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Seismic Performance Investigation of "O Grid" Lateral Bracing System

SUMEERA K[1], PRIYANKA DILIP P[2]

[1]PG Student, Dept. of Civil Engineering, AWH Engineering College, Kuttikkattoor, Calicut, India
[2]Assistant Professor, Dept. of Civil Engineering, AWH Engineering College, Kuttikkattoor, Calicut, India

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Abstract - *In steel structures, in order to resist lateral forces like earthquake and wind pressure, bracings are provided. There are many conventional types of bracings used. In this paper a new bracing is proposed and studied through FEM (finite element method) numerical analysis. These proposed bracing systems are called OGrid. These are braced frames with circular braces connected to MRF (moment resisting frame) with welded connections. Model analysis and time history analysis were carried out on fully O Grid braced multi storied frame and multi storied frames with different density of braces at different position using ANSYS workbench 16.1. The effects of some parameter like frequency, time period, storey displacement, base shear and acceleration of models were investigated.*

Key Words: O Grid bracing, Moment resisting frame, Time history analysis, Storey displacement

1. INTRODUCTION

Dynamic loads can impart significantly greater effect towards the structural response of a structure compared to the static loading. Dynamic loading especially those applied laterally such as the base shear due to earthquake ground motion are capable of exerting huge amount of energy on the structure. To avoid structural failure, some of the energy exerted by the dynamic load has to be properly dissipated so that the excessive lateral movement of the structure can be minimized. One of the most efficient methods for lateral movement resistance is structural bracing. Structural bracings work by providing lateral stiffness and stability to the structure, especially for the multi-storey and high-rise buildings. This subsequently increases the lateral resistance of the structure and reduces the internal forces through appropriate bracing arrangement. Thus, for economic reason, structural bracing has been widely used worldwide.

The development of lateral bracing systems and proper details of braces that began in 1960 and research's been continuing on them so far, has made it possible to achieve a system with suitable stiffness and ductility. The OGrid bracing system is braced frame with circular brace connected to moment resisting frame (MRF) with joint connections as shown in figure 1.1. The circular brace provides lateral stiffness to the system. At the lowest story, this brace must be connected to the foundation like the column. OGrid bracing system in tall buildings can be used with one circular brace in each two stories, that its advantage is decreasing the weight.

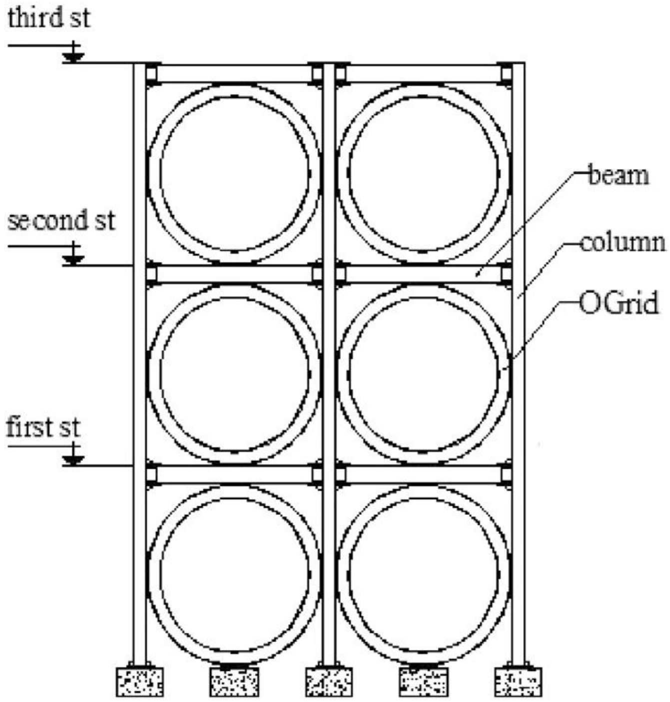

Fig-1: OGrid bracing system

1.1 Objectives

The main objectives of this thesis is to conduct model analysis and time history analysis of

- Fully braced multi storied frame
- Multi storied frames having different brace densities.

2. MODELLING

Five-bay and ten-storey frames with of OGrid braces were modelled using ANSYS WORKBENCH 16.1. Each storey of height 3000mm and bay of span 3000mm was used for the study. Standard hot rolled ISHB 150, ISMB 175 and ISMB 125 sections were used for column, beam and brace of the frame respectively. The different section geometries are selected from IS code and the geometries are shown in Table 1. The material properties of OGrid braced frame used in ANSYS are shown in Table 2.

The number of braces for fully braced frame was 50. But it is not economical to use a fully braced frame. To make it economical, reduced the number to 30. Multi storied frames having different density of braces at different position were modelled using 30 braces.

Table -1: Different Brace Section Geometries

Section property	ISMB 125	ISHB 150	ISMB 175
Depth	125	150	175
Width of flange	75	150	90
Thickness of flange	7.6	9	8.6
Thickness of web	4.4	8.4	5.5

Table -2: Material properties OGrid braced frame

Property	Value
Yield stress of steel	235MPa
Young's modulus	200000MPa
Poisson's ratio	0.3
Shear modulus	76923MPa
Bulk modulus	166670MPa
Density	7850 kg/m³

Figure 2 shows the model of fully braced frame (FB), figure 3 shows model of frame having braces denser at top (DT) figure 4 shows model of frame having braces denser at middle (DM) and figure 5 shows model of frame having braces denser at bottom (DB).

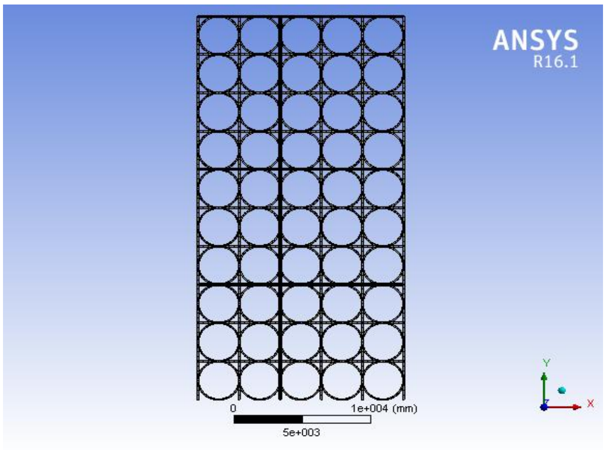

Fig -2: Model of fully braced frame

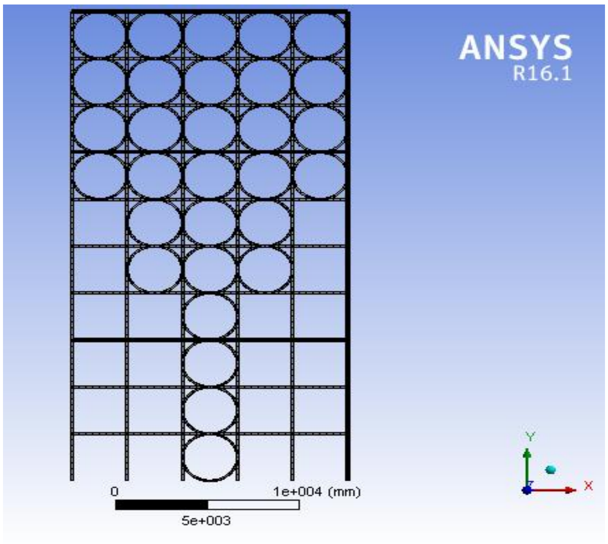

Fig -3: model of frame having braces denser at top

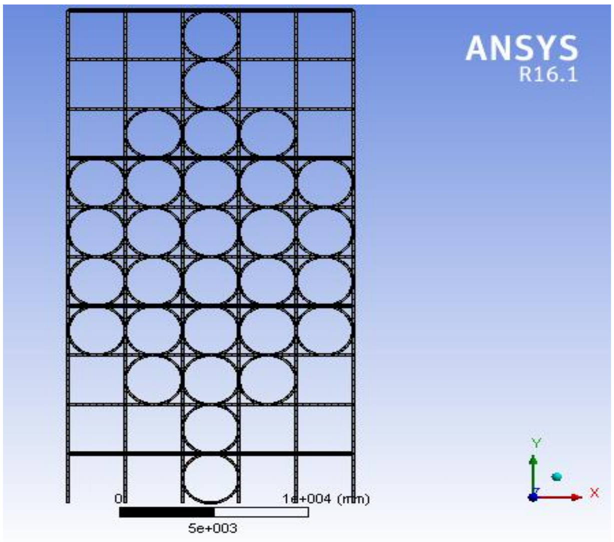

Fig -4: model of frame having braces denser at middle

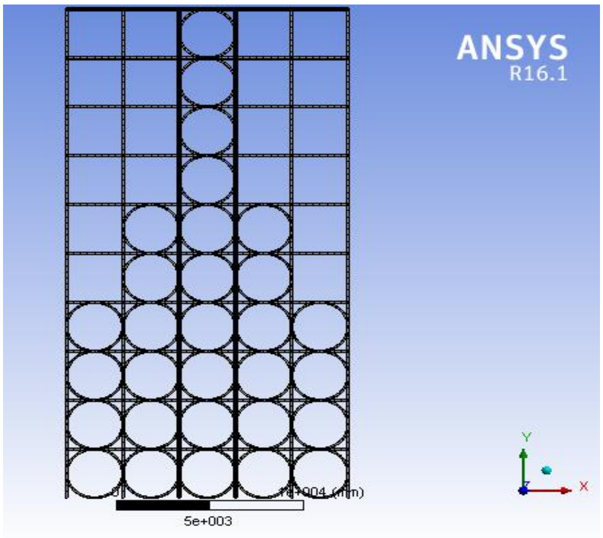

Fig -5: model of frame having braces denser at bottom

2.1 Loading and boundary conditions

Fixed supports were provided at all the 6 columns of bottom storey to restrain axial deformation. OG supports were also provided. El Centro earth quake data was provided for time history analysis of the models. Same boundary condition and same loading was applied for all the models for comparative study. Figure 6 shows the earthquake data provided.

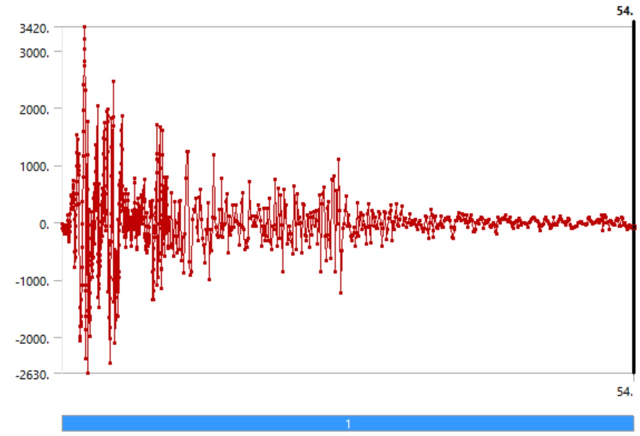

Fig -6: El Centro earthquake data provided

3. RESULTS AND DISCUSSION

Table 5.6 shows the analysis results in terms of acceleration, lateral displacement, base shear, frequency and time period of multi storied frames with different density of braces at different positions.

Table -3: Analytical results of models

MOD-EL NAME	ACCELE-RATION (mm/s²)	LATERAL DISPLAC-EMENT (mm)	BASE SHEAR (kN)	FREQ-UENCY (Hz)	TIME PERIOD (S)
DT	1282.9	17.481	47.053	1.666	0.6002
DM	920.71	14.78	37.236	1.8762	0.533
DB	785.06	12.449	36.804	2.1486	0.4654
FB	554.02	11.35	45.075	2.1518	0.4647

DB showing lowest value of acceleration than DT and DM. DT showing highest value it was 63.4% higher than DB and 39.33% higher than DM. Lateral displacement of DB was only 12.449 and it was 28.7% lesser than DT 18.72 % lesser than DM. . Base shear of DB was 36.804 kN, which was the lowest among the three. Base shear of DT was higher and the value was 27.8 % greater than DB. Higher frequency was showed by DB, which was 2.1486Hz. The frequency of DT was least one, which was 22.46 % lesser than DB. Lowest value time period showed by DB, and it was 0.4654s. Maximum and minimum storey displacement showed by DT and DB respectively.

Among DT, DM and DB, best model was DB. While comparing DB and FB the frequency and time period of these models were approximately equal. Acceleration of DB was 29.4% higher than FB. Lateral displacement of DB slightly higher than that of FB. Base shear of DB was 22.4% lesser than FB. Figure 7 and 8 shows acceleration vs time graph of DB and FB. Figure 9 and 10 shows lateral displacement vs time graph and figure 11 and 12 shows base shear vs time graph of DB and FB. Figure 13 shows the storey displacement vs height graph of all the four models.

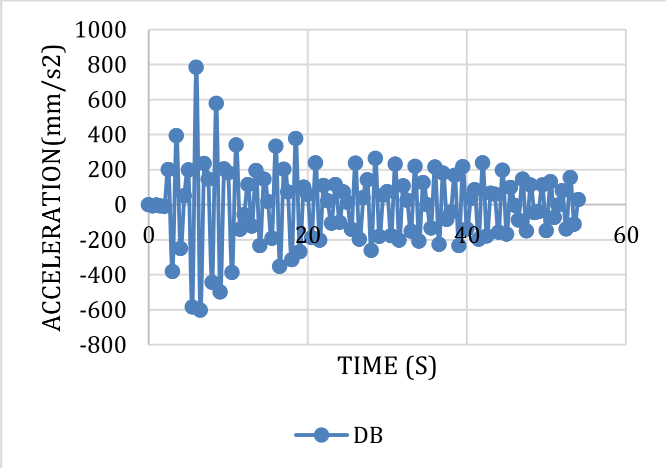

Fig -7: Acceleration vs time graph of DB

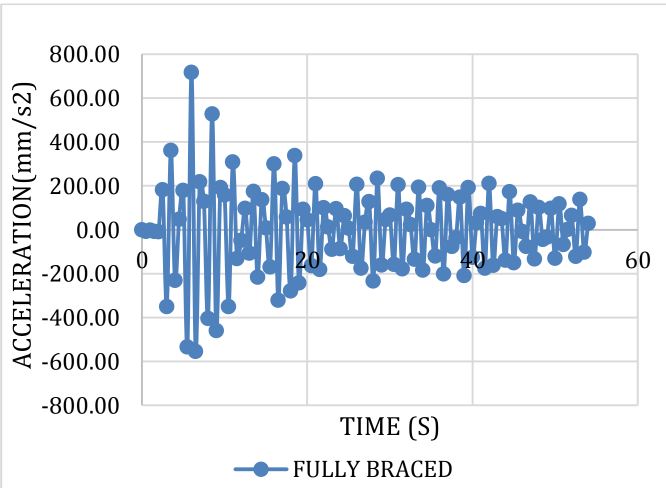

Fig -8: Acceleration vs time graph of FB

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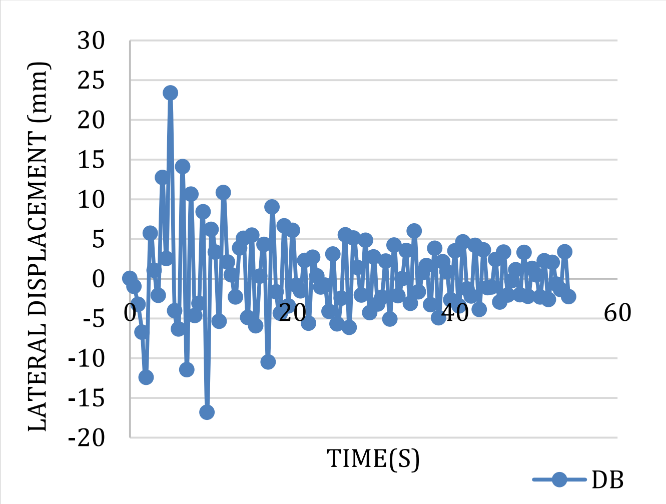

Fig -9: Lateral displacement vs time graph of DB

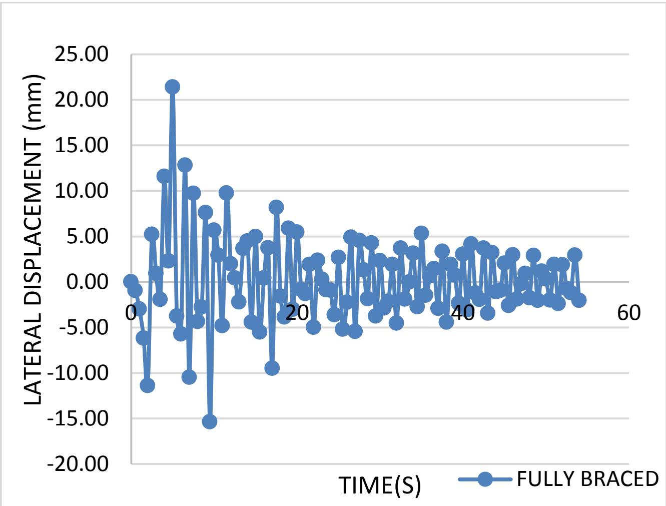

Fig -10: Lateral displacement vs time graph of FB

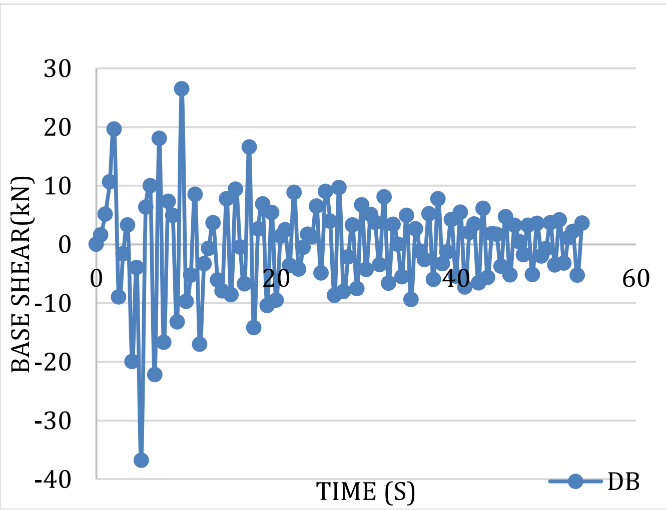

Fig -11: Base shear vs time graph of DB

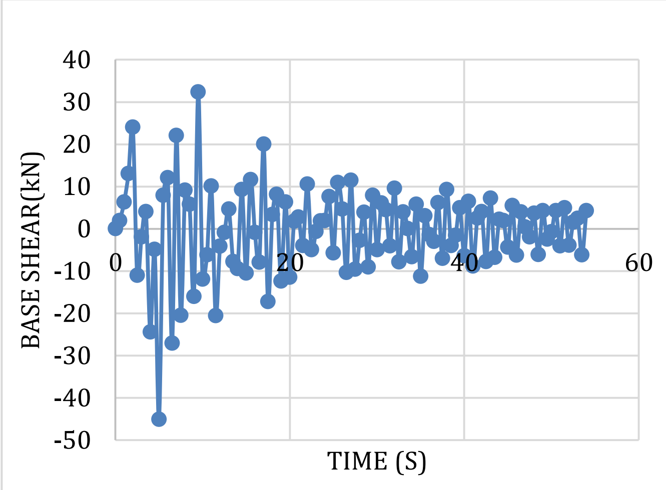

Fig -12: Base shear vs time graph of FB

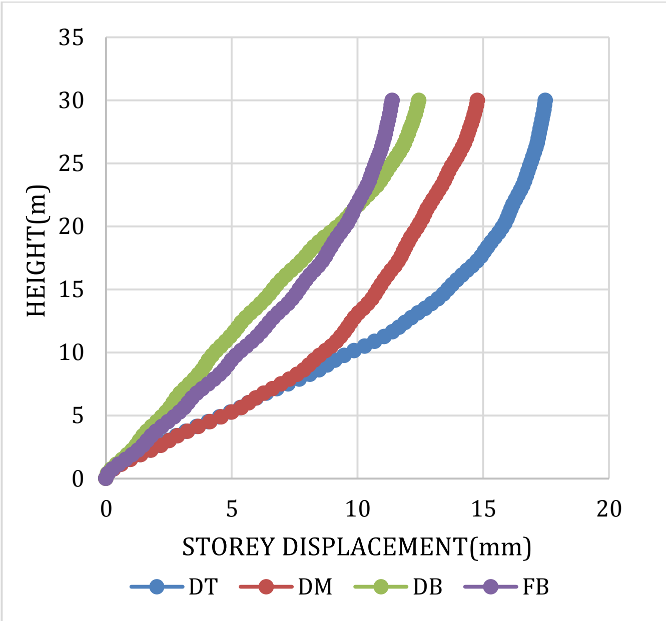

Fig -13: Storey displacement vs height graph

4. CONCLUSIONS

The following conclusions were obtained from the analysis carried out in this work.

- Among all the models better result showed by DB which is comparable with the results showed by FB frame.
- Acceleration of DB was 29.4% higher than FB. Lateral displacement of DB slightly higher than that of FB. Base shear of DB was 22.4% lesser than FB.
- Frequency and time period of DB and FB were approximately equal.
- For better performance of frames in an earthquake number of braces should be more at bottom stories than other stories.

- DB OGrid model have weight lesser than FB frame so it is economical.

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