Seismic Strengthening Analysis & Design (Retrofitting) of Educational Building at Nepal

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**Abstract**

Although the timing of a seismic event can be anticipated, it is a given that the damage it causes will be severe. The danger of earthquakes is substantially higher in Nepal than in many other metropolitan centres in developing nations. Uncontrolled development, subpar design, and poor building techniques have all contributed to the seismic risk. In the event of a significant earthquake, there will be significant property damage and loss of life. In order to minimise structural damage and lower mortality in the event of a major earthquake, it is strongly advised that buildings in cities like Kathmandu be designed and built with adequate care for the seismic load. Due to this, the design and construction of the structure have been prone to seismic zone.

**I Introduction**

One of the most feared natural calamities is an earthquake. earthquakes are waves that vibrate the earth's surface as a result of disturbances deep within the planet. It is a natural occurrence that depends on a number of variables. When it impacts an ever-increasing concentration of material goods and people, it becomes extremely destructive. Nepal experiences earthquakes frequently. This is so because Nepal is located in the Himalayan range, where tectonic plate collisions force the Indian and Eurasian plates to subduct. As a result, there has been an enormous buildup of strain energy, which has led to rapid breakdown of rock masses along the faults, which in turn leads to earthquakes. There have already been significant earthquakes in Nepal that have left a huge human and material toll.

Keywords- Retrofiting,Strengthening,SAP

Retrofiting design – background

The result of an earth shake manisfests incredible pulverization because of unpredicted seismic movement striking broad harm to incalculable structures of changing degree i.e either full or halfway or sligth. This harm to Designs in its turn cause a hopeless loss of the existence with countless setbacks. Subsequently scared tenants might decline to enter the structures except if guaranteed of the security of the structures. from future seismic tremors. It has been seen that greater part of such tremor harmed structures might be securely reused, on the off chance that they are changed over into seismically safe designs by utilizing a couple retrofitting measures. This ends up being a superior choice taking care of the financial contemplations and quick haven issues as opposed to substitutions of structures. Additionally it has frequently been seen that retrofitting of structures is by and large more practical when contrasted with destruction and reproduction even on account of serious underlying harm. Accordingly, seismic retrofitting of building structures is one of the main viewpoint for alleviating seismic risk particularly in quake inclined nations. The need of seismic retrofitting of structures emerges under two conditions: (I) tremor harm structures and (ii) quake weak structures that poor person yet experience extreme tremors.

Retrofitting Strategies

Various method used for retrofitting of reinforced concrete buildings Are:

1.Structural level (or Global)Retrofit Methods

Two approaches are used for structure-level Retrofitting.

i. Conventional method

This methods of retrofitting are used to enhance the seismic resistance of existing structure by elimination or reducing the adverse effect of design. It includes

Adding Shear walls

Adding Infill walls

Adding steel bracings

ii. Non-conventional methods

This methods of retrofitting are used to reduce the horizontal seismic forces.it includes

Seismic base isolation

supplemental damping device

2.Member Level (or Local) Retrofit Methods

Approaches Used for member level retrofit methods are:

i. Jacketing/confinements

ii. Jacketing of columns

iii. Reinforced concrete jacketing

iv. Steel jacketing

v. FRP jacketing

vi.Beam jacketing

vii. Beam-column jacketing

Adopted retrofiting Strategy : Reinforced concrete jacketing

Reinforced concrete jacketing can be used as a strengthening or repair method. Prior to its jacketing, damaged areas of the existing members should be rectified. In order to achieve a strong column-weak beam design, jacketing columns serves two main purposes: (i) increasing the shear capacity of the columns; and (ii) enhancing the column's flexural strength through the use of longitudinal steel of the jacket that is continuous through the slab system and anchored to the foundation. It is accomplished by inserting fresh concrete into the joints between the beam and column and passing new longitudinal reinforcement through holes drilled in the slab.

Details for reinforced concrete jacketing

Properties of jackets : 1. Match with the concrete of the existing structure 2. Compressive strength greater than that of existing structure by

5 N/mm^2 (50 Kg/cm^2), or at least equal to that of the existing structure.

Minimum width of jacket:

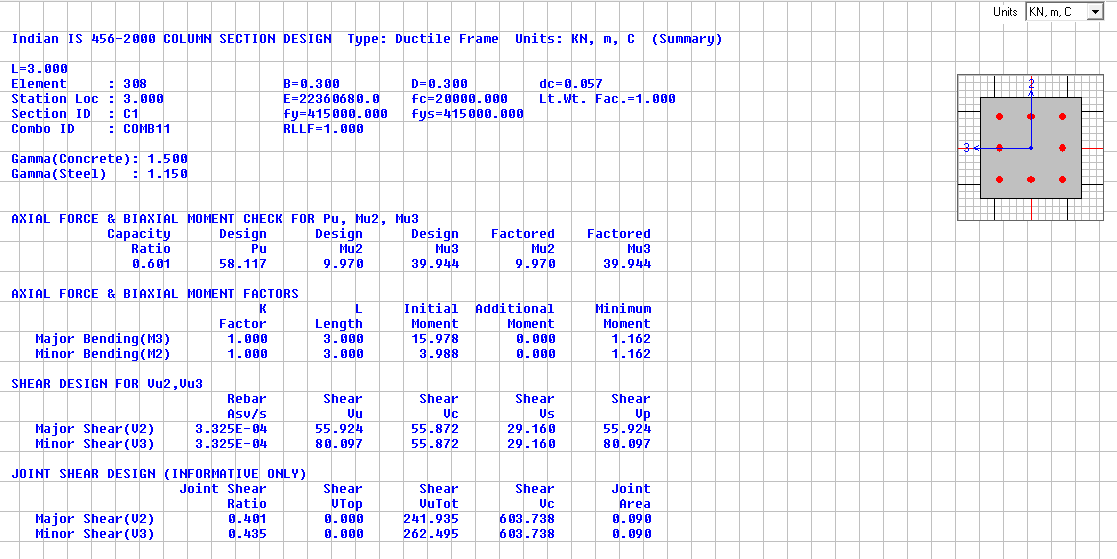
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| --- |
| 1. 10 cm for concrete cast in place and 4 cm for shotcrete |
| 2. If possible, four-sided jacket should be used  3. Narrow gap should be provided to prevent any possible increase in flexular capacity |
| Minimum area of longitudinal reinforcement:  1. Spacing should not exceed six times of width of the new elements (the jacket in the case ) up to limit of 60 cm.  2. Percentage of steel in the jacket with respect to jacket area should be limited between 0.015 and 0.04  3. At least, a 12 mm bar should be used at every corner for a four-sided jacket. |
| **Shear stress in the interfere:**  chipping the concrete cover of the original member and roughening its surface may improve the bond between the old and new concrete. |
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|  |

**Connector:**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 1. Connectors should be anchored in both the concrete such that it may develop at least 80% of the yeilding stress. | | | | |
|  | |
| 2. It is better to use reinforced bars anchored with epoxy resigns of grouts . | | | | |  | |
|  | |
| **Spacing of ties:** | |  | S= | (Fy\*d2)/(sqrtFck\*tj) | | |
|  |  |  |  |  | |  |
|  |  |  | Fy= | 500 | |  |
|  |  |  | d= | 10 | |  |
|  |  |  | Fck= | 25 | |  |
|  |  |  | tj= | 125 | |  |
|  |  |  |  |  | |  |
|  |  |  | S= | 80 | |  |
|  |  |  |  |  | |  |
| **Provide spacing of ties 10mm dia @ 75 mm c/c.** | | | | | |  |

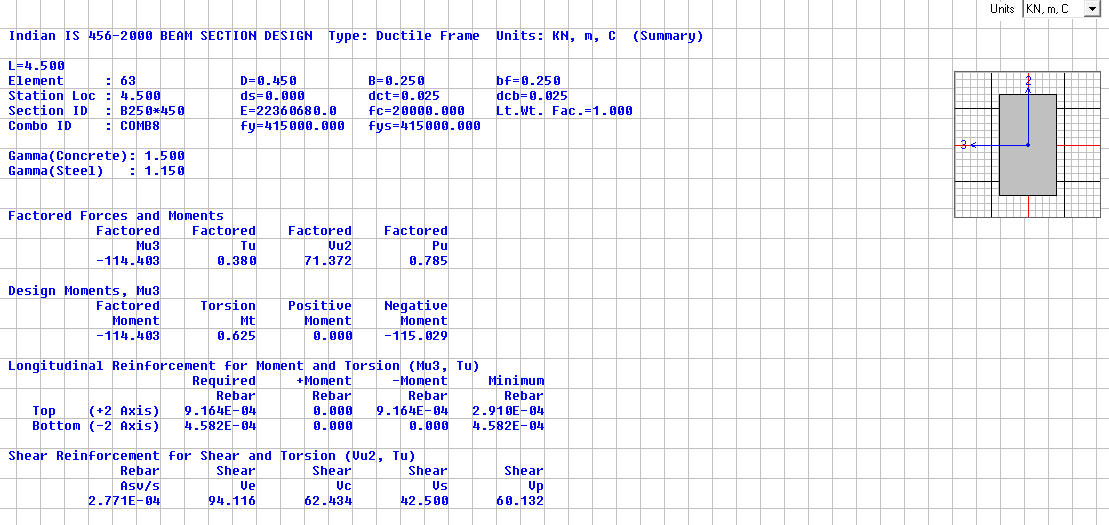
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| **II DESIGN DATA** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
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| 1 | | | | Building Type | | | | | | | | : | | | | Educational Building | | | | | | | | | | | | | | | | | | | | | | | | | |
|  | | | |  | | | | |  | | |  | | | |  | | | | |  | | | | | | | | |  | | |  | | | | |  | | | |
| 2 | | | | Type of structure | | | | | | | | : | | | | Frame Structure (Rigid joined Frame structure ) | | | | | | | | | | | | | | | | | | | | | | | | | |
|  | | | |  | | | | |  | | |  | | | |  | | | | |  | | | | | | | | |  | | |  | | | | |  | | | |
| 3 | | | | No. of Storey | | | | | | | | : | | | | 4 | | | | | | | | | | | | | | | | | | | | | |  | | | |
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| 4 | | | | Concrete Grade | | | | | | | | : | | | | M 25 | | | | | | | | | | | | | | | | | | | | | |  | | | |
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| 5 | | | | Reinforcement Used | | | | | | | | : | | | | Fe 415 | | | | | For Existing column | | | | | | | | | | | |  | | | | |  | | | |
|  | | | |  | | | | |  | | |  | | | | Fe 500 | | | | | Retrofit Column | | | | | | | | | | | |  | | | | |  | | | |
|  | | | |  | | | | |  | | |  | | | |  | | | | |  | | | | | | | | |  | | |  | | | | |  | | | |
| 6 | | | | Cement Used | | | | | | | | : | | | | Ordinary Portland Cement | | | | | | | | | | | | | | | | |  | | | | |  | | | |
|  | | | |  | | | | |  | | |  | | | |  | | | | |  | | | | | | | | |  | | |  | | | | |  | | | |
| 7 | | | | Load Taken | | | | | | | | | | | |  | | | | |  | | | | | | | | |  | | |  | | | | |  | | | |
|  | | | | Class | | | | | | | | | | | | | | | | |  | | | | | | | | | 3 | | | kN/sqm | | | | |  | | | |
|  | | | | Kitchen, Laundaries & Laboratories | | | | | | | | | | | | | | | | |  | | | | | | | | | 2.5 | | | kN/sqm | | | | |  | | | |
|  | | | | Toilets & Bathrooms | | | | | | | | | | | | | | | | |  | | | | | | | | | 2 | | | kN/sqm | | | | |  | | | |
|  | | | | Corridore, Passage & Lobby | | | | | | | | | | | | | | | | |  | | | | | | | | | 4 | | | kN/sqm | | | | |  | | | |
|  | | | | Finishing Load | | | | | | | | | | | | | | | | |  | | | | | | | | | 1.5 | | | kN/sqm | | | | |  | | | |
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| 8 | | | | Design Philosophy - Limit State Design Confirming IS : 456-2000 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
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| 9 | | | | Analysis Software Used = | | | | | | | | | | | | | | | | | SAP 2000 | | | | | | | | | VER 16 | | |  | | | | |  | | | |
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| 10 | | | | Earthquake Load Consideration = | | | | | | | | | | | | | | | | | IS 1893-2002 | | | | | | | | | | | |  | | | | |  | | | |
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| 11 | | | | Retrofitting Guidelines Consideration= | | | | | | | | | | | | | | | | | IS 15988-2013 | | | | | | | | | | | |  | | | | |  | | | |
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|  | | | **Load Combination** | | | | | | | | | | | | | | | | | | | |  | |  | | | | | | | | | | |  | | | |  | | | | | | |  | |  |
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|  | | | Combination | | | | | | | | | | | | | | | | | | | 1 | = | | (DL+LL)x1.5 | | | | | | | | | | | | | | |  | | | | | | |  | |  |
|  | | | Combination | | | | | | | | | | | | | | | | | | | 2 | = | | (DLx1.2 + LLx1.2+ EQ1x1.2) | | | | | | | | | | | | | | | | | | | | | |  | |  |
|  | | | Combination | | | | | | | | | | | | | | | | | | | 3 | = | | (DLx1.2 + LLx1.2+ EQ2x1.2) | | | | | | | | | | | | | | | | | | | | | |  | |  |
|  | | | Combination | | | | | | | | | | | | | | | | | | | 4 | = | | (DLx1.2 + LLx1.2+ EQ1x-1.2) | | | | | | | | | | | | | | | | | | | | | |  | |  |
|  | | | Combination | | | | | | | | | | | | | | | | | | | 5 | = | | (DLx1.2 + LLx1.2+ EQ2x-1.2) | | | | | | | | | | | | | | | | | | | | | |  | |  |
|  | | | Combination | | | | | | | | | | | | | | | | | | | 6 | = | | (.9 X DL+1.5X EQ1) | | | | | | | | | | | | | | |  | | | | | | |  | |  |
|  | | | Combination | | | | | | | | | | | | | | | | | | | 7 | = | | (.9 X DL-1.5X EQ1) | | | | | | | | | | | | | | |  | | | | | | |  | |  |
|  | | | Combination | | | | | | | | | | | | | | | | | | | 8 | = | | (.9 X DL+1.5X EQ2) | | | | | | | | | | | | | | |  | | | | | | |  | |  |
|  | | | Combination | | | | | | | | | | | | | | | | | | | 9 | = | | (.9 X DL-1.5X EQ2) | | | | | | | | | | | | | | |  | | | | | | |  | |  |
|  | | | Combination | | | | | | | | | | | | | | | | | | | 10 | = | | (1.5 XDL +1.5 X EQ1) | | | | | | | | | | | | | | | | | | | | | |  | |  |
|  | | | Combination | | | | | | | | | | | | | | | | | | | 11 | = | | (1.5 XDL -1.5 X EQ1) | | | | | | | | | | | | | | | | | | | | | |  | |  |
|  | | | Combination | | | | | | | | | | | | | | | | | | | 12 | = | | (1.5 XDL +1.5 X EQ2) | | | | | | | | | | | | | | | | | | | | | |  | |  |
|  | | | Combination | | | | | | | | | | | | | | | | | | | 13 | = | | (1.5 XDL -1.5 X EQ2) | | | | | | | | | | | | | | | | | | | | | |  | |  |
|  | | | | | | |  | | | | **Load Calculation** | | | | | | | | | | | | |  | | | | |  | | |  | | | | | | | | | | | |  | | | | | | |
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| 1 | | | | | | | **A. Slab Load** | | | | | | | |  | | | |  | | | | |  | | | | |  | | |  | | | | |  | | | | | | |  | | | | | | |
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|  | | | | | | | Slab Thickness | | | | 0.1 | | | |  | | | | 25 | | | | | 2.5 | | | | |  | | |  | | | | |  | | | | | | |  | | | | | | |
|  | | | | | | | Floor finish | | | |  | | | |  | | | |  | | | | | 1 | | | | |  | | |  | | | | |  | | | | | | |  | | | | | | |
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|  | | | | | | |  | | | |  | | | |  | | | | Total | | | | | 3.5 | | | | |  | | |  | | | | |  | | | | | | |  | | | | | | |
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|  | | | | | | | **B. Beam Load** | | | | | | | |  | | | |  | | | | |  | | | | |  | | |  | | | | |  | | | | | | |  | | | | | | |
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|  | | | | | | | L | | | | B | | | | Density | | | |  | | | | | WEIGHT/M | | | | |  | | |  | | | | | | | | | | | |  | | | | | | |
|  | | | | | | | 0.45 | | | | 0.25 | | | | 25 | | | |  | | | | | 2.81 | | | | |  | | |  | | | | |  | | | | | | |  | | | | | | |
|  | | | | | | | 0.35 | | | | 0.25 | | | | 25 | | | |  | | | | | 2.19 | | | | |  | | |  | | | | |  | | | | | | |  | | | | | | |
|  | | | | | | |  | | | |  | | | |  | | | | Total | | | | | 5.00 | | | | | kN/m | | |  | | | | |  | | | | | | |  | | | | | | |
|  | | | | | | |  | | | |  | | | |  | | | |  | | | | |  | | | | |  | | |  | | | | |  | | | | | | |  | | | | | | |
|  | | | | | | | **C. Column Load** | | | | | | | |  | | | |  | | | | |  | | | | |  | | |  | | | | |  | | | | | | |  | | | | | | |
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|  | | | | | | |  | | | | L | | | | B | | | | Density | | | | | H | | | | | WEIGHT | | |  | | | | |  | | | | | | |  | | | | | | |
|  | | | | | | | Column C1 | | | | 0.3 | | | | 0.3 | | | | 25 | | | | | 3 | | | | | 6.75 | | |  | | | | |  | | | | | | | | | | | | | |
|  | | | | | | | Rc 500\*500 | | | | 0.5 | | | | 0.5 | | | | 25 | | | | | 3 | | | | | 18.75 | | |  | | | | |  | | | | | | |  | | | | | | |
|  | | | | | | |  | | | |  | | | |  | | | |  | | | | | Total | | | | | **25.50** | | | kN/m | | | | |  | | | | | | |  | | | | | | |
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|  | | | | | | | **B.Wall Load** | | | | | | | |  | | | |  | | | | |  | | | | |  | | |  | | | | |  | | | | | | |  | | | | | | |
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|  | | | | | | | Description | | | | L | | | | B | | | | Density | | | | | H | | | | | WEIGHT | | | % of wall | | | | | Adopt | | | | | | |  | | | | | | |
|  | | | | | | |  | | | |  | | | |  | | | |  | | | | |  | | | | |  | | |  | | | | |  | | | | | | |  | | | | | | |
|  | | | | | | | 4" wall | | | | 1 | | | | 0.138 | | | | 19 | | | | | 2.655 | | | | | 6.96 | | | 4.87 | | | | | 5.00 | | | | | | |  | | | | | | |
|  | | | | | | |  | | | |  | | | |  | | | |  | | | | |  | | | | |  | | |  | | | | |  | | | | | | |  | | | | | | |
|  | | | | | | | 9" wall | | | | 1 | | | | 0.23 | | | | 19 | | | | | 2.655 | | | | | 11.60 | | | 8.12 | | | | | 10.00 | | | | | | |  | | | | | | |
|  | | | | | | |  | | | | Assuming | | | | 30 | | | | % of Openings | | | | | | | | | |  | | |  | | | | |  | | | | | | |  | | | | | | |
| **III Seismic weight of the building** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|  |  |  | | | | | | | | | | | | | | |  | | | | | | | | |  | | | | | | | |  | | | | | | |  | |  | |  |
| As per IS 1893(part I): 2002 Seismic weight of the building = dead load + percentage of imposed load | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|  |  |  | | | | | | | | | | | | | | |  | | | | | | | | |  | | | | | | | |  | | | | | | |  | |  | |  |
| As per IS 1893(part I): 2002 clause 7.3.1 percentage of imposed load = 25 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |  | |  |
|  |  | TABLE-1 **Joint Reactions** | | | | | | | | | | | | | | |  | | | | | | | | |  | | | | | | | |  | | | | | | |  | |  | |  |
|  |  | **TABLE: Joint Reactions** | | | | | | | | | | | | | | |  | | | | | | | | |  | | | | | | | |  | | | | | | |  | |  | |  |
|  |  | **Joint** | | | | | | | | | | | | | | | **OutputCase** | | | | | | | | | **CaseType** | | | | | | | | **F3** | | | | | | |  | |  | |  |
|  |  | Text | | | | | | | | | | | | | | | Text | | | | | | | | | Text | | | | | | | | KN | | | | | | |  | |  | |  |
|  |  | 262 | | | | | | | | | | | | | | | COMB15 | | | | | | | | | Combination | | | | | | | | 150.857 | | | | | | |  | |  | |  |
|  |  | 263 | | | | | | | | | | | | | | | COMB15 | | | | | | | | | Combination | | | | | | | | 173.731 | | | | | | |  | |  | |  |
|  |  | 264 | | | | | | | | | | | | | | | COMB15 | | | | | | | | | Combination | | | | | | | | 151.955 | | | | | | |  | |  | |  |
|  |  | 265 | | | | | | | | | | | | | | | COMB15 | | | | | | | | | Combination | | | | | | | | 152.032 | | | | | | |  | |  | |  |
|  |  | 266 | | | | | | | | | | | | | | | COMB15 | | | | | | | | | Combination | | | | | | | | 152.929 | | | | | | |  | |  | |  |
|  |  | 267 | | | | | | | | | | | | | | | COMB15 | | | | | | | | | Combination | | | | | | | | 152.459 | | | | | | |  | |  | |  |
|  |  | 268 | | | | | | | | | | | | | | | COMB15 | | | | | | | | | Combination | | | | | | | | 162.617 | | | | | | |  | |  | |  |
|  |  | 269 | | | | | | | | | | | | | | | COMB15 | | | | | | | | | Combination | | | | | | | | 132.027 | | | | | | |  | |  | |  |
|  |  | 270 | | | | | | | | | | | | | | | COMB15 | | | | | | | | | Combination | | | | | | | | 423.084 | | | | | | |  | |  | |  |
|  |  | 271 | | | | | | | | | | | | | | | COMB15 | | | | | | | | | Combination | | | | | | | | 503.824 | | | | | | |  | |  | |  |
|  |  | 273 | | | | | | | | | | | | | | | COMB15 | | | | | | | | | Combination | | | | | | | | 370.319 | | | | | | |  | |  | |  |
|  |  | 274 | | | | | | | | | | | | | | | COMB15 | | | | | | | | | Combination | | | | | | | | 370.391 | | | | | | |  | |  | |  |
|  |  | 275 | | | | | | | | | | | | | | | COMB15 | | | | | | | | | Combination | | | | | | | | 428.055 | | | | | | |  | |  | |  |
|  |  | 277 | | | | | | | | | | | | | | | COMB15 | | | | | | | | | Combination | | | | | | | | 370.214 | | | | | | |  | |  | |  |
|  |  | 278 | | | | | | | | | | | | | | | COMB15 | | | | | | | | | Combination | | | | | | | | 376.429 | | | | | | |  | |  | |  |
|  |  | 279 | | | | | | | | | | | | | | | COMB15 | | | | | | | | | Combination | | | | | | | | 346.72 | | | | | | |  | |  | |  |
|  |  | 280 | | | | | | | | | | | | | | | COMB15 | | | | | | | | | Combination | | | | | | | | 372.901 | | | | | | |  | |  | |  |
|  |  | 281 | | | | | | | | | | | | | | | COMB15 | | | | | | | | | Combination | | | | | | | | 449.389 | | | | | | |  | |  | |  |
|  |  | 282 | | | | | | | | | | | | | | | COMB15 | | | | | | | | | Combination | | | | | | | | 372.133 | | | | | | |  | |  | |  |
|  |  | 283 | | | | | | | | | | | | | | | COMB15 | | | | | | | | | Combination | | | | | | | | 371.788 | | | | | | |  | |  | |  |
|  |  | 284 | | | | | | | | | | | | | | | COMB15 | | | | | | | | | Combination | | | | | | | | 429.969 | | | | | | |  | |  | |  |
|  |  | 285 | | | | | | | | | | | | | | | COMB15 | | | | | | | | | Combination | | | | | | | | 371.399 | | | | | | |  | |  | |  |
|  |  | 286 | | | | | | | | | | | | | | | COMB15 | | | | | | | | | Combination | | | | | | | | 376.105 | | | | | | |  | |  | |  |
|  |  | 287 | | | | | | | | | | | | | | | COMB15 | | | | | | | | | Combination | | | | | | | | 347.977 | | | | | | |  | |  | |  |
|  |  |  | | | | | | | | | | | | | | |  | | | | | | | | |  | | | | | | | | 7509.304 | | | | | | |  | |  | |  |
|  |  |  | | | | | | | | | | | | | | |  | | | | | | | | |  | | | | | | | |  | | | | | | |  | |  | |  |
|  | | | | | |  | | | |  | | |  | | | | |  | | | |  | | | | | |  | | |  | | | |  | | | |  | | | | | | | | |  | | | |  |  |  |
| **IV EARTHQUAKE LOAD CALCULATION** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |  | | | | | | | | |  | | | |  |  |  |
| **Lateral load distribution** | | | | | | | | | | | | | | | | | | | | | | | | | | | |  | | |  | | | |  | | | |  | | | | | | | | |  | | | |  |  |  |
|  | | | | | |  | | | |  | | |  | | | | |  | | | |  | | | | | |  | | |  | | | |  | | | |  | | | | | | | | |  | | | |  |  |  |
| Type of soil = | | | | | | | | | | medium | | |  | | | | |  | | | |  | | | | | |  | | |  | | | |  | | | |  | | | | | | | | |  | | | |  |  |  |
| Height of building (H) = | | | | | | | | | | 12.000 | | | m | | | | |  | | | |  | | | | | |  | | |  | | | |  | | | |  | | | | | | | | |  | | | |  |  |  |
| base dimenstion of building at the plinth level (d) in X-direction = | | | | | | | | | | | | | | | | | | | | | | | | | | | | 20.60 | | | m | | | |  | | | |  | | | | | | | | |  | | | |  |  |  |
| base dimenstion of building at the plinth level (d) in Y-direction = | | | | | | | | | | | | | | | | | | | | | | | | | | | | 6.60 | | | m | | | |  | | | |  | | | | | | | | |  | | | |  |  |  |
| Time Period in X-direction = | | | | | | | | | | | | | 0.075H 0.75 = | | | | | | | | | 0.484 | | | | | | clause IS 1893:2002; 7.6.1 | | | | | | | | | | |  | | | | | | | | |  | | | |  |  |  |
| Time Period in Y-direction = | | | | | | | | | | | | | 0.075H 0.75 = | | | | | | | | | 0.484 | | | | | | clause IS 1893:2002; 7.6.1 | | | | | | | | | | |  | | | | | | | | |  | | | |  |  |  |
| Sa/g (X-dir) = | | | | | | | | | | 2.500 | | | Check | | | | |  | | | |  | | | | | | clause IS 1893:2002; 6.4.5 | | | | | | | | | | |  | | | | | | | | |  | | | |  |  |  |
| Sa/g (Y-dir) = | | | | | | | | | | 2.500 | | |  | | | | |  | | | |  | | | | | | clause IS 1893:2002; 6.4.5 | | | | | | | | | | |  | | | | | | | | |  | | | |  |  |  |
| Zone factor (Z) = | | | | | | | | | | 0.360 | | | for Zone V | | | | | | | | |  | | | | | | clause IS 1893:2002; Table 2 | | | | | | | | | | |  | | | | | | | | |  | | | |  |  |  |
| Importance factor (I)= | | | | | | | | | | 1.500 | | |  | | | | |  | | | |  | | | | | |  | | |  | | | |  | | | |  | | | | | | | | |  | | | |  |  |  |
| Response reduction factor (R)= | | | | | | | | | | | | | 5 | | | | | for special RCC building | | | | | | | | | | clause IS 1893:2002; Table 7 | | | | | | | | | | |  | | | | | | | | |  | | | |  |  |  |
|  | | | | | |  | | | |  | | |  | | | | |  | | | |  | | | | | |  | | |  | | | |  | | | |  | | | | | | | | |  | | | |  |  |  |
| **Seismic coefficient (Ah)** = (Z/2)\*(I/R)\*(Sa/g) = | | | | | | | | | | | | | | | | | | | | | | **0.135** | | | | | | clause IS 1893:2002; 6.4.2 | | | | | | | | | | |  | | | | | | | | |  | | | |  |  |  |
|  | | | | | |  | | | |  | | |  | | | | |  | | | |  | | | | | |  | | |  | | | |  | | | |  | | | | | | | | |  | | | |  |  |  |
|  | | | | | |  | | | |  | | |  | | | | |  | | | |  | | | | | |  | | |  | | | |  | | | |  | | | | | | | | |  | | | |  |  |  |
| **Seismic Weight (W)=** | | | | | | | | | | 7509.304 | | |  | | | | |  | | | | | | | | | |  | | |  | | | |  | | | |  | | | | | | | | |  | | | |  |  |  |
|  | | | | | |  | | | |  | | |  | | | | |  | | | | | | | | | |  | | |  | | | |  | | | |  | | | | | | | | |  | | | |  |  |  |
| Base Shear | | | | | | (vb)= | | | | Ah\*W | | | 1013.756 | | | | |  | | | | | | | | | |  | | |  | | | |  | | | |  | | | | | | | | |  | | | |  |  |  |
| U= | | | | | | (Trem/Tuse)0.5 | | | | | | |  | | | | |  | | | |  | | | | | |  | | |  | | | |  | | | |  | | | | | | | | |  | | | |  |  |  |
|  | | | | | |  | | | |  | | |  | | | | |  | | | |  | | | | | |  | | |  | | | |  | | | |  | | | | | | | | |  | | | |  |  |  |
|  | | | | | | 0.987 | | | |  | | |  | | | | |  | | | |  | | | | | |  | | |  | | | |  | | | |  | | | | | | | | |  | | | |  |  |  |
| Hence Taking U= | | | | | | | | | | | | | 1 | | | | |  | | | |  | | | | | |  | | |  | | | |  | | | |  | | | | | | | | |  | | | |  |  |  |
|  | | | | | |  | | | |  | | |  | | | | |  | | | |  | | | | | |  | | |  | | | |  | | | |  | | | | | | | | |  | | | |  |  |  |
| Final Base Shear | | | | | | | | | | (fvb)= | | | vb\*U= | | | | | 1013.756 | | | |  | | | | | |  | | |  | | | |  | | | |  | | | | | | | | |  | | | |  |  |  |
|  | | | | | |  | | | |  | | |  | | | | |  | | | | | | | | | |  | | |  | | | |  | | | |  | | | | | | | | |  | | | | 7509.306 | 1013.756 |  |
| Program Generated Base Shear along X direction | | | | | | | | | | | | | | | | | | | | | |  | | | | | |  | | |  | | | |  | | | |  | | | | | | | | |  | | | | 7509.306 | 1013.756 |  |
| **Base shear Vb x =** Ah X W **=** | | | | | | | | | | | | | 1013.756 | | | | | **KN** | | | |  | | | | | |  | | |  | | | |  | | | |  | | | | | | | | |  | | | |  |  |  |
|  | | | | | |  | | | |  | | |  | | | | |  | | | |  | | | | | |  | | |  | | | |  | | | |  | | | | | | | | |  | | | |  |  |  |
| Program Generated Base Shear along Y direction | | | | | | | | | | | | | | | | | | | | | |  | | | | | |  | | |  | | | |  | | | |  | | | | | | | | |  | | | |  |  |  |
| **Base shear Vb y =** Ah X W **=** | | | | | | | | | | | | | 1013.756 | | | | | **KN** | | | |  | | | | | |  | | |  | | | |  | | | |  | | | | | | | | |  | | | |  |  |  |
|  | | | | | |  | | | |  | | |  | | | | |  | | | |  | | | | | |  | | |  | | | |  | | | |  | | | | | | | | |  | | | |  |  |  |
|  | | | | | **TABLE-2 FOUNDATION LOAD** | | | | | | | | | | | | | | |  | | | | | | |
|  | | | | |  | | |  | | | | | |  | | | | | |  | | | | | | |
|  | | | | | **TABLE: Joint Reactions** | | | | | | | | |  | | | | | |  | | | | | | |
|  | | | | | **Joint** | | | **OutputCase** | | | | | | **CaseType** | | | | | | **F3** | | | | | | |
|  | | | | | Text | | | Text | | | | | | Text | | | | | | KN | | | | | | |
|  | | | | | 262 | | | COMB14 | | | | | | Combination | | | | | | 532.936 | | | | | | |
|  | | | | | 263 | | | COMB14 | | | | | | Combination | | | | | | 556.27 | | | | | | |
|  | | | | | 264 | | | COMB14 | | | | | | Combination | | | | | | 529.728 | | | | | | |
|  | | | | | 265 | | | COMB14 | | | | | | Combination | | | | | | 528.937 | | | | | | |
|  | | | | | 266 | | | COMB14 | | | | | | Combination | | | | | | 529.466 | | | | | | |
|  | | | | | 267 | | | COMB14 | | | | | | Combination | | | | | | 532.053 | | | | | | |
|  | | | | | 268 | | | COMB14 | | | | | | Combination | | | | | | 720.727 | | | | | | |
|  | | | | | 269 | | | COMB14 | | | | | | Combination | | | | | | 502.435 | | | | | | |
|  | | | | | 270 | | | COMB14 | | | | | | Combination | | | | | | 775.607 | | | | | | |
|  | | | | | 271 | | | COMB14 | | | | | | Combination | | | | | | 877.348 | | | | | | |
|  | | | | | 273 | | | COMB14 | | | | | | Combination | | | | | | 693.883 | | | | | | |
|  | | | | | 274 | | | COMB14 | | | | | | Combination | | | | | | 694.938 | | | | | | |
|  | | | | | 275 | | | COMB14 | | | | | | Combination | | | | | | 780.461 | | | | | | |
|  | | | | | 277 | | | COMB14 | | | | | | Combination | | | | | | 696.961 | | | | | | |
|  | | | | | 278 | | | COMB14 | | | | | | Combination | | | | | | 850.406 | | | | | | |
|  | | | | | 279 | | | COMB14 | | | | | | Combination | | | | | | 677.006 | | | | | | |
|  | | | | | 280 | | | COMB14 | | | | | | Combination | | | | | | 702.167 | | | | | | |
|  | | | | | 281 | | | COMB14 | | | | | | Combination | | | | | | 809.119 | | | | | | |
|  | | | | | 282 | | | COMB14 | | | | | | Combination | | | | | | 667.406 | | | | | | |
|  | | | | | 283 | | | COMB14 | | | | | | Combination | | | | | | 669.071 | | | | | | |
|  | | | | | 284 | | | COMB14 | | | | | | Combination | | | | | | 756.248 | | | | | | |
|  | | | | | 285 | | | COMB14 | | | | | | Combination | | | | | | 667.698 | | | | | | |
|  | | | | | 286 | | | COMB14 | | | | | | Combination | | | | | | 695.685 | | | | | | |
|  | | | | | 287 | | | COMB14 | | | | | | Combination | | | | | | 704.81 | | | | | | |
|  | | | | |  | | |  | | | | | | Total | | | | | | 16151.37 | | | | | | |

column 300\*300

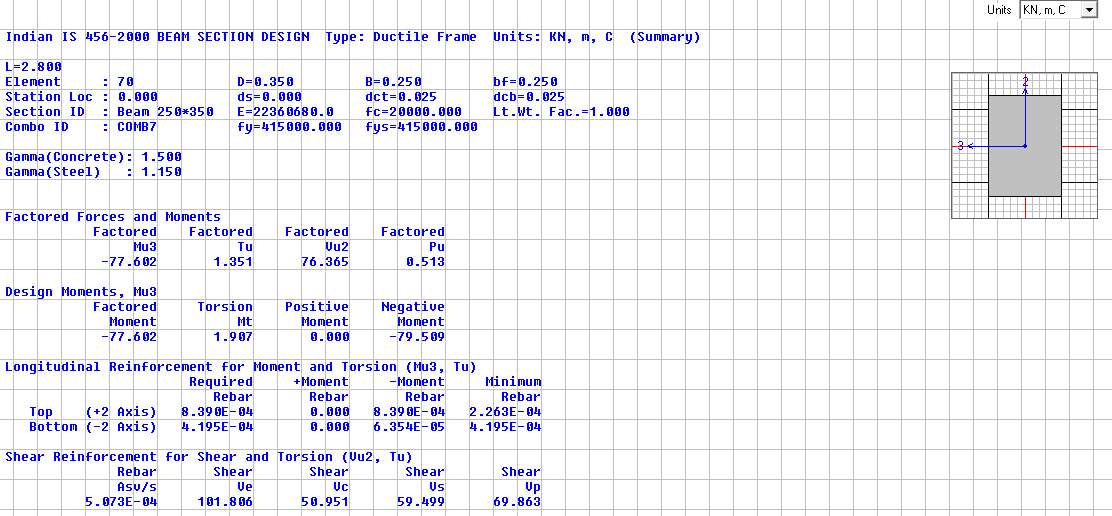


Beam design

bm 250\*450

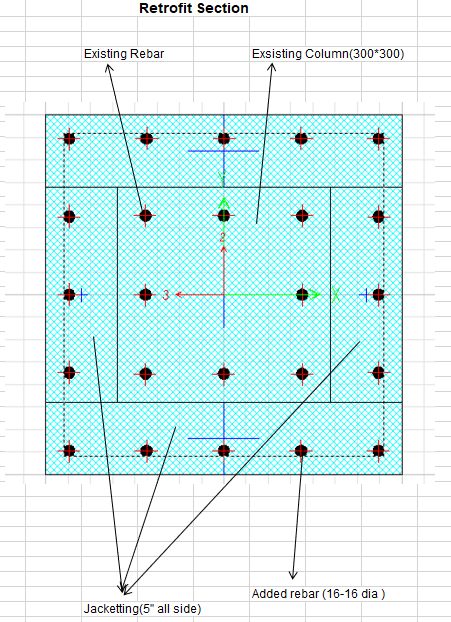
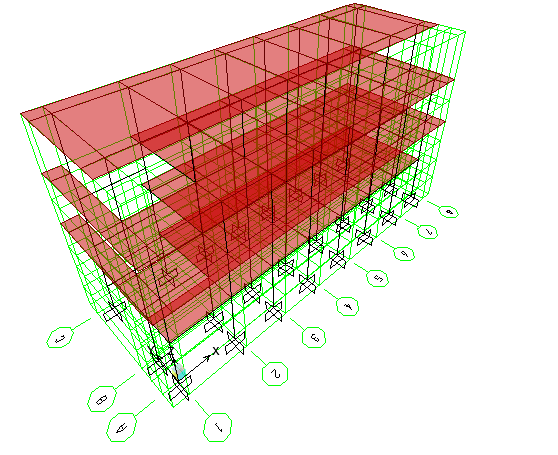


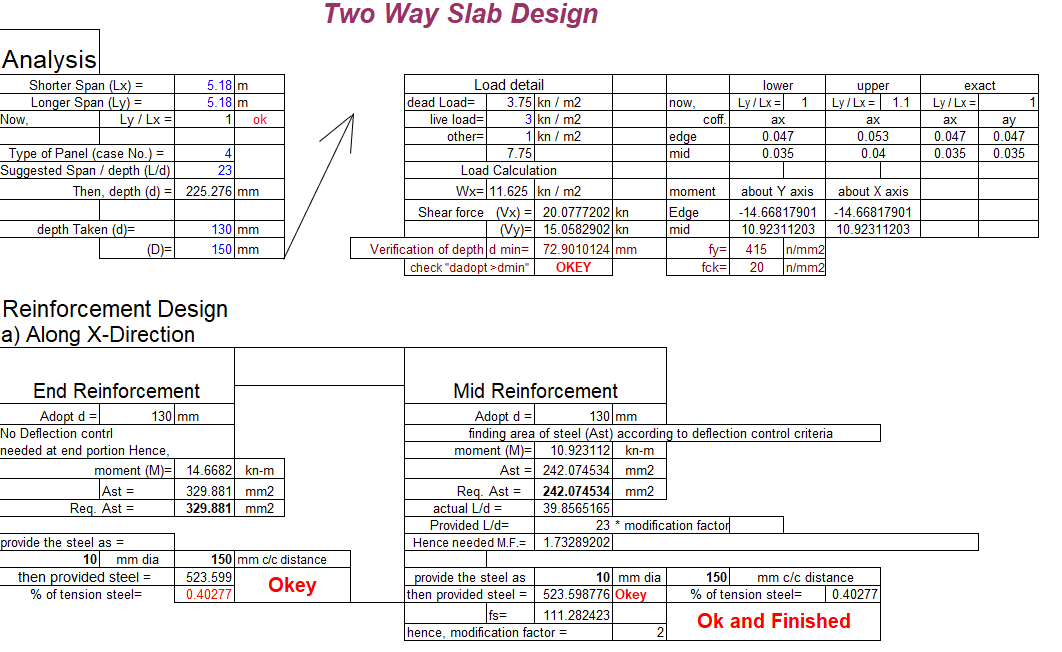
bm 250\*350

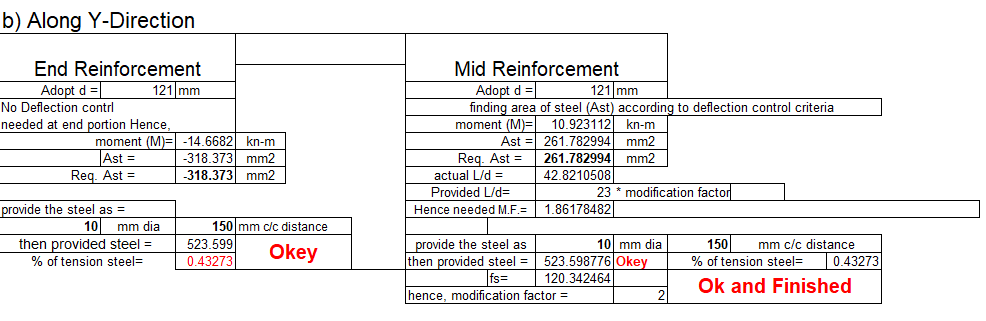


|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **TABLE-3** **Joint Reactions** | | | | | |  |  |  |
|  |  |  |
| **TABLE: Joint Reactions** | | |  |  |  |  |  |  |
| **Joint** | **OutputCase** | **CaseType** | **F3** | **Design Load** | **Bearing Load** | **Area required** | **Area Provided** | **Remarks** |
| **Text** | **Text** | **Text** | **KN** | **KN** | **KN/m^2** | **m^2** | **m^2** |  |
| 262 | COMB14 | Combination | 532.936 | 390.82 | 100 | 3.91 | 1.21 | micropiling Required |
| 263 | COMB14 | Combination | 556.27 | 407.93 | 100 | 4.08 | 1.21 | micropiling Required |
| 264 | COMB14 | Combination | 529.728 | 388.47 | 100 | 3.88 | 1.21 | micropiling Required |
| 265 | COMB14 | Combination | 528.937 | 387.89 | 100 | 3.88 | 1.21 | micropiling Required |
| 266 | COMB14 | Combination | 529.466 | 388.28 | 100 | 3.88 | 1.21 | micropiling Required |
| 267 | COMB14 | Combination | 532.053 | 390.17 | 100 | 3.90 | 1.21 | micropiling Required |
| 268 | COMB14 | Combination | 720.727 | 528.53 | 100 | 5.29 | 1.21 | micropiling Required |
| 269 | COMB14 | Combination | 502.435 | 368.45 | 100 | 3.68 | 1.21 | micropiling Required |
| 270 | COMB14 | Combination | 775.607 | 568.78 | 100 | 5.69 | 1.69 | micropiling Required |
| 271 | COMB14 | Combination | 877.348 | 643.39 | 100 | 6.43 | 1.69 | micropiling Required |
| 273 | COMB14 | Combination | 693.883 | 508.85 | 100 | 5.09 | 1.69 | micropiling Required |
| 274 | COMB14 | Combination | 694.938 | 509.62 | 100 | 5.10 | 1.69 | micropiling Required |
| 275 | COMB14 | Combination | 780.461 | 572.34 | 100 | 5.72 | 1.69 | micropiling Required |
| 277 | COMB14 | Combination | 696.961 | 511.10 | 100 | 5.11 | 1.96 | micropiling Required |
| 278 | COMB14 | Combination | 850.406 | 623.63 | 100 | 6.24 | 1.69 | micropiling Required |
| 279 | COMB14 | Combination | 677.006 | 496.47 | 100 | 4.96 | 1.69 | micropiling Required |
| 280 | COMB14 | Combination | 702.167 | 514.92 | 100 | 5.15 | 1.69 | micropiling Required |
| 281 | COMB14 | Combination | 809.119 | 593.35 | 100 | 5.93 | 1.69 | micropiling Required |
| 282 | COMB14 | Combination | 667.406 | 489.43 | 100 | 4.89 | 1.69 | micropiling Required |
| 283 | COMB14 | Combination | 669.071 | 490.65 | 100 | 4.91 | 1.69 | micropiling Required |
| 284 | COMB14 | Combination | 756.248 | 554.58 | 100 | 5.55 | 1.69 | micropiling Required |
| 285 | COMB14 | Combination | 667.698 | 489.65 | 100 | 4.90 | 1.69 | micropiling Required |
| 286 | COMB14 | Combination | 695.685 | 510.17 | 100 | 5.10 | 1.96 | micropiling Required |
| 287 | COMB14 | Combination | 704.81 | 516.86 | 100 | 5.17 | 1.69 | micropiling Required |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **TABLE -3 Top Storey Deflection** | | | |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
| **TABLE: Joint Displacements** |  |  |  |  |  |  |  |  |
| **Joint** | **OutputCase** | **CaseType** | **U1** | **Allowable deflection** |  |  |  |  |
| Text | Text | Text | mm | mm |  |  |  |  |
| 204 | EQX | LinStatic | 15.10 | 48 |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
| **TABLE -4 Time Period** | | |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
| **TABLE: Modal Periods And Frequencies** |  |  |  |  |  |  |  |  |
| **OutputCase** | **StepType** | **StepNum** | **Period** |  |  |  |  |  |
| Text | Text | Unitless | Sec |  |  |  |  |  |
| MODAL | Mode | 1 | 0.466 |  |  |  |  |  |
| MODAL | Mode | 2 | 0.446 |  |  |  |  |  |
| MODAL | Mode | 3 | 0.405 |  |  |  |  |  |
| MODAL | Mode | 4 | 0.158 |  |  |  |  |  |
| MODAL | Mode | 5 | 0.156 |  |  |  |  |  |
| MODAL | Mode | 6 | 0.139 |  |  |  |  |  |
| MODAL | Mode | 7 | 0.085 |  |  |  |  |  |
| MODAL | Mode | 8 | 0.084 |  |  |  |  |  |
| MODAL | Mode | 9 | 0.076 |  |  |  |  |  |
| MODAL | Mode | 10 | 0.061 |  |  |  |  |  |
| MODAL | Mode | 11 | 0.057 |  |  |  |  |  |
| MODAL | Mode | 12 | 0.055 |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
| **TABLE -5 Drift** | |  |  |  |  |  |  |  |
| According to IS 1893:2002 Clause 7.11.1 | | | |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
| **TABLE: Joint Displacements** |  |  |  | **Inter Storey Drift** | **Height** | **Drift Limitation** | **Check** |  |
| **Joint** | **OutputCase** | **CaseType** | **U1** |  |  | **0.004 x H** | **0.004 x H >** |  |
| Text | Text | Text | mm | mm | H (m) | mm | ID |  |
| 287 | EQx | LinStatic | 0.00 | 0 | 0 | 0 | PASS |  |
| 35 | EQx | LinStatic | 2.56 | 2.56 | 3 | 12 | PASS |  |
| 63 | EQx | LinStatic | 6.96 | 4.41 | 3 | 12 | PASS |  |
| 87 | EQx | LinStatic | 11.09 | 4.12 | 3 | 12 | PASS |  |
| 215 | EQx | LinStatic | 15.10 | 4.01 | 3 | 12 | PASS |  |
|  |  |  |  |  |  |  |  |  |
| **TABLE -6 Joint Displacements** |  |  |  |  |  |  |  |  |
| **TABLE: Joint Displacements** |  |  |  | **Inter Storey Drift** | **Height** | **Drift Limitation** | **Check** |  |
| **Joint** | **OutputCase** | **CaseType** | **U2** |  |  | **0.004 x H** | **0.004 x H >** |  |
| Text | Text | Text | mm | mm | H (m) | mm | ID |  |
| 287 | EQy | LinStatic | 0.00 | 0.00 | 3 | 12 | PASS |  |
| 35 | EQy | LinStatic | 2.40 | 2.40 | 3 | 12 | PASS |  |
| 63 | EQy | LinStatic | 6.35 | 3.95 | 3 | 12 | PASS |  |
| 87 | EQy | LinStatic | 10.07 | 3.72 | 3 | 12 | PASS |  |
| 215 | EQy | LinStatic | 13.86 | 3.79 | 3 | 12 | PASS |  |

3d model in SAP





**V Conclusion**

The design and detailing of the mentioned building has been conducted using SAP consideration of the earthquake load in strengthening f the building and durability of the structure.

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