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Design and Analysis of Earthquake Resistant Building (Three Storeyed R.C.C. School Building) using STAAD.PRO

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Abstract: ***The field of Earthquake Engineering has existed in our country for over 35 years now. Indian earthquake engineers have made significant contributions to the seismic safety of several important structures in the country. However, as the recent earthquakes have shown, the performance of normal structures during past Indian earthquakes has been less satisfactory. This is mainly due to the lack of awareness amongst most practising engineers of the special provisions that need to be followed in earthquake resistant design and thereafter in construction. In India, the multi-storied building is constructed due to high cost and scarcity of land. In order to utilize maximum land area, builders and architects generally proposed asymmetrical plan configuration. These asymmetrical plan buildings, which are constructed in seismic prone areas, are likely to be damaged during earthquake. Earthquake is a natural phenomenon which can be generate the most destructive forces on structure. Buildings should be made Safe for lives by proper design and detailing of structural member in order to have a ductile form of failure.***
The concept of earthquake resistant design is that the building should be designed to resist the forces, which arises due to Design Basic Earthquake, with only minor damages and the forces which arises due to Maximum Considered Earthquake, with some accepted structural damages but no collapse. This paper studies the Earthquake Resisting Building.

I. INTRODUCTION

A. General Introduction

Earthquake is known to be one of the most destructive phenomena experienced the Earth. It is caused due to sudden release of energy in earth's crust which results in seismic waves. When the seismic waves reach the foundation level of the structure, it experiences horizontal and vertical motion at ground surface level. Due to this earthquake is responsible for the damages to various man-made structures like building, bridges, roads, dams, etc. it also causes landslides, liquefaction, Slope-instability and overall loss of life and property. The complete protection against earthquake of all sizes is not economically feasible for structure. The Seismic design should be such that it prevents loss of life and minimize the damage of the property.
The concept of earthquake resistant design is that the building should be designed to resist the forces, which arises due to Design Basic Earthquake, with only minor damages and the forces which arises due to Maximum Considered Earthquake, with some accepted structural damages but no collapse.

The design philosophy was established considering the following aspects:

1) The structure should withstand the moderate earthquakes, which may be expected to occur during the service life of structure with damage within acceptable limits. Such earthquakes are characterised as Design Basic Earthquake (DBE).
2) The structure should not collapse when subjected to severe ground motion that could possibly occur at the site. Such earthquakes are characterised as Maximum Considered Earthquake (MCE).

II. LITREATURE REVIEW

Earthquake-resistant or aseismic structures are designed to protect buildings to some or greater extent from earthquake. While no structure can be entirely immune to damage from earthquakes, the goal of earthquake resistant construction is to erect structures that fare better during seismic activity than their conventional counterparts. According to building codes, earthquake-resistant structures are intended to withstand the largest earthquake of a certain probability that is likely to occur at their location. This means the loss of life should be minimized by preventing collapse of the buildings for rare earthquakes while the loss of the functionality should be limited for more frequent ones.

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A. Flanged Beams

There are two types of flanged beam-

1) T-beam
2) L-beam

B. Columns

1) A column may be defined as an element used primarily support axial compressive loads and with a height of a least three times its lateral dimension.
2) The strength of column depends upon the strength of materials, shape and size of cross section, length and degree of proportional and dedicational restrains at its ends.

C. Slabs

1) Slabs are most widely used structural elements forming floor and roof of building. Slab support mainly transverse load and transfer them to supports by bending actions more or one direction.
2) On basis of spanning direction: It is two type one-way slabs and two-way slabs
a) *One Way Slab:* -One way slab is a slab which is supported by beams on the two opposite sides to carry the load along one direction. The ratio of longer span (l) to shorter span (b) is equal or greater than 2, considered as One way slab because this slab will bend in one direction i.e., in the direction along its shorter span
b) *Two Way Slabs:* -Two-way slabs are slabs that are supported on four sides. In two-way slabs, the load will be carried in both directions, thus main reinforcement is provided in both directions for two-way slabs. The slabs are considered as spanning two-way when the longer to shorter span length is less than a ratio of two**.**

D. Seismic Zones In India

India is divided into 5 main zones: -

1) Zone1: minor damage
2) Zone2: little more than minor damage
3) Zone3: moderate damage
4) Zone4: high damage
5) Zone5: highest amount of damage

E. Vertical Development And Horizontal Development

1) Vertical Development

a) Vertical construction includes construction projects that stretch vertically like apartment buildings, office buildings, skyscrapers, and other types of commercial buildings.
b) Vertical construction projects utilize the talents of architects to design buildings that are structurally sound, safe, and aesthetically pleasing.
c) Because of this, there is often an overlap of blue-collar workers and architects who view themselves as artistic visionaries.
d) Another important distinction is that many vertical construction projects are funded privately, whereas horizontal construction projects are generally funded by the government.

2) Horizontal Development

a) They are often referred to as heavy civil construction, is often associated with structures that are no longer than they are tall
b) They are usually small in height and thus long
c) Major difference is that they rarely have to correspond with an architect, which is often preferred by contractors and their employees.
d) Typically, in this construction projects, the structural engineer acts as the project manager, which means an entity with closer ties to industry is in control.

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F. Properties

1) Ductility

a) Provided in beams and columns
b) Major topic considered
c) If no ductility- building will be collapsed
d) But if provided, structure will have movement, beam column may have repairable damages but building wont collapse.

2) Building Configuration

a) GEOMETRY
b) SIZE OF THE BUILDING
c) HORIZONTAL LAYOUTING
d) VERTICAL LAYOUTING

3) Floating Columns

Floating column is a column member that is constructed over the beam, unlike normal columns.
The floating column construction is a new development made to serve a certain architectural purpose in the building construction.
The load transfer is directly done by the non-floating column where it is safely transferred to the foundation.
In case of floating column, the load is taken by the below beam.
The column is arranged as a point lead over the beam. The load is equally distributed to the beam.

4) Pounding

Pounding is a phenomenon, in which two buildings strike due to their lateral movements induced by lateral forces"
Seismic pounding is defined as the collision of adjacent buildings during earthquakes"
Pounding of adjacent buildings can be very dangerous because adjacent buildings have different dynamic characteristics which cause their out of phase vibration during earthquake.
Thus, cause damage due to insufficient gap or improper energy dissipation systems, to accommodate the relative motion of these buildings
The main reason of the seismic pounding is the provision of insufficient gap or no gap in the building

G. Guidelines For Earthquake Resistant Structures

1) Design of building should be based on seismic codes is 1893 (part 1) 2002 & is 13920-1993.
2) Integral action of soil-foundation-superstructure system.
3) Building should be light in weight and avoid unnecessary masses.
4) Structure should not have large height to width ratio.
5) Columns & walls should be continuous without offsets from the roof to the foundation.
6) Beams and columns should be of equal width.
7) The structure should be ductile as far as possible.
8) Structure should have uniform floor height
9) Structure should be designed on strong column weak beam concept.

III. DESIGN AND ANALYSIS PROCEDURE

A. Design Procedure

1) Step 1: - Lumped Masses To Various Floor Levels

Dead load and live load of floor and roof is calculated and then added and the sum is called "Total Design Seismic Load". (denoted by "W")

2) Step 2: - Fundamental Natural Period(Ta)

Ta=0.09h where, h= height of building { IS 1893-2002 Page no-24}

d= base dimension of building

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3) *Step 3: - Design Seismic Base Shear (Vb)*

shear created will be at base/ground:

Vb=Ah*W { Page no 24}

W= total seismic weight of building

$$Ah = \frac{Z*I}{2*R} \quad \frac{Sa}{g}$$ {IS CODE Page no. 14}

Where, Z= zone factor ----- IS 1893, Table-2, Page no.-16

I= importance factor -----IS 1893, Table-6, Page no.-18

Sa/g = average response acceleration coefficient ------IS 1893, Page no. -16

R= response reduction factor -----IS 1893, Table-7, page no. -23

4) *Step 4: - Vertical Distribution Of Base Shear*

$$Q_i = V_B \frac{W_i h_i^2}{\sum_{j=1}^{n} W_j h_j^2}$$

Where,

Qi=design lateral force at floor i
Wi= seismic weight of floor i
h1= height of floor rom base(m)
n= number of storeys

IV. QUESTION SOLVED AND ANALYSED USING STAADPRO SOFTWARE

Question: The plan and elevation of three storey R.C.C. school building is shown in figure. The intensity of dead load is 12kn/m^2 (including columns, beams, and walls) and live load is 4kn/m^2. The building is situated in zone iv. The type of soil encountered is medium soil and it is proposed to design the building with a special moment resisting frame (SMRF). Determine the seismic forces and shears at each floor level using static coefficient method.

V. SUGGESTIONS

A. Avoid weak column and strong beam design
B. Provide thick slab which will help as a rigid diaphragm
C. Provide cross walls which will stiffen the structures.
D. Provide shear walls in symmetrical pattern
E. Increase transverse (shear) reinforcement
F. Horizontal lintel band must be provided
G. The building must be regular and symmetrical in the shape.
H. Reinforcing bars should be provided at the corners and the junctions of walls.

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VI. CONCLUSION

Earthquakes shake the ground surface, can cause buildings to collapse, disrupt transport and services, and can cause fires. They can trigger landslides and tsunami.

Earthquakes occur mainly as a result of plate tectonics, which involves blocks of the Earth moving about the Earth's surface. The blocks of rock move past each other along a fault. Smaller earthquakes, called foreshocks, may precede the main earthquake, and aftershocks may occur after the main earthquake. Earthquakes are mainly confined to specific areas of the Earth known as seismic zones, which coincide mainly with ocean trenches, mid-ocean ridges, and mountain ranges.

The point of origin of an earthquake is called the focus. The epicentre is the point on the Earth's surface directly above the focus. Most earthquake foci are within a few tens of kilometres of the Earth's surface. Earthquakes less than 70 km deep are classified as shallow-focus. Intermediate-focus earthquakes are 70-300 km deep, and deep-focus earthquakes more than 300 km deep. Shallow-focus earthquakes occur in all of the Earth's seismic zones, but intermediate- and deep-focus earthquakes are almost exclusively associated with seismic zones near ocean trenches.

The destructiveness of an earthquake depends on the size, the depth (shallow ones are more destructive) and the location. Earthquake size can be stated in terms of the damage caused (the intensity) or the amount of ground motion and the energy released by the earthquake (related to the Richter magnitude).

Also learnt about the various techniques used for calculation of earthquake load or seismic load. And calculation of seismic load and design of aseismic building theoretically (by using static coefficient method) and practically (by using staad pro software).

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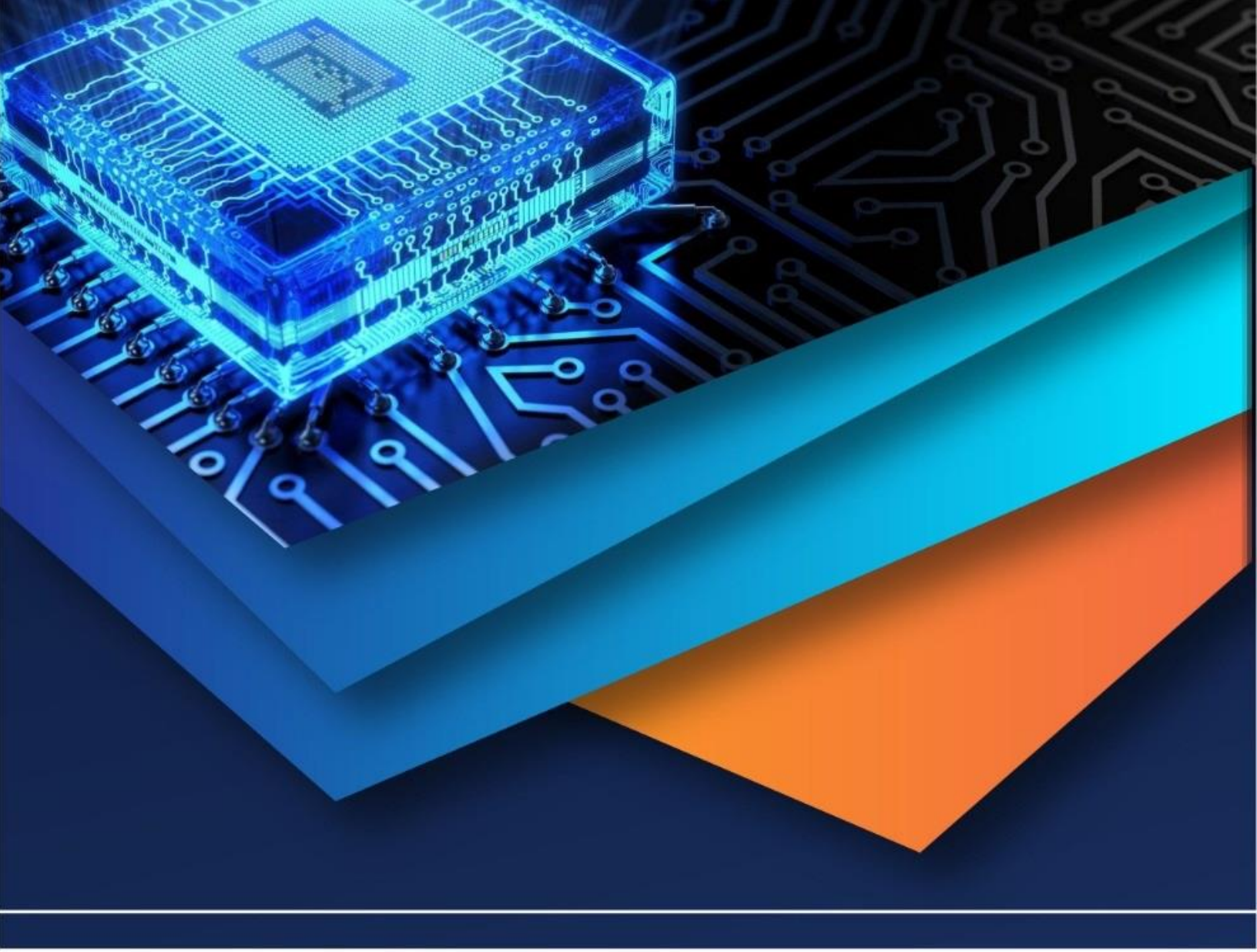

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