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

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**Abstract**

Although Seismic effect can be predicted when it occurs but it is certain that when it occurs the severity of damage will be significant. Like many urban areas in developing countries, Nepal’s risk is increased significantly basically in regard to earthquake hazard. Uncontrolled development process, poor design and construction practice has further increased the seismic vulnerability. If a large earthquake hits the area, it will cause heavy loss of life and properties. So, it is highly recommended to design and construct the structure s in cities like Kathmandu with due consideration to the seismic load to minimize the structural damage and reduce the casualties when a large earthquake hits the area. n view of this, the design and detailing of the mentioned building has been conducted with due consideration of the earthquake load and its summary has been presented herewith.

**I Introduction**

Earthquake is one of the most dreaded natural disasters. Vibration of earth’s surface caused by waves coming from a source of disturbances inside the earth are described as earthquakes It is a natural phenomenon, which depends upon various factors. It becomes considerably destructive when it affects an ever larger concentration of material property and population. The occurrence of earthquake is frequent in Nepal. This is because Nepal lies in the Himalayan range where continental tectonic plates collide causing Indian plate to subduct with Eurasian plate. This has caused built up of tremendous strain energy causing abrupt failure of rock masses along the faults, which in their turn cause earthquakes. Nepal has already witnessed large earthquakes causing heavy loss of life and property. The earthquakes of 1934 and 1988 and April 2015(Gorkha Earthquake) are the recent ones. It is believed that the medium earthquake occurs in Nepal in every 50 years and major earthquake occurs in an interval of 100 years. It is highly expected that another major earthquake is due in near future.

Keywords- Retrofiting,Strengthening,SAP

Retrofiting design – background

The aftermath of an earth quake manisfests great devastation due to unpredicted seismic motion striking extensive damage to innumerable buildings of varying degree i.e either full or partial or sligth. This damage to Structures in its turn cause a irreparable loss of the life with a large number of casualties. As a result frightened occupants may refuse to enter the buildings unless assured of the safety of the buildings. from future earthquakes. It has been observed that majority of such earthquake damaged buildings may be safely reused, if they are converted into seismically resistant structures by employing a few retrofitting measures. This proves to be a better option catering to the economic considerations and immediate shelter problems rather than replacements of buildings. Moreover it has often been seen that retrofitting of buildings is generally more economical as compared to demolition and reconstruction even in the case of severe structural damage. Therefore, seismic retrofitting of building structures is one of the most important aspect for mitigating seismic hazard especially in earthquake-prone countries. The need of seismic retrofitting of buildings arises under two circumstances: (I) earthquake-damage buildings and (ii) earthquake-vulnerable buildings that have not yet experience severe earthquakes.

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 employed as a repair or steengthrning scheme. Damaged regions of the exeisting members should be repaired prior to their jacketing. There are two main purpose of jacketing of columns: (i) increse in the shear capacity of columns in order to accompolish a strong column-weak beam design and (ii) to improve the column's flexural strength by the longitudnal steel of the jacket made continuous through the slab system and anchored with the foundation. It is achived by passing the new longitudnal reinforcement through holes driled in slab and by placing new concrete in the beam column joints.

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:

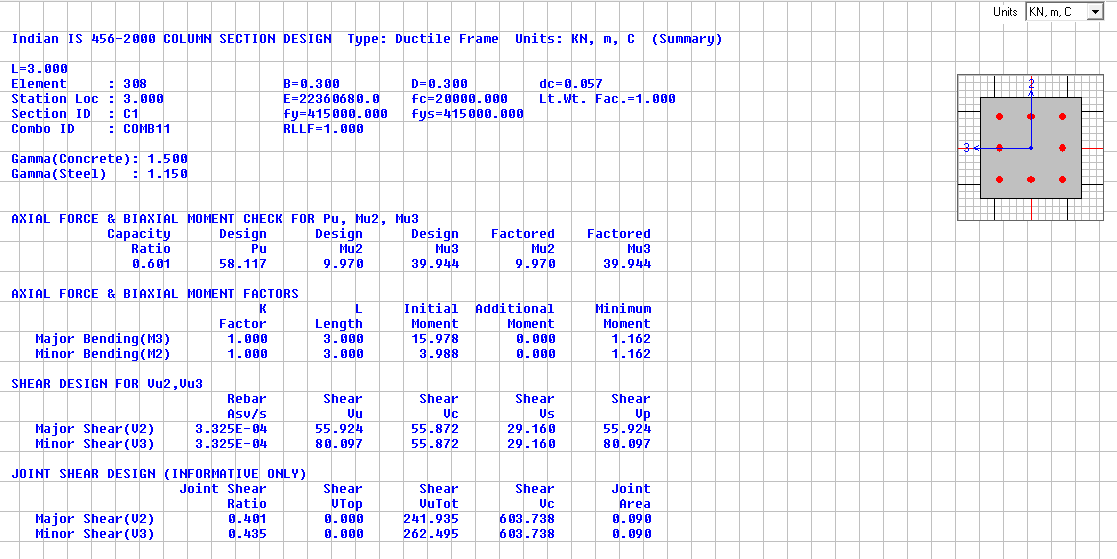
|  |
| --- |
| 1. 10 cm for concrete cast in place and 4 cm for shotcrete |
| 2. If possible, four-sided jacket should be used  3. Narrow gap should be provided to prevent any possible increase in flexular capacity |
| Minimum area of longitudinal reinforcement:  1. Spacing should not exceed six times 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. |
|  |
|  |

**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.** | | | | | |  |

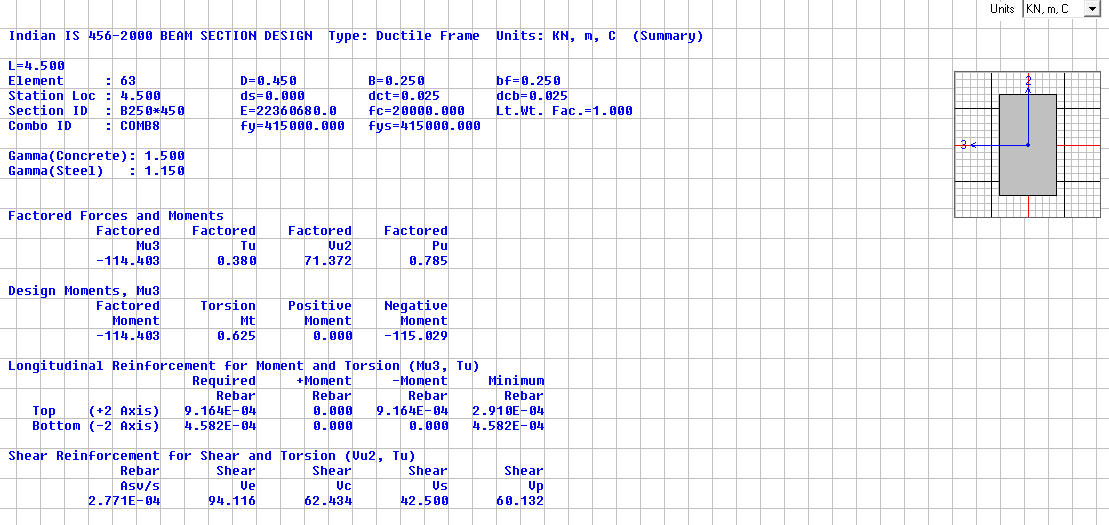
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| **II DESIGN DATA** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
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| 1 | | | | Building Type | | | | | | | | : | | | | Educational Building | | | | | | | | | | | | | | | | | | | | | | | | | |
|  | | | |  | | | | |  | | |  | | | |  | | | | |  | | | | | | | | |  | | |  | | | | |  | | | |
| 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 | | | | |  | | | |
|  | | | |  | | | | | | | |  | | | |  | | | | |  | | | | | | | | |  | | |  | | | | |  | | | |
| 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 | | |  | | | | |  | | | | | | |  | | | | | | |
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|  | | | | | | | **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

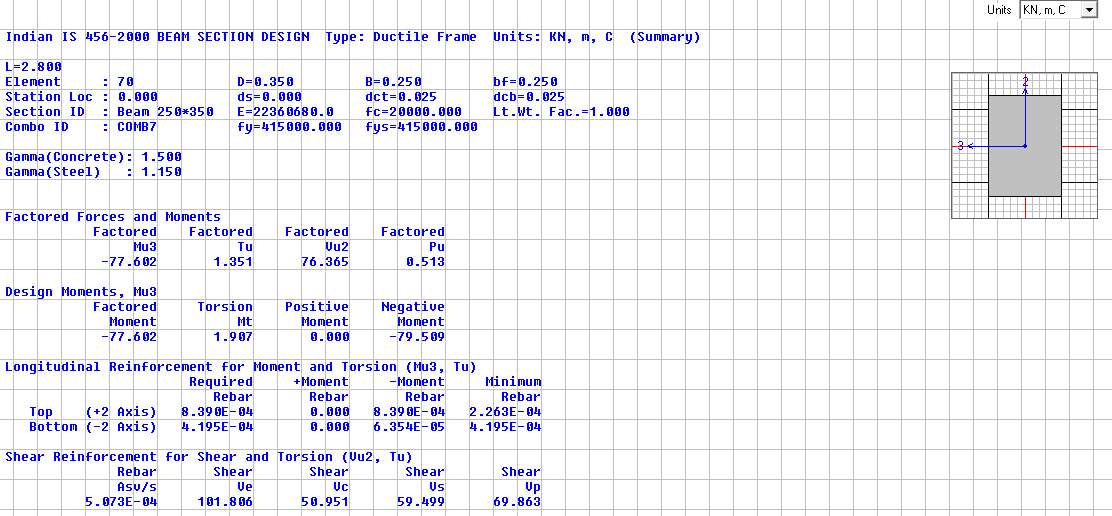


Beam design

bm 250\*450

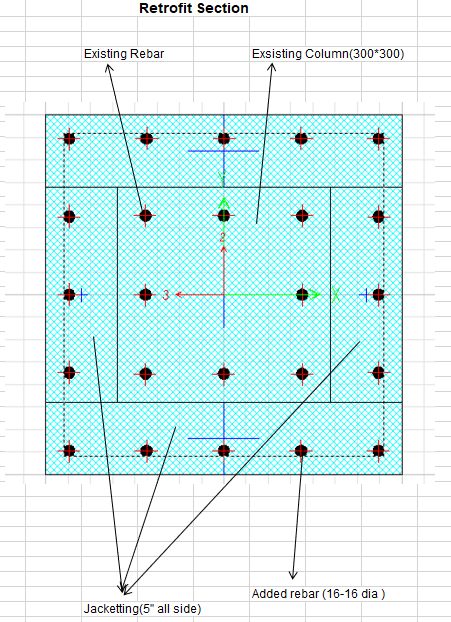
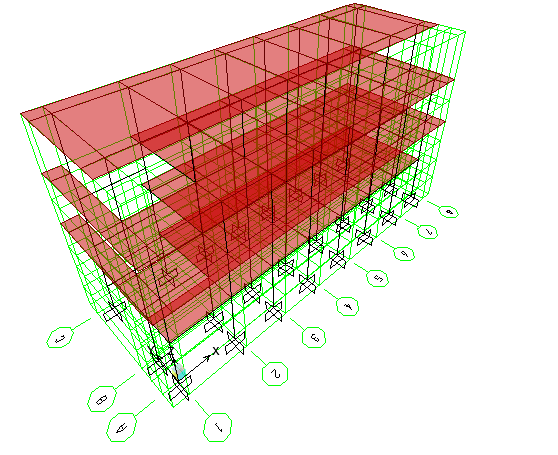


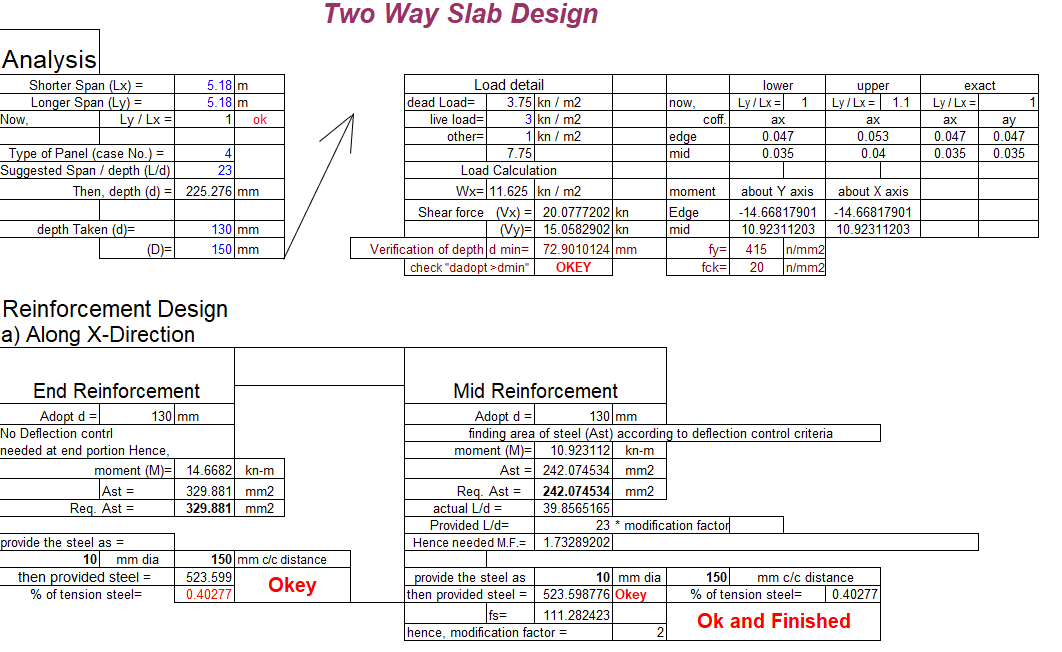
bm 250\*350

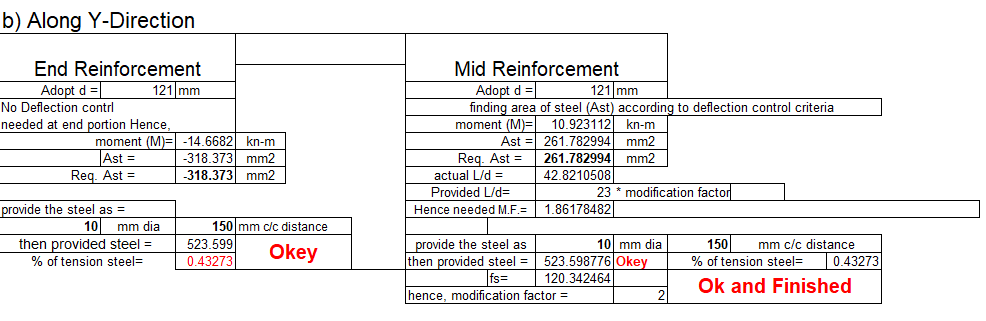


|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **TABLE-3** **Joint Reactions** | | | | | |  |  |  |
|  |  |  |
| **TABLE: Joint Reactions** | | |  |  |  |  |  |  |
| **Joint** | **OutputCase** | **CaseType** | **F3** | **Design Load** | **Bearing Load** | **Area 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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