# Seismic Analysis of Multistory Building by Using the IS 1893:2016 of Having Mass Irregularity

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**Abstract -** *Underlying structural engineer's most noteworthy test in the present situation is developing seismic safe structure. Vulnerabilities included and conduct reads are fundamental for all respectful designing constructions. The presence of vertical irregular structure subject to obliterating earthquake is matter of concern. The current paper endeavors to examine the corresponding dispersion of lateral force developed through seismic activity in every story level because of changes in mass of frame on vertically irregularity outline. According to the Agency of Indian Norm (IS) 1893:2016 (part1) arrangements, a G+20 vertically irregular structure is demonstrated as a streamlined knot mass model for the examination with mass abnormalities at 7th, 14th and 21th story. To reaction boundaries like story drift, story deflection and story shear of construction under seismic power under the linear static and dynamic examination is contemplated. This examination shows centers around the base shear conveying limit of a design also, execution level of design under sever zone of India. The outcome comments the end that, a structure with mass irregularity gives unsteadiness and pulls in tremendous story shear. A proportionate measure of mass is beneficial to authority over the story and base shear. The delicate registering instrument and business programming CSI-ETABS 2018 is utilized for demonstrating and examination.*

***Key Words:*** **Rcc, Base Shear, Composite Column, I.S 1893:2016 (Part1) Provisions, Analysis, Mass Irregularities, Structural Irregularities, Response Spectrum, Base Shear, Storey Displacement, Storey Drift, Vertical Irregularities, Etabs.**

## 1. INTRODUCTION

Generally, a few significant earthquakes have uncovered the inadequacies in structures, which prompt harm or breakdown. It has been discovered that normal formed structures perform better during quakes. The primary anomalies cause non-uniform burden dispersion in different individuals from a structure. There should be a persistent way for these inertial powers to be conveyed starting from the earliest stage the structure weight areas. A hole in this transmission way brings about disappointment of the design at that area. There have been several studies on irregularities

In the present paper, reaction of a G+ 20-storeyed vertically unpredictable frame to horizontal loads (lateral loads) is read for mass abnormality at various floor for example at seventh, fourteenth and 21th floor in the height. These irregularities are presented by changing the properties of the individuals from the story viable looking after aspect proportion for vertically irregularities casing indicated in I.S 1893:2016 (part1) rules. Mass irregularities remember substantial burdens for seventh, fourteenth and 21th floor which is applied on vertically irregular frame. Impacts on story-shear force, story drift and deflection of beams are considered.

## 2. STRUCTURAL IRREGULARITIES

There are different sorts of irregularities in the structures relying on their area and degree, however for the most part, they are isolated into two gatherings plan irregularities and vertical irregularities. In the Examination, the vertical irregularities are viewed as which are portrayed as follows.

Types of irregularities:

1. Vertical stiffness irregularity
2. Weight (mass) irregularities
3. Vertical geometric irregularities
4. In-plane discontinuity
5. Out-of-plane offsets
6. Discontinuity in capacity (weak storey)
7. Torsion sensitivity
8. Non-orthogonal systems

When:

$$I_E \cdot F_a \cdot S_a(0.2) > 0.35$$

(i.e., 2.4 times Calgary value when $I_E$ and $F_a$ are unity) + Any one of the 8 irregularity types.

The building is considered as irregular.

### 2.1. Irregularity Type and Definition Notes

#### 2.1.1 Vertical Stiffness Irregularity:

This is considered to exist when the lateral stiffness of the SFRS in a storey is less than 70% of any adjacent storey, or less than 80% of the corresponding average stiffness of the three storeys above or below. One-storey penthouses need not be considered.

#### 2.1.2 Weight (mass) Irregularity:

Mass irregularities are considered to exist where the compelling mass of any story is over 150% of viable mass of a neighboring story. The compelling mass is the genuine mass comprising of the dead weight of the floor in addition to the genuine load of partition and equipment. Abundance mass can prompt expansion in parallel inertial powers, diminished flexibility of vertical burden opposing components, and increased tendency towards breakdown because of P-Δ impact. Irregularities of mass conveyance in vertical and even planes can result in irregular response and complex dynamics. The central force of gravity is moved over the base if there should arise an occurrence of substantial masses in upper floors bringing about enormous twisting moments.

#### 2.1.3 Vertical Geometric Irregularity:

Vertical geometric irregularity shall be considered to exist where the horizontal dimension of the SFRS in any storey is more than 130 percent of that in an adjacent storey. One-storey penthouses need not be considered.

## 3. PROBLEM FORMULATION

The issue considered for the current examination is taken regarding IS 1893-(part1): 2016 and work done by Valmundsson and Nau, 1997 [3]. This G+20 vertically irregular frame is considered with mass inconsistency. Two frames including the base frame is referred. Two casings have been broke down utilizing identical static technique for IS 1893-(section 1): 2016 accepting starter information as area of design in seismic zone V, with soil type medium soil , viable damping 5% and importance factor 1. Investigation has been done utilizing ETABS 2018 program. Setup of edges is as given underneath and regular format is appeared in figure 1.

### 3.1. Frame 1

This is the base model frame of structure with geometrically vertical irregularities and having twenty bays and G+ 20 storeys, with a storey height of 3.0 m for ground floor and 3.0 m for remaining floor and the bay width of 2.5m. The basic specifications of the building are: Dimensions of the beam = 0.3 m × 0.5 m; Column size = 0.50 m × 0.30 m; Beam length = 2.5 m; Column length = 3.0 m; Load combinations as per clause 6.3.1.2 of IS 1893:2016 (Part-1) are;

a) 1.5 (DL+ LL),

b) 1.2 (DL + LL ± EQL),

c) 1.5 (DL ± EQL),

d) 0.9 DL ± 1.5 EQL

### 3.2. Frame 2

This is the base model frame of structure with geometrically vertical irregularities and having twenty bays and G+ 20 storeys, with a storey height of 3.0 m for ground floor and 3.0 m for remaining floor and the bay width of 2.5m. The basic specifications of the building are: Dimensions of the beam = ISMB250; Column size = 0.50 m × 0.30 m with ISMB500; Beam length = 2.5 m; Column length = 3.0 m;

This frame consists of heavier loading on the $7^{th}$, $14^{th}$ and $21^{th}$ story and the building becomes irregular. It has 20 bays and twenty storeys. The base model having the shape irregular to know the effect of mass irregularity on the shape (vertical geometric) irregular building the excess mass is applied on the $7^{th}$, $14^{th}$ and $21^{th}$ story as per the IS 1893:2016 (part-1). The structural data is same except of the following with respect to the base model.

The respective change is incorporated on the $7^{th}$, $14^{th}$ and $21^{th}$ storey. In reference to this condition following structural & seismic data for modeling the plan, elevation & 3-D view of the base model is included as shown in table 1.

**Table -1:** Details of base model (All dimensions are in mm)

| Specification | Details |
|---|---|
| 1 Type of structure | Composite Structure (Beam and column are composite in nature) |
| 2 Seismic zone | V |
| 3 Zone Factor | 0.36 |
| 4 Importance factor | 1.00 |
| 5 Response spectra | As per IS 1893 (part 1):2002 |
| 6 Type of soil | Medium soil |
| 7 Number of storey | G+20 |
| 8 Dimension of building | 17 m x 17 m |
| 9 Floor Height (Typical) | 3.0 m |
| 10 Base floor height | 3.0 m |

| | |
|---|---|
| 11 Infill wall | 230 mm thick wall |
| 12 Impose load | 5 KN/m2 |
| 13 Materials | Concrete (M40) and Reinforcement (Fe500) |
| 14 Specific weight of infill | 20 KN/m3 |
| 15 Size of Column | 500 mm × 300 mm with ISMB500 |
| 16 Size of Beam | ISMB250 |
| 17 Depth of slab | 200 mm |
| 18 Specific weight of RCC | 25 KN/m3 |

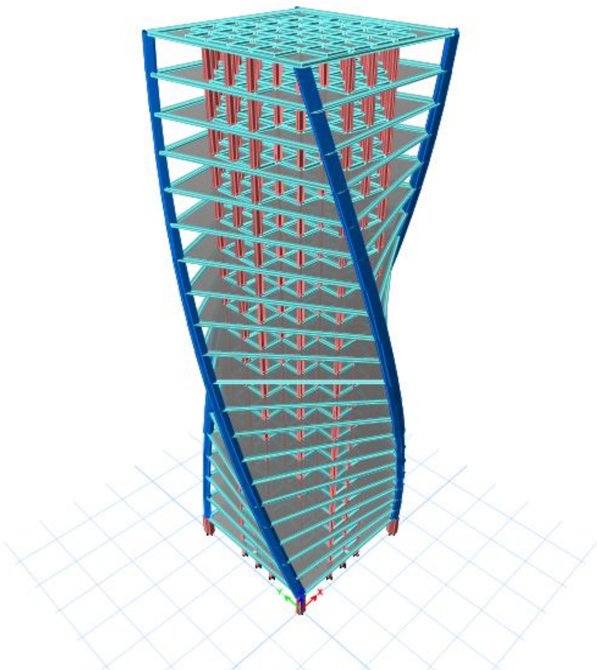


**Fig -1** Base Model (Frame-1) showing 3-D view

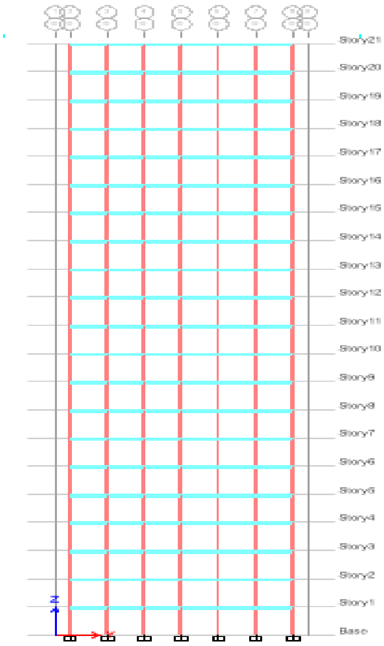


**Fig -2** Frame-2, 3-D view Mass Irregularity at 7th, 14th & 21thfloor

**4. ANALYSIS RESULTS**

Two frames have been examined and reactions like parallel lateral storey-displacements, storey drifts and base shears have been processed to consider the impacts of mass irregularity on the vertically irregular frame. The results are introduced and examined here after. Table-3 shows displacement of storeys of various frames in X-direction (even) graphically introduced in figure 2.

It tends to be seen that from table-3, the frame-2 gets somewhat displaced the more since the lateral stiffness concerning frame-1 and the last two stories is very not exactly different stories. Whereas its being least being in the base frame. Commonplace avoided states of two different casings in blends are addressed in figure 4.

**Table -2** Story displacement (Ux) in X-direction (mm)

| STORY | FRAME-1 | FRAME-2 |
|---|---|---|
| | Ux | Ux |
| Story21 | 1.883 | 2.09 |
| Story20 | 1.082 | 1.043 |
| Story19 | 1.198 | 1.447 |
| Story18 | 1.356 | 1.537 |
| Story17 | 1.548 | 1.718 |
| Story16 | 1.715 | 1.864 |
| Story15 | 1.848 | 1.978 |
| Story14 | 1.947 | 2.059 |

| | | |
|---|---|---|
| Story13 | 2.01 | 2.105 |
| Story12 | 2.033 | 2.113 |
| Story11 | 2.016 | 2.081 |
| Story10 | 1.958 | 2.011 |
| Story9 | 1.859 | 1.9 |
| Story8 | 1.717 | 1.749 |
| Story7 | 1.537 | 1.561 |
| Story6 | 1.32 | 1.338 |
| Story5 | 1.069 | 1.082 |
| Story4 | 0.79 | 0.799 |
| Story3 | 0.487 | 0.491 |
| Story2 | 0.212 | 0.207 |
| Story1 | 0.05 | 0.037 |
| Base | 0 | 0 |

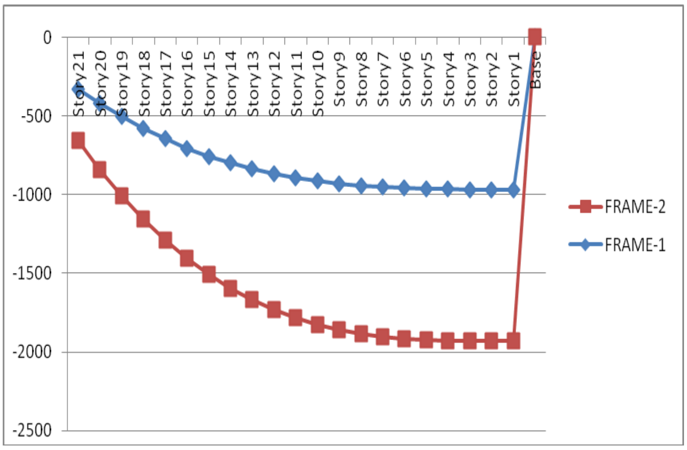
**Table -3** Storey drift in X-direction (mm)

| STORY | FRAME-1 | FRAME-2 |
|---|---|---|
| | Ux | Ux |
| Story21 | 0.000386 | 0.000535 |
| Story20 | 0.000207 | 0.000217 |
| Story19 | 0.000124 | 0.000122 |
| Story18 | 0.000091 | 0.000081 |
| Story17 | 0.000084 | 0.000079 |
| Story16 | 0.000082 | 0.000077 |
| Story15 | 0.000071 | 0.000066 |
| Story14 | 0.000062 | 0.000058 |
| Story13 | 0.000049 | 0.000044 |
| Story12 | 0.000037 | 0.000033 |
| Story11 | 0.000028 | 0.000025 |
| Story10 | 0.000033 | 0.000037 |
| Story9 | 0.000047 | 0.00005 |
| Story8 | 0.00006 | 0.000063 |
| Story7 | 0.000072 | 0.000074 |
| Story6 | 0.000084 | 0.000085 |
| Story5 | 0.000093 | 0.000094 |
| Story4 | 0.000101 | 0.000103 |
| Story3 | 0.000092 | 0.000095 |
| Story2 | 0.000059 | 0.000061 |
| Story1 | 0.000017 | 0.000012 |
| Base | 0 | 0 |

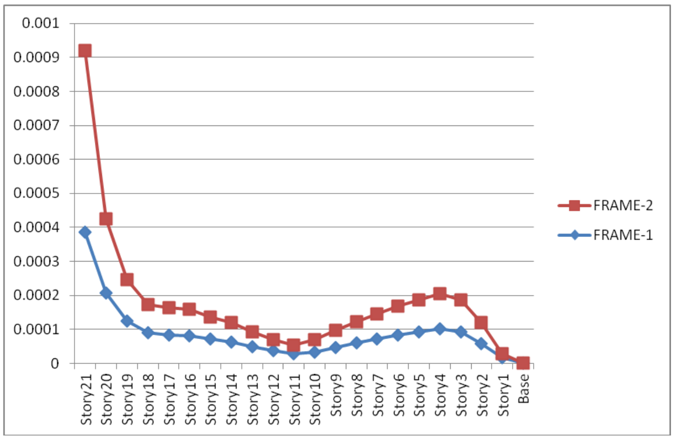
The storey shears as given by ETABS using IS 1893: 2016 (part1), are tabulated in table-5 and represented in figure 5(c). Frame-2, being the heaviest one, develops maximum amount of shear force in its storey compare to frame 1.

**Table -4** Story shear in X-direction (KN)

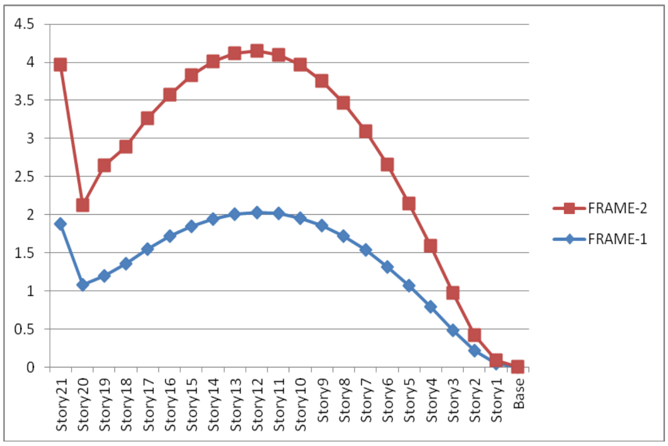
| STORY | FRAME-1 | FRAME-2 |
|---|---|---|
| | Ux | Ux |
| Story21 | -327.817 | -327.155 |
| Story20 | -421.32 | -419.979 |
| Story19 | -505.24 | -503.289 |
| Story18 | -580.095 | -577.599 |
| Story17 | -646.402 | -643.424 |
| Story16 | -704.68 | -701.278 |
| Story15 | -755.446 | -751.676 |
| Story14 | -799.219 | -795.13 |
| Story13 | -836.517 | -832.157 |
| Story12 | -867.857 | -863.27 |
| Story11 | -893.758 | -888.983 |
| Story10 | -914.738 | -909.81 |
| Story9 | -931.315 | -926.266 |
| Story8 | -944.007 | -938.866 |
| Story7 | -953.331 | -948.122 |
| Story6 | -959.806 | -954.551 |
| Story5 | -963.95 | -958.665 |
| Story4 | -966.282 | -960.979 |
| Story3 | -967.318 | -962.007 |
| Story2 | -967.577 | -962.265 |
| Story1 | -967.577 | -962.265 |
| Base | 0 | 0 |




a) Story Shear (mm)




b) Story Drift (mm)




c) Displacement (mm)

**Fig -3** Response of various frames with irregularities

## 5. DISCUSSION AND CONCLUSION

Thinking about the story displacement, the frame with heavy mass on seventh, fourteenth and 21th floor (frame-2) is more vulnerable than frame 1, as it endures the impressive change in displacement in all the floors. To the extent story drift is concerned, frame-2 is more fragile than the frame-1, as frame-2 having the impressive change in story drift. Story shear is greatest in frame-2. From this obviously the frame having mass inconsistency on vertically irregular frame is powerless to harm in earthquake inclined zone.

In this paper, two frames having various irregularities yet with same measurements have been investigated to consider their conduct when exposed to lateral loads. All the frames were investigated with a similar technique as expressed in IS 1893-section 1: 2016. Frame 1 (vertically irregular) grows least story drift while the working with mass irregularity on vertically irregular structure (frame 1) shows greatest story drifts on the particular story levels. Henceforth, this is the most powerless against harms under this sort of loading and similar frame with substantial loads creates greatest story shears, which ought to be represented in design of column appropriately.

The investigation demonstrates that vertically irregular designs are hurtful and the impact of mass irregularity on the vertically irregular design is additionally risky in seismic zone. Hence, quite far irregularities in a structure should be stayed away from. In any case, if inconsistencies must be presented in any capacity whatsoever, they should be planned appropriately following the states of IS 1893-section1: 2016 and IS-456:2000, and joints ought to be made ductile according to IS 13920:1993. Presently a day, complex shaped structures are getting mainstream, yet, they convey a danger of supporting harms during earthquakes. Subsequently, such structures ought to be planned appropriately dealing with their dynamic conduct.

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