Failure Analysis of Beam and Column of a 300 Beded Ladies Hostel (G+4)

Rashmita Baske
Department of Civil Engineering,
Centurion University of Technology and Management,
Bhubaneswar, India

Dr. Manoj Kumar Rath,
Corresponding Author
Department of Civil Engineering
Centurion University of Technology and Management.
Bhubaneswar, India
manojkumar.rath@cutm.ac.in

ABSTRACT
Structural engineers are facing the challenge of striving for the most efficient and economical design solution while ensuring that the final design of a building must be serviceable for its intended function, habitable for its occupants and safe over its design lifetime. As our country is the fastest growing country across the globe and need of shelter with higher land cost in major cities like Mumbai, Delhi, Ahmadabad, Vadodara where further horizontal expansion is not much possible due to space shortage, we are left with the solution of vertical expansion. Engineers, designers and builders are trying to use different materials to their best advantage keeping in view the unique properties of each material Structurally robust and aesthetically pleasing building are being constructed by combining the best properties at individual material & at the same time meeting specific requirements of large span, building load, soil condition, time, flexibility & economy high rise buildings are best-suited solution. Also Wind & Earthquake (EQ) engineering should be extended to the design of wind & earthquake sensitive tall buildings. This paper discusses the analysis & design procedure adopted for the evaluation of symmetric high rise multi-storey building (G+30) under the effect of Wind and EQ. forces. In these building R.C.C., Steel, & Composite building with shear wall considered to resist lateral forces resisting system. This study examines G+30 stories building are analyzed and design under the effect of wind and earthquake using ETABS. Total 21numbers of various models are analyzed& designed & it proves that steel-concrete composite building is a better option. Analytical results are compared to achieve the most suitable resisting system & economic structure against the lateral forces.

Keywords: Composite beam, Composite slab, Displacement, Seismic force.

1. INTRODUCTION
Building construction is the engineering deals with the construction of building such as residential houses. In a simple building can be define as an enclose space by walls with roof, food, cloth and the basic needs of human beings. In the early ancient times humans lived in caves, over trees or under trees, to protect themselves from wild animals, rain, sun, etc. as the times passed as humans being started living in huts made of timber branches. The shelters of those old have been developed nowadays into beautiful houses. Rich people live in sophisticated condition houses. Buildings are the important indicator of social progress of the county. Every human has desire to own comfortable homes on an average generally one spends his two-third life times in the houses. The security civic sense of the responsibility. These are the few reasons which are responsible that the person do utmost effort and spend hard earned saving in owning houses. Nowadays the house building is major work of the social progress of the county. Daily new techniques are being developed for the construction of houses economically, quickly and fulfilling the requirements of the community engineers and Meanwhile, the industrial revolution laid open the door for mass production and consumption. Aesthetics became a criterion for the middle class as ornamental products, once within the province of expensive craftsmanship, became cheaper under machine production. Vernacular architecture became increasingly ornamental. House builders could use current architectural design in their work by combining features found in pattern books and architectural journals. 1.1.1 Modern architecture: architects do the design work, planning and layout, etc, of the buildings. Draughtsman are responsible for doing the drawing works of building as for the direction of engineers and architects. The draughtsman must know his job and should be able to follow the instruction of the engineer and should be able to draw the required drawing of the building, site plans and layout plans etc, as for the requirements. A building frame consists of number of bays and storey. A multi-storey, multi-paneled frame is a complicated statically intermediate structure. A design of R.C building of G+6 storey frame work is taken up. The building in plan (40*28) consists of columns built monolithically forming a network. The size of building is 40x28m. The number of columns are 85. It is residential complex. **N:** The design is made using software on structural analysis design (staad-pro). The building subjected to both the vertical loads as well as horizontal loads. The vertical load consists of dead load of structural components such as beams, columns, slabs etc and live loads. The horizontal load consists of the wind forces thus building is designed for dead

load, live load and wind load as per IS 875. The building is designed as two dimensional vertical frame and analyzed for the maximum and minimum bending moments and shear forces by trial and error methods as per IS 456-2000. The help is taken by software available in institute and the computations of loads, moments and shear forces and obtained from this software.

1. David Gustafsson & Joseph Hehir Department of Civil and Environmental Engineering Master's Thesis 2005:12Division of Structural Engineering Concrete Structures Chalmers University of Technology Goteborg, Sweden 2005 David Gustafsson mentioned about the methods used for stability calculations of columns, solid shear walls, pierced shear walls, coupled and uncoupled components, cores, single storey structures and multi-storey structures and examined. The examination performed in order to ascertain advantages for different stabilizing components and systems. Analyses are made for deflection and buckling, combining, bending and shear for columns, solid shear walls and pierced shear walls. Calculation methods for single and multi storey structures concerning deflection and buckling due to translation, rotation or a combination of the two are analyzed and the results are compared with finite element analyses results.

2. Structural Stability. Eric M. Lui Department of Civil & Environmental Engineering, Syracuse University, Syracuse, NY 13244- 1240 USA Eric Lui defines stability is a field of mechanics that studies the behavior of structures under compression. When a structure is subjected to a sufficiently high compressive force or stress, it will have a tendency to lose its stiffness, experience a noticeably change in geometry, and becomes unstable. When instability occurs the structure loses its capacity to carry the applied loads and is incapable of maintaining a stable equilibrium configuration. Examples of structural instability include: buckling of a column under a compressive axial force, lateral torsional buckling (LTB) of a beam under a transverse load, sideways buckling of an unbraced frame under a set of concentric column forces, buckling of a plate under a set of in-plane forces, and buckling of a shell under longitudinal or axial stress, etc.

3. Stability Analysis of Steel Frame Structures: P Delta Analysis. Mallikarjuna B.N, P.G. Student, and Prof .Ranjith A is an Assistant Professor, Department of Civil Engineering, AIT, Chikmagalur, Karnataka, India Mallikarjuna B.N and Prof .Ranjith A. focused on P-delta analysis to be compared with linear static analysis. An 18storey steel frame structure with 68.9m has selected to be idealized as multi storey steel building model is to taken for their research. The model is analysed by using STAAD .Pro 2007 structural analysis software with consideration of P-delta effect. At the same time the influence of different bracing patterns has been investigated. The steel brace are usually placed in vertically aligned spans. This system allows obtaining a great increase of stiffness with a minimal added weight, so it is very effective for existing structure for which the poor lateral stiffness. The loads considered for the analysis are Gravity load, Live load and Wind load. The frame structure is analyzed for Wind load as per IS875 (part 3)-1987. After analysis, the comparative study is presented with respective to maximum storey displacement and axialforce.

4. An approximate method for lateral stability analysis of Wall-frame buildings including shear deformations of walls. KanatBurakBozdogan and DuyguOzturk. Department of Civil Engineering, Ege University, ˙Izmir, 35040 Turkey. Kanat and Duygu present an approximate method based on the continuum approach and transfer matrix method for lateral stability analysis of buildings. In this method, the whole structure is idealized as an equivalent sandwich beam, which includes all deformations. The effect of shear deformations of walls has been taken into consideration and incorporated in the formulation of the governing equations. Initially the stability differential equation of this equivalent sandwich beam is presented, and then shape functions for each storey is obtained by the solution of the differential equations. By using boundary conditions and stability storey transfer matrices obtained by shape functions, system buckling load can be calculated. Examples are shown that the results obtained from the proposed method are in good agreement with Finite Element Method and the analytical solution, which has been developed by Rosman. The proposed method is not only simple and accurate enough to be used both at the concept design stage and for final analyses, but at the same time takes less computational time than the Finite Element Method.

5.Stability design of structure with semi-rigid connections. TomislavIgić, SlavkoZdravković, DraganZlatkov, SrđanŽivković, Nikola Stojić. The paper presentstheoretical foundations and expressions of calculations of impacts on the stability of structure, that is, review of the Second order theory in a bridge with members semi-rigid connections in joints. In the real structures in general and the especially in the prefabricated structures the connection of members in the nodes can be partially rigid which can be very significant for the changes in tension and deformation. If the influence of the normal forces is significant and the structure is slender then it is necessary to carry out a calculation according to the second order theory because the balance between internal and external forces really established on the deformed configuration and displacements in strict formation are also unreal. The importance and significance of the calculations and distribution of impact according to the Second order theory were presented in numerical examples as well as the calculation of critical load as well International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056 Volume: 03 Issue: 03 | Mar-2016 www.irjet.net p-ISSN: 2395-0072 © 2016, IRJET | Impact Factor value: 4.45 | ISO 9001:2008 Certified Journal | Page 989 as the buckling length of members with semi-rigid connections in joint. . In this paper, a calculation according to the Second order theory will be briefly presented, which is particularly important when it is necessary to solve the stability issues of the structures with semi-rigid connections of members in nods, whose application in theory and practice is very difficult, and thus represents a valuable contribution to contemporary structural analysis.

6. Seismic Analysis of Multi-Storeyed Building with Underneath Satellite Bus Stop and Intermediate Service Soft Storey Having Floating Columns. ShrikanthBhairagondM.Tech Student (Structural Engineering) and Prof. Vishwanath. B. Patil, Professor in Department of Civil Engineering PoojyaDoddappaAppa College of Engineering Kalaburagi India. Shrikanth is mentioned, the present problems and use of soft-storey and its effects in structures.. Soft storeys at different levels of structure are constructed for other purposes like lobbies conference halls and for the service storeys etc. This storey is known as weak storey because storey stiffness is lower compare to above storeys. Experience in the past earthquake has shown that a building with discontinuity in the stiffness and mass

subjected to concentration of forces and deformations at the point of discontinuity, which may leads to the failure of member's at the junction and collapse of building. The presence of infill wall can improve the performance of the building in seismic analysis, and the best way to reduce the effect of soft storey is to provide the shear walls at perfect location and of correct shape to the building. And also, he mentioned that use of similar soft storey effect can be observed when soft storeys at different levels of structure are constructed. From the past earthquake, it has been observed that a building with discontinuity in the stiffness and mass subjected to concentration of forces and deformations at the point of discontinuity, which may leads to the failure of members at the junction and collapse of building. Most economical way to eliminate the failure of soft storey is by adding shear walls to the tall buildings

2. DESIGN PROCEDURES

Salient features:
Utility of building: residential complex
No of stories: G+4
Shape of the building:3 APARTMENTS
No of staircases: 5nos
No. of Beds: 300
No of lifts: 2 any
Type of construction: R.C.C framed structure
Types of walls: brick wall
Geometric details: Ground floor: 4m
Floor to floor height: 3m.
Height of plinth: 0.6m

2.1. Design of Multi Storied Residential Building

A structure can be defined as a body, which can resist the applied loads without appreciable deformations. Civil engineering structures are created to serve some specific functions like human habitation, transportation, bridges, storage etc. in a safe and economical way. A structure is an assemblage of individual elements like pinned elements (truss elements), beam element, column, shear wall slab cable or arch. Structural engineering is concerned with the planning, designing and thee construction of structures. Structure analysis involves the determination of the forces and displacements of the structures or components of a structure. Design process involves the selection and detailing of the components that make up the structural system. The main object of reinforced concrete design is to achieve a structure that will result in a safe economical solution.

The objective is: Failure analysis of
1. Beam
2. Column

These all are designed under limit state method
The acceptable limit for the safety and serviceability requirements before failure occurs is called a limit state.

2.1 Limit State of Collapse

This is corresponds to the maximum load carrying capacity. Violation of collapse limit state implies failures in the source that a clearly defined limit state of structural usefulness has been exceeded. However, it does not mean complete collapse.
This limit state corresponds to:
a) Flexural
b) Compression
c) Shear
d) Torsion

2.3 Limit State of Survivability

This state corresponds to development of excessive deformation and used for checking member in which magnitude of deformations may limit the rise of the structure of its components.
a) Deflection
b) Cracking
c) Vibration

2.4 Softwares

This project is mostly based on software and it is essential to know the details about these software's.
List of software's used
1. Staad pro(v8i)
2. Auto cad

2.5 Staad

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, whereas 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.

2.6 Auto Cad

AutoCAD is powerful software licensed by auto desk. AutoCAD is used for drawing different layouts, details, plans, elevations, sections and different sections can be shown in AutoCAD.

3. RESULTS AND DISCUSSION

Characteristics compressive strength test of concrete at 7 days

Table 1: Compressive strength test

Sl No	Area (In mm2)	Weight (In kg)	Weight Should be (In Kg)	Load (In KN)	Strength(In N/mm2)	Avg. Strength(N/mm2)	Remark
1	150 X 150	8.65 kg	8.1kg	650	28.88		Min strength should be 20N/mm2
2	150 X 150	8.6kg	8.1kg	660	29.33	28.95	Hence it is OK
3	150 X 150	8.59kg	8.1kg	645	28.66		

3.1 Tensile Strength of Steel

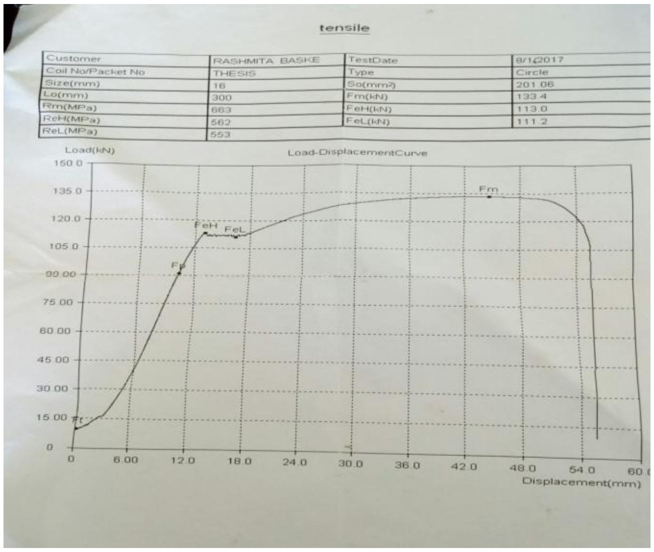

Figure 1: Tensile strength of steel

3.2 Mix Design

1. Grade Designation : M30
2. Type of Cement : PPC (Ultratech)
3. Workability : 100 mm
4. Condition : Exposer

3.3 Gradation of F.A (sand)

Table 2: Gradation of F.A (sand)

Sieve size	Wt. of fine aggregate retained	% Retained	Cumulative % Retained	Percentage
10	0	0	0	100
4.75	0	0	0	100
2.36	2	0.2	0.2	99.8
1.18	42	4.2	4.4	95.6
600 micron	207	20.7	25.1	74.49
300 micron	722	72.7	97.3	2.7
150 micron	25	2.5	99.8	0.2
Pan	2	0.2	100	0

So it comes under zone III

10.3 Specific Gravity of Cement

1. Weight of cement used, W = 60 grms
2. Initial Reading of flask, V1 = 0.95 ml
3. Final Reading of Flask, V2 = 22 ml
4. Volume of cement particle = V2-V1= 22-0.95 = 21.05
5. Weight of equal vol. of water = (V2-V1) X Specific gravity of water 21.05 X 1 =21.05

Specific gravity of Cement = 60/21.05 =2.85

10.4 Specific Gravity of C.A

A = Weight of saturated and surface dry aggregate = 992 gm
B = Weight of over dry sample =980 gm
C = Weight of Vessel + Water = 2764 gm
D = Weight of Vessel + Sample + Water = 3389gm
Specific Gravity = B/{A-(D-C)}
= 980/{992-(3389-2764)}
= 2.67

10.5 Specific Gravity of F.A

A = Weight of saturated and surface dry aggregate = 500 gm
B = Weight of over dry sample =491 gm
C = Weight of Pycnometer + Water = 1511 gm
D = Weight of Pycnometer + Sample + Water = 1830 gm
Specific Gravity = B/{A-(D-C)}
= 491 /{500-(1830-1511)}
= 2.71

10.6 Target Mean Strength

F'ck = fck + 1.65 X S
= 30 + 1.65 X 5
= 38.25 N/mm2

10.7 Selection of Water Cement Ratio

As per IS 456:2000, table no -5,
For M 30 concrete max water/cement= 0.45
Let's take water/cement =0.4
0.4<0.45 (Hence Ok)

10.8 Calculation of Water Content

From table no.2 of IS:10262 max. Water content = 186 ltr (For 50 mm slump)
Estimated water content for 100 mm slump = 186 + (186 X 6%) =197ltr
As super plasticizer is used the water content can be reduced up to 20% and above.
Let us take 25%.
Hence the arrived water content = 197 X 0.75 = 147.75 ltr
Let's take water content = 148 ltrs

10.9 Calculation of Cement Content

Water Cement Ratio= 0.4
Cement content =148/0.4 =370 kg.
From table no 5 of IS: 456:2000, minimum cement content for M30 grade of concrete is 320 kg/m3 and maximum cement content is 450kg /m3.
320 kg **< 370 Kg** <450Kg (Hence Ok)

3.4 Calculation of Aggregate Content

Volume of C.a. corresponding to 20 mm size aggregate and fine aggregate zone III (From IS:10262) for W/C of) 0.5 = 0.64.
In the present case water – cement ratio is 0.4.
As the water-cement ratio lowered by 0.10, 0.02 increases the proportion of volume of c.a.
Therefore, corrected proportion of volume of c.a. for water-cement ratio of 0.4 = 0.66.
For pump able concrete these value should be reduced by 10%.
So the volume of c. =0.64 X 0.9 = 0.58
Volume of fine aggregate = 1-0.58 = 0.42

Mix Calculation

1. Volume of concrete = 1 m3
2. Volume of Cement = (Mass of Cement / Specific gravity of cement) /1000=(370/2.85)/1000 = 0.130m3
3. Volume of water =(Mass of water / Specific gravity of water) /1000=(148/1)/1000 = 0.148m3

4. Volume of Chemical admixture (@2% of cement)= (Mass of admixture / Specific gravity of Admixture) /1000=(7.2/1.145)/1000 = 0.006
5. Volume of all in aggregate = [a-(b+c+d)]
=[1-(0.120+0.148+0.006)
=1-0.274=0.726 m3
6. Mass of c.a.= e X Vol.ofc.a.X Specific gravity of c.a X 1000
= 0.726 X 0.58 X 2.67 X 1000
=1124.2 kg
7.Mass of f.a = e X Vol.off.a.X Specific gravity of f.a X 1000
=0.726 X 0.42 X 2.71 X 1000
=826.3 kg
1. Cement = 370 kg /m3
2. Water=148kg /m3
3. Fine aggregate 826.3 kg/m3
4. Coarse Aggregate = 1124.2 kg/m3
5. Admixture =7.2 kg/m3
6. So the Proportion = 1 : 2.23 : 3.03

Figure 2: Mixing of concrete

Figure 3: Concrete cubes

3.5 Characteristics Compressive Strength Test of Concrete at 7 Days

Table 3: Compressive strength test of concrete at 7 days

Sl No	Area (In mm2)	Weight (In kg)	Weight Should be (In Kg)	Load (In KN)	Strength(In N/mm2)	Avg. Strength(N/mm2)	Remark
1	150 X 150	8.65 kg	8.1kg	650	28.88		Min strength should be 20N/mm2
2	150 X 150	8.6kg	8.1kg	660	29.33	28.95	Hence it is OK
3	150 X 150	8.59kg	8.1kg	645	28.66		

3.6 Plan

Orientation of the different rooms like bed room, bathroom, hall etc.. All the three apartments have similar room arrangement. The entire plan area is 27513 sqft.

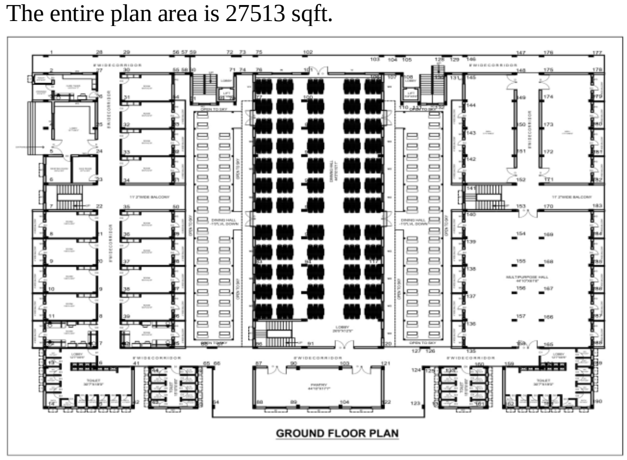

Figure 4: Hostel Plan

12. Loads Applied on the Structure

- Dead Load
- Live load
- Wind load
- Seismic Load

3.7 Dead Load

Dead loads consist of the permanent construction material loads compressing the roof, floor, wall, and foundation systems, including claddings, finishes and fixed equipment. Dead load is the total load of all of the components of the components of the building that generally do not change over time, such as the steel columns, concrete floors, bricks, roofing material etc. In staad pro assignment of dead load is automatically done by giving the property of the member. In load case we have option called self weight which automatically calculates weights using the properties of material i.e., density and after assignment of dead load the skeletal structure looks red in color as shown in the figure.

Dead Load taken:

Self weight = -2500 kg/m3

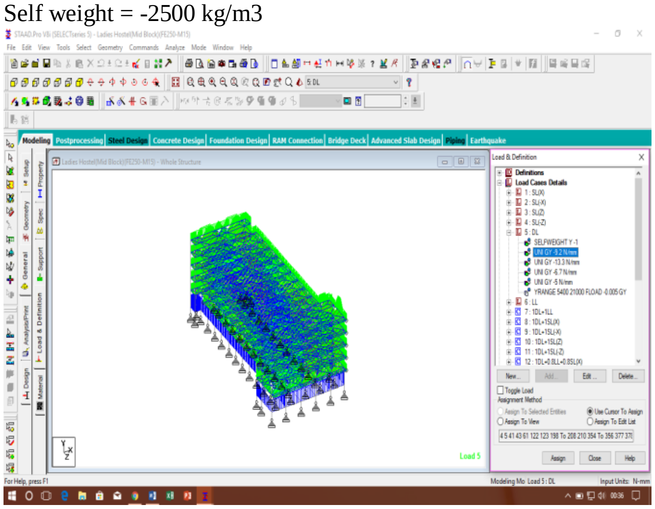

Figure 5: STAAD PRO design

Weight of 250 mm brick :-13.3 N/mm

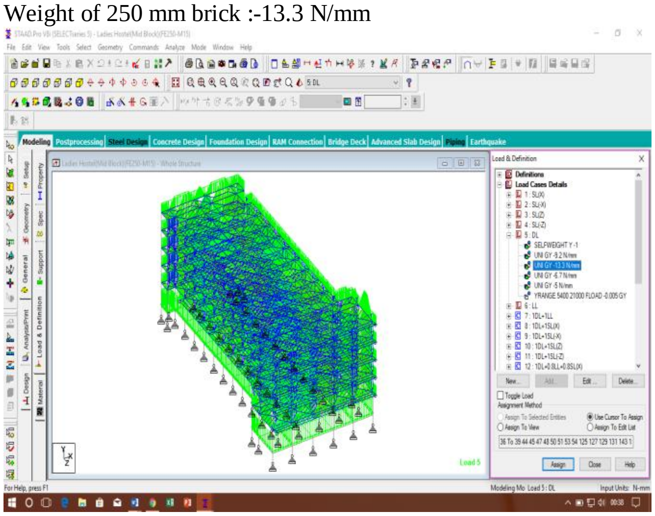

Figure 6: STAAD PRO design

Weight of 125 mm brick : -6.7 N/mm

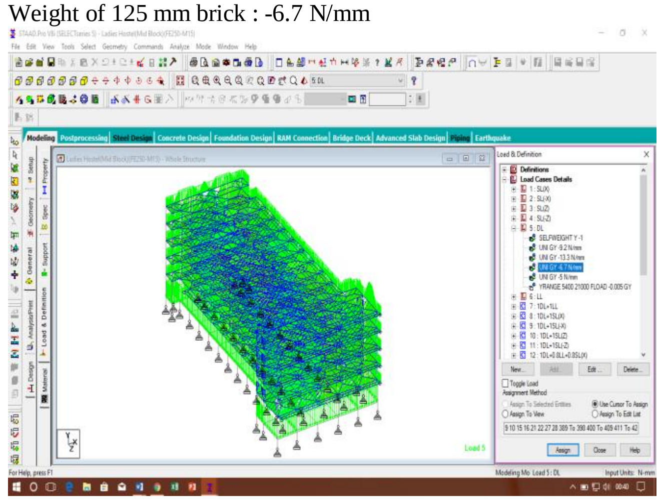

Figure 7: STAAD PRO design

Weight of tile in the floor:-5 N/mm

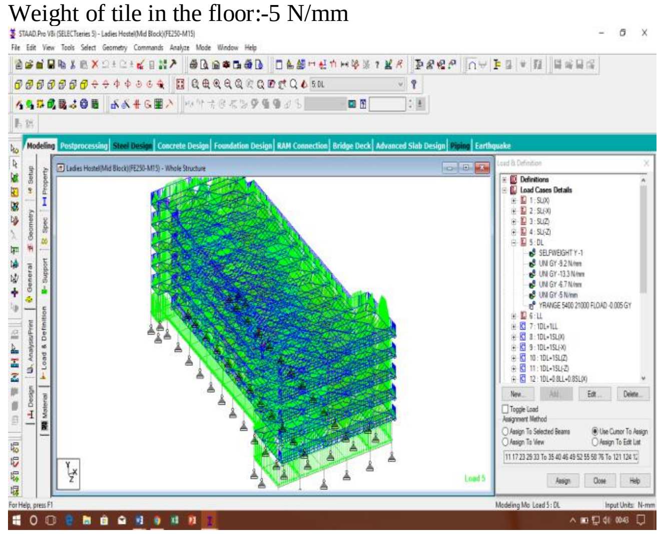

Figure 8: STAAD PRO design

3.8 Live Loads

Live loads are produced by the use and occupancy of a building. Loads include those from human occupants, furnishings, no fixed equipment, storage, and construction and maintenance activities. As required to adequately define the loading condition, loads are presented in terms of uniform area loads, concentrated loads, and uniform line loads. The uniform and concentrated live loads should not be applied simultaneously n a structural evaluation. Concentrated loads should be applied to a small area or surface consistent with the application and should b e located or directed to give the maximum load effect possible in enduse conditions. For example, the stair load of 300 pounds should be applied to the center of the stair tread between supports. In staad we assign live load in terms of U.D.L .we has to create a load case for live load and select all the beams to carry such load. After the assignment of the live load the structure appears as shown below. For our structure live load is taken as 25 N/mm for design. Live loads are calculated as per IS 875 part 2

3.9 Live loads in intermediate floors

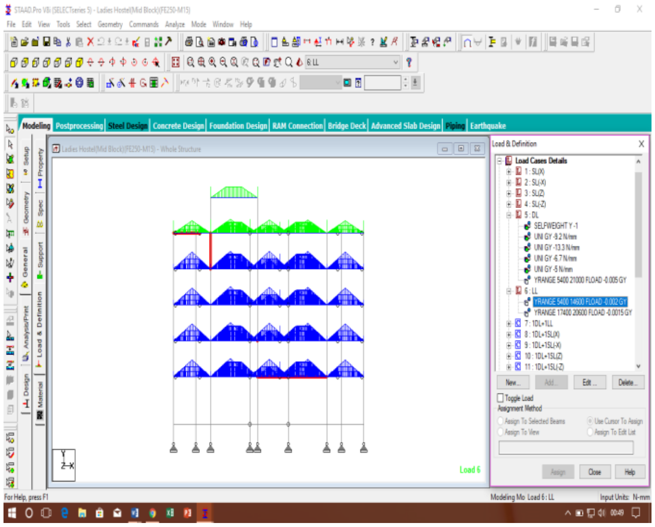

Figure 9: STAAD PRO design

3.10 Live Load in Terrace floor

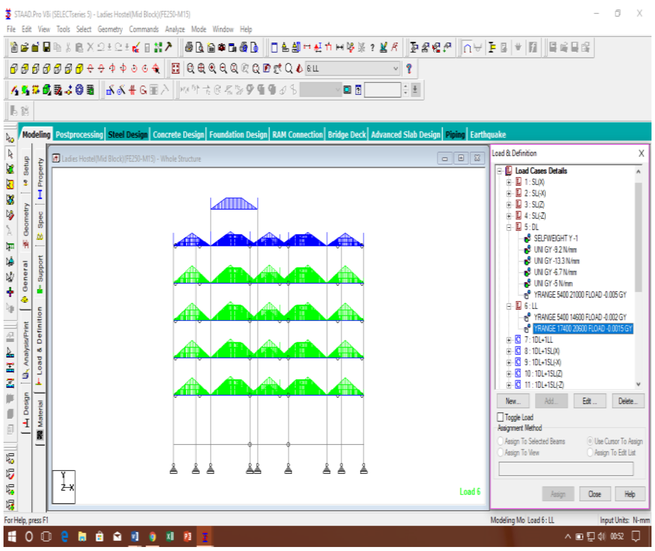

Figure 10: STAAD PRO design

3.11 Earth Quake Load

Significant horizontal loads can be imposed on a structure during an earthquake. Buildings in areas of seismic activity need to be carefully analyzed and designed to ensure they do not fail if an earthquake should occur. India has divided in to four zones as i.e. zone II, zone III, zone IV ,zone V

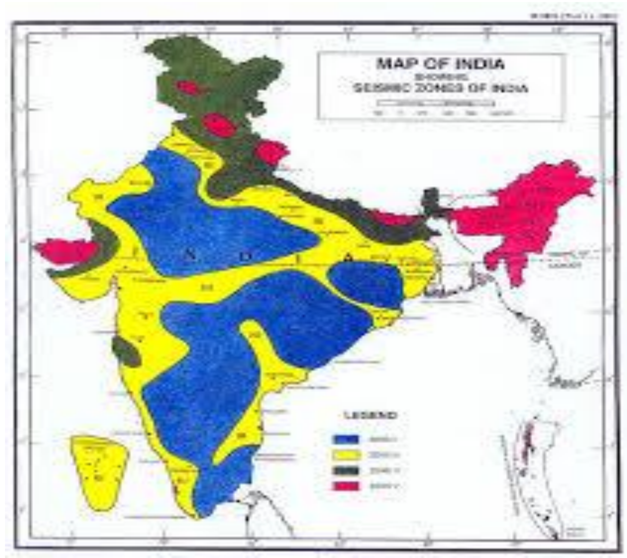

Figure 11: STAAD PRO design considering earthquake zone

This building is constructed At- Ramachandrapur, PO; Jatni, Bhubaneswar.
Bhubaneswar comes under the zone III.
Its zone factor is 0.10.

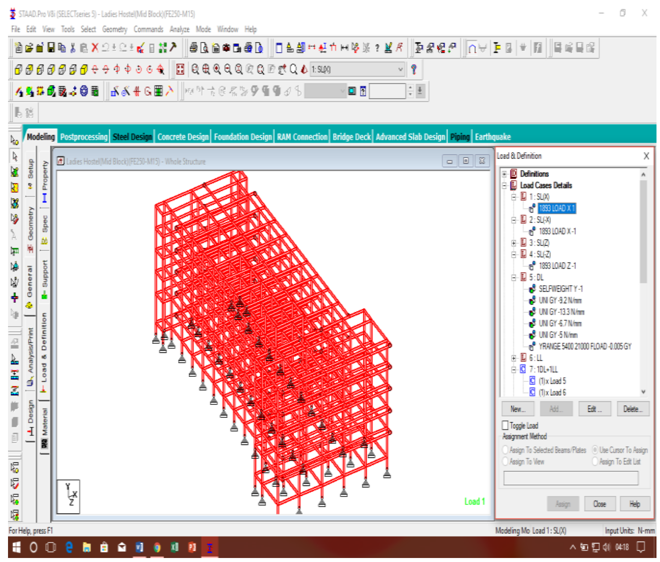

Figure 12: STAAD PRO design failure analysis

3.12 Load Combination

A **load combination** sums or envelopes the analysis results of certain load cases. Summation is often suitable for a linear analysis in which results are superimposed.
The load combinations done for the building is :

- 1 DL + 1 LL
- 1 DL + 1 SL (X)
- 1 DL + 1 SL (-X)
- 1 DL + 1 SL (Z)
- 1 DL + 1SL(-Z)

- 1 DL + 0.8LL + 0.8SL(X)
- 1 DL + 0.8LL + 0.8SL(-X)
- 1 DL + 0.8LL + 0.8SL(Z)
- 1 DL + 0.8LL + 0.8SL(-Z)
- 1.5 DL + 1.5 LL
- 1.5 DL+ 1.5SL(X)
- 1.5 DL + 1.5SL(-X)

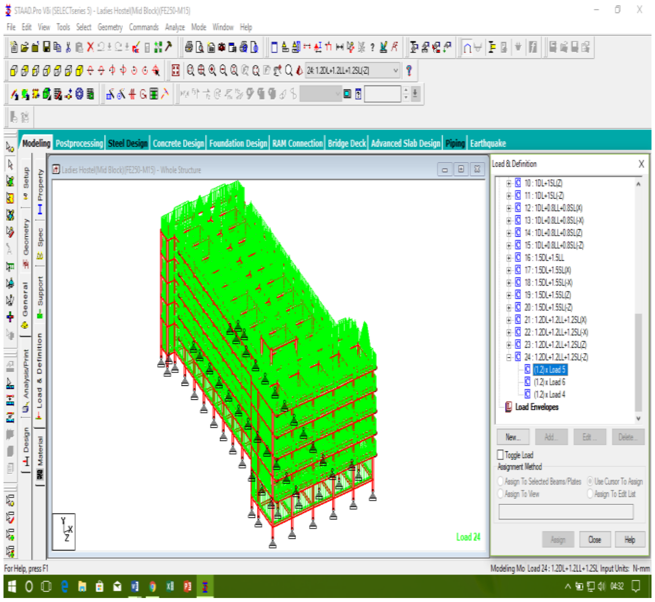

Figure 13: STAAD PRO design failure analysis

3.13. Failure analysis

3.14 Failure analysis of beam

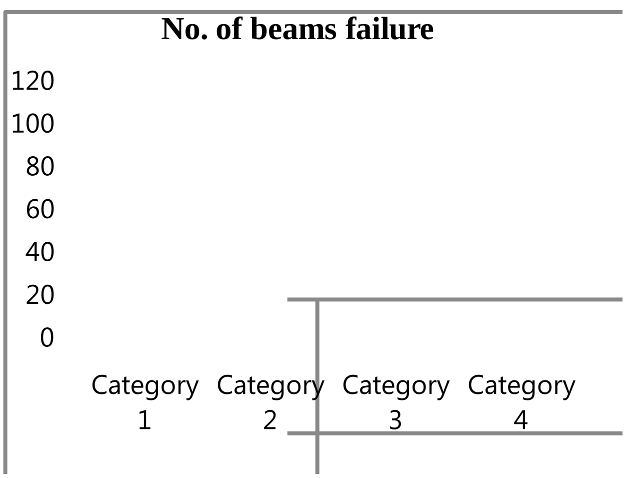

Figure 14: beam failure analysis

Category 1= When Fc= 20 N/sqmm and Fy=415 N/sqmm
Category 2= When Fc= 20 N/sqmm and Fy=250 N/sqmm
Category 3= When Fc=15 N/sqmm and Fy=415 N/sqmm
Category 4= When Fc= 15 N/sqmm and Fy=250 N/sqmm

3.15 Failure of Column

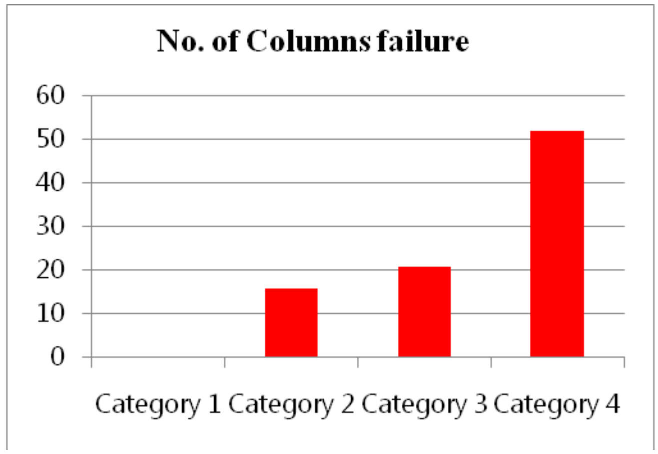

Figure 15: Column failure analysis

Category 1= When Fc= 20 N/sqmm and Fy=415 N/sqmm
Category 2= When Fc= 20 N/sqmm and Fy=250 N/sqmm
Category 3= When Fc=15 N/sqmm and Fy=415 N/sqmm
Category 4= When Fc= 15 N/sqmm and Fy=250 N/sqmm

3.16 Failure Analysis of Members Due to Increasing of Live Load

Live loads are taken in the structural design is 2 KN/sqm

For failure analysis of the structures, live load intensity is increased.

- When the properties of the material change the staadpro, automatically design the member by increasing required amount of steel area.
- As the members are failed when intensities of loading system increases, safe factor of safety of the loading system may be taken to avoid failure.
- As failure of members occur due to change in properties of the materials, while construction work going on same material properties may be taken as specified in the design, so that failure may not happen

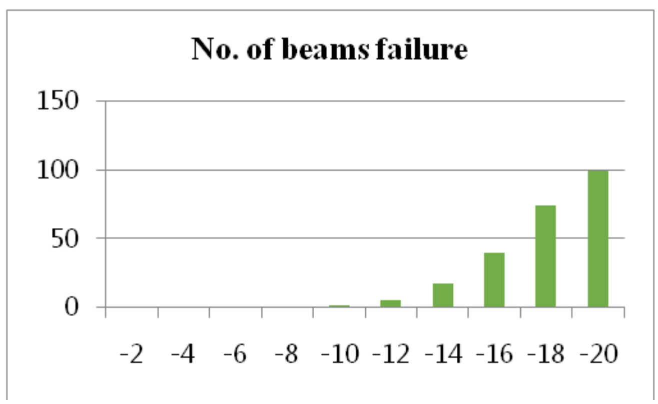

Figure 16: Beam failure analysis

4. CONCLUSION

The building is designed by applying the compressive strength of concrete 20 N/ Sqmm at 28 days and tensile strength of the steel 415 N/ sqmm. The area, where the building is located, it comes under the seismic zone III.It is concluded that when the properties of the building material changes and loading system increases gradually the failure number of beams and columns are increased.

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