SOIL STRUCTURE INTERACTION ON R C FRAME STRUCTURES RESTING ON RAFT FOUNDATION USING STAADPRO AND E-TABS

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ABSTRACT

In the analysis of framed structure the base is considered to be fixed neglecting the effect of soil and foundation flexibility. Flexibility of the soil causes the decrease in stiffness resulting increase in the natural period of the structure. Such increase in the natural periods, changes the seismic response of structure hence it may be an important issue for design considerations.

The process in which the response of the soil influences the motion of the structure and response of the structure influences the motion of the soil known as SOIL STRUCTURE INTERACTION. Soil structure interaction is very important to study the response of the structure resting on various type of soil at elevated ground surface. Here we are studying about soil structure interaction on multi-storeyed building with 6 storeys with 3 bays with RAFT FOUNDATION.

We are considering the soil structure interaction and its subsequent affect on structure during earthquake. When a structure is subjected to earthquake excitation it interacts the foundation and soil thus changes the motion of the ground. The structure system is influenced by type of soil as well as by the type of structure. The main aim of the system is criteria for earthquake resistance design of structure. It gives spectrum analysis for different type of soil as hard medium and soft and also soil structure interaction with various foundation systems. The 3D frame is analysed by using SAP 2000 V14. The soil and the structure are considered as a single continuum model. It also gives the study of the response of building subjected to seismic forces with raft foundation. The structure was analysed by response spectrum method using software SAP 2000. Hence the soil structure interaction analysis of multi-storey building is the main focus of this study; the effects of SSI are analysed for typical multi storey building resting on raft foundation.

The investigation on the energy transfer mechanism from soil to buildings during earthquakes is critical for the design of earthquake resistant structures and for upgrading existing structures. Thus the need for research into SOIL STRUCTURE INTERACTION (SSI) problem is greater than ever.

Keywords: Earthquake, Foundation, Soil Structure Interaction, Seismic load .

1. INTRODUCTION

Over the past 40 years, considerable progress has been made in understanding the nature of earthquakes and how they damage structures, and in improving the seismic performance of the built environment. However, much remains unknown regarding the prevention or mitigation of earthquake damage in worldwide, leaving room for further studies. During past and recent earthquakes, it is realized that the soil-structure interaction (SSI) effects play an important role in determining the behaviour of building structures. The experienced seismic excitation can be considered as function of the fault rupture mechanism, travel path effects, local site effects, and SSI effects. Irrespective of the structure, the local soil conditions can dramatically influence the earthquake motion from the bedrock level to the ground surface, through their dynamic filtering effects. One example is the 1985 Mexico City earthquake where deep soft soils amplified the ground motion and modified the frequency of ground shaking. Similar behaviour was observed during the 1989 Loma Prieta earthquake, in which the sections of the Cypress freeway in Oakland collapsed due to the soil-related motion amplification. The seismic soil structure interaction of multi-story buildings becomes very important after the destruction of recent major earthquakes. For the structure founded on the soil, the motion of the base of the structure will be different from the case of fixed base, because of the coupling of the structure-soil system. It is true that taking the soil into account when calculating the seismic response of the structure does complicate the analysis considerably. It also makes it necessary to estimate additional key parameters, which are difficult to determine, such as the dynamic properties of the soil such as site response, radiation damping and kinematic interaction.

II. E-TABS

ETABS stands for Extended hree dimensional Analysis of Building Systems. ETABS is commonly used to analyze: Skyscrapers, parking garages, steel & concrete structures, low and high rise buildings, and portal frame structures. ETABS was used to create the mathematical model of the Burj Khalifa, designed by Skidmore, Owings and Merrill LLP (SOM). The input, output and numerical solution techniques of ETABS are specifically designed to take advantage of the unique physical and numerical characteristics associated with building type structures. On ETABS we can analyse and design any shape of R.C.C buildings like rectangular. In this project, we mainly emphasizes on structural behaviour of multi-storey building for different plan configurations like T-shape and L-shape. Modelling of 10- storeys R.C.C. framed building is done on the ETABS Software for analysis. Post analysis of the structure, maximum shear forces, bending moments, and maximum storey displacement are computed and then compared for all the analyzed cases.

III. STAADPRO

Staad is powerful design software licensed by Bentley .Staad stands for structural analysis and design .Any object which is stable under a given loading can be considered as structure. So first find the outline of the structure, where as analysis is the estimation of what are the type of loads that acts on the beam and calculation of shear force and bending moment comes under analysis stage. Design phase is designing the type of materials and its dimensions to resist the load. This we do after the analysis. To calculate S.F.D and B.M.D of a complex loading beam it takes about an hour. So when it comes into the building with several members it will take a week. Staad pro is a very powerful tool which does this job in just an hour’s staad is a best alternative for high rise buildings. Now a days most of the high rise buildings are designed by staad which makes a compulsion for a civil engineer to know about this software. These software can be used to carry rcc, steel, bridge , truss etc according to various country codes.

IV. RAFT FOUNDATION

- **RAFT FOUNDATIONS** are a large concrete slab which can support a number of columns and walls .
- The slab is spread out under the entire building or at least a large part of it which lowers the contact pressure compared to the traditionally used strip or trench footings.

V. ADVANTAGES OF RAFT FOUNDATION

- If bearing capacity of soil is too low.
- If walls of the structure are so close that individual footings would overlap.
- It is used for large loads.
- It covers more than half of the construction area .
- It is economic due to combination of foundation and floor slab.
- It requires little excavation.
- It can cope with mixed or poor ground condition.
- It reduces differential settlement.

VI. STATEMENT OF PROJECT

Salient features:

Utility of building:	Residential complex
No of stories:	G+6
Shape of the building:	6 APARTMENTS
No of staircases:	1
No. of flats:	6
No of lifts:	1
Type of construction:	R.C.C framed structure
Types of walls:	brick wall

Geometric details:

Ground floor:	3m
Floor to floor height:	3m
Height of plinth:	0.6m
Depth of foundation:	500mm

Materials:

Concrete grade:	M 25
All steel grades:	Fe500 grade
Bearing capacity of soil:	250KN/m^2

VII. SEISMIC LOAD

➢ It is one of the basic concepts of earthquake engineering which means application of an earthquake generated agitation to a structure .

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- It happens at contact surfaces of a structure either with the ground, or with adjacent structures , or with gravity waves from tsunami.
- Seismic loading depends , primarily on :
  - Anticipated earthquakes parameters at the site known as seismic hazard
  - Geotechnical parameters of the site
  - Structure's parameters
  - Characteristics of the anticipated gravity waves and tsunami

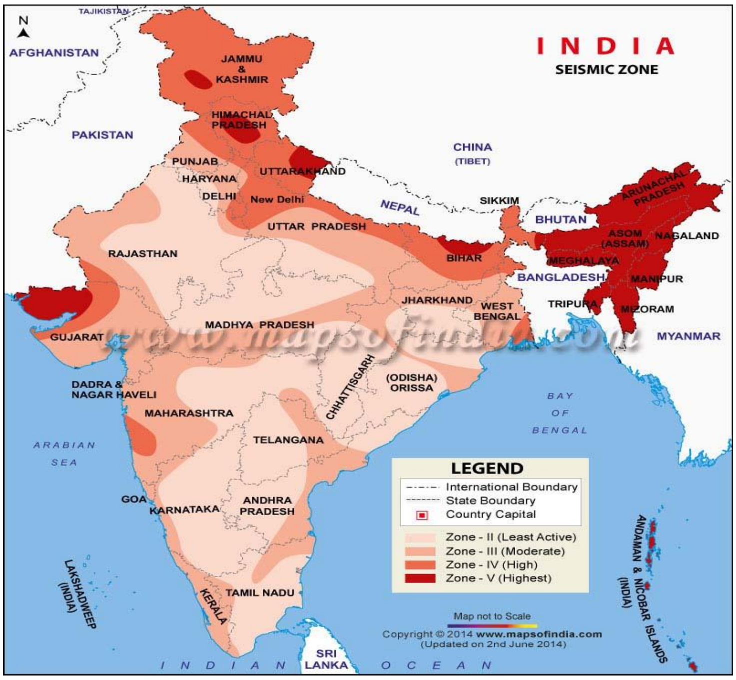
Table 1: Clear Cover

STRUCTURAL ELEMENT	
FOOTING	50mm
SLAB	15mm
COLUMN	40mm
STAIRCASE	20mm
BEAM	25mm

Table 2: Structural Data

GRADE OF CONCRETE	**M25**
WEIGHT PER UNIT VOLUME	25KN/m^3
MODULUS OF ELASTICITY	25000N/mm^2
POISSON'S RATIO	0.2
Fck	25000N/mm^2
Fy	500N/mm^2
COLUMN SIZE	200*450mm
SLAB THICKNESS	135 & 125mm
BEAM SIZE	200*450mm 200*350mm

VIII. EARTHQUAKE ZONES



IX. SEISMIC ACTIVE ZONES

The design of a seismic resistant building involves the usage of seismic coefficients. For the purpose manipulating these coefficients the country is divided into five zones (as recommended in IS 1897 – 1984).

X. ZONES

- ZONE 1: Area without any damage.
- ZONE 2: Area with major damages i.e., causing damages to structures with fundamentally periods greater than 1.0 second) earthquakes corresponding to intensities 5 to 6 of MM scale (MM – Modified Mercalli Intensity Scale).
- ZONE 3: Moderate damage corresponding to intensity 7 of MM scale.
- ZONE 4: Major damage corresponding to intensity 7 and higher of MM scale.
- ZONE 5: Area determines by pro seismically of certain major fault systems.

XI. DESIGN OF BEAM

Beam no: 1

fck = 25N/mm^2 d = 415mm

fy = 500N/mm^2 D = 450mm

B = 200mm EFF. COVER = 35mm

SPAN = 6.1m

Self weight = 0.20*0.45*25 = 2.25N/mm^2

UDL = 11.72KN/m

Live load = 2N/mm^2

w = 15.97 KN/m

RA = RB = (15.97*6.1)/2 = 48.70KN

V = wl/2 = (15.97*6.1)/2 = 48.78KN

M = wl^2/8 = 15.97*6.1^2/8 = 74.28KN-m

Mu = 74.28*1.5 = 111.42KN-m

K = M / (b*d*d) = (111.42*10^6) / (200*415*415)) = 3.23

Mulim = 0.133*fck*b*d*d = 0.133*25*200*415*415 = 91.62KN-m

K' = ((91.62*10^6)/ (200*415*415)) = 2.65 > K

K' > K, DOUBLY REINFORCED

- DOUBLY REINFORCED BEAM:

Mu = 0.87*fy* Ast*d*(1-((fy*Ast) / (fck*b*d))

111.42*10^6 = 0.87*500*Ast*415*(1-((500*Ast) / (25*200*415))

Ast = 819.46 mm^2

Taking 16mm dia bar

No. Of bars required = (819.46/201) = 4.07 ≈ 4

PROVIDE 2-T20+2-T16 dia bars

τv = Vu / (b*d) = 73.06*1000 / (200*415)

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τv = 0.88N/mm^2

100Ast / (b*d) = (100*1030.4) / (200*415) = 1.24

τc =0.708 N/mm^2

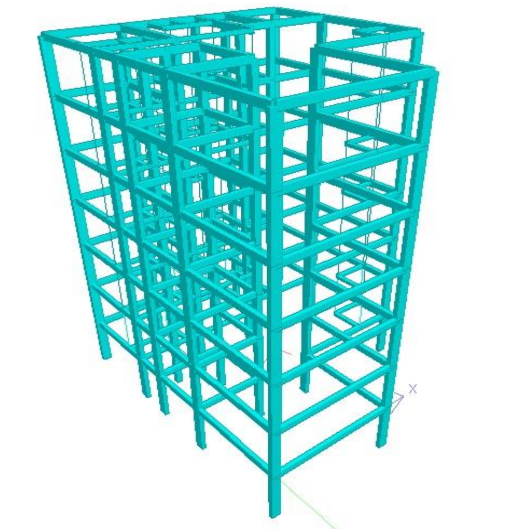
$\tau v > \tau c$ (safe)

Vus = Vu – (τc*b*d) = (τv-τc)*b*d = (0.88-0.708)*200*415 = 14296N

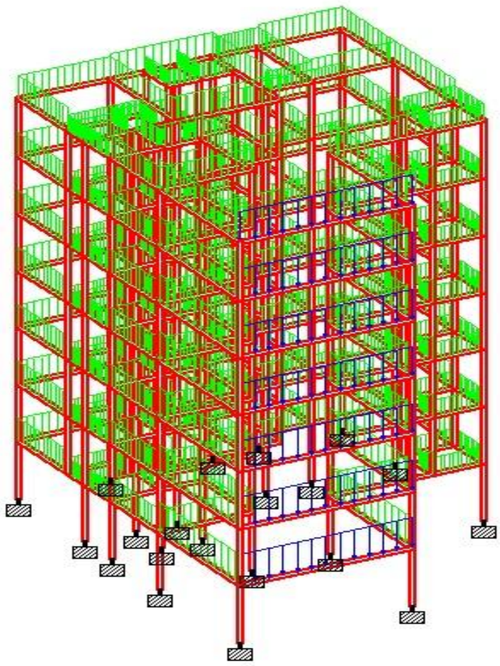
Sv = 0.87*fy*Asv*d/Vus =0.87*415*100.53*415/14296 = 1269.45mm

Provide 2L – 8mm dia bar at 175mm c/c

XII. STAADPRO IMAGES



Render View



Load Distribution

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XIII. STAADPRO RESULTS AND DISCUSSION

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     1. STAAD SPACE
INPUT FILE: C:\Users\SINDHU\Desktop\SVSS MAJOR PROJECT 2017 FULL FILES\svss final project 3.STD
     2. START JOB INFORMATION
     3. ENGINEER DATE 03-MAY-17
     4. END JOB INFORMATION
     5. INPUT WIDTH 79
     6. UNIT METER KN
     7. JOINT COORDINATES
     8. 1 0 0 0; 2 6.7 0 0; 3 0 0 5.5; 4 6.7 0 5.5; 5 0 0 8.7; 6 0 0 10.4; 7 3.6 0 5.5
     9. 8 3.6 0 8.7; 11 2 0 10.4; 12 3.6 0 10.4; 13 0 0 14.9; 14 3.6 0 14.9
    10. 15 7.6 0 10.4; 16 7.6 0 14.9; 17 7.6 0 11.3; 18 9.4 0 14.9; 19 9.4 0 11.3
    11. 20 12.7 0 14.9; 21 12.7 0 11.3; 22 12.7 0 5.5; 23 1.7 0 10.4; 24 2.8 0 10.4
    12. 25 0 0 11.6; 26 1.7 0 11.6; 27 2.8 0 11.6; 28 5.9 0 14.9; 29 4.7 0 14.9
    13. 30 7.6 0 13.4; 31 5.9 0 13.4; 32 4.7 0 13.4; 33 10.7 0 5.5; 34 12.7 0 7.4
    14. 35 10.7 0 7.4; 36 12.7 0 2.9; 37 10.1 0 5.5; 38 10.1 0 2.9; 39 2 0 8.7
    15. 40 0 -3 0; 41 6.7 -3 0; 42 0 -3 5.5; 43 6.7 -3 5.5; 44 0 -3 8.7; 45 0 -3 10.4
    16. 46 3.6 -3 5.5; 47 3.6 -3 8.7; 48 3.6 -3 10.4; 49 0 -3 14.9; 50 3.6 -3 14.9
    17. 51 7.6 -3 14.9; 52 7.6 -3 11.3; 53 9.4 -3 14.9; 55 12.7 -3 14.9
    18. 56 12.7 -3 11.3; 57 12.7 -3 5.5; 58 12.7 -3 2.9; 59 10.1 -3 5.5
    19. 60 10.1 -3 2.9; 61 0 3 0; 62 6.7 3 0; 63 0 3 5.5; 64 6.7 3 5.5; 65 0 3 8.7
    20. 66 0 3 10.4; 67 3.6 3 5.5; 68 3.6 3 8.7; 69 2 3 10.4; 70 3.6 3 10.4
    21. 71 0 3 14.9; 72 3.6 3 14.9; 73 7.6 3 10.4; 74 7.6 3 14.9; 75 7.6 3 11.3
    22. 76 9.4 3 14.9; 77 9.4 3 11.3; 78 12.7 3 14.9; 79 12.7 3 11.3; 80 12.7 3 5.5
    23. 81 1.7 3 10.4; 82 2.8 3 10.4; 83 0 3 11.6; 84 1.7 3 11.6; 85 2.8 3 11.6
    24. 86 5.9 3 14.9; 87 4.7 3 14.9; 88 7.6 3 13.4; 89 5.9 3 13.4; 90 4.7 3 13.4
    25. 91 10.7 3 5.5; 92 12.7 3 7.4; 93 10.7 3 7.4; 94 12.7 3 2.9; 95 10.1 3 5.5
    26. 96 10.1 3 2.9; 97 2 3 8.7; 98 0 6 0; 99 6.7 6 0; 100 0 6 5.5; 101 6.7 6 5.5
    27. 102 0 6 8.7; 103 0 6 10.4; 104 3.6 6 5.5; 105 3.6 6 8.7; 106 2 6 10.4

   118. 324 243 244; 325 244 242; 326 242 228; 327 239 241; 328 241 240; 329 209 172
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   120. 336 215 178; 337 210 173; 338 212 175; 339 244 207; 340 243 206; 341 242 205
   121. 342 228 191; 343 227 190; 344 226 189; 345 224 187; 346 222 185; 347 223 186
   122. 348 220 183; 349 249 247; 350 246 247; 351 246 248; 352 248 252; 353 252 253
   123. 354 248 250; 355 250 251; 356 251 256; 357 250 282; 358 282 253; 359 282 254
   124. 360 251 255; 361 255 257; 362 256 257; 363 268 269; 364 269 266; 365 269 270
   125. 366 270 267; 367 257 259; 368 255 258; 369 259 258; 370 273 274; 371 274 271
   126. 372 272 275; 373 275 274; 374 260 262; 375 261 259; 376 262 261; 377 262 264
   127. 378 264 263; 379 261 263; 380 264 265; 381 265 249; 382 280 281; 383 281 279
   128. 384 279 265; 385 276 278; 386 278 277; 387 246 209; 388 248 211; 389 250 213
   129. 390 251 214; 391 256 219; 392 255 218; 393 253 216; 394 252 215; 395 247 210
   130. 396 249 212; 397 281 244; 398 280 243; 399 279 242; 400 265 228; 401 264 227
   131. 402 263 226; 403 261 224; 404 259 222; 405 260 223; 406 257 220
   132. DEFINE MATERIAL START
   133. ISOTROPIC CONCRETE
   134. E 2.17185E+007
   135. POISSON 0.17
   136. DENSITY 23.5616
   137. ALPHA 1E-005
   138. DAMP 0.05
   139. TYPE CONCRETE
   140. STRENGTH FCU 27579
   141. END DEFINE MATERIAL
   142. MEMBER PROPERTY INDIAN
   143. 39 43 47 48 52 54 97 101 105 106 110 112 155 159 163 164 168 170 213 217 221 -
   144. 222 226 228 271 275 279 280 284 286 329 333 337 338 342 344 387 391 395 396 -
   145. 400 402 PRIS YD 0.2 ZD 0.45
   146. 1 TO 38 40 TO 42 49 TO 51 53 55 56 58 TO 96 98 TO 100 107 TO 109 111 113 114 -
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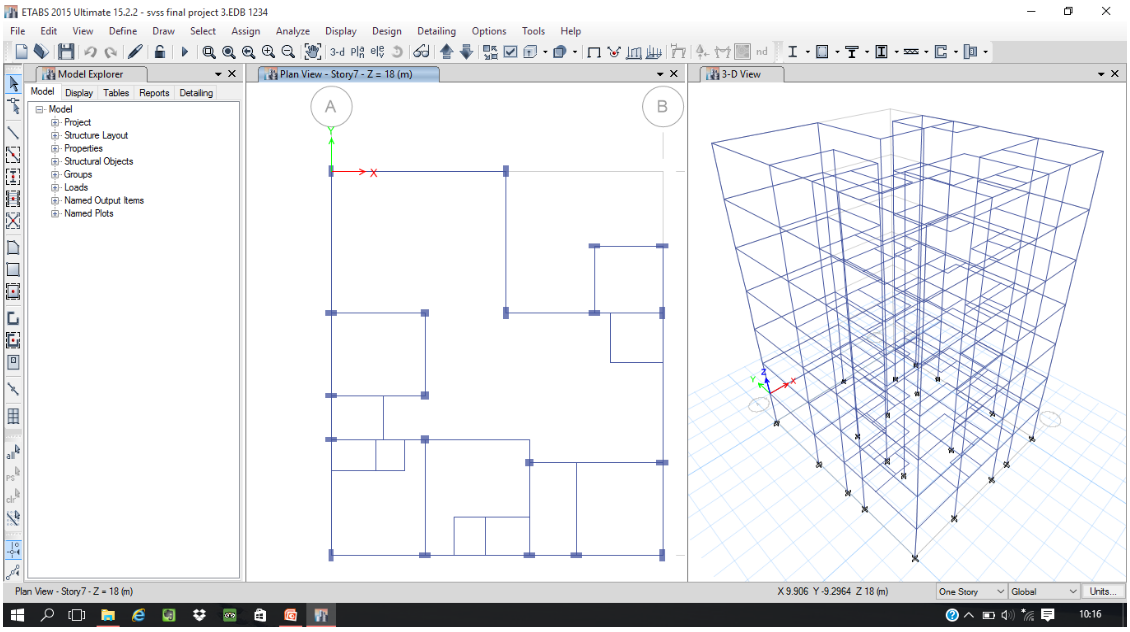
XIV. E-TABS IMAGES



XV. E-TABS RESULTS

Frame Loads - Distributed

Story	Label	Unique Name	Design Type	Load Pattern	LoadType	Direction	Relative Distance Start	Relative Distance End	Absolute Distance Start mm	Absolute Distance End mm
Story6	B1	191	Beam	sdl	Force	Gravity	0	1	0	5200
Story6	B2	192	Beam	sdl	Force	Gravity	0	1	0	3300
Story6	B3	193	Beam	sdl	Force	Gravity	0	1	0	1800
Story6	B4	194	Beam	sdl	Force	Gravity	0	1	0	4410
Story6	B7	195	Beam	sdl	Force	Gravity	0	1	0	5200
Story6	B11	196	Beam	sdl	Force	Gravity	0	1	0	6020
Story6	B8	197	Beam	sdl	Force	Gravity	0	1	0	3300
Story6	B10	199	Beam	sdl	Force	Gravity	0	1	0	3300
Story6	B12	200	Beam	sdl	Force	Gravity	0	1	0	3300
Story6	B13	201	Beam	sdl	Force	Gravity	0	1	0	1800
Story6	B14	202	Beam	sdl	Force	Gravity	0	1	0	3300
Story6	B15	203	Beam	sdl	Force	Gravity	0	1	0	4410
Story6	B16	204	Beam	sdl	Force	Gravity	0	1	0	3300
Story6	B17	205	Beam	sdl	Force	Gravity	0	1	0	1800
Story6	B18	206	Beam	sdl	Force	Gravity	0	1	0	3300
Story6	B19	207	Beam	sdl	Force	Gravity	0	1	0	4410
Story6	B20	208	Beam	sdl	Force	Gravity	0	1	0	1800
Story6	B21	209	Beam	sdl	Force	Gravity	0	1	0	3300
Story6	B22	210	Beam	sdl	Force	Gravity	0	1	0	4220
Story6	B23	211	Beam	sdl	Force	Gravity	0	1	0	4410
Story6	B24	212	Beam	sdl	Force	Gravity	0	1	0	4220
Story6	B25	213	Beam	sdl	Force	Gravity	0	1	0	5100
Story6	B27	215	Beam	sdl	Force	Gravity	0	1	0	6600

Story	Label	Unique Name	Design Type	Load Pattern	LoadType	Direction	Relative Distance Start	Relative Distance End	Absolute Distance Start mm	Absolute Distance End mm
Story5	B1	234	Beam	sdl	Force	Gravity	0	1	0	5200
Story5	B2	235	Beam	sdl	Force	Gravity	0	1	0	3300
Story5	B3	236	Beam	sdl	Force	Gravity	0	1	0	1800
Story5	B4	237	Beam	sdl	Force	Gravity	0	1	0	4410
Story5	B7	238	Beam	sdl	Force	Gravity	0	1	0	5200
Story5	B11	239	Beam	sdl	Force	Gravity	0	1	0	6020
Story5	B8	240	Beam	sdl	Force	Gravity	0	1	0	3300

XVI. CONCLUSION

1. Manual calculation is done by according to Indian standard code then compare with the software.
2. Designing using Software's like Staad reduces lot of time in design work.
3. Details of each and every member can be obtained using staad pro.
4. All the List of failed beams can be obtained and also Better Section is given by the software.
5. Accuracy is improved by using software.
6. The response spectrum analysis is done in e-tabs to check the seismic reactions.

XVII. REFERANCE

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  By, MOHAMMED ZUBAIR.

BIOGRAPHAICAL DATA

Prof. Mahadeva M is working as assistant professor in civil engineering department form last 2 years and he also worked as assistant professor in k s institute of technology. He received is **B E in civil engineering** and **M.Tech** with specialization in **CAD structures** from visvesvaraya technological university. He is national advisory board member for international conference and he secured “***Active Young Research Award”*** in international journals for his continuous contribution in research field. His research interest is in the field of soil structure interaction, structural engineering, earth quake engineering.

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