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EFFECT OF STIFFNESS OF SHEAR WALL, STAIRCASE AND INFILL WALL IN REINFORCED CONCRETE FRAMED STRUCTURE SUBJECTED TO WIND LOAD USING STAAD.PRO

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Abstract: Due to excessive displacements of tall buildings occasioned by lateral loads, lateral load resisting systems are usually provided to curtail the load effect. The resistance may be offered by Frame Action, SHEAR Walls, or combined Walls and Frames (also known as Dual System). In this study, 3D structural modelling based software STAAD.Pro V8i was used to generate and analyze three-dimensional building models for the assessment of the relative effectiveness of the lateral load resisting systems under the effect of wind. Ten types of RC frames with and without Staircase and shear wall have been considered; a bare frame, a frame with external infill 230mm & internal infill 115mm thick, a frame with only external infill of 230mm thick, a frame with only external infill of 150mm thick and a frame with only external infill of 115mm thick. Number of storey has been G+30. Each building model was analyzed for the determination of the lateral displacements at storey top.
From the pilot study, it is concluded the consideration of stiffness of different elements (i.e., staircase, shear and infill walls) in the frame analysis shows significant variation in the lateral displacement.

1. INTRODUCTION
In general, as the height of a building increases, its overall response to lateral load (such as wind and earthquake) increases. When such response becomes sufficiently great such that the effect of lateral load must be explicitly taken into consideration in design, a multistory building is said to be tall. Tall buildings are prone to excessive displacements, necessitating the introduction of special measures to contain these displacements. The lateral load effects on buildings can be resisted by Frame action, Shear Walls, or Dual System. Peak inter-storey drift and lateral displacement (or side sway) are two essential parameters used for assessing the lateral stability and stiffness of lateral force resisting systems of tall buildings. Selection of such a strong and stiff enough deformation resisting systems that will curtail the drift within acceptable code limits should be the main motive of structural designers. As it is well known to most of structural engineers who are familiar with the types of structural systems for resisting wind and seismic loads, they are called Shear systems such as-

1.1 Frames:
This is a frame system of rigid beams subjected to lateral loads where the developed moments in the middle of the columns are not existent and the shear forces will be distributed proportionally with the moment of inertia of the columns and the lateral displacements will be proportional to these forces.

1.2 Shear walls:
These systems resist the lateral loads with the shear walls whether these walls are separated or connected by beams.
The distribution of shear forces is proportional to the moment of inertia of the cross sections of the walls; the displacements in each floor or level are the result of the flexural deformations in the walls.

1.3 Dual systems
These systems are the result of combining the two latter systems to resist the lateral load, in these systems the shape of the deformations will differ from those in frames and walls systems, where effecting interacted forces occur and change the shape of shear and moment diagrams. One of the advantages of this combination is that the frames support the walls at the top and control their displacement. Besides, the walls support the frames at the bottom and decrease their displacement.

2. LITERATURE RIEVIEW
J Lavado et al (2004) suggested that under seismic loading, the effect of staircase can be very important in structures, constituted by frames. Study on a three and six storied building with and without staircase has been carried out. Results show development of local rigidity effect, generating a “shear wall effect” in columns surrounding the stairwell, hence increasing

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axial stresses in surrounding column and beams also, effecting strength and ductility demands which are not taken into account if the stair slabs are not introduced into the structure.
E Cosenza et al (2008) investigated seismic performance of existing moment resisting RC frame building and suggested that the stair increases structural strength and stiffness of the structure resulting into reduction of fundamental time period, also, attracting seismic forces that could fail into short columns due to high shear forces. Further, the structural solutions and design practice of stair slabs in gravity load designed structures are analysed to define their real geometric definition and to understand their performance.
Zhang Wang et al (2009) studied dynamic performance of RC building with staircase and found that the existence of staircase greatly affects the lateral stiffness of frame, performance under seismic loads, the peak of internal force and node response spectrum under different earthquakes.
Jiao Ke et al (2009) reported that for frame structures, corner column in staircase, staircase beams, staircase column and the slab of the staircase are yielded first and damage indicating the weakest point in the structure.
Zhang Cuiqiang et al (2010) described that by decoupling the stiffness of the stair, the stair stiffness contributions at each node were reported. It was observed from their study that stair can change the order of the mode and the weakness direction of the structure.
Y Cheng et al (2011) analysed and discussed seismic behaviour of R.C. stairs and their influence on the lateral stiffness of masonry stair well. The results show K-type bracing function of step slabs to main structure, decreasing shear deformation in floor and shear forces in seismic walls. However, there is increase in internal forces of stairs.
J J Zhu et al (2011) discussed the active and hazard impacts of staircase on structures under earthquake. Comparison of overall properties, pushover performances, seismic response and internal force of elements are summarized and discussed between two models, with and without staircase. Suggestions on designing process are also given.

3. METHODOLOGY

3.1 Basic model specifications

Building Type	:	High rise RC frame
Floor area	:	60.10m x 19.23m
Storey Height	:	3m
No. of Stories	:	G+30

Modeling done for bare frame, frame with infill wall of various thicknesses and frame with staircase & core wall (with and without infill wall of various thicknesses) subjected to wind load.
Comparison made for Lateral displacements of frames with and without consideration of staircase &shear wall, having different thickness of infill walls.

3.2 Material Properties

The materials used for the study were Reinforced concrete with M-30 grade concrete and fe-415 grade reinforcing steel.The Stress-Strain relationship used as per IS 456:2000. The basic material properties used are as follows:

Modulus of Elasticity of steel, Es = 21,0000 MPa
Ultimate strain in bending, εCU =0.0035
Characteristic strength of concrete, FCK = 30 MPa
Yield stress for steel, FY = 415 MPa

3.3 Modelling of Structures

Ten types of RC frames with and without Staircase and shear wall have been considered; a bare frame, a frame with External & Internal infill of 230mm & 115mm thick, a frame with external infill of 230mm thick, a frame with external infill of 150mm thick and a frame with external infill of 115mm thick. Number of storey has been G+30. The overall plan dimension of RC frame structures is 60.10m x 19.23m. All the buildings are assumed to be fixed at ground level and storey heights are taken to be 3m. A solid RCC slab of 150mm thickness has been considered and all the members of the structure are assumed to be homogeneous isotropic and having elastic modulus same in compression as well as in tension, details are shown in Table.
Section details

MEMBER	SIZE (mm)
Plinth Beams	300 X 300
Floor & Roof Beams	300 X 450
Columns	300 X 1200
External Walls	230, 150 & 115
Internal Walls	115
Slab	150

Loads
Following loads used for analysis
Dead Load (IS 875 -part I)
Live Load (IS 875 – part II)
Wind Load (IS 875 –part III)

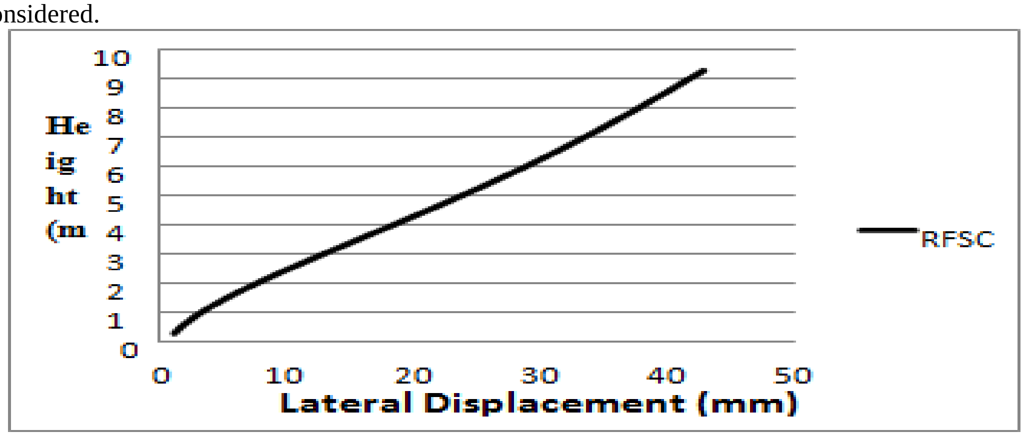
4. RESULTS AND DISCUSSION

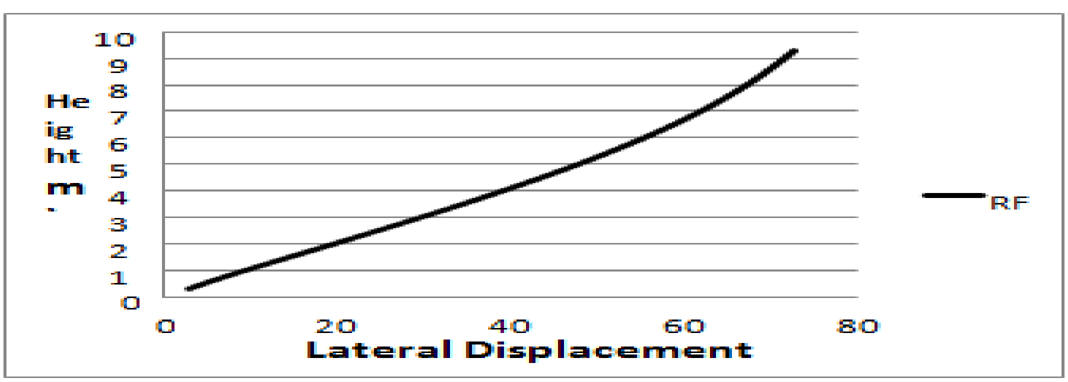
4.1 General Consideration

- Analyzed for G+30 storey structure with a 60.10m x 19.23m plan area.
- Ten types of RC space frames analyzed with and without Staircase and shear wall having different thickness of Infill walls.
- Considered under permanent vertical loads and Wind load (basic wind speed 50m/s).
- Lateral Displacements checked.

4.2 Case 1: Bare Frame

- The columns are of 300mm x 1200mm size, plinth beams are of 300mm x300mm, floor & roof beams are 300 x450mm and size150mm thick Slab is considered on the all floors & Roof.
- The loads acting on the structure are assigned. Here Self weight, live load, wall loads, slabs Loads and Wind loads are considered.



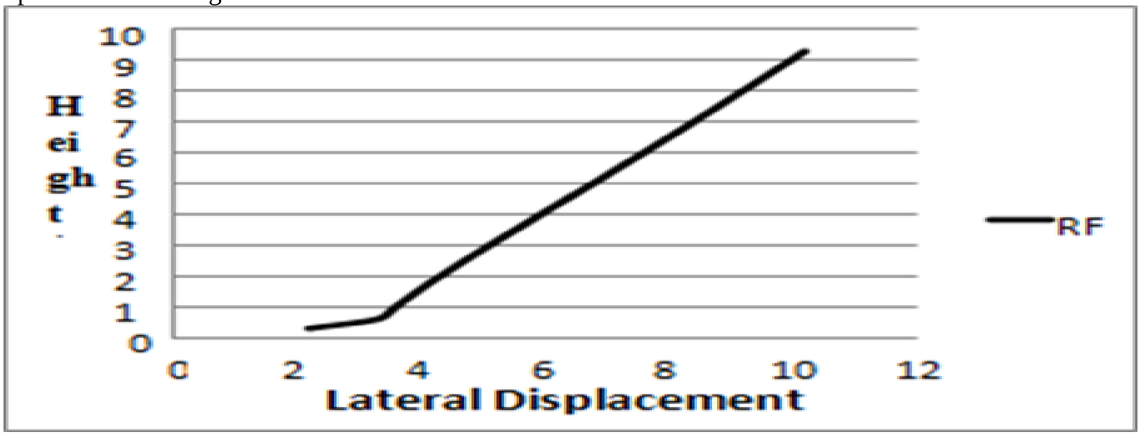


- Then the structure is analyzed for linear static analysis.

4.3 Case 2: Frame with External infill 230mm and internal infill 115mm

- The columns are of 300mm x 1200mm size, plinth beams are of 300mm x300mm, floor & roof beams are 300 x450mm and size150mm thick Slab is considered on the all floors & Roof.
- The External infill of 230mm and internal infill of 115mm thick are provided.
- The loads acting on the structure are assigned. Here self weight, live load, wall loads, slabs Loads and Wind loads are considered.
- Then the structure is analyzed for linear static analysis.

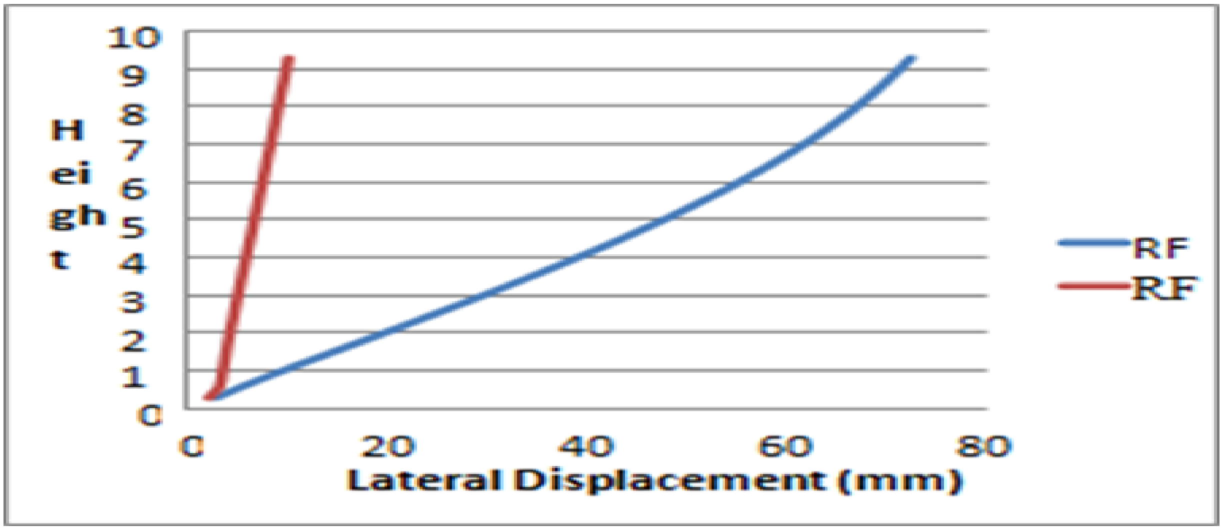
Lateral Displacement Vs Height for frame with External & Internal infill of 230mm & 115mm thick



Case 3: Frame with Staircase and Shear Wall

The columns are of 300mm x 1200mm size, plinth beams are of 300mm x300mm, floor & roof beams are 300 x450mm and size150mm thick Slab is considered on the all floors & Roof.
The Staircase 4.20m x3.29m and shearwall 230mm thick.
The loads acting on the structure are assigned. Here self weight, live load, wall loads, slabs Loads and Wind loads are considered.
Then the structure is analyzed for linear static analysis.
Comparison between (RF1) and Frame with Bare Frame External infill 230mm & Internal infill 115mm (RF2)

Type of Structure	Max. Lateral Displacement (mm)	Permissible Lateral Displacement (mm)	Percentage of Variation in Lateral Displacement ((RF1-RF2)/RF1))X100
Bare Frame (RF1)	726.714	186	86.45
Frame with external infill 230mm and internal infill 115mm (RF2)	101.197	186	



5. CONCLUSION

The lateral displacement of R.C framed structure with and without considering Staircase, shear wall & infill walls was investigated using the linear static analysis. Following were the major conclusions drawn from the study.

The lateral displacement in Bare frame (RF1) is the greatest among the ten lateral load resisting systems investigated.

In all the options the values of story lateral displacements are within the permissible limits as per code limits except Bare Frame (RF1) and Frame with staircase &shearwall (RFSC1). However, it is observed that there was a considerable variation in the lateral displacement of frame with staircase & core wall while compared with bare frame.

There is a reduction in percentage of variation in later displacement of 86.45% at top storey (i.e., 93m level), when compared to bare frame (RF1) to frame with staircase, shear wall and external infill 230mm (RFSC3).

It is concluded, consideration of stiffness of different elements (i.e., staircase, shear and infill walls) in the frame analysis shows significant variation in the lateral displacement.

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