DEFLECTION CONTROL OF HIGH RISE SYMMETRICAL FRAMED STRUCTURE USING BIRD CAGE INTERLOCKING STEEL FRAME

D. Hussain Basha[1], M. Mallikarjuna[2],

[1]Post-Graduate Student, [2]Associate Professor in Civil Engineering, S.V.R Engineering collage, Nandyal

ABSTRACT

Earthquakes are among the most deadly natural hazards. To overcome due to seismic and wind loads, providing birdcage like structure around the building which consists of steel sections (like I-sec, C-sec, & etc.) It protects the building by providing cage around the structure at elevation which prevents the structure from deflection or displacement of building due to wind and seismic loads. Some buildings have supporting steel frames that interlock called Birdcages. A shear walls are entirely responsible for the lateral load resistance of the building due to seismic and wind loadings. These shear walls act as vertical cantilevers in the form of separate planar walls

In present project 22 storied building analyzing with different wind speeds & earthquakes comparing with different soils(I,II,III) and earthquake zones(Z-2,Z-5).

An Educational package ETABS has been utilized for analyzing high-rise building of 66.5m height and for different zones The results of the analysis on the Deflection, Shear force, Bending moment are compared and found to become less for different models

KEYWORDS: *Birdcage Interlocking Steel frame, Shear Wall.*

1. INTRODUCTION:

A 22 storied building is introduced with Birdcage Interlocking steel frame and Shear wall is analyzing and designing with different wind speeds & earthquakes comparing with different soils(I,II,III) and earthquake zones(Z-2,Z-5). An Educational package ETABS has been utilized for analyzing high-rise building of 66.5m height and for different zones The results of the analysis on the Shear force, Bending moment are compared. The results are presented in tabular and graphical form. The results on the displacement are checked and are compared and presented in tabular form. Concluding remark has been made on the basis of this analysis & comparison tables.

2. SEISMIC RESISTIVE COMPONENTS:

2.1 Shear wall structures:

IS 13920 (1993) clause 9 [7] deals with the requirements and design of simple free standing shear walls. Adequate stiffness is to be ensured in high rise buildings for resistance to lateral loads induced by wind or seismic events. Reinforced concrete shear walls are designed for buildings located in seismic areas, because of their high bearing capacity, high ductility and rigidity.

2.2 Bird Cage Interlocking Frame:

It is Steel Frame which is provided around the Framed Structure to resist the structure from lateral loads, Earth Quake Loads & Wind load .A Steel Section of I, Channel Sections are used for the interlocking System. It Interlocks the Building against the lateral forces so it is named as Bird Cage Interlocking Frame.

3. Lateral loads:

3.1 Wind loading IS 875(Part 3 -1987): The basic wind speed (V_b) for any site shall be obtained from IS 875(Part 3 -1987) [4] it is 44 m/sec and shall be modified to include the following effects to get design wind velocity at any height (V_z) for the chosen the structure.

3.2 Earthquake loading [IS 1893 (PART 1) 2002]: It is a factor to obtain the design spectrum depending on (lie perceived maximum seismic risk characterized by Maximum considered Earthquake (MCE) in the zone in which the structure is located. The basic zone factors included in this standard are reasonable estimate of effective peak ground acceleration.

As per IS 1893(Part-I)-2002 the Zone factors that should be considered is

Seismic Zone	II	III	IV	V
Seismic intensity	Low	Moderate	severe	Very severe
Z	0.10	0.16	0.24	0.36

Z = Zone factor is determined from the following table
Zone factor given in the above table is for the Maximum Considered Earthquake (MCE) and service life of structure in a zone

4. NUMERICAL MODELING AND ANALYSIS

4.1 Geometrical Properties:

1.	Height of typical storey	=	3 m
2.	Height of ground storey	=	3.5 m
3.	Length of the building	=	40 m
4.	Width of the building	=	40m
5.	Span in both the direction	=	8 m
6.	Height of the building	=	66.5 m
7.	Number of stores	=	22
8.	Wall thickness	=	230 mm
9.	Slab Thickness	=	120 mm
10.	Grade of the concrete	=	M30
11.	Grade of the steel	=	Fe415
12.	Thickness of shear wall	=	230 mm
13.	Support	=	fixed
14.	Column sizes	=	0.9 m X0.9 m up to 9 story 0.75m X 0.9 m from 10th to 14th storey 0.45 m X 0.6 m from 15th to 18th storey 0.35 m X 0.45 m from 19th to 22nd storey
15.	Beam size	=	0.45 m X 0.5 m up to 9th storey 0.4 m X 0.45 m from 10th to 16th storey 0.35 m X 0.4m from 17th to 22nd storey

4.2 Loads:

- Live load from 1st floor to 22nd floor = 3 kN/m^2
- Dead load is taken as prescribe by the IS: 875 -1987 (Part-I) [3] Code of Practice Design Loads (other than earthquake) for Buildings and structure.

Unit weight of R.C.C.	=	25 kN/m^3
Unit weight of brick masonry	=	20 kN/m^3
Floor finish	=	1.5 kN/m^2
Water proofing	=	2 kN/m² on terrace roof
Wall load	=	13.8 kN/m on all floors expect terrace Roof
	=	6.9 kN/m on terrace roof

- Wind load

The basic wind speed (V_b) for any site shall be obtained from IS 875(Part 3 -1987) [4] it is 44 m/sec and shall be modified to include the following effects to get design wind velocity at any height (V_z) for the chosen the structure.

A) Wind Exposure parameters
  - i) Wind direction angle = 0 Degree
  - ii) Windward coff. Cp = 0.8
  - iii) Leeward coff Cp = 0.5

B) Wind coefficients
  - i) Wind speed = 44 m/s
  - ii) Terrain category = 2
  - iii) Structure class = B
  - iv) Risk coefficient (k1) = 1
  - v) Topography (k3) = 1

- Seismic loading

a. Zone factor (Z):Zone factors = 0.10 (Zone-II) and 0.36 (Zone-V) (from IS 1893 (Part-I)-2002, Table.- 2

b. Response reduction factor I: Response reduction factor = 5.0 (from IS 1893 (Part-1)-2002, Table-7. I

c. Importance factor (I): Importance factor (1) = 1 (from IS 1893-2002 (Part-I), Table-6).

d. Soil type: Soil site factor (1 for hard soil, 2 for medium soil, and 3 for soft soil) depending on type of soil average response acceleration coefficient Sa/g is calculated corresponding to 5% damping Refer Clause 6.4.5 of IS 1893-2002. In the present work three type of soil (i.e. Soil-1 , Soil-2 , Soil-3) are used.

4.3 Material properties:

1. Modulus of Elasticity: $E = 5000\sqrt{fck}$

Where =**Short term static modulus of elasticity in KN/m^2**

2. Poisson's Ratio: Poisson's ratio lies in the range of 0.15 to 0.20 when actually determined from strain measurement. For the present work Poisson's ratio is assumed as 0.2 for reinforced concrete.

4.4 LOAD COMBINATIONS:

The following Load are the load combinations that can be consider

Combination-I:

1. (DL+ LL)
2. (DL ± EQX)
3. (DL ± EQY)
4. (DL + LL ± EQX)
5. (DL + LL ± EQY)
6. (DL ± WLX)
7. (DL ± WLY)
8. (DL + LL ± WLX)
9. (DL + LL ± WLY

DL – Dead Load

LL – Live Load

EQ–Earthquake load

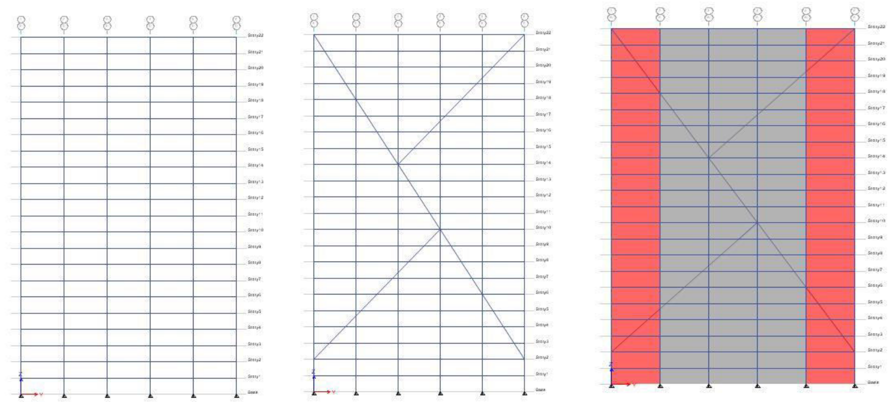
WL - Wind load

5. MODEL PLAN AND LAYOUT

Model 1: In this model building with 22 floors is modeled as a "'Rigid frame" with only, beams, columns & slabs as shown in Fig.5.1. The dead loads of other elements (slabs, stairs and walls) are taken as member loads on the respective beams. The wall load is considered as uniformly distributed load on beams. In this case the effect of rigid floor this model is taken into consideration.

Model 2: In this model building with 22 floors is modeled as Dual frame system with Bird Cage Interlocking Frame System Fig.5.1. The loads are taken same as in Model 1

Model 3: In this model building with 22 floors is modeled as Dual frame system with Bird Cage Interlocking Frame System & Shear wall placed in the edges of the building as shown in Fig.5.1. The loads are taken as same in Model 1.

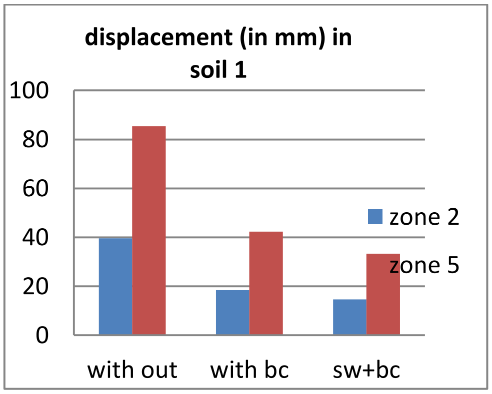


MODEL-1 MODEL-2 MODEL-3

6. RESULTS

6.1 Comparison of Displacement between Z-2 & Z-5 in three soils

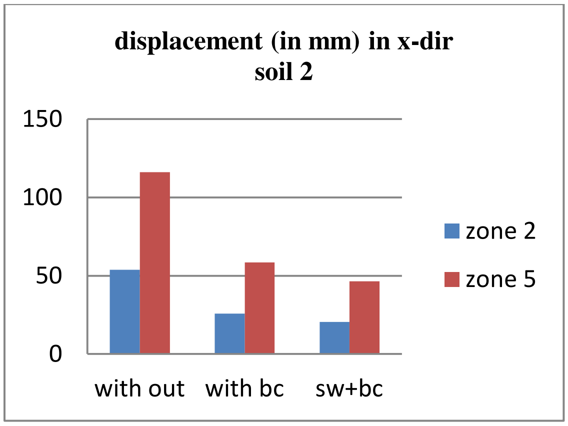
6.1.1Showing comparison values of displacement (in mm) in Z-2, Z-5 & S-1



soil 1	with out	with bc	sw+bc
zone 2	39.6	18.4	14.7
zone 5	85.4	42.3	33.4

GRAPH 6.1 Showing comparison values of displacement (in mm) in Z-2, Z-5 & S-1

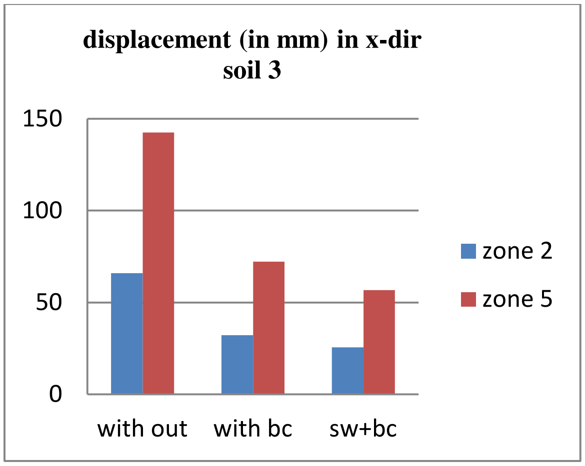
6.1.2Showing comparison values of displacement (in mm) in Z-2, Z-5 & S-2



soil 2	with out	with bc	sw+bc
zone 2	53.8	25.8	20.5
zone 5	116.1	58.4	46.5

GRAPH 6.2 Showing comparison values of displacement (in mm) in Z-2, Z-5 & S-2

6.1.3Showing comparison values of displacement (in mm) in Z-2, Z-5 & S-3

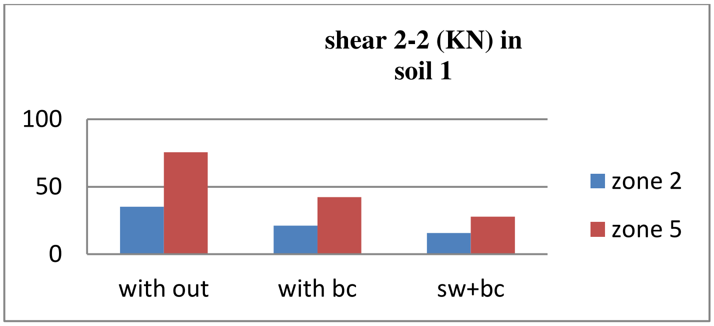


soil 3	with out	with bc	sw+bc
zone 2	66	32.2	25.5
zone 5	142.6	72.2	56.8

GRAPH 6.3 Showing comparison values of displacement (in mm) in Z-2, Z-5 & S-3

6.2 Comparison of Shear between Z-2 & Z-5 in three soils

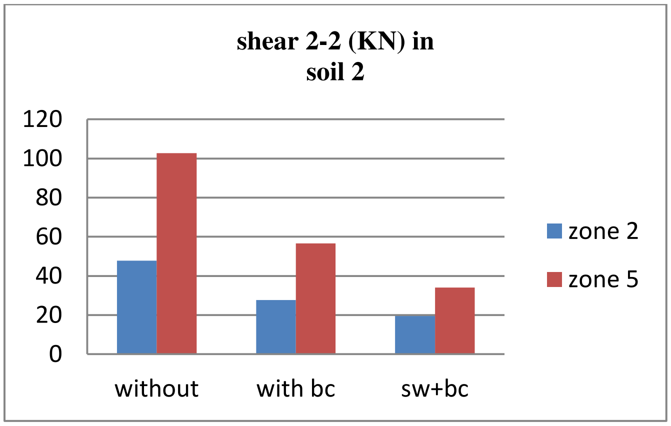
6.2.1 Showing comparison values of shear (in KN) in Z-2, Z-5 & S-1



soil 1	with out	with bc	sw+bc
zone 2	35.17	21.17	15.75
zone 5	75.6	42.35	27.92

GRAPH 6.4 Showing comparison values of shear (in KN) in Z-2, Z-5 & S-1

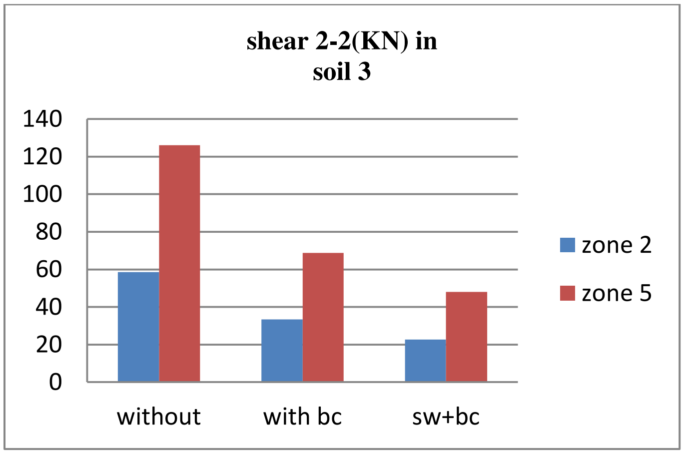
6.2.2 Showing comparison values of shear (in KN) in Z-2, Z-5 & S-2



soil 2	without	with bc	sw+bc
zone 2	47.72	27.74	19.53
zone 5	102.7	56.55	33.98

GRAPH 6.5 Showing comparison values of shear (in KN) in Z-2, Z-5 & S-2

6.2.3 Showing comparison values of shear (in KN) in Z-2, Z-5 & S-3

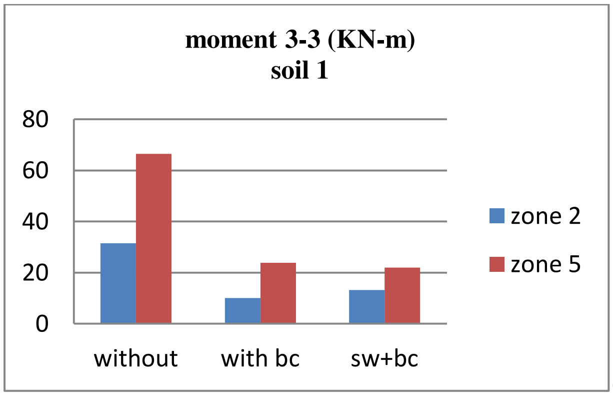


soil 3	without	with bc	sw+bc
zone 2	58.52	33.4	22.78
zone 5	126.04	68.78	48.1

GRAPH 6.6 Showing comparison values of shear (in KN) in Z-2, Z-5 & S-3

6.3Comparison of Moment between Z-2&Z-5 in three soils

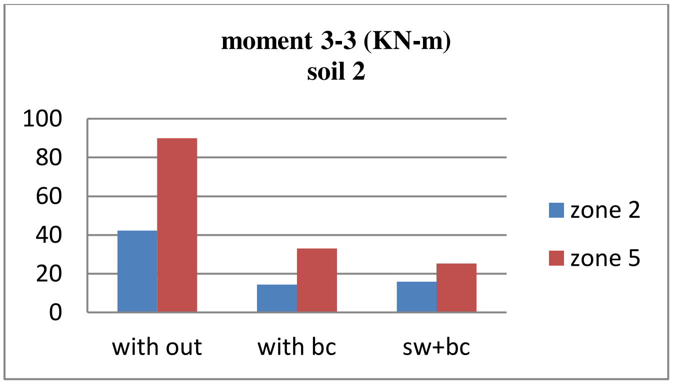
6.3.1 Showing comparison values of Moment (in KN-M) in Z-2, Z-5 & S-1



soil 1	without	with bc	sw+bc
zone 2	31.51	10.13	13.23
zone 5	66.52	23.88	21.98

GRAPH 6.7 Showing comparison values of Moment (in KN) in Z-2, Z-5 & S-1

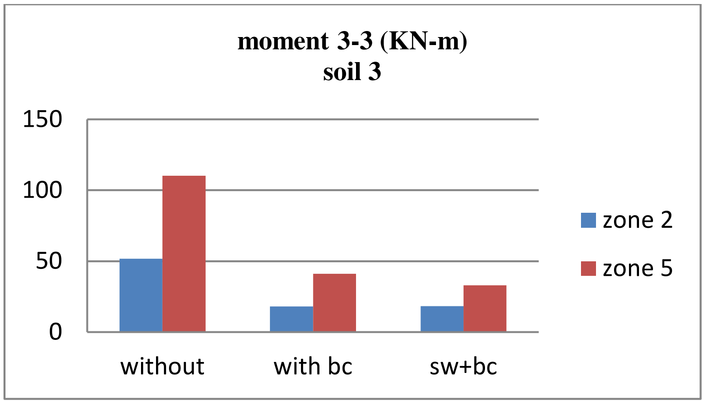
6.3.2 Showing comparison values of Moment (in KN-M) in Z-2, Z-5 & S-2



soil 2	with out	with bc	sw+bc
zone 2	42.37	14.4	15.94
zone 5	89.98	33.09	25.33

GRAPH 6.8 Showing comparison values of Moment (in KN) in Z-2, Z-5 & S-2

6.3.3 Showing comparison values of Moment (in KN-M) in Z-2, Z-5 & S-3



soil 3	without	with bc	sw+bc
zone 2	51.73	18.07	18.28
zone 5	110.19	41.04	32.9

GRAPH 6.9 Showing comparison values of Moment (in KN) in Z-2, Z-5 & S-3

7. CONCLUSION

1. In this project experimental study is carried out to control dynamic response of building model using Bird cage interlocking Frame and Shear wall. Response quantities like displacements are obtained and compared for three Models
2. It has been observed that maximum Storey displacement was decreased of about 40% by providing Bird Cage Interlocking Frame and decrease in 60% of story displacement by providing Birdcage Interlocking steel frame and Shear Wall, hence we observe there is a decrement in storey displacement.
3. It has been observed that maximum Storey Shear and Base Shear was decreased of about 50% and story moment about 50% was decreased by providing Bird Cage Interlocking Frame and shear wall as compared to normal building and Modeled building
4. It is observed by comparing for different seismic zones the response quantities like Displacement, Shear & Moment are lesser in Zone-II compare to Zone-V with any soil. It is observed by comparing different types of soils the response quantities are lesser in Soil-I type.

REFERENCES

[1]. IS: 456-code of practice for plain and reinforced concrete.
[2]. IS: 875(part 1-5) - code of practice for structural safety of Building loading standards
[3]. IS 1893(Part-1):2002, Criteria for earthquake resistant design of structures.
[4]. IS 13920:1993, Ductile detailing of reinforced concrete structure subjected to seismic forces- code of practice.
[5]. SP: 16-design aids for reinforced concrete
[6] Earthquake resistant design by pankaj agarwal.
[7] Rosinblueth and Holtz "Analysis of shear walls in tall buildings" (1960)
[8] Clough.R, King I.P and Wilson E.I-"Structural analysis of multi storied buildings" (1964)
[9] Khan, F.R. and Sbrounis, J.A, (7) „Introduction of shear wall with frames in concrete Sabrcounis structure under lateral loads (1964).
[10].www.iitk.ac.in/.../SeismicBehaviour_Design&DetailingofShearWalls-...
[11] Agarwal P. and M Shrikhande (2007), "Earthquake Resistant Design of Structures", Prentice Hall of India Pvt. Ltd., 2007, New Delhi.
[12] Stefano, M.D., and Pintucchi, B., june 2-5,2002, **"**A Model For Analyzing Inelastic Seismic Response Of Plan-Irregular Buiding Structures*"*, 15th ASCE engineering mechanics conference, Columbia University, New York, NY
[13] Aoyama, H.,2001, *Design of Modern High Rise Reinforced Concrete Structures,* Imperial College Press, London, UK
[14] Ashraf, M.,Siddiqi, Z.A.,andJaved, M.A. (2008)."Configuration of a multi-storey building subjected to lateral forces." Asian Journal of civil Engineering (Building and Housing), Vol. 9, No.5 Pages 525-537.
[15] Anshuman, S.,DipenduBhunia, BhavinRamjiyani (2011)," Solution of shear wall location in Multi-storey building." International Journal of civil and structural Engineering Vol. 2,No.2 Pages 493-506.
[16] ShrikhandeManish,AgrawalPankaj(2010)."Earthquake Resistant Design of Structures." PHI Learning Private Limited New Delhi.