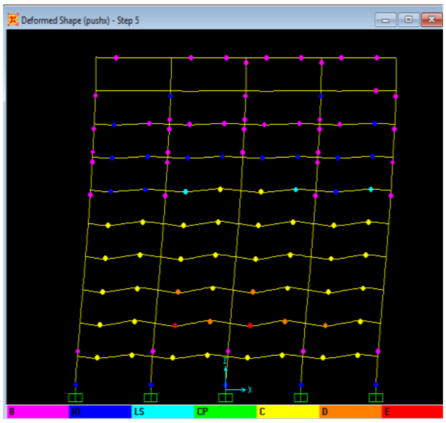


Fig. 10. Hinge pattern in X direction for frame with haunch length of 150mm

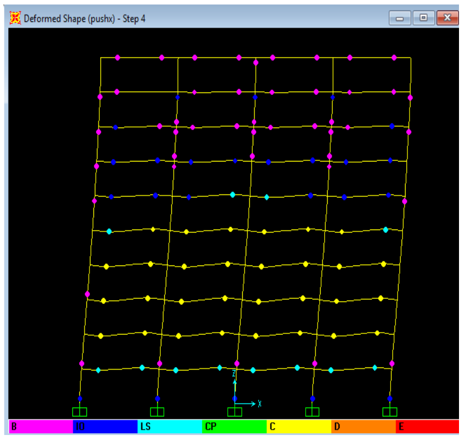


Fig. 11. Hinge pattern in X direction for frame with haunch length of 200mm

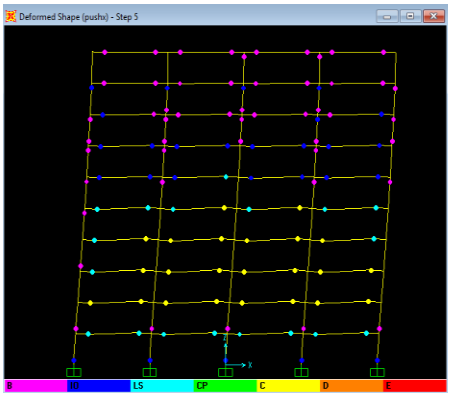


Fig. 12. Hinge pattern in X direction for frame with haunch length of 250mm

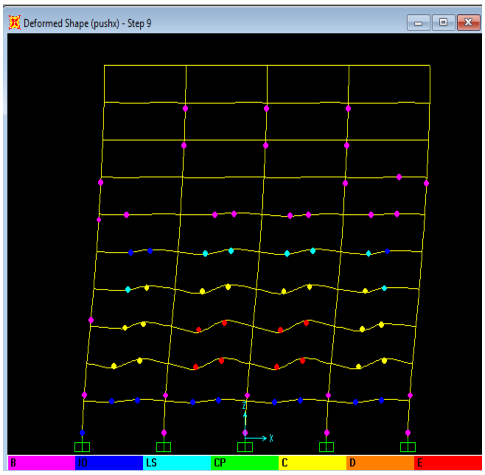


Fig. 13. Hinge pattern in X direction for frame with haunch length of 300mm

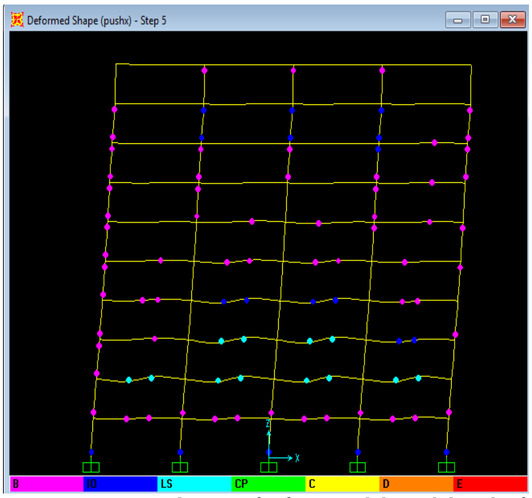


Fig. 14. Hinge pattern in X direction for frame with haunch length of 350mm

CONCLUSION

1. Building designed with IS 1893:2002 found to have an efficient performance under given earthquake.
2. Frames with lower haunch length members have lesser base shear when compared with higher haunch length member frames as the stiffness increases with increase in haunch depth.
3. When the length is increased from 150mm to 350mm for the haunched beam at support section, base shear gets increased by about 26%
4. Variation in haunch length have a slight effect on higher storey displacements
5. Collapse hinges were mainly located in mid-storey beams till point E in case of haunch length varied frames. Full collapsed beams were found at lower haunch length frames. As haunch length increases, the overall stiffness of frame increases and as a result hinge concentrates much on lower storey beams.
6. Frames with lower haunch depth members have lesser base shear when compared with higher haunch depth member as the stiffness is low.
7. Variation in haunch depth don't have much effect on higher storey displacements
8. The hinges were found at lower storey till the point D in case of haunch depth varied frames. At lower haunch depth frames, collapse hinges were found to propagate towards the upper storey beams while at higher haunch depth, hinge concentrates much on lower storeys
9. Natural time period decreases with increase in haunch depth and length.
10. The presence of non-prismatic member can affect the seismic behaviour of frame structure In general, we can conclude that increase in haunch depth and length can increase the seismic performance of a structure due to increase in stiffness of the overall structure.
11. In haunched building frames, collapse hinges are mainly concentrated at lower storey beams.

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REFERENCES

[1] Y.H Ng, N.E Shanmugam, J.Y Richard Liew, "*Experimental studies on composite haunched beam*", National university of singapore and Malaysia,2012

[2] Anu Joli, Vidya Vijayan, "*Structural behaviour of reinforced concrete haunched beam, a study on ansys and etabs*", International Journal of Innovative Science, Engineering & Technology, Vol. 3 Issue 8, August 2016

[3] Prerana Nampalli, Prakarsh Sangave, "*linear and non-linear analysis of reinforced concrete frames with members of varying inertia*", IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) , Volume 12, Issue 5 Ver. I (Sep. - Oct. 2015)

[4] Arturo, T., C., Becerril, M. and Andres, L, "Lateral stiffness of reinforced concrete moment frames with haunched beams", World Conference on Earthquake Engineering,2012

[5] Aranda, H., I., A. and Colunga, A., T, "Cyclic behavior of reinforced concrete haunched beams failing in shear", World Conference on Earthquake Engineering, 1-8,2008

[6] Golghate K., Baradiya V. and Sharma A., (2013), Pushover analysis of 4 Storey's reinforced concrete building, International Journal of Latest Trends in Engineering and Technology (IJLTET),Vol. 2 (3), 80-84.