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Seismic Analysis of Regular or Irregular Structures

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ABSTRACT- Previous earthquakes in India have discovered that most of the buildings aren't designed to be earthquake resistant. In general, buildings are designed taking into account just the gravity loads. Furthermore, the present look seismic codes are not completely practiced while developing a building. a thus a thus higher degree of damage might be expected during an earthquake in case the seismic resistance of the structure is insufficient. The existing work describes the various reinforced concrete (RC) frames having various irregularities but with same dimensions which are analysed to study the behaviour of theirs when put through seismic lateral loads. All of the frames were analysed with the same strategy as mentioned in Is 1893-Part-1:2002. By the end result, it's been interpreted the base frame (regular) evolves least story drifts while the structure with floating columns shows maximum storey drifts on the soft story levels. Hence, this's very vulnerable to damages under this particular type of loading. The structures with irregularities also proved unsatisfactory consequences to some degree. The frame with heavy loads produces maximum storey shears, which ought to be accounted for in design of columns suitably. The evaluation proves that irregularities are unsafe for the buildings and it's crucial that you have regular and simpler shapes of frames in addition to uniform load distribution within the building. Thus, as far as possible irregularities in a construction must be stayed away from. Nevertheless, if irregularities need to be introduced for every reason, they should be designed properly following the circumstances of Is actually 13920:1993. The complex shaped structures are days getting common, but they have a threat of sustaining damages during earthquakes. Thus, such buildings must be designed effectively taking proper care of the dynamic behaviour of theirs.

KEYWORDS: Dynamic response, structural irregularity, mass irregularity, stiffness irregularity.

I. INTRODUCTION

1.1 GENERAL

Vertical irregularities in structures are extremely typical function in Area that is urban. In many of situations, buildings start to be vertically irregular within the planning phase itself as a result of several architectural and functional purposes. This kind of buildings demonstrated more vulnerability within the past earthquakes. The topics regarding of vertical irregularities have been in focus of research for many years. Numerous studies have been performed in this specific area in deterministic domain. Hence the focus of existing study is assessing the relative performances of typical vertically irregular structures in a Probabilistic domain.

This kind of irregularities arises because of unexpected reduction of strength or stiffness in a specific storey. For extremely high seismic zone area, irregularity in building is probably a great problem to an excellent structural engineer. A lot of vertical irregular buildings occur in modern-day urban infrastructures. Among them Open ground storey as well as stepped kinds of structures are extremely typical in Urban India. A common Open Ground Storey and a Stepped irregular framed building are revealed in Figure 1.1.



Figure 1.1 Vertically irregular buildings. (a) OGS Building (b) Stepped type building

Open ground storey structures may also be known as ‘open first storey buildings’ or perhaps ‘pilotis’ ‘stilted buildings’. Due to the scarcity of land, the earth storey is kept open for no infill and parking purpose walls are provided in ground storey although all above storey are as supplied with infill walls

The 2001 Bhuj earthquake (Magnitude M7.9 and PGA 0.11g) was among the most devastating a person to witness the collapse of several open ground storey RC buildings. A typical open ground storey residential building at Ahmadabad. The soil storey columns are badly harmed as found in Figure 1.2 (a) & (b). Figure 1.3 displays the failure of the very first storey columns as a result of shear in Earthquake.



(a)

Figure 1.2 Failure of the OGS buildings in Bhuj Earthquake (Ref: www.nicee.org)



Figure 1.3 Shear failures of ground storey columns (Ref. World Housing Encyclopedia, EERI & AIEE)

Figure 1.4 stand for the soft storey ground floor with soft storey ground floor at China Earthquake of a 6 storey developing because of the plastic hinge formation at the soil storey column which is likely to increase the inter storey drift at ground floor.



Figure 1.4 Plastic hinged formation at column ends of the ground storey columns in China Earthquake 2008

1.2 CRITERIA FOR VERTICAL IRREGULARITY IN BUILDINGS

In the prior code of Is actually 1893, there was no design recommendations particularly for OGS frames mentioned for vertical irregularity. However in the aftermath of Bhuj earthquake was revised in 2002. In the latest version of code Is actually 1893 (2002) (part1)-, incorporated a brand new design recommendation for OGS buildings.

Clause 7.10.3 (a) states "The columns & beams of the soft storey are to be designed for 2.5 times the storey shear and moments calculated under seismic load of bare frame type of buildings". The magnification factor (MF) 2.5 is examined by Subramanian (2004), Kanitkar and Kanitkar (2001) Kaushik and (2006). The Magnification factor MF 2.5 is not advisable for design of beam as that very likely to end up a "strong beam- weak column" situation.

It needs not to develop the beams of the soft-storey additionally to design for larger storey shears as highly recommended by the above mentioned clause. Strengthening of beams will even further increase the need on the columns, and also deny the plastic development within the beams. These suggestions have met with a bit of opposition in style & construction practice due to congestion of heavy reinforcement within the column.

As per is actually 1893 (2002) code, 5 kinds of irregularities for structures are listed out as follows:

i) a) Stiffness Irregularity - Soft Story: is identified to occur when there's a story in which the lateral stiffness is under 70 % of which within the story above or perhaps less than 80 % of the common stiffness of the 3 stories above.

b) Stiffness Irregularity - Extreme Soft Story is identified to occur where there's a story in which the lateral stiffness is under 60 % of which within the story above or perhaps under 70 % of the common stiffness of the three stories above.

ii) Weight (Mass) Irregularity - It's deemed to occur where real mass of every story is much more than 150 % of the effective mass of an adjacent story.

iii) Vertical geometric irregularity - It shall be regarded as to occur where horizontal dimension of the lateral force resisting method in virtually any story is much more than 130 % of which within an adjacent story.

iv) In plane Discontinuity - In Vertical Lateral-Force-Resisting Elements is defined to exist where an in plane offset of the lateral-force-resisting elements is greater than the length of those components or even where there's a decrease in stiffness of the resisting component within the story below.

v) Discontinuity in Capacity - The weak story is only one in that the story lateral strength is under 80 % of which in the above mentioned story. The story lateral strength is definitely the complete lateral strength of all the seismic-resisting elements sharing the story shear in the consideration direction.

1.3 STEPPED BUILDINGS

Reduction of lateral dimension of the structure along their level is categorized as "stepped building". Due to the aesthetic and functional design these types of buildings are chosen in contemporary multi storey building construction. The main benefits of this particular kind of structures are they offer excellent ventilation with sufficient sun lights on the reduced storey, Sarkar et.al. (2011). this particular kind of building type also provides for compliance with building bye law restrictions associated to ' floor area ratio'. Stepped buildings are being used to boost the heights of masonry structures by distributing gravity loads created by building components like brick stone etc. These buildings also allow the all-natural erosion to take place without compromising the structural integrity of the structure.

A significant earthquake shook villages and cities across the south Asian, a number of villages in Pakistan and providing over 1000 people feared dead. The magnitude 7.6 earthquake killed 157 many people across India's Kashmir and Jammu. Scores of individuals have been feared killed or even captured in two 12 storey apartment blocks reduced to rubble in Islamabad as Figure (a) shows.

The stepped building (Timeball Station in Christchurch) at New Zealand is among the landmarks and buildings in the community which has become reduced to ruin due to a numerous a numerous 6.3 magnitude of earthquake rocked New Zealand that causing widespread damage and killing at least 65 people.(Figure (b)).



Figure 1.5 Behaviour of Stepped building in Earthquake Ref @AFP

1.7 PROBLEM STATEMENT

The majority of the residential buildings have been developed just for live and dead loads. Individuals are not conscious of the seismic design of buildings. But for the different buildings that are placed in the zone IV or V really needs being seismic resistant.

In this particular thesis, a current building has become undertaken for retrofitting. Think about a G+ 9 storey residential present building. It's a framed structure with complete eight stories above ground level. The ground level is an open storey being used as parking. It hence makes up a soft storey. On the roof, there's a water tank also. This particular building has been designed for the dead and the live a lot only. Consequently, two primary issues are determined in this particular building with respect to the seismicity of the structure. Firstly, the structure hasn't integrated in it the Earthquake loads. Second, no provisions are made up for the current soft storey. Thus, ground storey has to be provided with particular attention.

1.8 SCOPE AND LIMITATION OF PROJECT

The RC framed Buildings are considered for the analysis by assuming regular in plan. The Out of plane action of walls is neglected in the analysis. The asymmetric arrangement of walls is ignored of the buildings. The Soil structure interaction effects are not considered in the analysis. The Flexibility of floor diaphragms are neglected and considered as rigid diaphragm. The base of the column is assumed to be fixed in the analysis.

II. LITERATURE REVIEW

Afarani and Nicknam et al. (2012) (1) observed the behaviour of the vertically irregular building under seismic loads by Incremental Dynamic Analysis. They've talking about eight stories regular building using two bays with four m width in y direction has and four bays with three m width in x direction with three m storey height is believed. They considered Dead load as two ton/m is sent out on beams. In order to stay away from torsional effects they considered symmetric building and also steel moment resisting frames that are created based on IBC 2006 and ANSI/AISC 360-05

FEMA 440 et al. (2000) (2) studied Eighteen ground motion records from Pacific Earthquake Engineering Research Centre (PEER) database are collected from Far Field with distance far more than ten km from site as well as have Richter magnitudes of five to eight on firm soil. The structure is modelled in SeismoStruct-V5 software as a nonlinear dynamic analysis, Steel is modelled as Elastic Perfectly Plastic (EPP) hysteresis with no expertise of lateral and local buckling and the connections happened to be failure according to FEMA 440. Maximum inter story drift ratios and first mode spectral acceleration are calculated by Incremental dynamic analysis and IDA curved are plotted to get the collapse points. The evaluation of the structure is targeted on the collapse prevention limit state of the components. Fragility curves are generated by using Cumulative Distribution Function via the lognormal distribution through collapse points

Elnashai and Jeong et al. (2006) (3) research the fragility analysis for an irregular RC building under bidirectional earthquake loading has studied by For the account of the irregularities in structure, bidirectional response and the torsion are used as 3d structural response features to represent the destruction states of the structure irregularities is

provided through a reference derivation. A 3 story RC frame is obtained with asymmetric in plan with thickness of slab is 150 mm and beam depth is 500 mm to learn the damage assessments.

The total damage index is estimated for the planar frames in the backbone envelope curve as a mix of harm due to in plane monotonic displacement plus strength reduction. Coefficient of variation (COV) is discovered function as the ratio of standard deviation to mean value of damage index

Tantala and Deodatis et al. (2002) (4) analysis a 25 story of reinforced concrete moment resisting frame Building having three-bays. generated fragility curves a they've a they've broad variety of ground motion intensities. They've utilized a bit of time histories are modelled by stochastic processes. Simulation is accomplished by power spectrum probability and duration of earthquake by conducting 1000 simulation for every parameter. The nonlinear analysis is done by considering the P- Δ effects and by ignoring soil-structure interaction. They have considered the nonlinearity in material properties in model with nonlinear rotational springs a bilinear moment-curvature relationship by since the stiffness degradation through hysteretic energy dissipation capacity over successive cycles of the hysteresis. They've utilized Monte Carlo simulation approach for simulation of the ground motion.

Murat and Zekeria et al. (2006) (5) studied the yielding and also collapse behaviour of RC frame buildings in Istanbul was analysed through fragility analysis primarily based on numerical simulation. They've studied amount of accounts of buildings as three, five & seven storeys designed as per Turkish seismic design code (1975).The fragility curves have been designed with the assistance of the outcomes of regression analysis. They've examined with twelve artificial ground motions because of the evaluation. Incremental powerful analysis (IDA) method is employed for estimating structural performance under many ground motions. The Characteristic strength of concrete as 16Mpa and 2 completely different steel type as 220Mpa & 420Mpa are used. The anxiety because of scatter of substance along with the soil structure interaction was dismissed in their layout mean importance of material power was taken into account that had been examined experimentally. Performance limit state inelastic displacement demand as well as corresponding deformations for fast collapse and occupancy prevention is evaluated. From the fragility curves last they've realized that with the collapse prevention performance level, a good correlation between spectral displacement limit and also the quantity of stories was noticed though similar observation wasn't valid for the instant occupancy level.

III. RESULT AND DISCUSSION

The building is then analysed using staad pro v8i software (Fig. 2).both the static and the dynamic analysis have been done for this building. Firstly, dead and the live loads are found out separately. The unit weights of the material are taken from is 875: part 1. The live loads of residential building, accessible and inaccessible roof is taken from [11] is 875 part 2. The seismic loads are taken out taking the help from is 1893:2002. Analysis and the design of the concrete building are then carried out.

FRAME-1 : This is the basic and ten storey height of 3.5m and the bay width of 5m. The basic specifications of the building are: Dimensions of the beam = 0.450x0.25 m ; Column size = 0.30x0.30 ; Beam Length = 5 m ; Column Length = 3.5 m ; Dead load = 12 KN/m² ; Live Load = 10KN/ m²

FRAME-2 : Frame having 1st and 2nd storeys soft. No floor slab has been provided which makes these two storeys less stiff, i.e., softer.

FRAME-3 : This frame has 4th and 5th storeys soft. No floor beams (Vertical) have been provided which makes these two storeys soft.

FRAME-4: Frame with heavy loading on 3rd and 6th storeys. Two storeys of the building, i.e. , 3rd and 6th storeys carry heavier loads, hence making the building irregular.

FRAME-5: The frame carries heavier loading on the Top story, e.g., in the top story swimming pool has been introduced hence making the top storey heavy, and the building becomes irregular.

FRAME-6: In this frame the intermediate columns are removed making the ground story soft and thus an irregularity is introduced in the building.

FRAME-7: The frame is made irregular by removing the end columns and placing the intermediate columns in it.

FRAME-8:This frame has 4th and 5th storeys soft. No floor beams (horizontal) have been provided which makes these two storeys soft .

FRAME-9: In this frame the geometry of building is changed by changing the height of building in three bays and hence introducing the irregularity in the building.

FRAME-10:In this frame along with geometric irregularity the intermediate columns are removed ,irregularity is introduced by doing so.

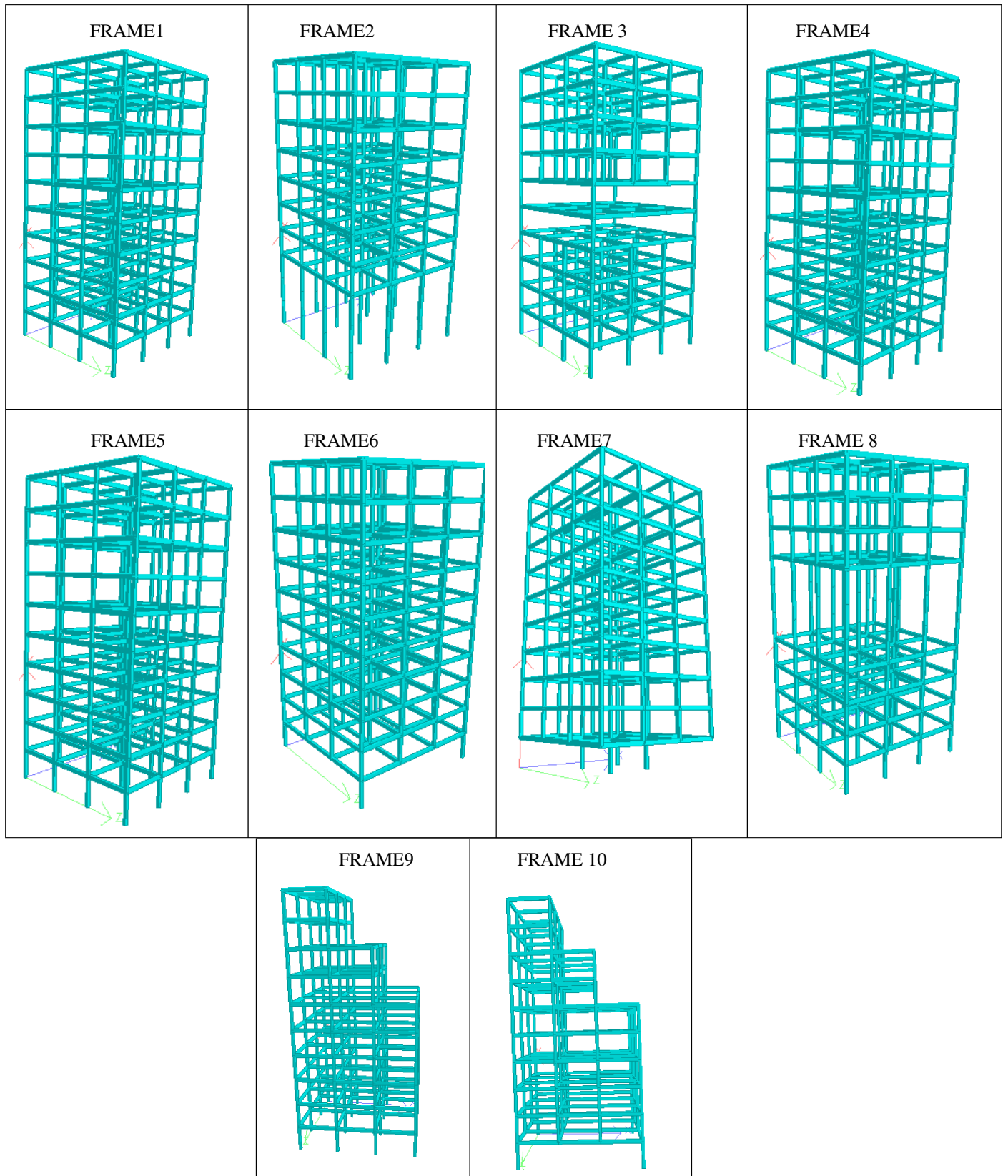


Fig 3.2 3D Frame

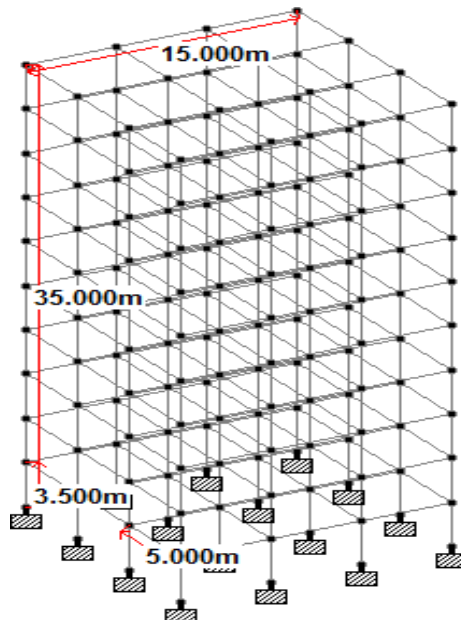
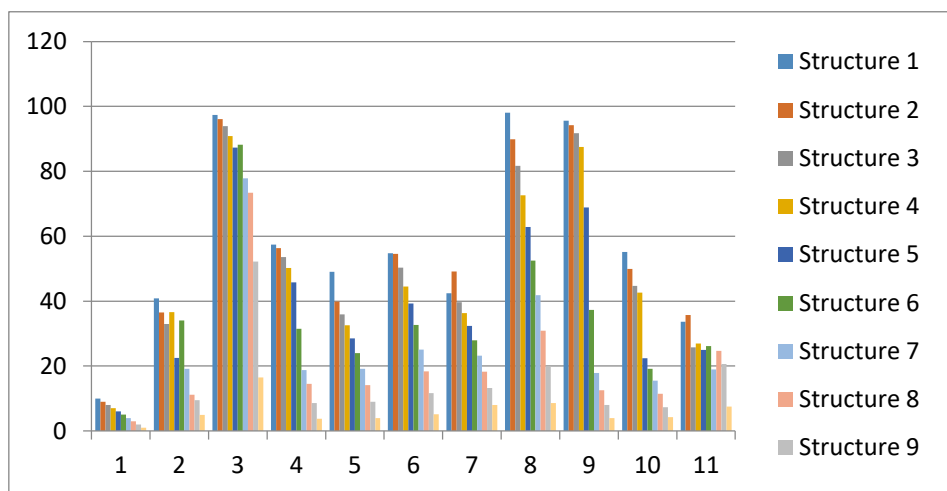


Fig.3.1 Ideal frame with Dimentions



Graph.3.1 Graph of displacement of each structure w.r.t each storey.

3.1 Structure 1 and Structure 2

- It is mentioned that in Beam 31 the worth of maximum shear force (Fy) from standard to irregular frame decreases from 130.07 kN/m to 114.9 kN/m.
- It is mentioned that in Beam 36 the worth of maximum axial force (Fx) from normal frame to irregular frame decreases from 1288.17 kN to 715.38 kN respectively.
- It is mentioned that in Beam 36 the worth of maximum bending moment (Mz) from regular frame to irregular frame increases from 268.19 kNm to 626.90 kNm respectively.

3.2 Structure 1 and Structure 3

- It is mentioned in that Beam 271 the worth of maximum shear force (Fy) from normal to irregular frame increases from 78.75 kN/m to 391.66 kN/m.
- It is mentioned that in Beam 271 the valuation of maximum bending moment (Mz) from regular frame to irregular frame increases from 140 kNm to 804.3 kNm respectively.

• It is mentioned that in Beam 54 the valuation of maximum axial force (F_x) from regular frame to irregular frame increases from 478.01 kN to 3599.90 kN respectively.

3.3 Structure 1 and Structure 4

- It is mentioned that in Beam 271 the valuation of maximum shear force (F_y) from standard frame to irregular frame increases from 78.75 kN/m to 78.8 kN/m respectively.
- It is mentioned that in Beam 271 the valuation of maximum bending moment (M_z) from regular frame to irregular frame decreases from 190.42 kNm to 140.42 kNm respectively.
- It is mentioned that in Beam 47 the worth of maximum axial force (F_x) from regular frame to irregular frame increases from 478.01 kN to 1159.77 kN respectively.

3.4 Structure 1 and Structure 5

- It is mentioned that in Beam 74 the valuation of maximum shear force (F_y) from regular frame to irregular frame increases from 67.5 kN/m to 69.62 kN/m respectively.
- It is mentioned that in Beam 74 the value of maximum bending moment (M_z) from regular frame to irregular frame decreases from 105.32 kNm to 100 kNm respectively.
- It is mentioned that in Beam 74 the valuation of maximum axial force (F_x) from regular frame to irregular frame decreases from 26.3 kN to 22.02 kN respectively.

3.5. Structure one and Structure 6

- It is mentioned that in Beam 271 the valuation of maximum shear force (F_y) from regular to irregular frame decreases from 78.75 kN/m to 54.29 kN/m.
- It is mentioned that in Beam 271 the valuation of maximum bending moment (M_z) from normal frame to irregular frame increases from 95.73 kNm to 140.42 kNm respectively.
- It is mentioned that in Beam 271 the valuation of maximum axial force (F_x) from regular to irregular frame increases from 170.95 kN to 478.01 kN.

3.6 Structure 1 and Structure 7

- It is mentioned that in Beam 274 the valuation of maximum shear force (F_y) from standard to irregular frame decreases from 78.80 kN/m to 54.15 kN/m.
- It is mentioned that in Beam 51 the valuation of maximum bending moment (M_z) from regular frame to irregular frame increases from 96.63 kNm to 154.59 kNm respectively.
- It is mentioned that in Beam 274 the valuation of maximum axial force (F_x) from regular to irregular frame decreases from 478.01 kN to 171.38 kN.

3.7. Structure 1 and Structure 8

- It is mentioned that in Beam 268 the value of maximum shear force (F_y) from regular to irregular frame decreases from 138.35 kN/m to 66.25 kN/m.
- It is mentioned that in Beam 268 the value of maximum bending moment (M_z) from regular frame to irregular frame increases from 243.46 kNm to 348.54 kNm respectively.
- It is mentioned that in Beam 268 the valuation of maximum axial force (F_x) from regular to irregular frame decreases from 987.65 kN to 669.55 kN.

3.8. Structure 1 and Structure 9

- It is mentioned that in Beam 211 the valuation of maximum shear force (F_y) from regular to irregular frame decreases from 103.48 kN/m to 101.94 kN/m.
- It is mentioned that in Beam 211 the valuation of maximum bending moment (M_z) from regular frame to irregular frame increases from 183.94 kNm to 199.83 kNm respectively.
- It is mentioned that in Beam 211 the valuation of maximum axial force (F_x) from regular to irregular frame decreases from 915.55 kN to 150.81 kN.

3.9. Structure 1 and Structure 10

- It is mentioned that in Beam 168 the valuation of maximum shear force (F_y) from regular to irregular frame increases from 97.38 kN/m to 235.77 kN/m.

- It is mentioned that in Beam 168 the valuation of maximum bending moment(M_z) from regular frame to irregular frame increases from 271.68 kNm to 437.05 kNm respectively.
- It is mentioned that in Beam 211 the valuation of maximum axial force(F_x) from regular to irregular frame decreases from 915.85 kN to 152.36 kN.

IV. CONCLUSION

Considering the storey displacement, the frame and structure with floating columns (frame 2) may be the most fragile since it suffers the highest displacement as the base frame and structure exhibits the very least displacement. So far as storey drift is concerned, frame two (with bottom 2 soft storeys) may be the most fragile since it's the maximum storey drift which changes abruptly. Frame 8 also shows pattern that is similar for bottom 2 storeys. Storey shear is however maximum in frame four and structure four (with 3rd and 6th storeys major). It may be inferred naturally the frame and structure with floating columns represents the even worse situation since it faces the highest displacement and is very susceptible to damages under this particular lateral loading. While, on the flip side it could be observed that the base frame and structure contains the very least drift and displacement, hence least vulnerable to the harm.

In this particular thesis different structures and frames having completely different irregularities but with exactly the same dimension were analysed to learn their behaviour when put through lateral loads. All of the frames and also components have been analysed with exactly the same technique as mentioned in Is actually 1893 part 1: 2002. The starting frame and structure that is ideal develops least story drifts while the structure with floating column shows maximum storey drifts on soft story levels. Thus this's probably the most susceptible to damages under this particular type of loading. The many other structures with irregularities also proved unsatisfactory success to some degree. The frame with heavy loads produces maximum storey shears that should always be accounted for in design of columns suitably. The analysis reveals the dynamic approach provides us much more refined results as than static evaluation of the structure.

The evaluation too demonstrates that irregularities are unsafe for the buildings and also it's crucial that you have regular and simpler shapes of frames in addition to even load distribution within the construction. Thus, as much as potential irregularities in a construction should be avoided. But if irregularities need to be introduced without any reason, they should be designed effectively adhering to the circumstances of Is actually 13920: 1993. And now days, complex shaped buildings are becoming famous though they have a threat of sustaining damages during earthquakes. Therefore such structures must be created effectively taking care their dynamic behavior.

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