ANALYSIS OF OUTRIGGER SYSTEM FOR TALL VERTICAL IRREGULARITES STRUCTURES SUBJECTED TO LATERAL LOADS

Shivacharan k[1], Chandrakala S[2], Narayana G[3], Karthik N M[4]

[1]Post Graduate Student, Department of Civil Engineering, SJCIT, Karnataka, India
[2]Assistant Professor, Department of civil engineering, SJCIT, Karnataka, India
[3]Head of the Department, Department of civil engineering, SJCIT, Karnataka, India
[4]Assistant Professor, Department of civil engineering, CMRIT, Karnataka, India

Abstract

The Analysis of the tall building is carried out to find the optimum position of outrigger system and belt truss by using lateral loads. The three dimensional model is considered and designed for the gravity load and placing of first and second position of the outrigger. Considering the design of Wind load is calculated by using IS 875 (Part 3) and Design of Earthquake load is calculated by using code IS 1893(part-1): 2000 in order to achieve reduction in drift, Deflection and story shear. The analysis is done by considering tall vertical irregularity of 30th storey of 7 X 7 bay for 1 to 10th storey and 7X6 bay 11th to 20th storey and 7X5 Bay 21st to 30th storey.

Keywords: *vertical irregularities, outrigger, linear static analysis Wind and earthquake load.*

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1. 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.

1.1 Vertical Geometric Irregularity

According to code Vertical geometric irregularity shall be considered to exist where the horizontal dimension of the lateral force resisting system in any storey is more than 150 percent of that in its adjacent storey (Table 5, Page 18, IS 1893-2002 Part-1).

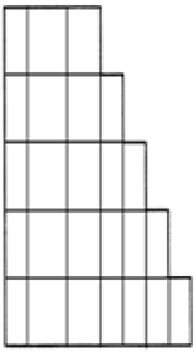


Fig1: Elevation irregularities with abrupt change in geometry

1.2 Outriggers

Outrigger beams connected to the core and external columns are relatively more complicated and it is understood that the performance of such coupled wall systems depends primarily on adequate stiffness and strength of the outrigger beam.

The lateral bracing system consisting of core with outriggers is one of the most efficient systems used for high rise construction to resist lateral forces caused by wind and earthquakes.

The integration of the outrigger to the concrete core can be further optimized by guaranteeing concentrated core forces into the outriggers.

This project implements a basic design optimization technique of tall steel structures for lateral loads, mainly wind, into trying to find the optimum locations and number of outriggers for a specific high-rise building. The structure is analyzed for an Earthquake and wind loading.

2. METHODOLGY

The three dimensional structure is modeled and designed to the gravity loading such as dead load , live load and floor load. Then place outrigger and belt truss for certain height and check for the drift and deflection.

Fix the first optimum position and vary the second outrigger position and check for the drift and deflection and storey shear.

2.1 Details of the Model:

Table 1: Model Dimensions

STOREY	DESCRIPTION
1-10	7 X 7 Bay Spacing 5.5m
11-20	7 X 6 Bay Spacing 5.5m
21-30	7 X 5 bay Spacing 5.5m

2.2 Section Properties

- Beam Details:
  Breadth – 230 mm
  Depth – 450 mm
- Slab Details: Thickness – 150 mm
  Live load - 3 kN/m^2
  Floor Finish – 1 kN/m^2
- Shear Wall: Thickness – 300 mm
- Column Details: 1^{st} and 2^{nd} storey 800 x 800mm
  3^{rd} to 5^{th} storey 700 x 700mm
  6^{th} to 10^{th} storey 600 x 600mm
  11^{th} to15^{th} storey 500 x 500mm
  16^{th} to 30^{th} storey 400 x 400mm
- Outrigger Property: 300 x 300mm with Belt truss
- Concrete Grade: M_{40}.
- Steel: Fe_{500}.
- Wind load: (IS: 875(Part 3) -1987) – Bhuj
  Design Speed – 50 m/s
  Terrain Category – 3
  Class – B
  Diaphragms – Rigid
- Earth Quake Load:
  (1893(Part 1): 2002) – Bhuj
  Zone V – 0.36
  Importance factor – 1
  Type of soil – Medium Soil
  Reduction Factor – 5
  Mass Source Definition
  Dead Load - 1
  Floor Finish- 1
  Live Load- 0.25

3. LOAD COMBINATION

COMBO-1: (DL+LL) x1.5

COMBO-2: (DL+LL+FL) x1.5

COMBO-3: (DL+LL+FL+WL) x1.2

COMBO-4: (DL+LL+FL-WL) x1.2

COMBO-5: (DL+LL+FL+EQ) x1.2

COMBO-6: (DL+LL+FL-EQ) x1.2

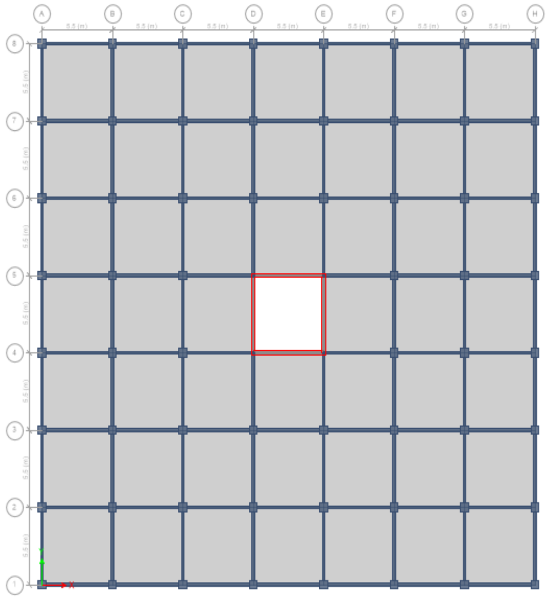


Fig 2: Plan

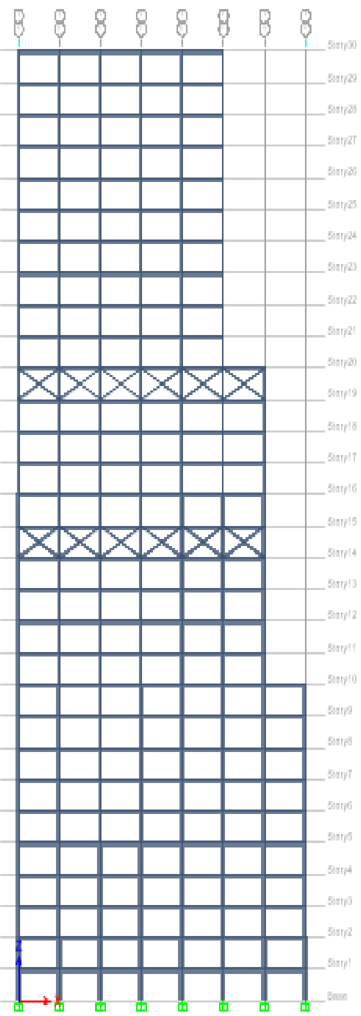


Fig : 3 Elevation of the structure

3. RESULTS AND DISCUSSION

Case 1: Bare Frame Analysis and Design

Case 2: Analysis of Bare Frame with outrigger system for the first optimum location.

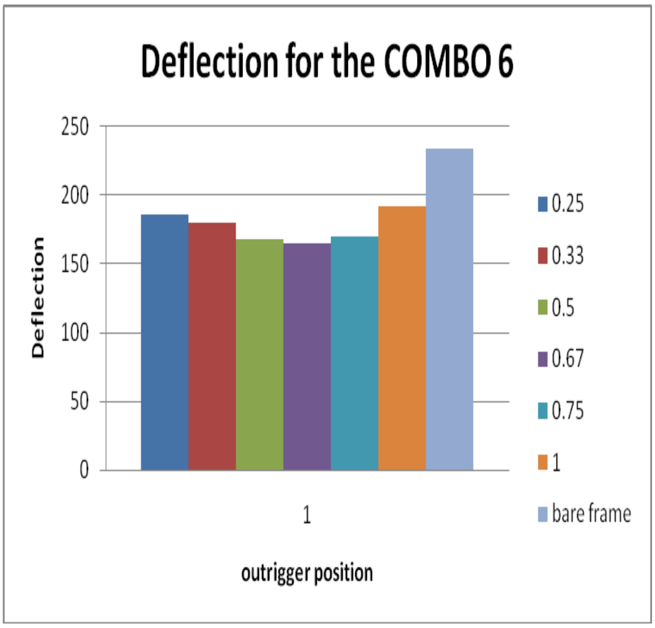
- Outrigger with Belt truss at 0.25 Position
- Outrigger with Belt truss at 0.33 Position
- Outrigger with Belt truss at 0.5 Position
- Outrigger with Belt truss at 0.67 Position
- Outrigger with Belt truss at 0.75 Position
- Outrigger with Belt truss at top Position

Case 3: Analysis of Bare Frame with outrigger system for Second position keeping first position common at 0.67.

- Outrigger with Belt truss at 0.25 Position
- Outrigger with Belt truss at 0.33 Position
- Outrigger with Belt truss at 0.5 Position
- Outrigger with Belt truss at 0.75 Position
- Outrigger with Belt truss at top Position

Table 1: Deflection for the Combo 6

Outrigger Position	Deflection ,mm
0.25	185.7
0.33	179.6
0.5	168.4
0.67	164.9
0.75	169.5
1	192.4
bare frame	233.8

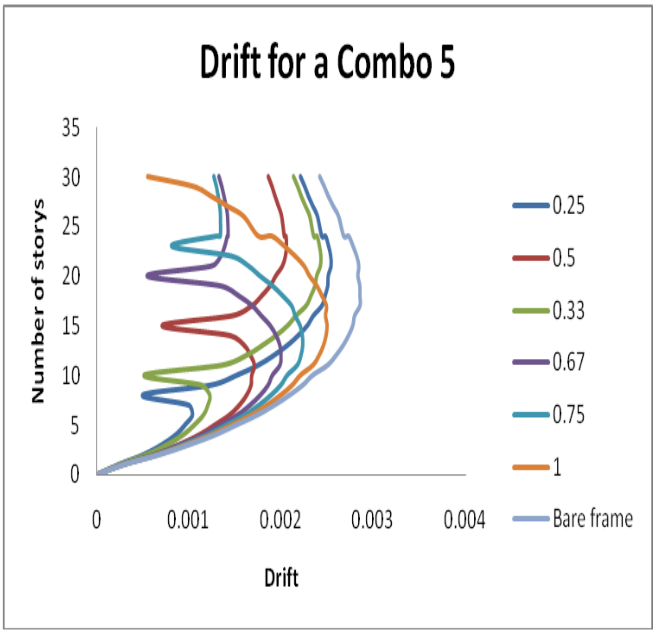


Graph 1: Deflection for Combo 6

Table 2: Deflection for the Combo 5

Outrigger Position	Deflection ,mm
0.25	165.2
0.33	156.7
0.5	143.8
0.67	130.4
0.75	143.8
1	164.2
bare frame	206.9

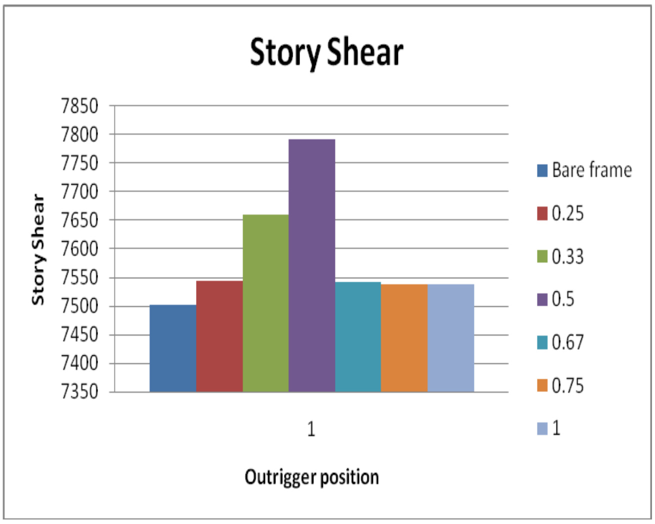
From the deflection graphs we use to get combo5 as the critical position and optimum position is 0.67H



Graph 2 : Drift for Case1 and case2

Table 3: Story Shear for Case1 and Case2

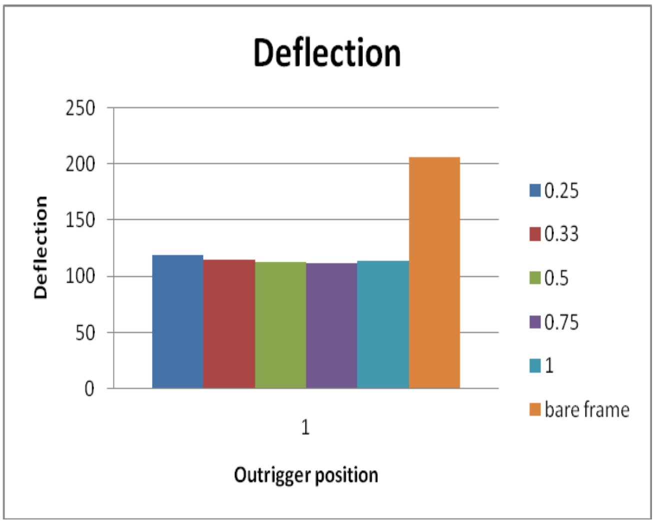
		Base Shear (kN)
Bare frame		7501.437
Outrigger position	0.25	7544.49
	0.33	7659.824
	0.5	7791.578
	0.67	7541.178
	0.75	7537.866
	1	7537.866



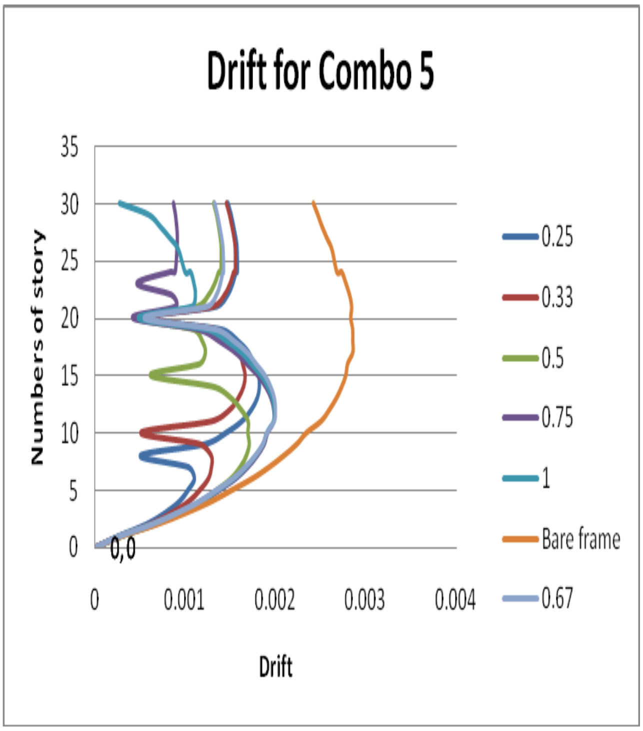
Graph 3 : Story Shear for Case1 and Case 2

Table 4 : Deflection for Case1 , Case2 and case3

Outrigger Position	Deflection ,mm
0.25	119.4
0.33	115.6
0.5	113.4
0.75	112.1
1	114.1
bare frame	206.9



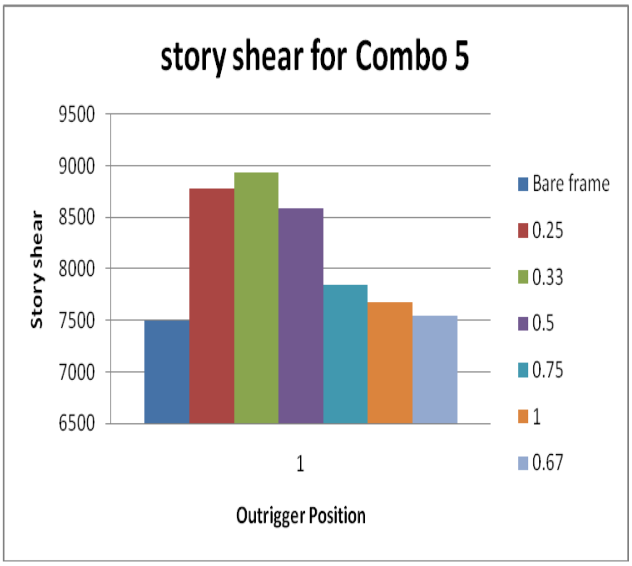
Graph 4 : Deflection for Case1, Case 2 and Case 3



Graph 5 : Drift for Case1, Case 2 and Case 3

Table 5: Story Shear for Case1, Case2 and Case3

Structure type		Base Shear (kN)
Bare frame		7501.437
Outrigger position	0.25	8780.646
	0.33	8936.549
	0.5	8585.365
	0.75	7840.687
	1	7671.84
	0.67	7541.178



Graph 6 : Story Shear for Case1, Case 2 and Case3

4. CONCLUSION

The most significant basic parameter monitored throughout the whole analysis process was drift and deflection of the building. The following fig 7 and fig 8 shows the variation of drift and deflection: It is observed that 29.8% and 36.9% of the deflection and drift is controlled by providing one position outrigger at 0.67 height compared to bare frame. 45.1% and 40% of the Deflection and drift is controlled by providing outrigger with belt truss at 0.67 and 0.5 when compared with bare frame. 13% and 14.64% of the deflection and drift is controlled by comparing first position outrigger system and second position of outrigger system of the building.

The following conclusions are made from the present study

1- The use of outrigger and belt truss system in high-rise buildings increase the stiffness and makes the structural form efficient under lateral load.
2- The maximum drift at the top of structure when only core is employed is around 206.9 mm and this is reduced by suitably selecting the lateral system. The placing of outrigger at 0.67 height is 130.4mm.
3- Using second outrigger with 0.67h gives the reduction of 16.64% and 13% for drift and deflection. The optimum location of second outrigger is middle height of the building.
4- It can be conclude that the optimum location of the outrigger is between 0.5 times its height.
5- For the second optimum position of outrigger base shear is significantly high compared to first optimum position and bare frame with shear wall.(fig 12) shear wall stress and axial load in the columns to the opposite side of the earthquake direction.

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BIOGRAPHIES

Mr Shivacharan K, Pursuing Final year Mtech in SJC institute of Technology Chickbalapur. Completed My Under Graduation In CBIT Kolar Under VTU.

Mrs. CHANDRAKALA S, Asst Prof, SJC Institute of Technology-Chickbalpur. Under Graduation under VTU. Post graduation (Structural Enginerring) at SJCIT Chickbalapur. She Had Very Wide Experience Over 6 years In Teaching Field.

Dr. NARYANA G, Professor and Head Of Department, Department of Civil Enginerring SJC Institute of Technology-chickballapur. He had very wide experience of Teaching and Research in the Field of Structural Engineering, also a Structure designed Consultant for many Projects.

N.M. KARTHIK, Asst Prof, CMR Institute of Technology-Bangalore. Worked as a lecturer for 2 years, as an assistant professor 2 years, experience in design field for a year, Guided 5 post graduation students, 24 under graduation students for their project and dissertation as Asst Prof with 2 journal publications.