Comparative Study of Outriggers with Braced Frame Core and Shear Core in High Rise Buildings

Lekshmi Soman¹
¹PG Scholar
Sree Buddha College of Engineering,
Alappuzha/Pathanamthitta cluster of APJ Abdul Kalam Technological University,
Ayathil, Elavumthitta P.O, Pathanamthitta-689625

Sreedevi Lekshmi²
²Assistant Professor
Sree Buddha College of Engineering,
Alappuzha/Pathanamthitta cluster of APJ Abdul Kalam Technological University,
Ayathil, Elavumthitta P.O, Pathanamthitta-689625

Abstract—Today’s increased need for housing in metropolitan cities leads to the emergence of high rise buildings. Tall buildings are becoming more and more slender and this leads to more possible sway during the occurrence of lateral loads. When building height increases tremendously, the structure should have lateral load resisting system other than shear walls for avoiding the effect of these loads, since the shear walls when used alone are suitable only upto 20 stories high. Outrigger systems are one such prominent system and are now considered to be the most popular and efficient because they are easier to build, save on costs and provide good lateral stiffness. Outrigger braced structures is an efficient structural form in which the central core is connected to the outer columns. The structural concept of these systems is that when the central core tries to tilt, its rotation at the outrigger level induces a tension-compression couple in the outer columns acting in opposition to that movement. Most importantly, outrigger braced structures can strengthen a building without disturbing its aesthetic appearance and this is a significant advantage over other lateral load resisting systems. This paper presents the results of an investigation on storey drift and base shear reduction in RC building frame with rigid outriggers, through Response Spectrum Analysis using the software ETABS 2015.

Keywords: Outrigger structural system, Response spectrum Analysis, Base Shear, Storey Drift

I. INTRODUCTION
Mankind is always fascinated for Tall building. In Early era the symbol of economic power and leadership is the skyscraper. There has been a demonstrated competitiveness that exists in present mankind to proclaim to have the tallest building in the world. The design of tall and slender structures is controlled by three governing factors, strength (material capacity), stiffness (drift) and serviceability (motion perception and accelerations), produced by the action of lateral loading, such as wind. Outrigger structural system encompass of a central core wall either shear wall or braced frames with outrigger truss connecting between core and the peripheral columns. These are the horizontal members designed to control overturning moment and stiffens the building by fastening the core to the exterior column through stiff horizontal members referred as a outrigger member, where as core acts a single-redundant cantilever beam for lateral forces and hence battle the rotation at the top by stretching and shortening action results in tensile and compressive action consequentially restoring couple by combating twisting of core thus cap truss be positioned as a restraining spring at the apex which considerable reduces the lateral deflection and base moments.

II. OBJECTIVE
• To study the characteristics of a high rise building with the inclusion of outriggers.
• To arrive at the optimum outrigger position at top,at top and one fourth height,at top and mid height,at top and three fourth height.
• To investigate the comparative lateral load resistance of the structure with a braced frame core and RC shear core along with outrigger system.

III. SCOPE
• Analytical study on multistorey building frame with two levels of outriggers using standard structural software.
• Parameter varied in the analytical study is the location of outrigger.
• This work is limited to Response Spectrum analysis using ETABS 2015.
• This work is under seismic zone 5 and medium type soil.

IV. LITERATURE REVIEW
Sreelekhsmi S et al.(2016)¹,studied the performance of outriggers in high rise buildings. Today in modern tall buildings, lateral loads induced by both wind and earthquake were battled by an arrangement of coupled shear walls. This paper presents the results of an investigation on displacement, drift and base shear reduction in steel building frame with rigid outriggers, through time history analysis using the software ETABS 2015. Results shows that double outrigger system can effectively reduce seismic response of the building and optimum location of outriggers was found to be 0.75 times its height along with cap truss.

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Sandesh Kumar Shirole Y et al. (2016)[2], Studied the Behavior of Outriggers in High Rise Building under seismic loading. The lateral seismic forces acting on the structure is effectively resisted by using outrigger lateral system. In the present study a 30 storey model is modelled using ETABS 2015 software. The optimum location of the outriggers is determined by the varying the location of outriggers throughout the height of the structure.

A Vijay et al (2012)[3], conducted Feasibility Studies on the use of Outrigger System for RC core frame. This research work is an attempt made to study the effect of provision of outriggers for single bay frame at single level and two levels for single bay of different heights 30m, 45m, and 60m. Finite element analysis has been done using standard structural software. The frame and outriggers are modeled by three degrees of freedom per node beam elements. Both symmetrical and unsymmetrical provisions of outriggers are included with the considered static loads. From the analysis the lateral displacements, internal forces, base shear values are obtained for each level of outrigger. The reduction in lateral displacement of core frame values is taken as the index of efficiency of outrigger system at a particular level. The optimum position of outrigger so as to give maximum efficiency is found out. Optimum position of single level symmetrical and unsymmetrical outrigger for 30m, 45m and 60m are at H/2, H/2.5 and H/2.85 from top. Where H is the storey height and height of the frame.

All of the above journals had done their study by finding out lateral displacement, storey drift, base shear, axial force etc. And their study revealed the efficiency of outriggers compare two buildings where outriggers are provided at in tall buildings. Till now, most of the studies are carried out on regular RC buildings with shear RC core. So my aim is to various positions both in braced frame core and RC shear core.

V.METHODOLOGY
The study is carried out for the behaviour of G+40 storied R.C frame buildings with a regular plan. Floor height provided as 3 m. And also properties are defined for the frame structure. 8 models are created in ETABS software by providing rigid outrigger structures at various positions of the building.

Various types of load considered are discussed in succeeding sections. For static behavior dead load of the building is considered as per IS 875 Part I and live load is considered as per IS 875 Part II, lateral load confirming IS 1893(part 1)2002

The three dimensional reinforced concrete structures with G+40 storey were analyzed by Response spectrum analysis using ETABS software. The analysis results will show effectiveness of outriggers in terms of storey drift, base shear etc.

The optimum location of the outriggers is determined by varying the location of outriggers throughout the height of the structure. Outriggers are provided at four different positions in order to compare the base shear and storey drift values. In this study outriggers are provided at top and one fourth position, top and two fourth position, top and three forth position and top only in both braced frame core and RC shear core.

A. BUILDING PLAN AND DIMENSION DETAILS
The Following are the specification of G+40 storied regular building located in seismic zone in medium type soil. The complete detail of the structure including modelling concepts is given below:

<table>
<thead>
<tr>
<th>Parameters considered for Analysis</th>
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<tbody>
<tr>
<td>Total height of building</td>
</tr>
<tr>
<td>No. of stories</td>
</tr>
<tr>
<td>Height of each storey</td>
</tr>
<tr>
<td>Grade of concrete</td>
</tr>
<tr>
<td>Grade of steel</td>
</tr>
<tr>
<td>Depth of slab</td>
</tr>
<tr>
<td>Size of beams</td>
</tr>
<tr>
<td>Size of columns</td>
</tr>
<tr>
<td>Shear wall thickness</td>
</tr>
<tr>
<td>Plan area</td>
</tr>
<tr>
<td>Braces</td>
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<tr>
<td>Outrigger Beam</td>
</tr>
</tbody>
</table>
B. ASSIGNING LOADS

- Dead load
  - Dead load intensity = 1.5 kN/m²
- Live load
  - Live Load Intensity specified (Public building) = 4kN/m²
- Wall weight
  - Wall weight = 13.8 kN/m²
- Load combination

The following Load Combinations have been considered for the analysis,
1. DL
2. DL+LL
3. 1.5(DL+LL)
4. 1.2(DL+LL+ EQX)
5. 1.2(DL+LL+ EQY)
6. 1.2(DL+LL - EQX)
7. 1.2(DL+LL - EQY)
8. 1.5(DL+EQX)
9. 1.5(DL+EQY)
10. 1.5(DL- EQX)
11. 1.5(DL- EQY)
12. 0.9DL+1.5EQX
13. 0.9DL+1.5EQY
14. 0.9DL - 1.5EQX
15. 0.9DL - 1.5EQY

VI. SEISMIC ANALYSIS OF BUILDING

C. SEISMIC PARAMETERS CONSIDERED (AS PER 1893(PART 1): 2002)

<table>
<thead>
<tr>
<th>Zone</th>
<th>Parameters considered for seismic analysis</th>
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<tbody>
<tr>
<td></td>
<td>Importance factor</td>
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<td></td>
<td>Response reduction factor</td>
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<td>Soil type</td>
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<td></td>
<td>Damping Ratio</td>
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<table>
<thead>
<tr>
<th>Outrigger Position</th>
<th>Storey Drift</th>
<th>Base Shear</th>
</tr>
</thead>
<tbody>
<tr>
<td>At one fourth and Top</td>
<td>0.000492</td>
<td>2223.388</td>
</tr>
<tr>
<td>At two forth and Top</td>
<td>0.000529</td>
<td>2197.0968</td>
</tr>
<tr>
<td>At three forth and Top</td>
<td>0.000457</td>
<td>2097.558</td>
</tr>
<tr>
<td>At top only</td>
<td>0.001021</td>
<td>2418.11</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Outrigger Position</th>
<th>Storey Drift</th>
<th>Base Shear</th>
</tr>
</thead>
<tbody>
<tr>
<td>At one fourth and Top</td>
<td>0.000857</td>
<td>3653.15</td>
</tr>
<tr>
<td>At two forth and Top</td>
<td>0.000853</td>
<td>3829.146</td>
</tr>
<tr>
<td>At three forth and Top</td>
<td>0.000754</td>
<td>3576.1359</td>
</tr>
<tr>
<td>At top only</td>
<td>0.0008666</td>
<td>3654.7275</td>
</tr>
</tbody>
</table>
VII. RESULTS AND DISCUSSIONS

D. Comparison of Storey Drift Values for Various Positions of Outriggers in Braced Frame Core and Shear Core

![Storey Drift Graph]

E. Comparison of Base Shear Values for Various Positions of Outriggers in Braced Frame Core and Shear Core

![Base Shear Graph]

VIII. CONCLUSION

This study assessed the overall behaviour of outrigger braced building under lateral loads from which the following conclusions can be drawn based on the above results. The selected models where analysed using the response spectrum method and the conclusions obtained from the analysis are:

- Compared the seismic analysis of various positions of outriggers with braced frame core and shear core in a regular RC building
- Response Spectrum Analysis were conducted on a 40 storied steel structure providing outriggers at top, one fourth, middle and three fourth height of the building
- The percentage reduction of storey drift for building with RC shear wall is 39.38% compared to building with braced frame core for an outrigger position of three fourth and top.

Hence we can concluded that the building with outrigger position at 0.75 times the total height is good in terms of storey drift and base shear and a notable reduction was observed while evaluating the base shear and storey drift by Response Spectrum Analysis.

ACKNOWLEDGEMENT

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REFERENCES


