International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

# Comparison of Low-Rise Open Ground Storey Framed Building in Different Earthquake Zone

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ABSTRACT

The current research is focused on framed buildings (G+3) with an open ground floor in seismic zones II, III, IV, and V. The main goal of this project is to use STAAD PRO to analyze a low-rise (G+3 storied) structure (3-D frame). The presence of infill walls in the frames affects the building's lateral load behavior. However, it is standard industrial practice to disregard the stiffness of the infill wall when analyzing a framed structure. Engineers feel that analyzing a structure without taking into account infill stiffness results in a cautious design. However, this is not always the case, particularly in the case of vertically uneven buildings with discontinuous infill walls. The Indian Standard IS 1893: 2002 provides for the study of open ground storey buildings (OGS) without taking infill stiffness into account, but with a multiplication factor of 2.5 to account for the stiffness discontinuity. According to the rule, the open ground storey (OGS) column and beams must be constructed for 2.5 times the storey shears and moments estimated under bare frame seismic loads (i.e., without considering the infill stiffness). However, as engineers in design offices have discovered, a multiplication factor of 2.5 is unrealistic for low-rise buildings. The seismic response of the structures is explored in this study under earthquake excitation in terms of member force and joint displacement. Using the STAAD PRO. design program, this reaction is examined for the G+3 building structure.

Key Words: open ground storey (OGS), STAAD.Pro, seismic analysis, low rise building.

## INTRODUCTION

Car parking space for residential units in crowded cities has been a serious challenge in recent years as the population has grown. As a result, the trend has been to use the ground floor of the structure for parking. Open Ground Floor (OGS) structures are those that have no infill masonry walls in the ground storey but are infilled in all upper storeys. They're also known as 'first-floor open buildings.'

These structures have major functional advantages, but they are regarded to be more vulnerable in terms of seismic performance. The principal types of failure that occurred in OGS buildings during previous earthquakes included cracking of lateral ties, crushing of core concrete, buckling of longitudinal reinforcement bars, and so on. The higher storeys are substantially stiffer than the open ground levels due to the existence of infill walls in the entire upper storey except for the ground storey.

As a result, the upper storeys move almost as a single block, while the soft ground story accounts for the majority of the building's horizontal displacement. As a result, the ground floor columns must be sufficiently strong and ductile. The dramatic decreasing of lateral stiffness and strength in the ground level, compared to upper storeys with infill wall, is linked to the fragility of this form of building.

When infill walls are included in the OGS building frame, the fundamental time period is reduced compared to a bare frame, which raises the base shear demand and design forces in the ground floor beams and columns. The typical bare frame analysis does not account for the additional design forces in the ground floor beams and columns of the OGS buildings. Modeling the strength and stiffness of infill walls is an appropriate technique to analyze the OGS buildings. Unfortunately, there are no modeling standards in IS 1893: 2002 (Part-1) for infill walls.

A bare frame analysis, which ignores the strength and stiffness of the infill walls, is sometimes employed as an alternative. "The soft storey columns and beams must be designed for 2.5 times the storey shears and moments computed under seismic loads of bare frames," says Clause 7.10.3(a). As a multiplication factor, the factor 2.5 can be expressed (MF). The stiffness discontinuity is expected to be compensated for by this multiplication factor (MF). Multiplication factors are also recommended for this type of structure in other national codes. As a result, the purpose of this thesis is to examine the applicability of the 2.5 multiplication factor in ground storey beams and columns when the building is designed as an open ground storey framed building, as well as to investigate the impact of infill strength and stiffness in the seismic analysis of low rise open ground storey buildings.

## AIMS AND OBJECTIVE OF MY WORK

1. To study the effect of infill strength and stiffness in the seismic analysis of OGS buildings.
2. Comparison of low- rise open ground storey framed building in different earthquake zones with the help of STAAD.Pro V8i Software.

## METHODOLOGY

The methodology worked out to achieve the above-mentioned objectives is as follows:

1. Review the existing literature and Indian design code provision for designing the OGS building.
2. Select an existing building model for the case study.
3. The analysis is being done in zone II, III, IV, V.
4. Preparing of model of G+3 residential building in 'STAAD.Pro'.
5. The static analysis and seismic analysis of the building is carried out in STAAD.Pro and the results obtained are compared.
6. Observations of results and discussions.

## REVIEW OF LITERATURE

The frame and the infill wall initially remain intact when subjected to lateral pressure. At the unloaded (tension) corner, the infill wall separates from the surrounding frame as the lateral load increases, but the infill walls remain intact at the compression corners. The length of contact refers to the distance between the infill wall and the frame. The load is transferred via an imaginary diagonal that acts as a compression strut. Infill walls can be treated as an analogous diagonal strut linking the two compressive corners diagonally due to their behavior. The stiffness property of the strut should be such that it is only active when compressed.

Mallick and Severn (1967) used finite element analysis to study the influence of slip and interface friction between the frame and the infill wall. Linear elastic rectangular finite elements with two degrees of freedom at each of the four corner nodes were used to model the infill panels. The contact length between the frame and the infill was calculated after modeling the interface. The slip between the frame and the infill was taken into consideration by employing a link element to consider frictional shear forces in the contact zone. This element's nodes each have two translational degrees of freedom. The element is capable of transferring compressive and bonding forces but not tensile forces.

Choubey and Sinha (1994) evaluated the influence of several parameters on infilled frames under cyclic loading, including separation of infill wall from frame, plastic deformation, stiffness, and energy dissipation. Arlekar et al. investigated the behavior of RC-framed OGS buildings when subjected to seismic loads (1997). Equivalent Static Analysis and Response Spectrum Analysis were used to determine the forces and displacements of a four-story OGS building. This research demonstrates that the OGS frame behaves differently from the bare frame.

Scarlet (1997) looked into the qualification of seismic forces in OGS structures. For OGS building, a multiplication factor for base shear was proposed. The stiffness of the infill walls must be modeled in the analysis for this technique to work. As the number of storeys increases from six to twenty, this study offered a multiplication factor ranging from 1.8 to 3.28.

Even though the brick masonry in an infilled frame is intended to be non-structural, Deodhar and Patel (1998) pointed out that it might have a significant impact on the building's lateral response.

According to Davis and Menon (2004), the addition of masonry infill panels dramatically alters the structural load distribution in an OGS building. In the presence of masonry infill at the upper floor of the building, the total storey shear force increases as the stiffness of the building increases. In addition, the bending moments in the ground-floor columns increase (by more than two times), and the failure mode is a soft storey mechanism (formation of hinges in ground floor columns).

When infill walls are included in a structure, Das and Murthy (2004) found that the damage incurred by the RC framed members of a fully infilled frame during earthquake shaking is generally reduced. Lower-story columns, beams, and infill walls are more sensitive to damage than upper-story columns, beams, and infill walls.

Asokan (2006) investigated how the presence of masonry infill walls in a building's frames affects the structure's lateral stiffness and strength. This study presented a plastic hinge model for infill walls for use in nonlinear performance-based building analysis, concluding that the ultimate load (UL) technique, along with the proposed hinge feature, gives a superior approximation of the building's inelastic drift.

Hashmi and Madan (2008) studied OGS buildings using non-linear time history and pushover analysis. According to the findings, the MF recommended by IS 1893 (2002) for such structures is adequate for preventing collapse.

Despite the wall's brittle failure modes, Sattar and Abbie (2010) determined that the pushover analysis revealed a gain in initial stiffness, strength, and energy dissipation of the infilled frame compared to the bare frame. Similarly, the results of dynamic analysis show that fully-infilled frames have the lowest risk of collapse, whereas naked frames are the most sensitive to earthquake-induced collapse. The superior collapse performance of fully-infilled frames was linked to the system's increased strength and energy absorption, as well as the addition of walls.

Numerous research efforts on the seismic behavior of OGS buildings and modeling infill walls for linear and nonlinear analysis can be found. However, there was no published material on the IS 1893:2002 (Part-1) design criterion for OGS low-rise buildings. This is the primary motivation for the current research.

## STRUCTURAL MODELLING

The development of a computational model on which analysis is performed is critical. STAAD.Pro V8i software has been considered as a tool to perform in this regard. As a result, we'll go over the parameters that define the computational models, as well as the basic assumptions and geometry of the chosen building for this study. The modeling of RC building frames is discussed in great detail.
For this study, an OGS-framed building in India (Seismic Zones II, III, IV, and V) was chosen. In terms of plan and elevation, the structure is fairly symmetrical.

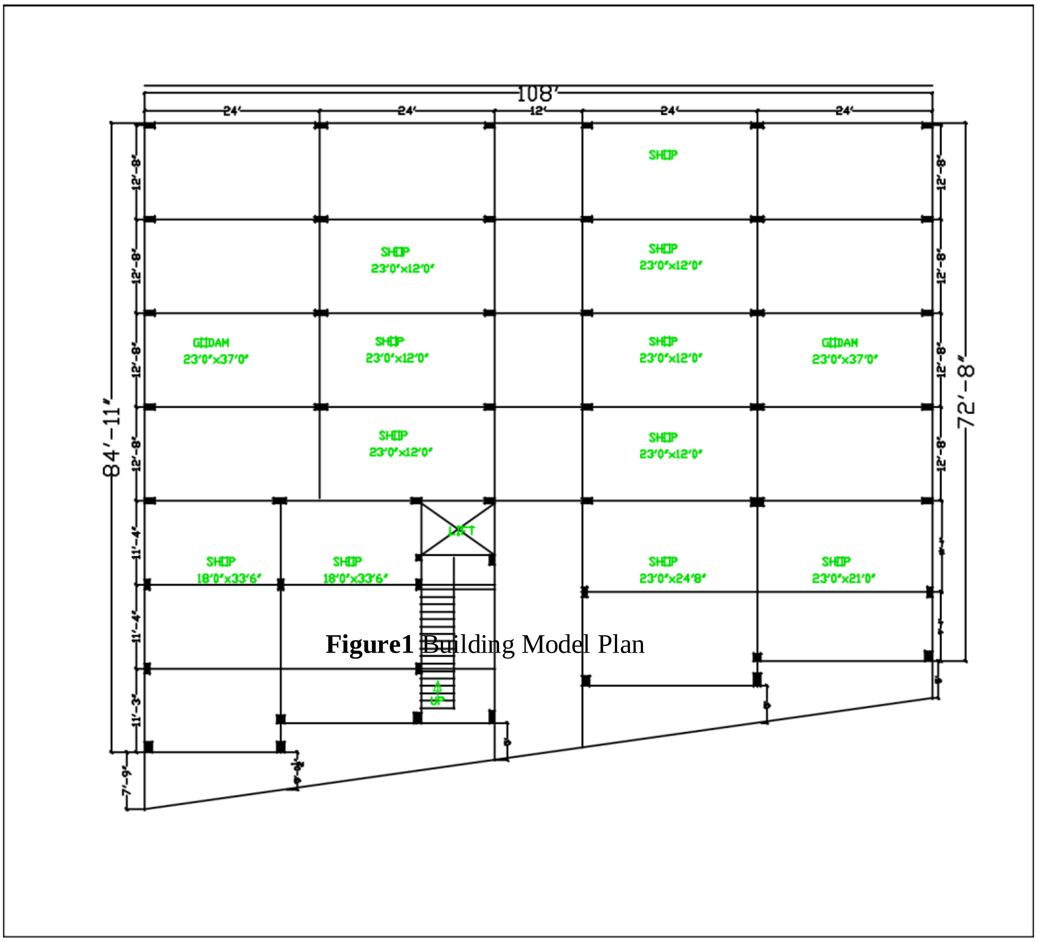


**Figure1** Building Model Plan

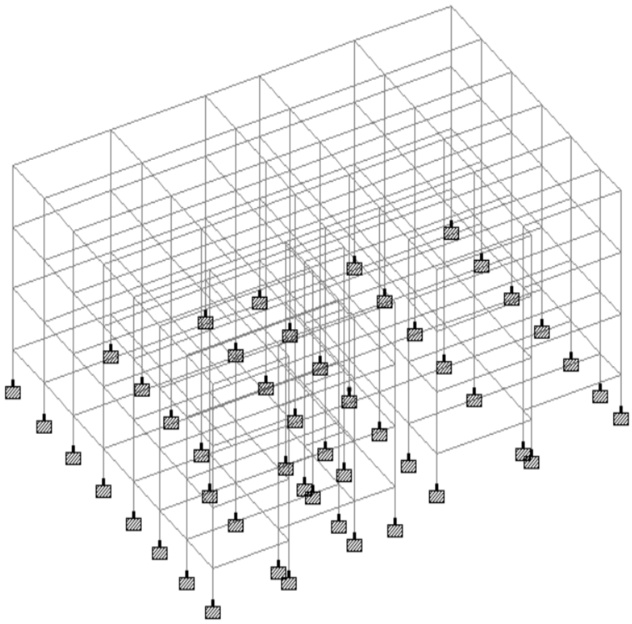

**Figure2** STAAD. Pro Model

**Building Description**
Number of Storey = G+3
Beam size = 300 x 600, 300 x 400 (cover = 25 mm)
Column size = 200 x 400 , 200 x 500 , 300 x 500 ,400 x 200 , 200 x 200 , 400 x 300 , 500 x 300 (cover = 40 mm )
Concrete grade = M25
Steel = Fe415

**Earthquake parameters**
Seismic zone = II, III, IV, V
Response Reduction factor = 5
Importance Factor = 1
Type of soil = Medium soil
Damping of structure = 0.05
Passion ratio = 0.2
Density = 23.5616
Reinforcement factor= 4
Earthquake load = As per IS: 1893 (part1)

## RESULTS

Step – 1: Creation of nodal points. In view of the columns situating of plan we entered the node points into the STAAD file.

Step – 2: Assigning the property of beams and columns. Fix the dimension and apply to direction in X, Y or Z.

Step – 3: Assign the support which is fixed and then go to seismic definitions (IS1893 Part 1:2002) and punch the value we had taken out above in particular section respectively in +X, -X, +Z, -Z directions.

Step – 4: Apply types of weight i.e. self-weight, floor weight etc. Take the value we have taken out by calculation done above. Figure 3 & 4 shows the structure after dead load and live load is applied.

Step – 5: Adding all the load mixes. After that, the load combinations are given with suitable factor of safety as per IS 875 Part 5.

Step – 6: Then, analysis after the completion of all the above advances we have played out the examination and checked for errors using run analysis command.

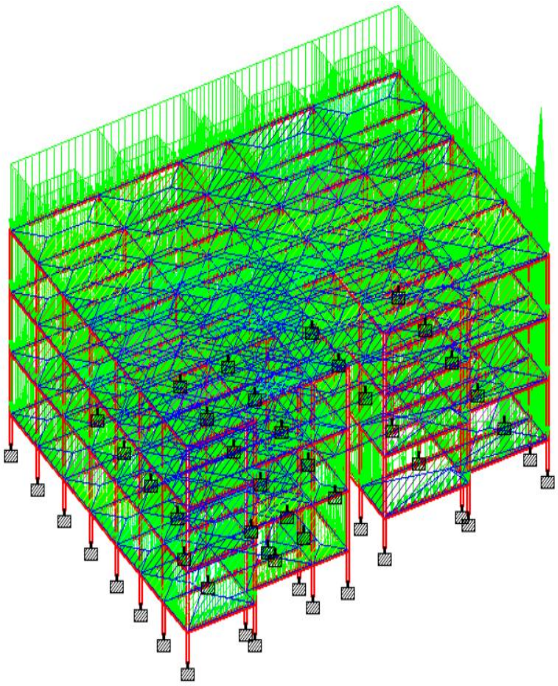

**Figure3 When Dead Load is applied**

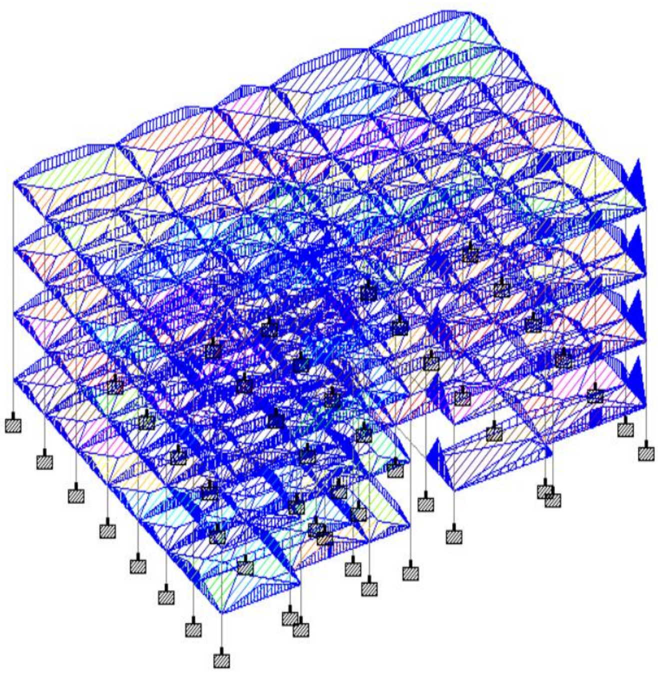

**Figure4** When Live Load is applied

**Table1 Nodal Displacement**

| | Node | L/C | Horizontal X mm | Vertical Y mm | Horizontal Z mm | Resultant Mm | Rotational rX rad | Rotational rY rad | Rotational rZ rad |
|---|---|---|---|---|---|---|---|---|---|
| Max X | 187 | 1X | 7.754 | 0.028 | 0.526 | 7.772 | 0.000 | -0.000 | -0.000 |
| Min X | 198 | 3DL | -3.624 | -1.687 | -2.179 | 4.553 | -0.001 | -0.000 | 0.003 |
| Max Y | 147 | 2Z | -0.032 | 0.283 | 9.193 | 9.198 | 0.000 | -0.000 | -0.000 |
| Min Y | 185 | 3DL | -0.631 | -5.789 | -1.579 | 6.033 | 0.001 | -0.000 | -0.000 |
| Max Z | 157 | 2Z | 0.216 | 0.068 | 12.254 | 12.257 | 0.000 | -0.000 | -0.000 |
| Min Z | 200 | 3DL | -3.208 | -1.561 | -2.364 | 4.279 | -0.001 | 0.000 | 0.001 |
| Max rX | 155 | 3DL | -0.O89 | -2.722 | -1.761 | 3.243 | 0.001 | 0.000 | 0.000 |
| Min rX | 189 | 3DL | -1.264 | -3.762 | -1.615 | 4.285 | -0.002 | 0.000 | -0.001 |
| Max rY | 200 | 3DL | -3.208 | -1.561 | -2.364 | 4.279 | -0.001 | 0.000 | 0.001 |
| Min rY | 196 | 3DL | -2.032 | -3.782 | -2.166 | 4.809 | -0.000 | -0.000 | 0.011 |
| Max rZ | 196 | 3DL | -2.032 | -3.782 | -2.166 | 4.809 | -0.000 | -0.000 | 0.011 |
| Min rZ | 195 | 3DL | -1.845 | -3.736 | -2.062 | 4.649 | -0.000 | -0.000 | -0.011 |
| Max Rst | 157 | 2Z | 0.216 | 0.068 | 12.254 | 12.257 | 0.000 | -0.000 | -0.000 |

**Table2 Nodal Reactions**

| | Node | L/C | Horizontal Fx KN | Vertical Fy KN | Horizontal Fz KN | Moment Mx KNm | Moment My KNm | Moment Mz KNm |
|---|---|---|---|---|---|---|---|---|
| Max Fx | 245 | 3DL | 77.365 | 896.339 | 4.783 | 3.490 | 0.039 | -46.489 |
| Min Fx | 246 | 3DL | -74.899 | 911.526 | -2.008 | -0.589 | 0.193 | 44.351 |
| Max Fy | 230 | 3DL | 20.465 | 1440.716 | 14.888 | 8.487 | 0.405 | -12.923 |
| Min Fy | 247 | 2Z | 0.132 | -61.313 | -3.836 | -3.505 | 0.001 | -0.088 |
| Max Fz | 243 | 3DL | -1.877 | 504.988 | 17.238 | 10.716 | 0.017 | 0.978 |
| Min Fz | 251 | 3DL | 1.476 | 356.146 | -24.330 | -12.188 | -0.082 | -1.960 |
| Max Mx | 243 | 3DL | -1.877 | 504.988 | 17.238 | 10.716 | 0.017 | 0.978 |
| Min Mx | 250 | 2Z | 0.293 | 94.038 | -16.484 | -37.334 | 0.059 | -0.280 |
| Max My | 248 | 3DL | -42.915 | 606.696 | -9.889 | -4.759 | 0.564 | 21.039 |
| Min My | 250 | 3DL | -17.688 | 645.703 | -13.305 | -7.727 | -1.475 | 7.768 |
| Max Mz | 246 | 3DL | -74.899 | 911.526 | -2.008 | -0.589 | 0.193 | 44.351 |
| Min Mz | 245 | 3DL | 77.365 | 896.339 | 4.783 | 3.490 | 0.039 | -46.489 |

The underlying arrangement in the aggregate Lagrangian definition in horizontal and vertical dimensions, as well as the last met setup in the refreshed Lagrangian plan, are used to refer to nodal displacements in the X, Y, and Z directions in the above table. This research also presents a relative nodal migration technique for dealing with the position and introduction of nodes in framed systems. Because the presented methodologies quantify relative nodal relocations in relation to an adjacent nodal reference outline, they are nevertheless insignificant for a framed structure suffering massive damage due to small size components. As a result, component details created under the suspicion of minor distortions are still significant for structures undergoing massive disfigurations, which completely disentangle the conditions of harmony. A diagram is used to speak to a basic framework in order to build up the overseeing conditions of harmony for general frameworks. In the table above, two computational successions are described. The forward way grouping, for example, is used to recover Cartesian nodal removals from relative nodal uprooting and travel a chart from the node hub to the terminal hubs. The other is regressive manner succession, which is used to recover nodal powers in the relative facilitation framework from known nodal controls in obviously the mastermind structure and crosses from the terminal hub to the base hubs.'

## CONCLUSIONS

The research paper enables to consolidate the knowledge of analysis and design of structure during seismic effects. The building is more practically analysed over STAAD.Pro software which is nowadays a helpful tool in the analysis of frame for various loading condition. In the paper, design and detailing of all require element of building were calculated manually and values were kept in required field in the software.

Detailed structural design of building is important aspect of construction procedure. Practically an engineer employed must have knowledge on designs, construction procedures, site study etc. The work was only related with the practical application of the studied courses in the field. Finally, I hope that efforts and coordination for the work will prove much useful in our career it will be helpful in providing information on the earthquake resistant design and its safe practice.

Comparison of design manually and STAAD.Pro. Manually design is time taking procedure but STAAD. Pro design is least time taking procedure. Analysis of each and every column and beam if it much easier in STAAD.Pro. Design of each structure member if a click away. You can click over design with multiple standards. STAAD.Pro is fast procedure comparison of manually procedure. Reinforcement steel change in different zones.

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