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Effect of Mega Column in Outrigger System of High-Rise Building

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Abstract* - Analysis of the high rise structure is carried out to study the behavior of outrigger in high rise building with/without mega column and its efficiency for its optimum position for different condition. The three dimensional models of outrigger with/without mega column subjected to earthquake load and define best system from that and outrigger with mega column are subjected earthquake load, analyzed and compared to find the lateral displacement reduction related to the outrigger and mega column and the earthquake load obtained using IS 1893 (Part-1): 2002. The location of outrigger reducing lateral displacement and building drift. To evaluate the performance of high rise building with outrigger system respect to same column and mega column in high rise building, Response spectrum analysis has been conducted by using SAP 2000. To achieve this objective, the high rise building with 50 storey and with shear wall and with/without outrigger different location and with/without mega column were analyzed. Comparative study of the displacement, drift and base shear of the structure is studied.

***Keywords*- Outrigger, Mega column, shear wall, Response spectrum, Base shear, Displacement, Drift**

I. INTRODUCTION

The demands of high rise structures are becoming imperative almost everywhere in the world. Development in the structural systems of tall buildings has been a continuously evolving process since the growth in tall buildings began in 1880s. Development of new technology occurs based upon necessity, and the technology evolves towards enhanced efficiency.

Outrigger beam define as the element of outrigger system connecting the core shear wall and external column and also the external columns are tied to a reinforced-concrete or braced steel frame main core with very stiff horizontal cantilever members at one or more levels commonly referred to as “outriggers". Those column which located at end of outrigger which restrain the outrigger. Outrigger system is most effective system for controlling deflection and story drift of high rise building above 40 stories. The outrigger system consist of Outrigger beam provided between the core shear wall and external column and all external columns are connected peripheral by belt truss. The outriggers are generally in the form of trusses in steel structures, or mega bracing walls and also inclined member in concrete structures that effectively act as stiff headers inducing a tension-compression couple in the outer columns. Belt trusses are often provided to distribute these tensile and compressive forces to a large number of exterior frame columns. The belt trusses also help in minimizing differential elongation and shortening of columns.

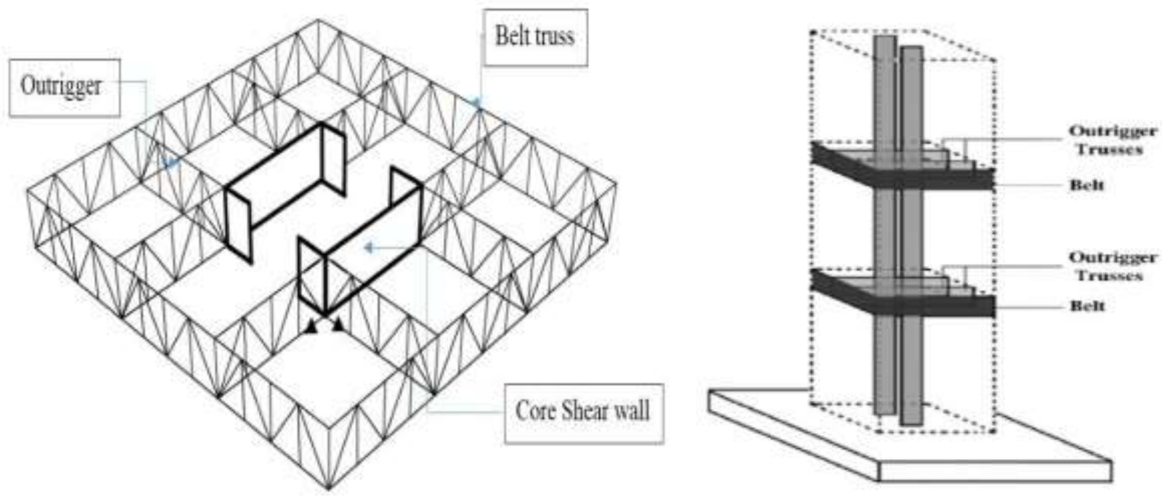

Figure 1: Outrigger connect with shear wall and external column

Generally columns having same size are provided in high rise building for outrigger system. But if mega column is provided at the end of outrigger its gives better performance. The mega column is one types of column but size of this column is higher than other column. Mega column is connected with outrigger system which increase stiffness of building so its reduced displacement and story drift of building. Here given performance is comparison of different models with same size of column or mega column with different position of outrigger in high rise building.

The core is used to resist horizontal shear and the outriggers are used to transfer the vertical shear to the exterior columns. With proper placing of the outriggers, the flexural capacity of the building increases but the shear capacity remains the same.

The methodology of this study is performance of outrigger in terms of Concrete X mega bracings in high rise structure. The size of column and location of outrigger is effect on the displacement and storey drift. The present study is limited to reinforced concrete (RC) multi-storied symmetrical building. As the lateral loads deform the concrete core into a cantilever, the stiffness of the outrigger levels forces the participation of the exterior columns with the development of a couple of axial forces. The analysis of these models is carried out by equivalent static method and response spectrum method using software SAP 2000.

II. NUMERICAL STUDY

There are twelve model which are divide into two groups. Each group having six model with different position of outrigger. One of these group has same column size and other group has same mega column. Mega column is define as size of column is larger than other column in a model. Comparative study of these two group in term of evaluating displacement, storey drift and base shear.

2.1. Model group: 1

Model of group 1 is G+50 storey building with core shear wall. This building model having all columns size is same. The location of outrigger in horizontal plan and shear wall is same in all models. The location of outrigger in plan and shear wall and Plan of group 1 model show in fig.

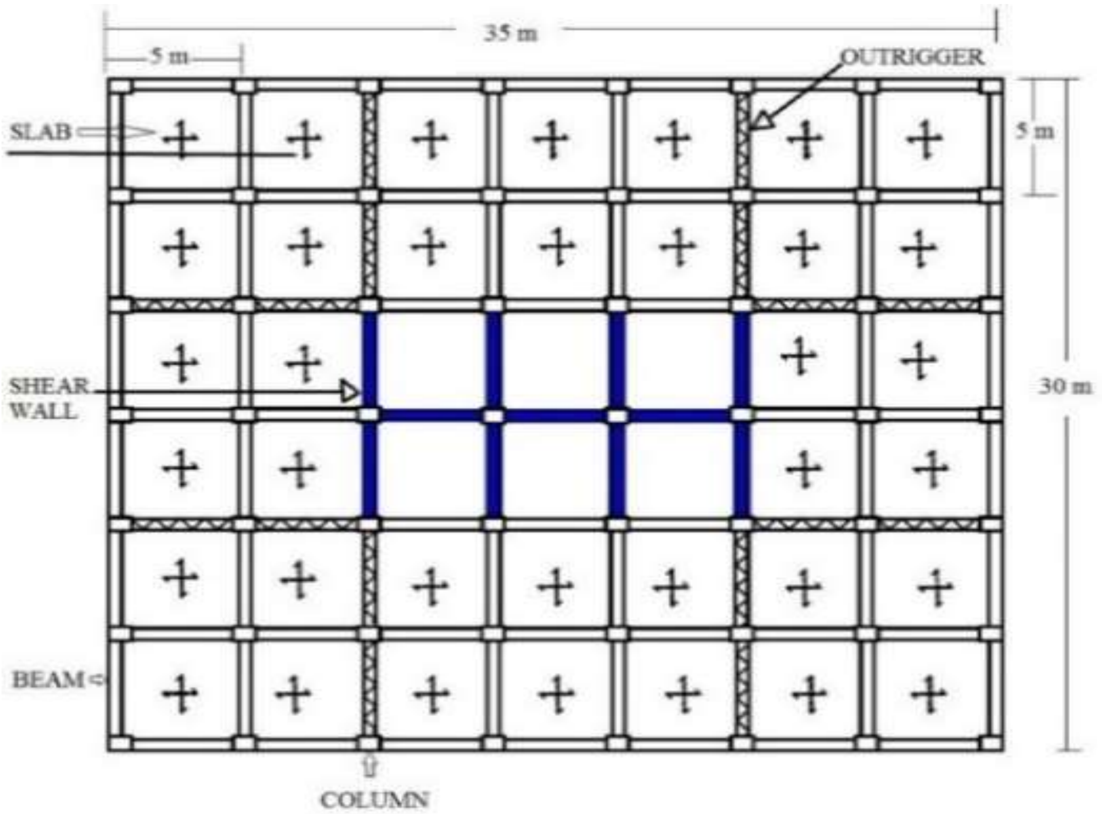

Figure 2. Plan of model group 1

Area of column
Normal Column size : 1.2 m * 1.2 m
No of column : 56
Total Column area = (1.2 * 1.2) * 56 : 80.64 m^2

Table 1. Model list of group 1

Model No	Model Code	Details
1	G-1-1	Model with Shear wall
2	G-1-2	Model with Shear wall and outrigger at top
3	G-1-3	Model with Shear wall and outrigger at middle
4	G-1-4	Model with Shear wall and outrigger at 2/3 from bottom
5	G-1-5	Model with Shear wall and outrigger at 1/3 from bottom
6	G-1-6	Model with Shear wall and outrigger at top and middle

2.2. Model group: 2

Model of group 2 is G+50 storey building with core shear wall and mega column. This building model having normal column and mega column. The location of outrigger in plan, shear wall and mega column is same in all group 2 models. The location of outrigger, shear wall and mega column and Plan of group 2 model show in fig.

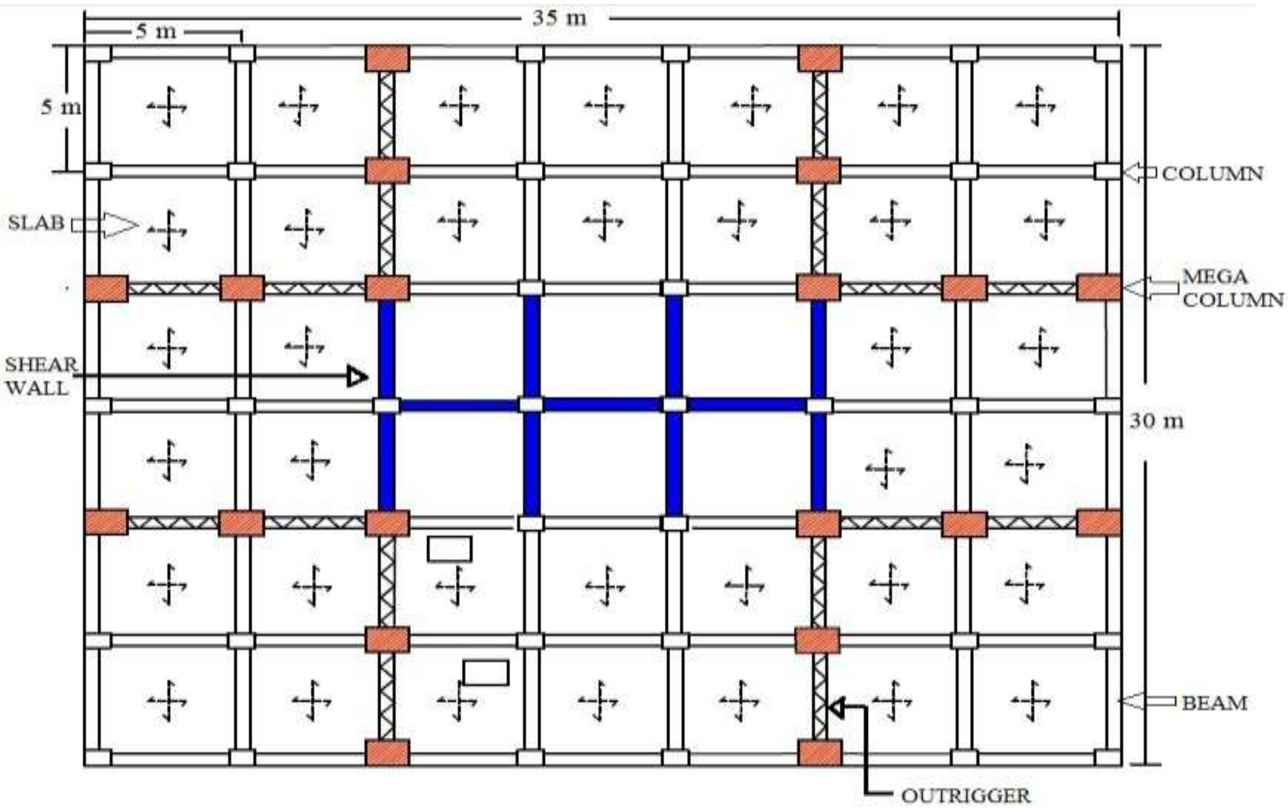

Figure 3. Plan of model group 2

Area of column in plan
Normal column size : 0.8 m * 0.8 m
Mega column size : 1.5 m * 1.5 m
No of normal column : 36
No of mega column : 20
Area of column : [(0.8 * 0.8) * 36] + [(1.5 * 1.5) * 20] : 68.04 m^2

Table 2. Model list of group 2

Model No	Model Code	Details
1	G-2-1	Model with Shear wall
2	G-2-2	Model with Shear wall and outrigger at top
3	G-2-3	Model with Shear wall and outrigger at middle
4	G-2-4	Model with Shear wall and outrigger at 2/3 from bottom
5	G-2-5	Model with Shear wall and outrigger at 1/3 from bottom
6	G-2-6	Model with Shear wall and outrigger at top and middle

2.3. Model Configuration

Table 3. Structural data are used for analysis and study of results

No of storey	G + 50	Slab Thickness	0.130 m
Height of basement	2.5 m	Grade	M25
Height of storey	3 m	Shear Wall Thickness	0.180 m
Total height of building	152.50 m	Grade	M25
No of bay : X direction	7	External Wall	
Y direction	6	Thickness	0.230 m
Width of bay	5 m	Grade	M20
Width of building :		Internal Wall	
X direction	35 m	Thickness	0.115 m
Y direction	30 m	Grade	M20
Beam Size	0.5 * 0.5 m	Outrigger Size	0.5 * 0.5 m
Grade	M25	Grade	M25
Column:		Structure	SMRF
Model Group -1		Location	Ahmedabad
Normal column size	1.2 * 1.2 m	Seismic Zone	III
Grade	M40	Soil type	II
Model Group – 2		Importance Factored	1
Normal Column Size	0.8 * 0.8 m	Reduction Factored	5
Mega column size	1.5 * 1.5 m	Live load	3 KN/mm^2
Grade	M40	Software	SAP 2000

III. ANALYSIS AND RESULTS

All model analysis by using sap 2000 and measuring the base shear, displacement and storey drift for all models and prepared the graphs base on displacement value and comparative study of this two group models.
Here, Top storey displacement Comparison between models of group model 1 and models of group model 2 and also comparison between group model 1 and group model 2

3.1. Column area difference in model group 1 and model Group 2

Model Group 1 column area	: 80.64 m^2
Model Group 2 column area	: 68.04 m^2
Area difference	: 12.6 m^2
Area Difference in %	: 15.625 %

3.2. Displacement comparison
Displacement Difference between group 1 and Group 2 models

Table 4. Displacement of top storey

	Group 1 Displacement	Group 2 Displacement	Displacement Difference	Difference in %
Model 1	63.263	61.593	1.670	2.64
Model 2	60.118	58.148	1.970	3.28
Model 3	56.903	55.097	1.806	3.17
Model 4	57.4562	55.747	1.709	2.97
Model 5	57.4238	55.525	1.899	3.31
Model 6	54.7086	52.717	1.992	3.64

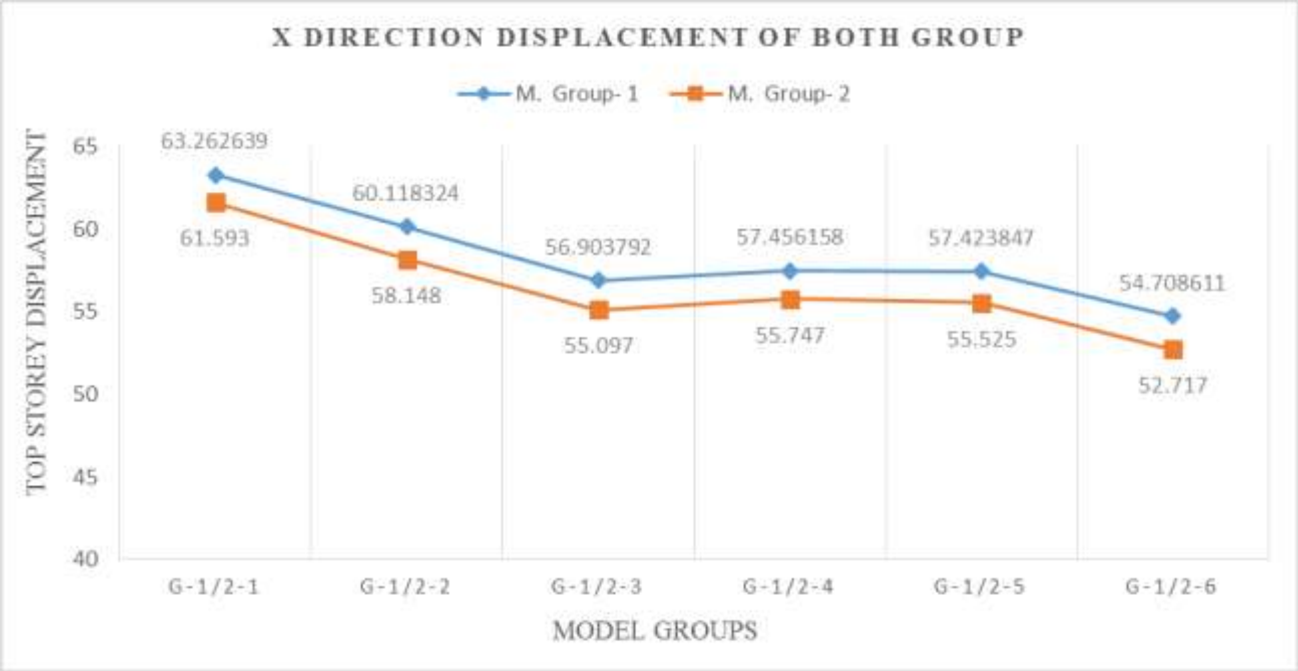

Figure 4: Combine graph of top storey X direction displacement of both group

3.3) Storey Drift Comparison:

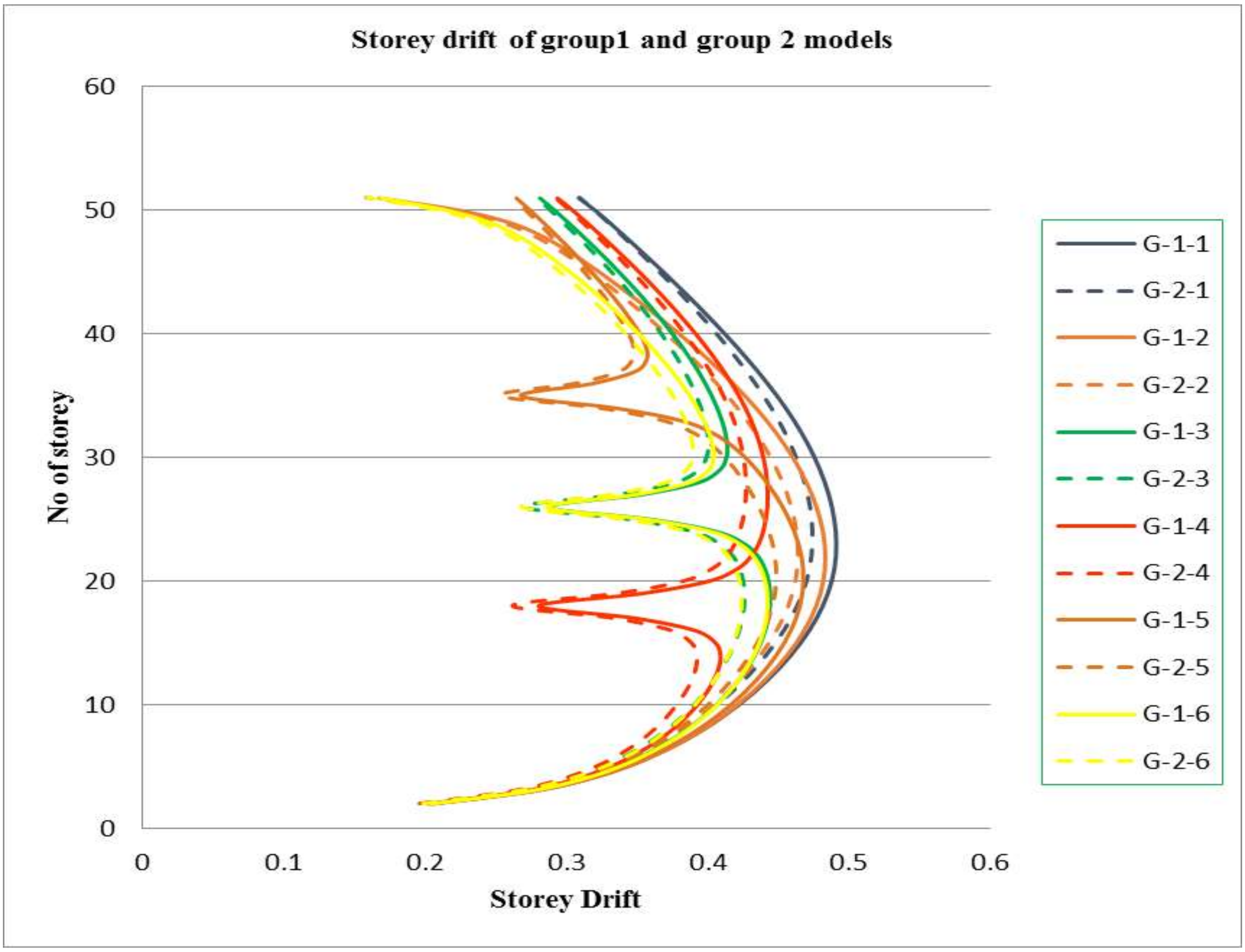

Figure 5. Comparison of storey drift of group 1 and group 2 models

3.4. Base shear Comparison

Table 5: Base shear for group 1 & 2 Models

	M.Group 1	M.Group 2
Model - 1	8147.003 KN	7740.704 KN
Model - 2	8181.159 KN	7772.219 KN
Model - 3	8158.649 KN	7746.494 KN
Model - 4	8200.152 KN	7790.974 KN
Model - 5	8165.599 KN	7756.669 KN
Model - 6	8192.348 KN	7779.707 KN

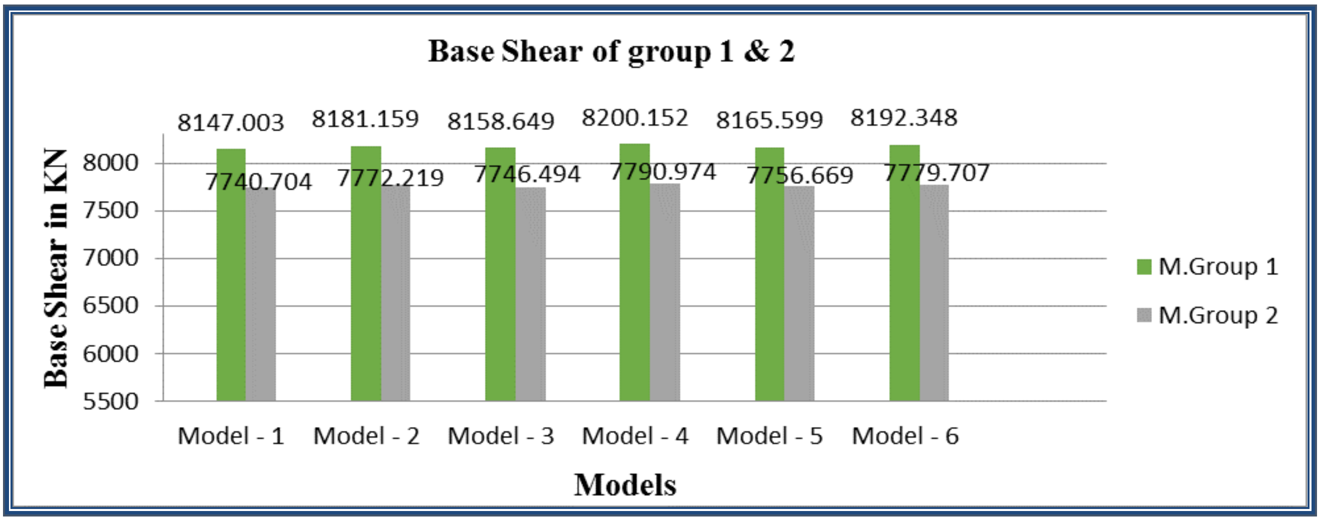

Figure 6. Base shear of model group 1 and group 2

IV.CONCLUSION:

I. Result and graph of group 2 models show that mega column use in outrigger system then 3.31 % and 3.64 % reduction in displacement in one outrigger and two outrigger models respectively.

II. Result of group model 1 of storey drift graph show that, storey drift is reduce in model with outrigger compare to without outrigger and also result from model group 2 , more reduction in story drift when mega column use in outrigger system.

III. Area of column in model with mega column is reduced upto 15.625 % compare with model with same size column.

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