STUDY THE BEHAVIOUR OF RCC BUILDING FRAME BY PUSHOVER ANALYSIS

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Abstract
Nonlinear static analysis, or pushover analysis, has been developed over the past twenty years and has become the preferred analysis procedure for design and seismic performance evaluation purposes as the procedure is relatively simple and considers post elastic behaviour. However, the procedure involves certain approximations and simplifications that some amount of variation is always expected to exist in seismic demand prediction of pushover analysis. To study the behaviour of RCC building frame by providing different types of bracing to various models with different height using pushover analysis..
Keyword: Pushover analysis, Static analysis of building, Nonlinear static pushover analysis, Types of bracings.

I. INTRODUCTION

High-rise buildings can be classified as residential or commercial. Nowadays, more and more complex high-rise buildings with various architectural feature and style are appearing. The degree of high-rise buildings indicates the economics and technological strength of a country.

Most of the cities are dominated by high-rise building because of the growth of economy and population density. The influence of its tallness creates different conditions and difficulties in design, construction and operation. Therefore, a proper understanding of methods and techniques is required of the planning, design, construction and operation. High-rise buildings should be designed to have a capacity to carry combined actions include permanent actions, variable actions and seismic actions at certain safety level and at certain degree of reliability. Therefore, proper account of actions, material properties, structural systems and method of analysis should be considered while designing the high-rise buildings.

II. PUSHOVER ANALYSIS

As the name states "Push - over", push the building until you reach its maximum capacity to deform. It helps in understanding the deformation and cracking of a structure in case of earthquake and gives you a kind of fair understanding of the deformation of building and formation of plastic hinges in the structure. It is a sort of approximate tool to understand your building performance. All kind of existing structures can be analyzed. Normally it is done for high rise buildings. Can also be done for bridges, water tank, chimney, irregular structures etc.In cases where you want to be aware of the non-linear or plastic behavior of a structure (this effectively models the situation where some damage is received, however, total collapse is avoided). Pushover analysis helps you understand how a structure behaves after some damage on structural members would occur, in order for the designer to make some use of the behavior of the structure when it would receive some damage but it would avoid total collapse.

The pushover analysis of a structure is a static non-linear analysis under permanent vertical loads and gradually increasing lateral loads. A plot of the total base shear verses top displacement in a structure is obtained by this analysis that would indicate any premature failure or weakness. The analysis is carried out up to failure, thus it enables determination of collapse load and ductility capacity.

III. STATIC ANALYSIS OF BUILDING

As India is developing country, the population has increasing rapidly. As population increases the rise for building the structures increases. Nowadays, the heavy and tall structures are developed in small areas due to unavailability of space. Therefore to overcome such situations, structures of more height than previous one are taken for further study. Accordingly, different types of bracings are provided to this structure to know the behavior of building.

The projects aim at comparative study on analysis of High rise structure using Pushover analysis. Analysis is done for high rise buildings with different bays .All the structures are provided with different bracings at different locations i.e,at centre and at end. Different types of bracings:

1. V type bracing
2. Single Diagonal
3. Cross Diagonal

As per IS 1893 (part1)-2002, Seismic Coefficient analysis Procedure is summarized.

IV. BRACINGS IN BUILDING FRAME

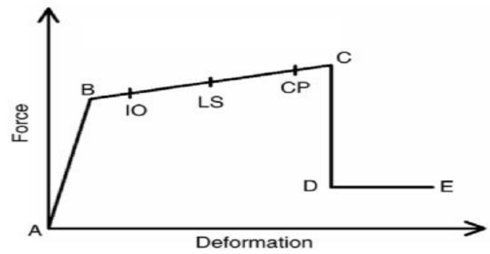
All the structures i.e., G+12,G+15 and G+18 are further analyzed by providing various types of bracing.

There are several types of bracings in steel structures but for study purpose I have taken only three types of bracings. Three types of bracings are:

1. Single Diagonal Bracing
2. Cross Diagonal Bracing
3. V-Type Bracing

V. NONLINEAR STATIC PUSHOVER ANALYSIS

The model frame used in the static nonlinear pushover analysis is based on the procedures of the material, defining force – deformation criteria for the hinges used in the pushover analysis. Fig.1 describes the typical force-deformation relation proposed by those documents. Five points labeled A, B, C, D and E are used to define the force deflection behavior of the hinge and these points labeled A to B – Elastic state, B to IO- below immediate occupancy, IO to LS – between immediate occupancy and life safety, LS to CP-between life safety to collapse prevention, CP to C – between collapse prevention and ultimate capacity, C to D- between C and residual strength, D to E- between D and collapse >E – collapse.



VI. PROCEDURE OF NONLINEAR STATIC PUSHOVER ANALYSIS

The following general sequence of steps is involved in a nonlinear static pushover analysis:

1. Create a model.
2. Define arbitrary static load cases, if needed, for use in the pushover analysis. Note that the program also has built-in capability to define the distribution of lateral load over the height of the structure based on both uniform acceleration and mode shapes.
3. Define the pushover load cases.
4. Define hinge properties.
5. Assign hinge properties to frame objects and wall objects. It is important that frame objects and wall objects be designed, e.g., reinforcement should be defined for the concrete frames and walls, prior to running the pushover analysis.
6. Run the pushover analysis by selecting a static nonlinear load case on the Set Load Cases to Run form. The load case will be available only if there is at least one frame or wall object with a hinge property assigned to it, and there is at least one pushover load case defined.
7. Review the pushover results.

VII. RESULTS

.Following are the results of G+12,G+15 and G+18 Structures with and without bracings for 6 and 8 bays.

BF-Bare frame

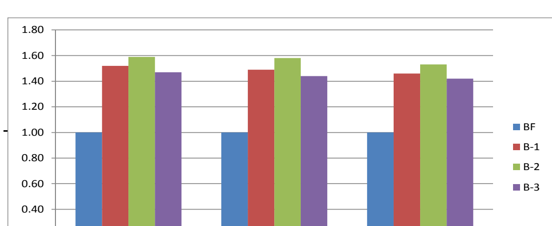
B1-V type bracing

B2-Cross diagonal bracing
B3-Single diagonal bracing

6 BAY				
	BF	B1	B2	B3
G+12				
DISP(m)	0.277	0.197	0.191	0.203
TP(s)	2.06	1.61	1.50	1.68
BS(KN)	5963.51	9823.46	10193.84	9091.8
G+15				
DISP(m)	0.357	0.258	0.248	0.266
TP(s)	2.61	2.06	1.93	2.13
BS(KN)	5497.80	8941.81	9412.97	8390.1
G+18				
DISP(m)	0.443	0.323	0.314	0.330
TP(s)	3.17	2.52	2.38	2.56
BS(KN)	5179.65	8317.16	8600.36	7888.0

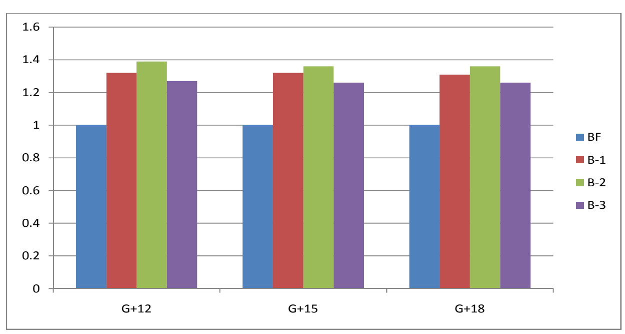
8 BAY				
	BF	B1	B2	B3
G+12				
DISP(m)	0.279	0.228	0.217	0.230
TP(s)	2.07	1.81	1.65	1.82
BS(KN)	10062.3	13982.63	14801.95	13229.0
G+15				
DISP(m)	0.361	0.297	0.282	0.303
TP(s)	2.61	2.30	2.11	2.36
BS(KN)	9286.36	12952.81	13655.35	12353.1
G+18				
DISP(m)	0.447	0.372	0.354	0.375
TP(s)	3.17	2.86	2.59	2.89
BS(KN)	8742.30	12202.73	12821.97	11745.2

Variation of Base Shear With Reference To the Bare Frame For Different Heights And Different Bays**.**



Base shear for 6 bay with reference to bare frame

1. For 6 Bay, Base shear value increases by 52% for V type bracing,59% for Cross diagonal bracing and 47% for Single diagonal bracing with respect to bare frame results for G+12 building frame.
2. For G+15 building frame, V type bracing increases by 49%, Cross diagonal bracing increases by 58% and Single diagonal bracing increases by 44% as compared to bare frame.
3. For G+18 building frame, V type bracing increases by 46%,Cross diagonal bracing increases by 53% and Single diagonal bracing increases by 42% as compared to bare frame.
4. In case of base shear for 6 bay, Cross diagonal bracing frame increases by 59%, 58% and 53% for G+12,G+15 and G+18 respectively. Therefore as number of stories increases, the value of increase in base shear also decreases as compared to bare frame.
5. Base shear graph shows that Cross diagonal bracing has the highest value than other bracings as compared to bare frame building frame.



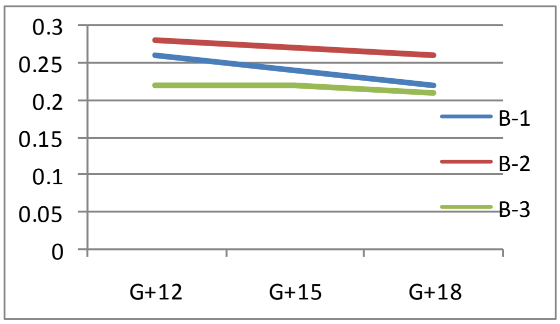
Base shear for 8 bays with reference to bare frame

1. For 8 bay, Considering G+12 building frame, V type bracing increases by 32%,Cross diagonal bracing increases by 39% while Single diagonal bracing and

increases by 27% as compared to building frame without bracing.

2. For G+15 storey, V type bracing increases by 32%,Cross diagonal bracing increases by 36% and single diagonal bracing increases by 26% as compared to building frame without bracing.
3. For G+18 storey, V type bracing increases by 31%,Cross diagonal bracing increases by 36% and single diagonal bracing increases by 26% as compared to building frame without bracing.
4. As number of storey increases, the rate of increase in base shear value with respect to bare frame increases.

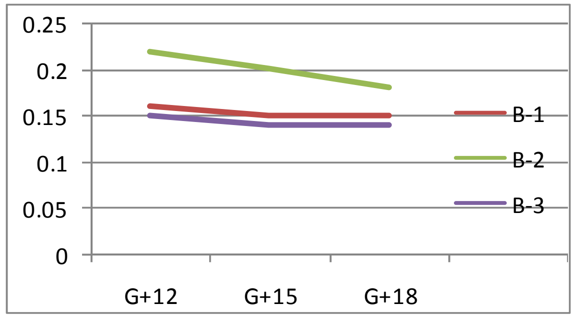
B. Variation of Displacement Ratio With Reference To The Bare Frame For Different Heights And Different Bays.



Displacement ratio for 6 bays

1. For G+ 12 storeys with 6 bay, Displacement decreases by 26% for V type bracing, 28% for Cross diagonal bracing and 22% for Single diagonal bracing as compared to bare frame structural frame.
2. For G+15 storey, Displacement is reduced by 24% for V type bracing, 27% for Cross diagonal bracing and 22% decreased for Single diagonal bracing.
3. In Case of G+ 18 storeys, results are approximately same as for G+15 Storey, i.e. Displacement decreases by 22%, 26% and 21% for three bracings respectively.
4. In case of 6 bay, displacement for cross diagonal bracing reduced by 28%,27% and 26% for G+12,G+15 and G+18 structure respectively. Hence it is seen that as height of storey increases reduction in displacement decreases.
5. Cross diagonal bracing has more increase in percentage for displacement reduced.

Therefore in case of Displacement, Cross diagonal bracing has least displacement than other bracings as compared to bare frame results



1. For G+12 storey, V type bracing is reduced by 15%,Cross diagonal bracing is reduced by 22% and Single diagonal bracing is reduced by 15% as compared to bare frame results.
2. For G+15 storey, V type bracing is reduced by 10%,Cross diagonal bracing is reduced by 20% and Single diagonal bracing is reduced by 14% as compared to bare frame results.
3. For G+18 storey, V type bracing is reduced by 15%,Cross diagonal bracing is reduced by 18% and Single diagonal bracing is reduced by 14% as compared to bare frame results.
4. From all the above results, V type bracing gives less displacement than Single diagonal bracings.
5. Accordingly, Cross diagonal bracings has least displacement than V type bracings.
6. Therefore, from above all results Cross diagonal bracing is stiffer than others bracings.

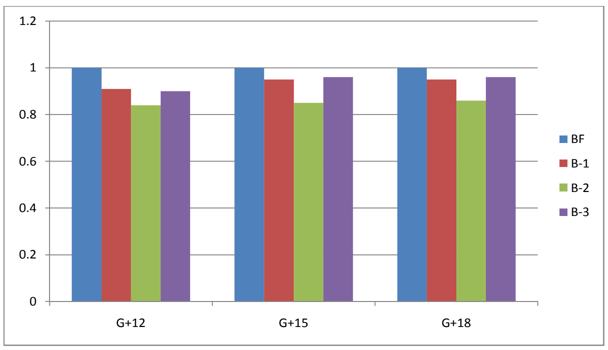
C. Variation of Displacement Ratio With Reference To The Bare Frame For Different Heights And Different Bays

Time period for 6 bays

1. For G+ 12 storeys with 6 bay, Time period decreases by 18% for V type bracing, 22% for Cross diagonal bracing and 17%

for Single diagonal bracing as compared to bare frame structural frame.

2. For G+ 15 storeys, Time period is reduced by 16% for V type bracing, 21% for Cross diagonal bracing and 16% decreased for Single diagonal bracing.
3. In Case of G+ 18 storeys, results are approximately same as for G+15 Storey, i.e. Displacement decreases by 16%, 18% and 16% for three bracings respectively.
4. Cross diagonal bracing has more decrease in percentage for time period reduced.
5. Therefore in case of Time Period, Cross diagonal bracing has least time period than other bracings as compared to bare frame results.



Time period for 8 bays

1. For G+12 storey, V type bracing is reduced by 10%,Cross diagonal bracing is reduced by 16% and Single diagonal bracing is reduced by 9% as compared to bare frame results.
2. For G+15 storey, V type bracing is reduced by 5%,Cross diagonal bracing is reduced by 15% and Single diagonal bracing is reduced by 4% as compared to bare frame results.
3. For G+18 storey, V type bracing is reduced by 5%,Cross diagonal bracing is reduced by 14% and Single diagonal bracing is reduced by 4% as compared to bare frame results.
4. From all the above results, V type bracing gives less displacement than Single diagonal bracings.

VIII. CONCLUSION

1. The pushover analysis is a relatively simple way to explore the non linear behavior of Buildings.
2. The concept of using steel bracing is one of the advantageous concepts which can be used to strengthen or retrofit the existing structures.
3. For bare frame, as height of structure increases displacement increases, time period increases and base shear decreases.
4. For G+12,G+15 and G+18 structures, when cross diagonal bracings are provided, Base shear increases up to 40% to 60% for 6 bays,35% to 55% for 7 bays and 20% to 40% for 8 bays
5. For G+12,G+15 and G+18 structures, when cross diagonal bracings are provided, Displacement decreases up to 20% to 30% for 6 bays,15% to 25% for 7 bays and 10% to 25% for 8 bays.
6. For G+12,G+15 and G+18 structures, when cross diagonal bracings are provided, Time period decreases up to 15% to 25% for 6 bays,5% to 20% for 7 bays and 4% to 15% for 8 bays.
7. Therefore all the values of parameters i:e,displacement,time period and base shear decreases as number of bays increases.
8. The storey displacement of the building is reduced by 20% to 30% by using cross diagonal bracing
9. The time period of the structure decreases with incorporation of braces as the stiffness of the building increases. Difference between rate of reduction of percentage of displacement for Single diagonal bracing and v type bracing is very less as compared to cross diagonal bracing.
10. Maximum reduction in displacement is observed in cross diagonal braced frame as compared to bare frame, hence cross diagonal braces can be recommended.
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IX. REFERENCES

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