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OPTIMUM SHAPE OF OUTRIGGER SYSTEM FOR HIGH-RISE REINFORCED CONCRETE BUILDINGS UNDER EARTHQUAKE LOADINGS

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Abstract —*Tall building development has been rapidly increasing worldwide introducing new challenges that need to be met through engineering judgment. In modern tall buildings, lateral loads induced by wind or earthquake are often resisted by a system of coupled shear walls. But when the building increases in height, the stiffness of the structure becomes more important and introduction of outrigger beams between the shear walls and external columns is often used to provide sufficient lateral stiffness to the structure. This study aims to identify the optimum outrigger belt truss shape in tall buildings under earthquake loads. A 70 (triple belt) storey , 50 (double belt) storey and 35 (single belt) storey building was investigated with three different shape (warren , X & N) of outrigger belt truss , and optimum location for single , double and triple belt take according to Bangle s. taranath , and from comparative study of without and with variation of shape of belt truss with parameters displacement and storey drift under earthquake loading , and get a optimum shape of outrigger belt truss for single(35 storey) , double(50 storey) and triple(70 storey).*

Keywords-*Tall structure, Outrigger belt trust system, Under seismic load , optimum shape of belt truss.*

I. INTRODUCTION

Outriggers are rigid horizontal structure i.e. truss or beam which connect core wall and exterior column of building to improve building strength and overturning stiffness. Outriggers have been used in tall building for nearly 5 decades century, but innovative design principle has been improving its efficiency. Outrigger system is structural system which is formed from a cantilever shaped horizontal member connected to structures inner-core and exterior-columns. Through the connection, the moment arm of the core will be increased which lead to higher lateral stiffness of the system. Central core in a building act as cantilever, outriggers are provided to decrees overturning moment in core and to transfer moment from core to outer column by connecting the core and column. Wall frame outrigger trusses is one of the most efficient and economical structure system in tall building, at outer end they connected to the foundation through exterior columns. When the structure is subjected to lateral loading, the outrigger trusses will rotate, causing compression in the downwind column and tension in column on the upwind side, these axial forces will resist the rotation in the wall.

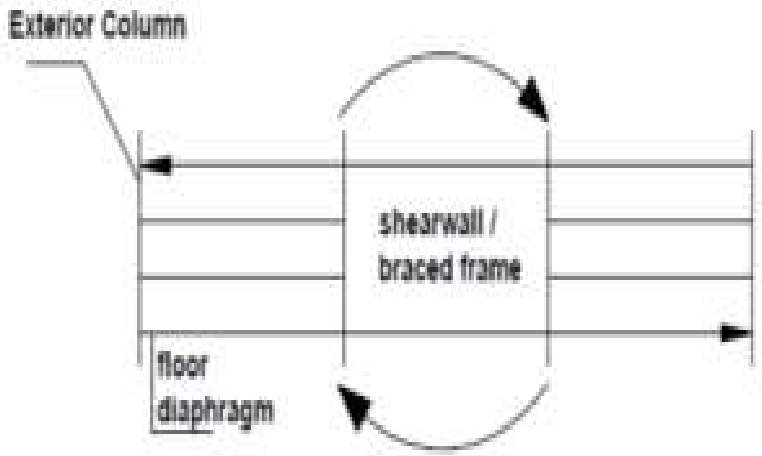

Figure 1. Lateral load transfer path

II. PROCEDURE OF METHODOLOGY

A. Study the different structural system for tall-structure

B. Model parameter from the above literature

1) Structure layout (Rectangle)
2) Model height (35,50&70 storey)
3) Shape of belt truss (Warren , X-shape, N-shape)
4) Analysis type (Response spectrum)
5) Software selection (ETABS)

C. Software Study And Validation

D. Model analysis (response spectrum)

1) 35-storey (single outrigger belt)
2) 50-storey (double outrigger belt)
3) 70-storey (triple outrigger belt)

E. Data Analysis (from ETABS)

1) Displacement value
2) Storey drift ratio value

III. RESULTS

A. ***Single outrigger belt truss system (35-storey)***

For single outrigger belt truss system 35-storey model with one by one belt at the middle of the structure, warren, X shape and N shape after analysis obtain values comparison of displacement and storey drift ratio:

Table 1. **Single belt truss (displacement and story drift ratio)**

Model Title	Location of outrigger belt	Deflection at to (mm)	Max Storey drift ratio	Variation of displacement	Variation of Storey drift ratio
35-1	---	103.9	0.001041	0 %	0%
35-2	@ mid height	87.2	0.000849	16%	18.44%
35-3	@ mid height	85.8	0.000832	17.42%	20.08%
35-4	@ mid height	87.4	0.000852	15.88%	18.16%

B. ***Double outrigger belt truss system (50-storey)***

Table 2. **Single belt truss (displacement and story drift ratio)**

Model Title	Model arrangements	Location of outrigger belt	Deflection at top (mm)	Max Storey drift ratio	Variation of displacement	Variation Of Storey drift ratio
50-1	Without outrigger belt	---	260	0.001872	0%	0%
50-2	Warren outrigger belt	1st @ H/3 & 2nd @ H/3	145.1	0.000998	44.19%	46.68%
50-3	X-shape outrigger belt		137	0.000994	47.31%	46.90%
50-4	N-shape outrigger belt		146.1	0.001007	43.81%	46.21%

C. ***Triple outrigger belt truss system (70-storey)***

Table 3. **Triple belt truss (displacement and story drift ratio)**

Model Title	Model arrangements	Location of outrigger belt	Deflection at top (mm)	Max Storey drift ratio	Variation of displacement	Variation of Storey drift ratio
70-1	Without outrigger belt	---	278.7	0.001670		
70-2	Warren outrigger belt	1st @ H/3, 2nd @ 2H/3 & 3rd @ 4H/3	156	0.000889	44.02%	46.76%
70-3	X-shape outrigger belt		130.7	0.000822	53.10%	50.89%
70-4	N-shape outrigger belt		151.9	0.000891	45.49%	46.64%

H = height of structure
1st outrigger belt truss at H/3 = 17th Storey
2nd outrigger belt truss at 2H/3 = 34th Storey
3rd outrigger belt truss at 4H/3 = 51th Storey

IV. CONCLUSION

This study assessed the global behavior of outrigger belt truss system with variation of shape of outrigger belt truss system for single belt system (35-storey) , double belt truss system (50 storey) and three belt truss system (70 storey) under earthquake loads from which the following conclusions can be drawn based on the above results:

35-STOREY (Single belt outrigger system)

From the above table, for single belt outrigger system for 35 Storey model:

a) Deflection
- warren outrigger belt decrees deflection up to 16 %
- X shape outrigger belt decrees deflection up to 17.42%
- N SHAPE outrigger belt decrees deflection up to15.88 %

b) Storey drift ratio
- warren outrigger belt decrees Storey drift ratio up to18.44 %
- X shape outrigger belt decrees Storey drift ratio up to 20.08 %
- N SHAPE outrigger belt decrees Storey drift ratio up to18.16 %

From above result, we can say the x-shape outrigger belt is more efficiency than warren outrigger belt and N-shape outrigger belt system.

50-STOREY (double belt outrigger system)

From the above table , for double belt outrigger system for 50 Storey model.

a) Deflection
- warren outrigger belt decrees deflection up to 44.19 %
- X shape outrigger belt decrees deflection up to 47.31 %
- N SHAPE outrigger belt decrees deflection up to 43.81 %

b) Storey drift ratio
- warren outrigger belt decrees Storey drift ratio up to 46.68 %
- X shape outrigger belt decrees Storey drift ratio up to 46.90 %
- N SHAPE outrigger belt decrees Storey drift ratio up to 46.21 %

From above result, we can say that for double outrigger belt system x-shape outrigger belt is more efficiency than warren outrigger belt and N-shape outrigger belt system for double outrigger belt system.

70-STOREY (Three belt outrigger system)

From the above table, for triple belt outrigger system for 70 Storey model:

a) Deflection
   - warren outrigger belt decrees deflection up to 44.02 %
   - X shape outrigger belt decrees deflection up to 53.10 %
   - N SHAPE outrigger belt decrees deflection up to 45.49 %

b) Storey drift ratio
   - warren outrigger belt decrees Storey drift ratio up to 46.76 %
   - X shape outrigger belt decrees Storey drift ratio up to 50.89 %
   - N SHAPE outrigger belt decrees Storey drift ratio up to 46.64 %

From above result, we can say that for three outrigger belts system x-shape outrigger belt is more efficiency than warren outrigger belt and N-shape outrigger belt system for double outrigger belt system.

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