STUDY OF OUTRIGGER RC FRAME WITH PLAN IRREGULARITIES SUBJECTED TO SEISMIC LOADING

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Abstract - *An attempt has been made to study the performance of outrigger system for static approach and dynamic approach for a 60 storey building with plan irregularities and different outrigger materials provided at different location to check the optimum position using software ETABSv2015.*
Modeling has done for square plan concrete outrigger provided at four different locations with central core in zone 3.results includes lateral displacement, percent reduction and storey stiffness.
Key Words: Outrigger system, Seismic load, Response spectrum, central core, lateral displacement.

1. INTRODUCTION

The tallest and most primitive structures present on this planet were the pyramids of Egypt made by people on the planet more than 3800 years back. The great pyramid of Giza shaped by ancient people with a height of 146.5m is the first tallest structure ever found. In thirteenth century universes tallest building was dependably a church. Thereafter a new era in the nineteenth century a new form of structures was urbanized in Chicago named skyscrapers using iron/steel as an internal structure. Thereafter in 19th century new epoch switched with innovative form of structures in Chicago termed as skyscrapers with internal structure utilizing iron//steel. So far the world's tallest building is regarded as Burj Khalifa with 828m (2717 ft) in height. During 19th century trend of tall structures appeared in USA. Now days they are universally scattered notably in countries like JAPAN, KOREA, CHINA AND MALAYSIA.

1.1 Outrigger Structural System

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.

The Victoria office tower (1965) is the first outrigger structural system designed by Nervi and Morerri. These outrigger systems are very popular among tall structures.

1.2 Benefits of outrigger structural system

1.2.1Deformation reduction

Tall structures provided with outrigger can experience decrease in core overturning moment up to 40% compared to cantilever and by incorporating mega columns for super tall structures overturning moment can be reduced up to 60%. It can be observed that there is a significance reduction of drift.

1.2.2Efficiency

Outrigger system provided with belt truss and peripheral columns increases the efficiency and also optimal location of outrigger can increase the efficiency of the structure.

1.2.3Foundation forces

Overturning loads can be effectively distributed on foundation by providing outrigger.

2. MODELLING AND ANALYSIS

Modeling process involves 60 storey 6 bays in x direction and 6 bays in y direction with central core of 6×6 are considered.

A. Material properties

- Concrete -M30
- Steel -Fe 345
- Rebar -Fe415
- Material type – isotropic
- Modulus of elasticity - 5000√fck

B. Section properties

- Concrete beam: 450*750 mm
- Concrete column: 750*750 mm
- Concrete outrigger beam : 350*1000 mm
- Steel outrigger beam: shape ISB 200 structural steel
- Concrete core shear wall:M30 concrete 300 mm thick
- Steel core shear wall: shape ISB 200 structural steel
- Belt truss and cap truss: ISB 200 [box section]
- Slab: Shell thin membrane 200 mm

C: Load considerations:

For static behavior dead load of the building is considered and live load is taken as 3 KN/m2 and super dead load as 2 KN/m2 ,lateral load confirming IS 1893(part 1)2002

For zone 3: soil type – medium (type 2)

Importance factor (I=1.5)

Response reduction factor (R=5)

Time period: Program calculated

Analysis is done for different location of outrigger and belt truss then results are tabulated and graphs are plotted for different parameters chosen.

Following models are made in ETABSv2015 and investigated

Case 1: Square plan: Structure without outrigger

Concrete outrigger

- Structure with outrigger at 60
- Structure with outrigger at 60 and 45
- Structure with outrigger at 60 and 30
- Structure with outrigger at 60 and 15

Steel outrigger

- Structure with outrigger at 60
- Structure with outrigger at 60 and 45
- Structure with outrigger at 60 and 30
- Structure with outrigger at 60 and 15

Case 2: L Shape plan:

Concrete outrigger

- Structure with outrigger at 60
- Structure with outrigger at 60 and 45
- Structure with outrigger at 60 and 30
- Structure with outrigger at 60 and 15

Steel outrigger

- Structure with outrigger at 60
- Structure with outrigger at 60 and 45
- Structure with outrigger at 60 and 30
- Structure with outrigger at 60 and 15

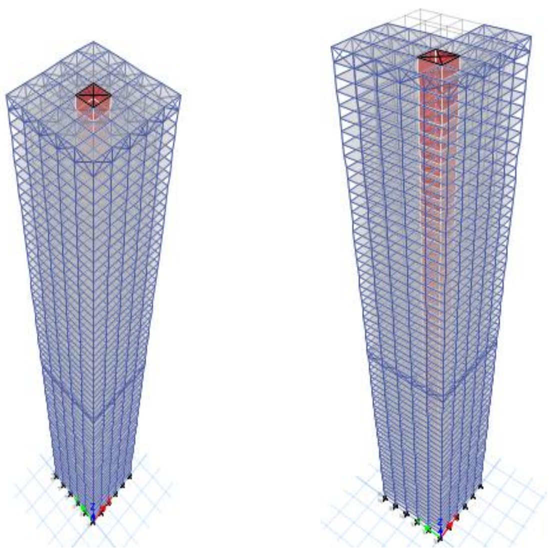
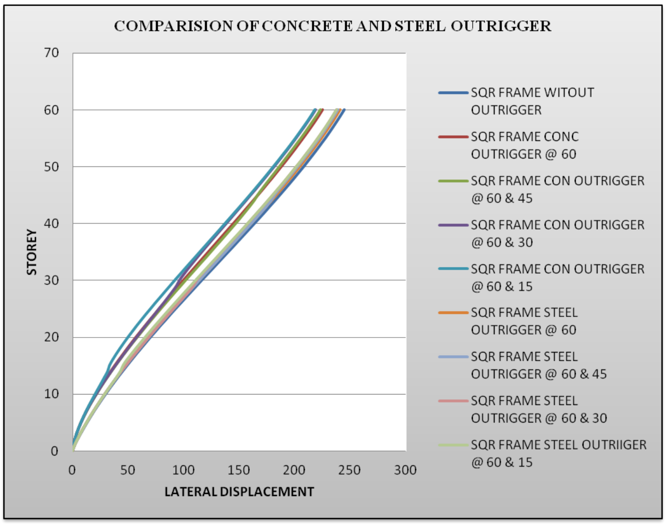


Fig -1: **Models of square and L shape with outrigger at mid height**

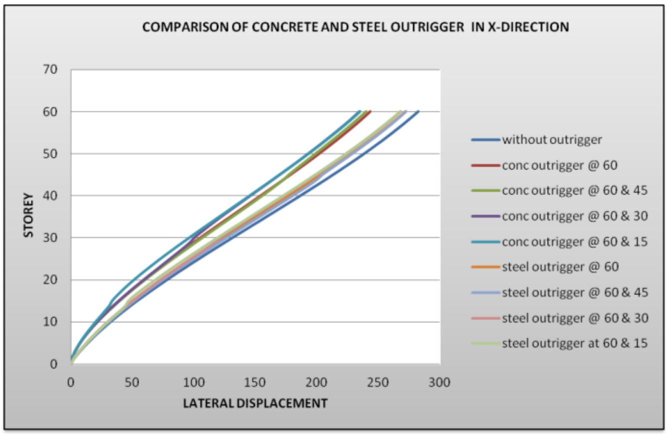
3. RESULTS AND DISCUSSION

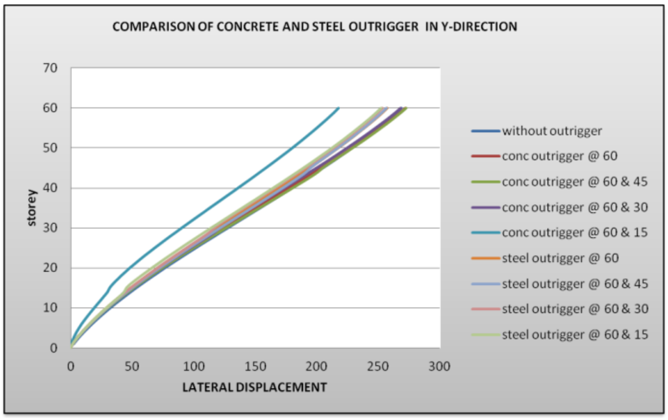
Chart 1: Comparison of concrete and steel outrigger for square shape RC frame building



Discussion:
From graphical representation square frame with concrete outrigger shows significant reduction of lateral displacement compared to structure provided with steel outrigger, also it is represented in the table below.

Chart 2: Comparison of concrete and steel outrigger for L shape RC frame building in X direction and Y direction.





Discussion:
From graphical representation concrete outrigger provides more stiffness to the structure when compared to steel outrigger.

Chart 3: Storey stiffness for square outrigger

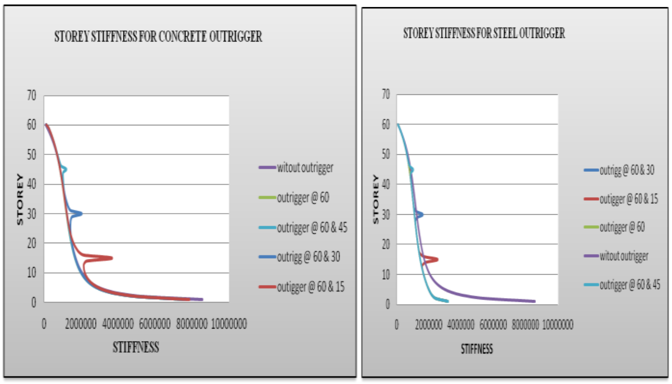
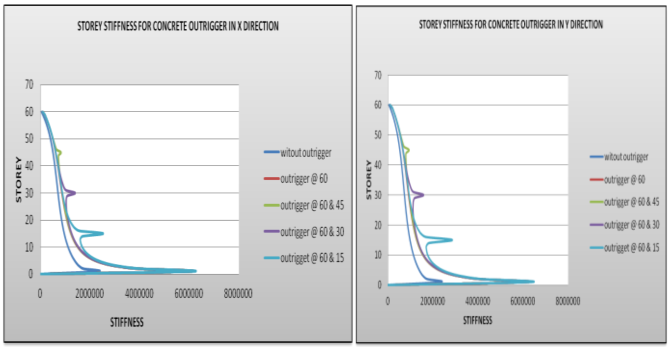
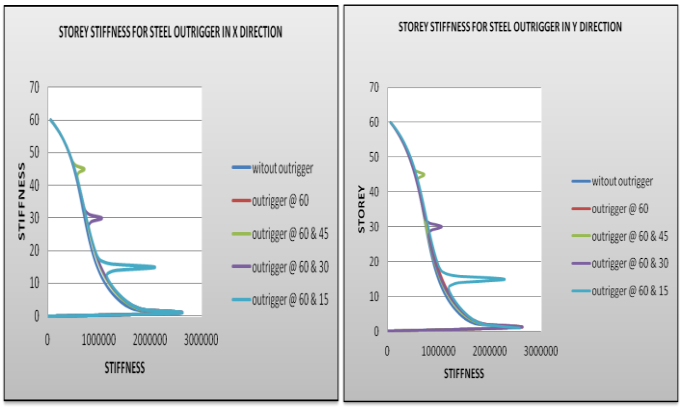


Chart 4: Storey stiffness for L Shape outrigger both in X and Y direction.





Discussion:

From graphs it can be observed that structure without outrigger is less stiff than structure with outriggers. Concrete outrigger shows better stiffness than steel outrigger.

Chart 5: Base shear for square plan building

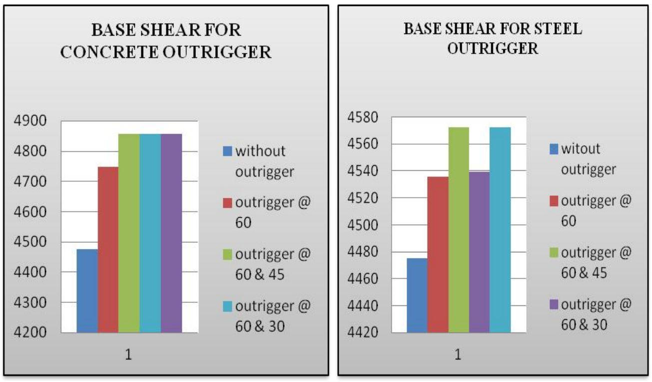
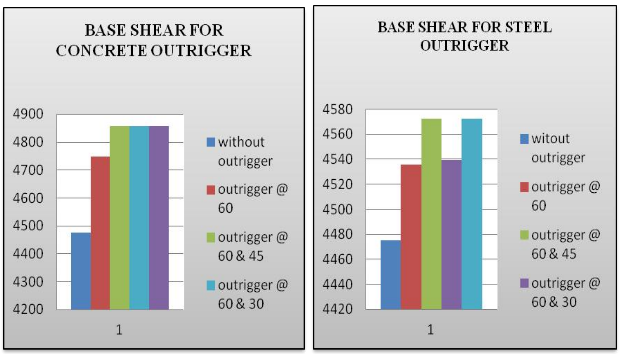


Chart 6: Base shear for L shape plan building



Discussion:

Base shear mainly depends on the weight of the structure .it is the estimation of total horizontal load acting over the structure ,With the decrease of time period the stiffness of the structure increases.

Table 1: Lateral displacement and percent reduction for both concrete and steel outrigger tabulated separately with square plan.

SQUARE CONCRETE OUTRIGGER					
SL NO	OUTRIGGER LOCATION	MAXI DISPLACEMENT EQX	% REDUCTION	MAXI DISPLACEMENT EQY	% REDUCTION
1	WITHOUT OUTRIGGETR	244.5		244.5	
2	OUTRIGGER AT 60	225	7.98	225	7.98
3	OUTRIGGER AT 60 AND 45	222.9	8.83	222.9	8.83
4	OUTRIGGER AT 60 AND 30	218.7	10.55	218.7	10.55
5	OUTRIGGER AT 60 AND 15	218.1	10.79	218.1	10.79

SQUARE STEEL OUTRIGGER					
SL NO	OUTRIGGER LOCATION	MAXI DISPLACEMENT EQX	% REDUCTION	MAXI DISPLACEMENT EQY	% REDUCTION
1	WITHOUT OUTRIGGETR	244.5		244.5	
2	OUTRIGGER AT 60	241	1.43	241	1.43
3	OUTRIGGER AT 60 AND 45	239	2.25	239	2.25
4	OUTRIGGER AT 60 AND 30	237.9	2.70	237.9	2.70
5	OUTRIGGER AT 60 AND 15	237.6	2.82	237.6	2.82

Table 2: Lateral displacement and percent reduction for both concrete and steel outrigger tabulated separately with L Shape plan

L SHAPE OUTRIGGER					
SL NO	OUTRIGGER LOCATION	MAXI DISPLACEMENT EQX	% REDUCTION	MAXI DISPLACEMENT EQY	% REDUCTION
1	WITHOUT OUTRIGGETR	282.4		268.9	
2	OUTRIGGER AT 60	243.5	13.77	226.7	15.69
3	OUTRIGGER AT 60 AND 45	240.4	14.87	222.6	17.218
4	OUTRIGGER AT 60 AND 30	234.7	16.89	216.7	19.41

5	OUTRIGGER AT 60 AND 15	235.5	16.6	217.7	19.04

L SHAPE STEEL OUTRIGGER					
SL NO	OUTRIGGER LOCATION	MAXI DISPLACEMENT EQX	% REDUCTION	MAXI DISPLACEMENT EQY	% REDUCTION
1	WITHOUT OUTRIGGETR	244.5		244.5	
2	OUTRIGGER AT 60	225	7.98	225	7.98
3	OUTRIGGER AT 60 AND 45	222.9	8.83	222.9	8.83
4	OUTRIGGER AT 60 AND 30	218.7	10.55	218.7	10.55
5	OUTRIGGER AT 60 AND 15	218.1	10.79	218.1	10.79

4. CONCLUSIONS

- By introducing outrigger structural system in tall building flexibility of the structure is reduced and stiffness increases that makes the structure efficient under lateral load.
- Structure provided with outrigger and belt truss structural system shows significant variation in lateral displacement for L Shaped structure with reduction of 19.41% in Y direction provided with concrete outrigger at the mid height of the structure than the steel outrigger hence it can be concluded that L Shape is the suitable for seismic zone 3.
- Modal investigation is carried to catch the time period of the structure significant vibrations and high flexibility is seen in the structure without outrigger when compared to other models.

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