HANDOUT NOTES

EARTHQUAKE RESISTANT BUILDING :

1. Earthquake resistant design is not earthquake proof design.
2. Sufficient lateral stiffness is required to ensure that building does not get damaged under minor shaking.
3. The frame should be consistent under major earthquakes also, although it is allowed to get deformed or have more deflections.
4. Structural designers have the duty to consider that the structure would be subjected to an earthquake atleast once during the life time of the structure for which it is designed.
5. Four virtues of the Earthquake resistant structure are :
    1. Good seismic configuration – i.e. Least complexities
    2. Lateral stiffness
    3. Lateral Strength
    4. Good overal ductility

For working out the earthquake loading on a building frame, the dead load and imposed load and

weights are to be lumped at each column top on the basis of contributory areas. The imposed load is

to be reduced as specified in IS: 1893 (Part1)-2002 for seismic load determination. Let us call them

Wi at ith floor and Wnat the nth level at the roof level for a n-storey building. Hence the total load

at the base of the building just above the foundation will be

n

$W = \Sigma\ i=1$

W i + Wo

where Wo is the weight of elements in the ground storey.

--> IS 13920:1993 Ductile Detailing of Reinforced Concrete Structures Subjected to Seismic Forces – Code of Practice

--> IS: 4326-1993, "Earthquake Resistant Design and Construction of Buildings - Code of Practice (Second Revision)"

--> IS: 456 -2000 “Code of Practice for Plain and Reinforced Concrete”

-->IS: 1904-1987 “Code of Practice for Structural Safety of Buildings: Foundation

-->IS: 1905-1987, Code of Practice for Structural Safety of Buildings: Masonry

-->IS-NBC-2005: National Building Code of India

-->IS: 875-1987Design loads (other than earthquake) for buildings and structures, Part2 Imposed Loads

--> IS: 875-1987Design loads (other than earthquake) for buildings and structures ,Part 3 Wind Loads

CALCULATIONS(Earthquake Loads) :

Now the following steps may be taken:

(a) Estimate fundamental time period Ta using empirical expressions given in the Code IS: 1893-

2002.

$Ta= 0.075\ H^{0.75}$,

IS: 1893 Cl.7.6.1 for bare frame along each axis

$Tax= 0.09h/\sqrt{d}$ along x-axis IS: 1893 Cl.7.6.2 for frame with substantial infills

$Ta\ z = 0.09h/\sqrt{b}$, along z-axis, IS: 1893 Cl.7.6.2 for frame with substantial infills

where h is the height of the building and d and b are the base dimensions of the building

along x and z axis respectively.

(b) Calculate the design horizontal Seismic coefficient Ah

Now compute the fundamental time periods T/x and T/z for the bare frame along the two axes by

dynamic analysis. These are generally found to be higher than Tax and Taz respectively.

The design horizontal coefficient Ah is given by

Ah= (Z/2). (I/R). (Sa/g)

MATERIALS FOR SAFE DESIGN:

a) Cement: Ordinary portland cement conforming to IS 269 - 1976 shall be usedalong with fly ash

after carrying out the design mix from approved consultant.

b) Reinforcement: Cold twisted high yield strength deformed bars grade Fe 415 conforming to IS:

1786-1985, or preferably TMT bars of standard manufacturer e.g. TATA Steel, SAIL or equivalent

shall be used.

The following grades of concrete mix may beadopted or as required for safe design:

(a) For RCC columns in lowest few storeys : M35

(b) For RCC columns in the middle few storeys : M30

(c) For RCC columns in the top few storeys : M25

(d) For beams, slabs, staircase etc. : M20

(e) For raft foundation : M 20 or 25

(f) Max. Water cement Ratio : 0.45

(g) Minimum cement content : 300 kg/m3 of concrete.

(h) Admixtures of approved brand may be used as per mix design

CLEAR COVER TO ALL REINFORCEMENT:

Some of the duties of a design engineer:

1. Maintain economy
2. Maintain stability
3. Maintain Safety even during earthquake
4. Maintain stiffness of the structure
5. Maintain Durability of the structure
6. Make Correct estimation of the future loads
7. Make estimation of the future expansion of the structure
8. Make Design as much detailed as possible

CLEAR COVER TO ALL REINFORCEMENT:

For mild Exposure and fire rating of 1 hr. following clear covers may be adopted

(a) For foundation R.C.C.:

i) Footings : 60 mm.

ii) Raft : 60 mm.

(b) For columns : 40 mm

(c) For Beams : 25 mm or main bar dia. whichever is more.

d. For Slab : 20 mm.

EARTHQUAKE ZONES OF INDIA

MODELING OF THE STRUCTURE

All things in this universe are created twice. So, before we create structure on ground – i.e. Physically, we make it on software- and this is modeling of structure with all possible future acting forces.UNDERSTANDING- What is a structure ? Answer- Structure is a portal frame which transfers the load to the ground.

Loads to be considered in the model :

1. **Dead Loads - Floor Load, Self Weight,**
2. **Live loads**
3. **Wall Loads**
4. **Seismic Loads – EQx, EQy**
5. **Load Combinations :**
    1. **1.5*(D.L. +L.L.)**
    2. **1.2*(D.L. +L.L.+ Eqx)**
    3. **1.2*(D.L. +L.L.+ EQy)**
    4. **1.5*(L.L. + Eqx)**
    5. **1.5*(L.L. + EQy)**
    6. **.9DL+1.5EQx**
    7. **.9DL+1.5EQy**

What we are going to do :

1. **Decide sections of column and beams**
2. **Decide column positions**
3. **Decide column orientations**
4. **Decide beam positions**
5. **Apply loading**
6. **Make Load Combinations**
7. **Analyze structure**

What we are going to check -

1. **Overall deflection of beams and columns –**
2. **Beam Moments – To design Beams**
3. **Support reactions – To design footing**
4. **Column Axial Forces – To design Column**
5. **Storey Drift**

What we cannot do in STAADPro.

1. **Mode shifts cannot be analysed**
2. **Vibration Analysis cannot be done**
3. **Designing cannot be performed**
4. **Stiffness of walls and slabs cannot be analysed**
5. **Slab Moments cannot be analysed**

Step by Step Approach

Assumed audience is familier with STAAD.Pro. (Tools,Commands, Commands, and Loads)

Working with shortkeys of STAAD.Pro can be given in this.

Step1 – Import

Step2 – Check Multiple Structure- Hence Break Structure at Selected Nodes

Step 3 – Perform all 6 Checks in Tools Menu

Step 4 – Copy Plinth Beam – and make them 1st Floor Beams(Learning how to copy and paste)

Step 5 – Assign Property to column and Beams (Columns – Square Cross Section)

Step 6 – Make load cases- Live, Dead, Floor, Wall, Seismic EQx and Seismic EQy

Step 7 – Change units – make it Meter and KiloNewton

Step 8 – Add Live load – 3KN/m2, than Self-Weight, than Floor(Calculate it),

What we have not included-

Effect of column orientation

Primary and Secondary Beams is not undertaken

Concept of Moment releases is not explained

Non Linear Bheaviour of Concrete

Working with the output file of STAAD.Pro

Time History