Seismic Response of Cellwise Braced Multistoried Frames

Patil S.S.
Head of Civil Engineering Department, W.I.T. Solapur, Maharashtra, India.

Aland S.S.
P. G. Scholar, Civil Engineering Department, W.I.T. Solapur, Maharashtra, India

Abstract - This paper presents reinforced concrete frames with 5 bay 12 story structure which have been analyzed for gravity as well as seismic force for cellwise braced system inconsideration of savings in cost of material of structure. Cellwise braced frame was tried to combine the advantages especially regarding the economy of tried pattern and to provide an obstruction free/ hindrance free openings. This helps the frame discharge the function more elegantly. Every attempt has been made to describe the things in dimensionless forms. Results are concluded from tables and discussed comprehensively.

Keywords - Analysis of multistoried buildings, A-Braces, Bare Frame, Cellwise braced frames, Fully Braced Frame, V-Braces

I. INTRODUCTION

The multistoried building frames are designed to carry gravity loads as well as lateral loads and their combinations. Horizontal loads exerted at each level of a building will produce a shear, a moment, and sometimes a torque for irregular buildings concerned. Hence it becomes necessary to make comparative study of following types of building frames with different geometric parameters. Perhaps optimization is the most challenging class of problems in structural optimization because of an infinite number of iterations which are difficult to classify and quantify. At the same time, such optimization is of considerable importance because it leads to significant material savings. Cross-sectional dimensions are the simplest design variables. Cellwise braced frame was tried to combine the advantages especially regarding the economy of tried pattern and to provide an obstruction free/ hindrance free openings. This helps the frame discharge the function more elegantly.

II. OBJECTIVE OF STUDY

In this article use of bracing to increase the stiffness of structure has been tried. The A- type, V- type of bracing system has been used. Frames were considered as fully braced frames in preceding discussion, however, partially braced frames are also analyzed and optimum locations of braces have been found. Behavior of bare frame, fully braced frames, partially braced frames with the cellwise braced frames is studied and has been presented in results and discussion.

III. DESCRIPTION OF STUDY BUILDING

Since the analysis are problem specific it is felt necessary that an attempt must be made to generalize the same and results so obtained that such results and finding can be directly used to predict the behavior of real life structures. With this view point all parameters in dimensionless form, to include geometry of frame, axial forces, shear forces, bending moments, displacements, location of bracing etc. have been used. For all frames 350 mm beam depth is considered. For braced frames cross-section of bracing 230 mm x 230 mm is considered. The sections of columns of bare frames are reduced from top to bottom, which is kept same for every 3 storey i.e. 1-3, 4-6, 7-9 and 10-12, in order to achieve an economy in bare frames itself. In the limit state design of reinforced concrete structures, load combinations shall be accounted as per I.S. 1893 (Part I) – 2002.

IV. PARAMETRIC STUDY

Analysis has been made to study and compare following parameters:

1) To study internal forces i.e. axial force, shear force and bending moment in a particular column segment.
2) Cellwise braced frame were tried with some specific assumptions regarding the locations and bracing pattern suggested. The tried patterns are;
   a. cellwise optimization regarding baywise braced frame
   b. cellwise optimization regarding levelwise braced frame

V. RESULT AND DISCUSSION

5.1 Cellwise bracing i.e. moving levelwise

For 5 bay 12 story structure central bay braced structure pre-sent 7.70% economy as compared to bare frame. Hence it is decided to provide cellwise bracing pattern i.e. moving levelwise in respective levels to find out such a cell braced frame which gives more economy as compared to bare as well as optimally central bay braced frame. So it is tried to find out more economy due to the provision of double cell braced rather than providing whole central bay braced. It also provides the way for architectural provisions and offers the space to accommodate the opening requirements for doors and windows. The hidden advantage behind the provision of cellwise bracing is that, the speedy construction which is faster than other bracing patterns utilized. The same logic is applied for the combinations of cells braced more than one i.e. two and/or three cells braced at a time and so on.

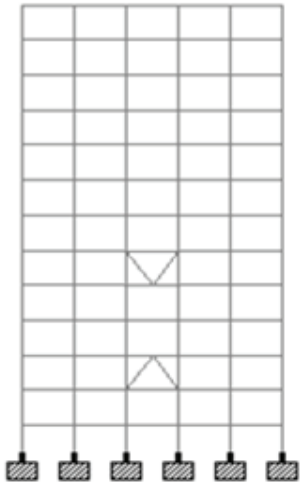
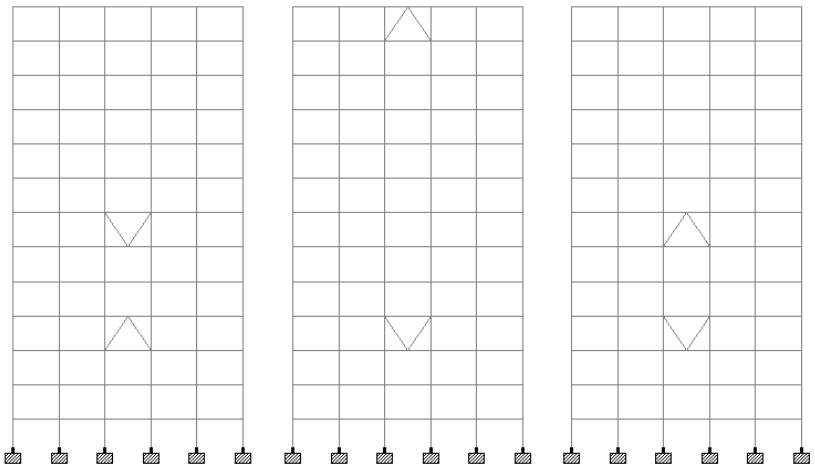


Figure 1. Typical Frame showing the bracing combinations of braces moving levelwise

5.1.1 Two Cells Braced at a Time

It is seen from the table that the combination of 3rd & 9th floor cell gives 17.20% economy which is more than central bay braced throughout, but as we move towards upper floor cellwise bracing combinations the economy is going to de-crease slightly for 6th & 9th floor cell and 3rd & 6th floor cell braced at time respectively.

Cell Braced	% Of Saving
Bare	---
3V 9A	17.20%
6V 9A	16.86%
3A 6V	16.70%



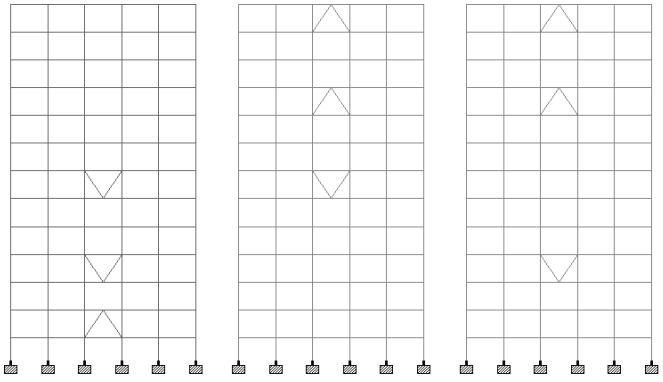
(a) 3V 9A (b) 6V 9A (c) 3A 6V

Figure 2. Frames showing the bracing combinations of braces moving levelwise

5.1.2 Three Cells Braced at a Time

It is seen from following table that the combination of 1A 3V 6V floor cell gives 16.02% economy out of other combinations of three cells braced, which is more than central bay braced throughout, as we move towards upper floor cellwise bracing combinations the economy is going to reduce. The results are tabulated in the following Table.

Cell Braced	% Of Saving
Bare	---
1A 3V 6V	16.02%
6V 9A 12A	15.93%
3V 9A 12A	15.81%



(a) 1A 3V 6V (b) 6V 9A 12A (c) 3V 9A 12A

Figure 3. Frames showing the bracing combinations of braces moving levelwise

Overall two cells braced frames are offering more economy as compared to other cases of cell braced combinations such as three cells braced at a time and so on which is seen from above tables, but more than central bay braced throughout for 5 bay 12 story structure. Hence it depicts that it is advantageous to adopt combinations of cellwise braced frames rather than adopting a structure whose whole bay is braced throughout but position is geometrically similar, though it offers more economy as compared to bare frame.
From the comparisons of the savings achieved in various cellwise bracing combinations it predicts that there is no relationship between the algorithms which were tried to get more economy. It means that when two cells braced locations which are offering more economy when tried for three cells or more cells braced combination of their own doesn't yield more economy as concluded. The economy is yielded in different combined locations of cells.

5.2 Cellwise bracing i.e. moving baywise

The levelwise bracing combinations are restricted up to three levels only since because of the bracing combinations beyond third floor are not offering more economy. When ground floor is braced for 5 bay 12 story structure throughout in levelwise such bracing pattern offers 7.87% economy and hence it is decided to provide cellwise bracing that is moving baywise in respective bays to yield more economy. The same logic is applied for the combinations of cells braced more than one i.e. two and/or three cells braced at a time and so on for respective floors which offered more economy already.

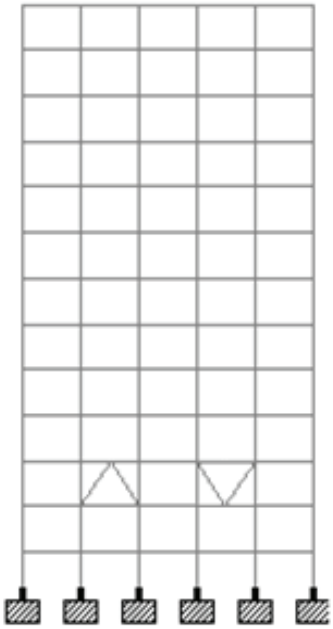
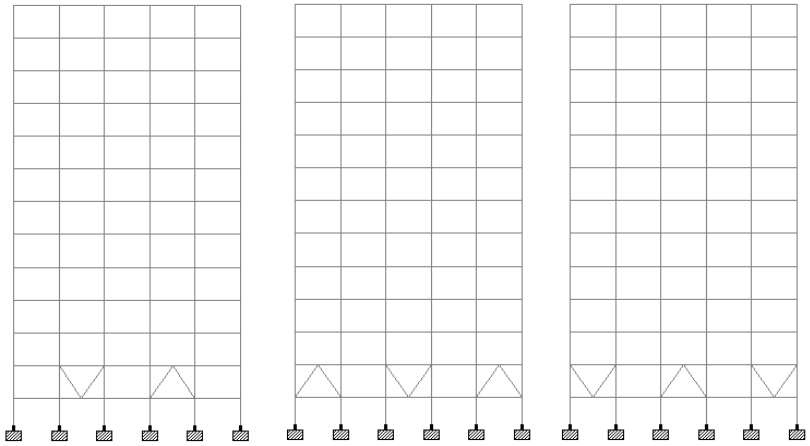


Figure 4. Typical Frame showing the bracing combinations of braces moving baywise

5.2.1 First Floor Braced

When cellwise bracing is provided by moving baywise it is wise to consider symmetrical cases since they behave symmetrically in case of change in earthquake directions. The double cell which is symmetrically placed in the first floor is offering an economy of 9.99%. Following Table shows the other cases of cell braced at first floor only seeking the case of specific cell braced which debt more economy.

Case no.	% Of Saving
Bare	---
1st Floor Cell No. 2A 4V	8.65%
1st Floor Cell No. 1A 3V 5A	9.75%
1st Floor Cell No. 1V 3A 5V	9.99%



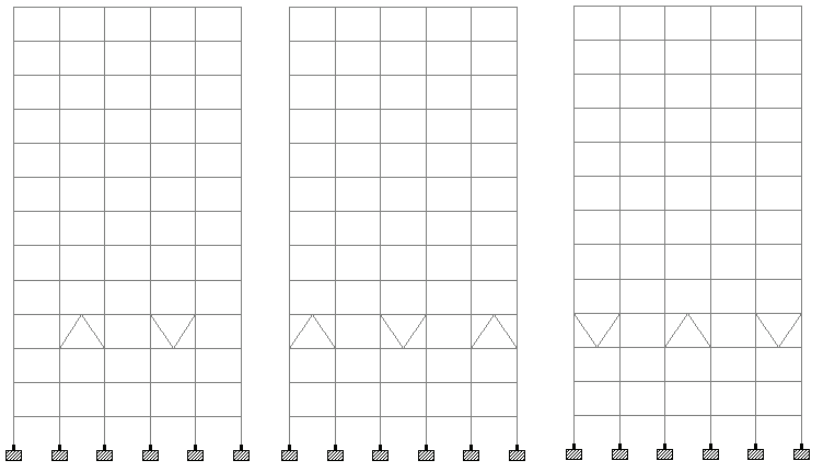
(a) 2A 4V (b) 1A 3V 5A (c) 1V 3A 5V

Figure 5. Frames showing the bracing combinations of braces moving baywise

5.2.2 Third Floor Braced

Now for this case third floor is braced cellwise to see the frame with optimum economy. As discussed earlier, the cellwise bracing is provided by moving baywise and it is wise to consider symmetrical cases since they behave symmetrical in case of change in earthquake directions. Following table shows the cases of cell braced frames at third floor only with symmetry, offering more economy.

Case no.	% Of Saving
Bare	---
3rd Floor Cell No. 2A 4V	10.79%
3rd Floor Cell No. 1A 3V 5A	10.99%
3rd Floor Cell No. 1V 3A 5V	11.77%



(a) 2A 4V (b) 1A 3V 5A (c) 1V 3A 5V

Figure 6. Frames showing the bracing combinations of braces moving baywise

In 3rd & 9th floor braced frame i.e. braced cell 3V 9A offers 17.20% economy which indicates that such configurations offer more stiffness to the frame as compared to other cases. Also the relative displacement of two cells braced frame is reduced nearly half that of bare frame which ultimately gives the economy. It concludes that as we move towards upper level with increased number of cell bracing combinations will offers more saving.

VI. CONCLUSION

Comparing the economy of all the different cellwise braced configurations with respect to different floors, overall it is seen that the economy is more in the case of cellwise braced frames that is moving levelwise as compared to cellwise braced frames that is moving baywise. Columns near to the brace carry more axial force as compared to other and/or penultimate columns. It is seen that the maximum economy is obtained when less number of bracings are used with the proper position.

REFERENCES

[1] J. C. D. Hoenderkamp & M.C.M. Bakker, “Analysis of High-rise Braced Frames with Outriggers” The struct. Design Tall and Spec. Build. 12, 335-350 (2003).

[2] Mahmoud R. Maheri, R. Akbari, “Seismic behavior factor, for steel x-braced and knee-braced RC buildings”, Engineering Structures, Volume 25, Issue 12, October 2003, Pages1505-1513.

[3] V.N. Vazirani and M.M. Ratawani, Analysis of structures (10th Ed., Khanna Publishers, 1985).

[4] I.S. 456-1993, Indian standard code of practice for plain and reinforced concrete (fourth revision), Bureau of Indian standards, New Delhi.

[5] I.S. 1893(Part 1)-2002, Criteria for earthquake resistant design of structure, general provision and building, Bureau of Indian standards, New Delhi.

[6] Patil S.S., Aland S.S., Kore P.N. "Seismic Response of Concentrically Braced Reinforced Concrete Frames", International Journal of Scientific and Engineering Research, Volume 4, Issue7, July 2013 Edition.

[7] Kulkarni J. G., Kore P. N. "Seismic response of Reinforced Concrete Braced frames", International Journal of Engineering Research and Applications Vol. xx, Issue xx, January -February 2013