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# Design of Steel Structure Building using Speedfloor Technology

Divya Jyothi V[1] ,Sashidhar C[2]

[1]Department Of Civil Engineering & JNTUA College of Engineering,
[2]Department Of Civil Engineering & JNTUA College of Engineering

***Abstract***— ***The principle objective of this project is to analyse and design of Steel multi storied Building (2cellars+1 stilt + 6floors) using STAAD.Pro V8i and the methodology used is Speedfloor Technology. Speedfloor Technology is an new emerging field in the construction of steel structure which is already been used in Australia, Newzealand and other western countries. Speedfloor, the unique suspended concrete flooring system, is an innovation to the building industry. Speedfloor is quick and easy to install. Speedfloor is a lightweight, cost-effective system that's perfect for multi-storied residential or commercial buildings and parking garages. Compared to normal constructions the walls used are EPS(Expanded Polystyrene Panels) walls. Its weight is less compared to Brick masonry and it provides diaphragm action. The overall weight of the structure is reduced and the composite floor is provides with ply wood as base and is removed once the deck has hardened. The spacing of the beams can be decided based on the vendor input.Complicated and high rise structures need very time taking and cumbersome calculations using conventional manual methods. STAAD Pro provides as a fast , efficient, easy to use and accurate platform for analyzing and designing structures.***

***Keywords— Speedfloor, Expanded Polystyrene, emerging, high rise structures, cumbersome***

## I. INTRODUCTION

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 now a days into beautiful buildings and houses. The construction technology has advanced since the beginning from primitive construction technology to the present concept of modern buildings. The present construction methodology for buildings calls for the best aesthetic look, high quality and fast construction, cost effective and innovative touch.

Due to the concentration and increase of population into urban cities there is a need to accommodate the influx in the urban cities. However, due to rapid increase of land cost, and limited availability of land the trend is to high rise building. The advantages of high rise buildings include but not limited to high ratio rentable floor space per unit area of land.

Various types of structural system have been used to facilitate the demand of high rise structures. Thousands of high rise buildings are being built all over the world with steel as well as reinforced concrete.

Now a days the building is major work of the social progress of the country. Daily new techniques are being developed for the construction of buildings economically , quickly and fulfilling the requirements of the community engineers and architects do the design work, works of building as for the direction of engineers and 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 an 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.

### AIM OF THE PRESENT PROJECT

- After designing the study circle the total tonnage of steel required is estimated by this preliminary design.
- Taking Dalit study circle as case study, we try to construct the concrete slab by using Speedfloor Technology.
- And walls used are EPS( Expanded Polystyrene) walls in this study circle.

### SCOPE OF PRESENT PROJECT

Following points will be covered in project work

- Planning of various components of a building.
- Study of design of various elements of building.
- Introduction of STAAD Pro.
- Modelling of the building in the STAAD-Pro giving all boundary conditions(supports, loadings etc.,).
- Analysis and design of various structural components of the modal building.

- Detailing of beams, columns, slab with section proportioning and reinforcement.

**METHODOLOGY**

Dalit study circle Building is analysed by using Limit state method. For this purpose STAAD-Pro is used. In this design new technology is used called Speedfloor Technology with EPS(Expanded Polystyrene) walls. Speed floor, the unique suspended concrete flooring system, is an innovation in the building industry. Speedfloor the perfectly simple, simple perfect solution to multi-storey construction. The design methods used in this project STAAD- Pro analysis are limit state Design conforming to Indian Standard Codes of Practice. STAAD- Pro provides us a fast, efficient, easy to use and accurate platform for analyse and designing structures compared conventional manual methods.

## II. REVIEW OF LITERATURE

**GENERAL**

Many papers have been published related to infill effect in the RC buildings. Some of them are discussed below.

**Code of practice for design loads**

Indian standard code of practice for design loads(other than earthquake) for building and structures. It includes five parts as follows

**IS:875 (Part 1)-1987,** this code includes the dead load to be considered for the structure.
**IS:875 (Part 2)-1987,** this code involves the imposed load or live load acting on the structure.
**IS:875 (Part 3)-1987,** this code involves the wind load consideration for a structure.
**IS:875 (Part 5)-1987,** this involves the special code and load combination to be considered. The different combination of dead load, live load, wind load and erection load after proper application of factor is given in this code.

**Design philosophy**

Over the years, various design philosophies have evolved in various parts of world. They are of three types of design philosophies.

- Working stress method
- Ultimate load method
- Limit state method

**Limit state method**

This philosophy is an advancement over the traditional design philosophies. It considers the safety at the ultimate load and serviceability at the working load, sort of extension of the working stress method and ultimate load method.There are 2 types of limit states

1. Ultimate Limit State
It considers strength , overturning, fatigue, sliding etc.,
2. serviceability Limit State
It considers crack width, deflection, vibration etc.,

Porter et al. [1] carried out a large number of experimental investigations on the composite deck slabs.
Porter and Ekberg [2] have conducted experimental studies on the shear-bond failure characteristics of one-way composite slabs and reported several observations on the significant parameters which are influencing the composite behaviour.
Rohit Raj[3] has been made to review the various aspects of EPS imbedded in the reinforced concrete and its prospective design & implementation in the building to make it energy efficient. The unit weight of EPS embedded structure is upto 35% less than the conventional concrete structure and the pre-assembled units reduces the overall cost of structure significantly. Hence, EPS embedded structure results in a sustainable and economical structure.
The New Zealand Building Code is performance based which means ‘Acceptable Solutions’ and ‘Approved Verification Methods’ that demonstrate compliance with the code can be used through satisfaction of the performance objectives of that code.

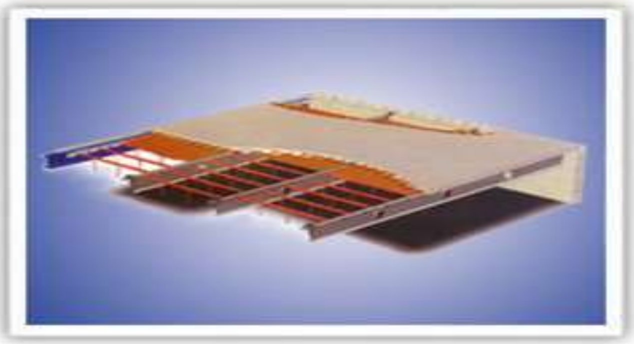
**Projects using Speedfloor**

7 storey building constructed using structural steel frame with speedfloor
The ground floor retail complex exposing Speed floor joists
The store’s services, such as electrical cabling, have been accommodated through the exposed joists.
The lightweight Speed floor joists and structural steel resulted in minimal foundations in the 10 storey car park
Completed in 16 weeks
Two storey commercial building with basement car building with basement car parking.
12 level, apartment block built at a high susceptible seismic region.
Twin 12 storey apartment buildings built using a pre-cast concrete core and structural steel frame.
Speed of erection is the prime consideration for using Speed Floor in the Towers.

III. SPEEDFLOOR TECHNOLOGY & EXPANDED POLYSTYRENE

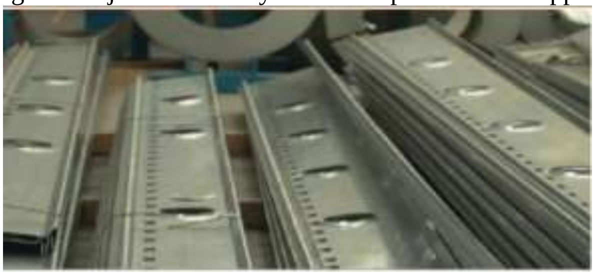
**SPEEDFLOOR TECHNOLOGY**

Speedfloor Technology is an emerging technology used for fast construction for residential, commercial complex. The system has been developed combining modern techniques and roll forming technology for a fast, light weight concrete/steel composite floor at a cost effective price. Speedfloor system is a suspended concrete flooring system using a roll formed steel joist as an integral part of the final concrete and steel composite floor. The Speedfloor system essentially is a hybrid concrete/ steel tee-beam in one direction and an integrated continuous one -way slab in other direction. The joists of different depths are manufactured from pre-galvanised high tensile steel in a one pass roll former, where it is roll formed, punched, pressesd and slotted in a fully computerized machine. The joist depth and the concrete thickness are varied depending on the span, imposed loads and other functional considerations. The speedfloor composite floor system is suitable for use in all types of construction . The Speedfloor joists are custom manufactured to suit particular job conditions.



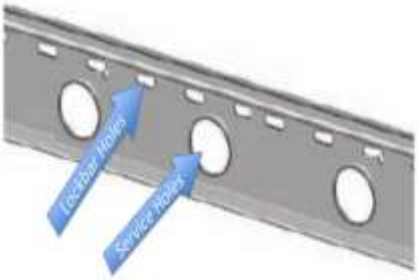
**JOIST**

The individually marked, lightweight steel joists are easily lifted into place on the support medium.



**LOCKBAR**

Lockbars, which will support the plywood, are slid into slots punched in the top section of the joist and by engaging the notches at both ends of the lockbar, the exact spacing of the joist is secured.




**TEMPORARY PLYWOOD FORMWORK**

The plywood is installed from the top and is held in place by the cam action of the lockbars. A working platform can be quickly created with the rest of the plywood as it progresses down the building.

## REINFORCING MESH

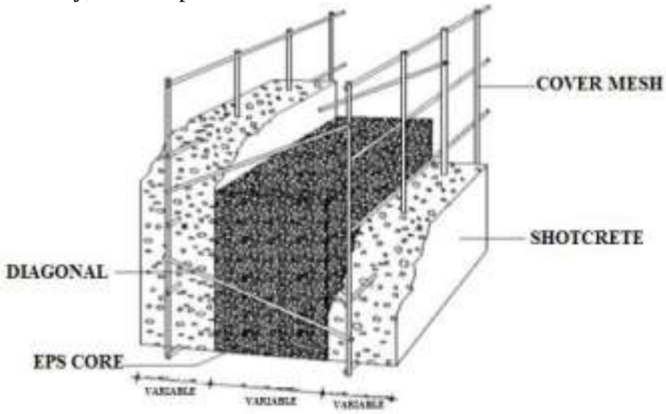
The mesh or rebar is laid out and tied into place. No stools are required as it is held off the deck by the top section of the joist, which becomes embedded in the concrete and will gain composite action once the concrete cures.

## CONCRETE

The finished floor after the lockbars and plywood are removed reveals the concrete soffit and exposed joist where services can be passed through the pre punched holes. The bottom of the joist can support a fire rated suspended ceiling fixed directly to the joist.

## EXPANDED POLYSTYRENE PANELS(EPS)

This material is formed by either a moulding or an extrusion process. In the moulding process, tiny polystyrene beads are impregnated with a blowing agent, typically pentane. The beads are then exposed to pressurized steam, causing the blowing agent to vaporize and thereby partially expanding the beads. They are then placed in large moulds and exposed to pressurized steam, causing them to fully expand and fuse together to form a solid piece called a billet. The billet can then be cut into boards, schematically, the 3D panel cross section.




## ADVANTAGES OF EPS PANELS

The advantages of EPS panels include

- High load bearing capacity at low weight
- Effective and durable thermal insulation
- Absolute water and vapour barrier
- Air-tightness for controlled environments

- Long life, low maintenance
- Lightweight, fast and economic construction
- Most cost effective insulation material available

**PROPERTIES OF EPS PANELS**

EPS has been a material of choice for over half a century because of its technical versatility, performance and cost effectiveness. It is widely used in many everyday applications where its light weight, strength, durability, thermal insulation and shock absorption characteristics provide economic, high performance products.

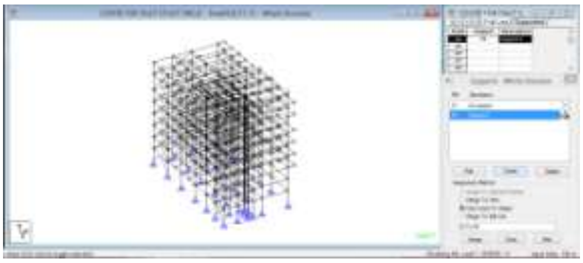
- Light weight
- Durability
- Moisture Resistance
- Thermal Efficiency
- Shock Absorption
- Versatility
- Ease of use

## 4. ANALYSIS OF STEEL BUILDING USING STAAD

### INTRODUCTION

STAAD-Pro is a Structural Analysis and Design computer program developed by Bentley systems, Inc., which is a powerful tool for structural analysis and design. Complicated and high-rise structures need very time taking and cumbersome calculations using conventional manual methods.

STAAD-Pro provides us a fast, efficient, easy to use and accurate platform for analyses and designing structures. Design and construction of a structure are intimately related and the achievement of good workmanship depends, to a large degree, on the simplicity of detailing of the members and of their connections and supports.



**Physical parameters of building**

Length = 5 bays = 18.44m
Width = 6 bays =34.976m
Height = 21.250m

**Supports**

The base supports of the structure were assigned as pinned. The supports were generated using the STAAD.Pro support generator.

**Loading**

Loads in a structure can be specified as joint load, member load, temperature load and fixed end member load. STAAD can also generate the self-weight of the structure and use it as uniformly distributed member loads in analysis. Any fraction of this self weight can also be applied in any desired direction

The loadings were calculated partially manually and rest was generated using STAAD.Pro load generator. The loading cases were categorized as:

Self-weight
Dead load from slab
Live load
Wind load

Seismic load

**Load combinations**

Load combinations for design and assessment of buildings or parts are to be selected based on the required performance level of the buildings or the parts. The required performance level of buildings or parts must be determined by designers based on importance, sociality, economy, relevance to existing design codes, etc.

Loading states to be considered are, according to actual conditions, as follows

- State of live loading
- State of snow load
- State of earthquake
- State of temperature change

## 5. RESULTS AND DISCUSSION

Some of the sample analysis and design results have been shown below for beam number 393, which is at floor level, column number 134 and bracing number 1548.

**Design of Beam**

The design of laterally supported beam consists of selecting a section on the basis of the modulus of section and checking it for shear capacity, high/ low shear case, web buckling, web crippling and deflection. The design is done in the following manner.

1. The service loads expected on the beam are ascertained. The service loads are multiplied with the load factor $\gamma_f$ to determine the factor loads.
2. The maximum bending moment M and maximum shear force V are calculated for the beam.
 The forces are referred to as design actions.
3. A trial plastic section modulus for the beam is worked out by

$$Z_{pz,req} = \frac{M\gamma_{mo}}{f_y}$$

where M= design moment
$f_y$= yield stress of the material
$\gamma_{mo}$= partial safety factor=1.1

4. From Appendix VIII a suitable section having plastic section modulus equal to or more than $Z_{pz,req}$ is selected as a trial section an the properties of the section are not .
5. The classification of section is checked an it is classed as plastic, compact or semi compact depending upon the specified limits of $b/t_f$ and $d/t_w$ .
6. The trial section is checked for shear.
   (i). The design shear force V should be less than the design shear capacity $V_d$

$$V_d = (A_v.\ f_y)/(\sqrt{3}x\gamma_{mo})$$

where h= overall depth of the section
$t_w$= thickness of the web
 (ii) The beam is checked for high/low shear case
 If $V \leq 0.6\ V_d$ , the case is of low shear whereas if $V>0.6\ V_d$, it is high shear case.
7. The trial section is checked for design bending strength.
 For low shear case $M_d > M$
 where $M_d$= design bending moment strength (for plastic or compact section)
 M= design of bending moment of semi-compact section
 $==(Z_e.f_y)/(\ \gamma_{mo})$
 The bending design strength
 $M_{dv} = M_d - \beta(M_d - M_{fd})$
 $\leq 1.2\ Z_e\ (f_y/\ \gamma_{mo})$
 $Z_{fd} = Z_p - A_w y_w$
 where $A_w$= area of the web= $ht_w$
 $y_w$= h/4
8. The trial section is checked for web buckling.
 If $d/t_w \leq 67\varepsilon$ (for webs without stiffeners) the web is generally considered to be safe in web buckling and the shear strength of the web is governed by the plastic shear resistance. However, in case of high shear, even if this limit is satisfied, the web should be checked for buckling. Web buckling strength should be greater than the design shear force .
 The capacity of the section = $A_b\ f_{cd}$
 $A_{b=}$ area of the web at the neutral axis of the beam=$Bt_w$
 $f_{cd}$ = design compressive stress
9. The trial section is checked for web bearing

$$F_w > V$$

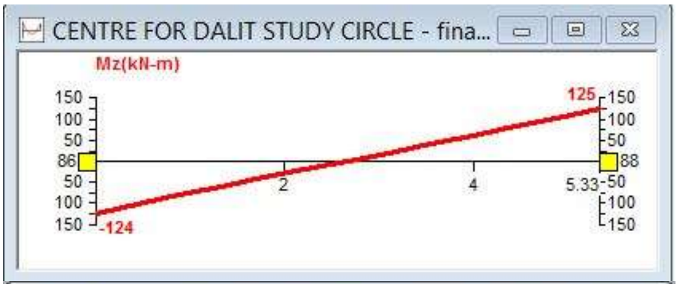
 where $F_w$ = web bearing strength
 $= A_e\ f_{yw} / \gamma_{mo}$

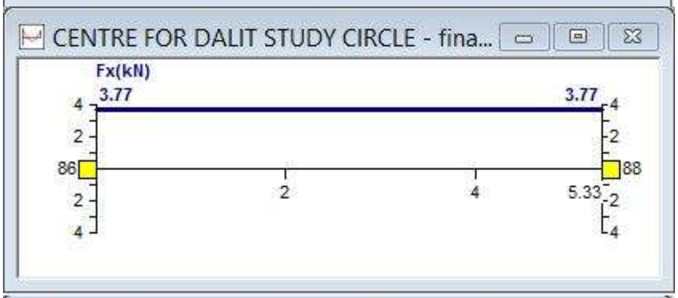
where $A_e = [b+2.5(t_f+R_1)]t_w$
$f_{yw}$ = yield stress of the web of the beam section.

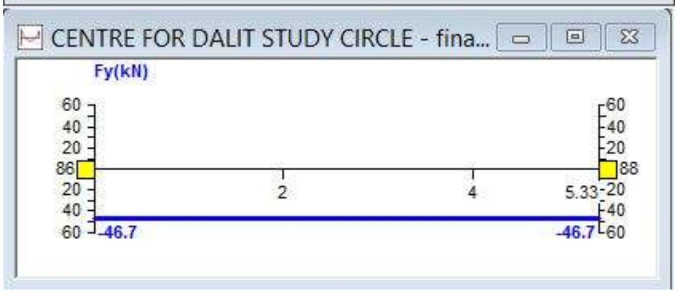
10. The trial section is checked for deflection. Deflection is serviceability criteria and as such the maximum deflection is calculated for service loads and it should be less than the permissible deflection(l/300).

**BEAM DESIGN**

```
| Member Number:    393                                          |
| Member Section:      TAP ERED       (INDIAN SECTIONS)                  |
| Status: PASS  Ratio:  0.342  Critical Load Case:  105  Location:      4.89  |
| Critical Condition: Sec. 9.3.1.3                               |
| Critical Design Forces:  (Unit: KN    METE)                          |
|     FX:      6.845E+00 C     FY:     134.819E+00      FZ:     -1.722E+00     |
|     MX:      2.363E+00       MY:      44.111E+00      MZ:    197.717E+00     |
|-------------------------------------------------------------------------------|
| Section Properties:    (Unit:  CM  )                                 |
| AXX:     225.200E+00       IZZ:    222.353E+03       RZZ:     31.422E+00|
| AYY:      85.200E+00       IYY:     14.302E+03       RYY:      7.969E+00|
| AZZ:     140.000E+00       IXX:    227.563E+00        CW:     19.040E+06|
| ZEZ:       5.929E+03       ZPZ:      6.622E+03                        |
| ZEY:     817.251E+00       ZPY:      1.251E+03                          |
|-------------------------------------------------------------------------------|
| Slenderness Check:    (Unit:  KN    METE)                              |
| Actual Length:       5.330E+00                                    |
| Parameters:     LZ:       5.330E+00  LY:       1.500E+00                 |
|              KZ:         1.000  KY:           1.000                   |
| Actual Ratio:  18.82 Allowable Ratio: 400.00  LOAD:   131 FX:     -2.069E+00 T  |
|-------------------------------------------------------------------------------|
| Section Class: Semi-Compact; Flange Class: Semi-Compact; Web Class:      Plastic
```




**Column Design**

Step 1: Type of the Section

$P_d = Axf_{cd}$ $\qquad \frac{d}{t_w}$

Step 2: Determination of Effective Length
Step 3: Calculate the Slenderness Ratio
Step 4: Determination of Non Dimensional

$$\lambda_x = \sqrt{\frac{f_y}{f_{cc}}} = \sqrt{\frac{f_y\left(\frac{KL}{r}\right)^2}{\pi^2 E}}$$

Step 5: Calculation of ϕ

$$\phi = 0.5\left[1+\alpha(\lambda-0.2)+\lambda^2\right]$$

Step 6: Calculation of Stress Reduction Factor

$$\chi = \frac{1}{\left[\phi+\left(\phi^2-\lambda^2\right)^{0.5}\right]}$$

Step 7: Determination of design Compressive Stress $f_{cd}$

$$f_{cd} = \frac{f_y/\gamma_{mo}}{\phi+\left[\phi^2-\lambda^2\right]^{0.5}}$$

Step 8: Determination of Compressive stress $P_d$

$$P_d = A \times f_{cd}$$

**COLUMN DESIGN**

```
|  Member Number:    134                                          |
|  Member Section:      TAPERED       (BRITISH SECTIONS)                    |
|  Status: PASS  Ratio:   0.392  Critical Load Case:   105  Location:       3.35   |
|  Critical Condition: Sec. 9.3.2.2 (Y)                               |
|  Critical Design Forces:  (Unit: KN    METE)                                |
|     FX:       1.912E+03 C     FY:    -102.060E+00       FZ:      -3.167E+00      |
|     MX:      0.000E+00       MY:     -10.610E+00      MZ:     341.902E+00      |
|--------------------------------------------------------------------------------|
|  Section Properties:    (Unit:  CM  )                                |
|  AXX:     320.000E+00        IZZ:     353.734E+03        RZZ:      33.248E+00|
|  AYY:     120.000E+00        IYY:      27.942E+03        RYY:       9.344E+00|
|  AZZ:    200.000E+00        IXX:     519.067E+00        CW:      36.484E+06|
|  ZEZ:      8.221E+03        ZPZ:       9.902E+03                         |
|  ZEY:      1.242E+03        ZPY:       2.079E+03                         |
|--------------------------------------------------------------------------------|
|  Slenderness Check:    (Unit:  METE)                                  |
|  Actual Length:       3.350E+00                                |
|  Parameters:     LZ:       3.350E+00  LY:        3.350E+00                  |
|               KZ:           1.000  KY:            1.000                 |
|  Actual Ratio:  35.85 Allowable Ratio: 180.00  LOAD:   101 FX:      2.056E+03 C  |
|--------------------------------------------------------------------------------|
| Section Class: Semi-Compact; Flange Class: Semi-Compact; Web Class:      Plastic |
|--------------------------------------------------------------------------------|
|--------------------------------------------------------------------------------|
|  Member Number:    134                                          |
|  Member Section:      TAPERED       (BRITISH SECTIONS)                    |
|--------------------------------------------------------------------------------|
|  Tension:    (Unit:KN    METE)                                 |
|  Parameters:     FYLD:      345.000E+03       FU:      420.000E+03              |
|                 NSF:           1.000     ALPHA:           0.800     DBS: 0     |
|  Capacity:       8.602E+03          As per sec. No.:Cl. 6.3                 |
|  Actual Design Force:       0.000E+00       LC:       0                 |
|--------------------------------------------------------------------------------|
|  Compression:    (Unit:KN    METE)                                   |
```

```
| Buckling Class:   Major: b    Minor: c    As per Sec. No.:Cl. 7.1.2.2          |
| Capacity:       8.638E+03         As per sec. No.:Cl. 7.1.2                     |
| Actual Design Force:       2.056E+03      LC:     101                           |
|-------------------------------------------------------------------------------|
| Shear:    (Unit:KN  )                                                          |
| Major Axis:  Actual Design Force:   -102.060E+00  LC:   105  Loc:      3.350E+00|
|              Capacity:       2.173E+03    As per sec. No.:Cl. 8.4.1            |
| Minor Axis:  Actual Design Force:     -3.317E+00  LC:   104  Loc:      0.000E+00|
|              Capacity:       3.622E+03    As per sec. No.:Cl. 8.4.1            |
|-------------------------------------------------------------------------------|
| Bending:    (Unit:KN     METE)                                                 |
| Parameters:   Laterally Unsupported    KX:   1.00  LX:   3.350E+00  General    |
| Major Axis:  Actual Design Force:    341.902E+00  LC:   105  Loc:      3.350E+00|
|              Capacity:       2.662E+03    As per sec. No.:Cl. 8.2.2            |
| Minor Axis:  Actual Design Force:     11.111E+00  LC:   104  Loc:      3.350E+00|
|              Capacity:     389.498E+00    As per sec. No.:Cl. 8.2.1.2          |
|-------------------------------------------------------------------------------|
| Combined Interaction:                                                          |
| Parameters:  PSI: 1.00   CMX:    0.900   CMY:    0.900   CMZ:    0.900         |
| Interaction Ratio:     0.392    As per sec. No.:Sec. 9.3.2.2 (Y)               |
| LC:      105     Loc:       3.350E+00                                          |
|-------------------------------------------------------------------------------|
| Checks             Ratio    Load Case No.      Location from Start            |
|                                                                                |
| Tension             0.000       0               0.000E+00                      |
| Compression         0.261     101               0.000E+00                      |
| Shear Major         0.047     105               3.350E+00                      |
| Shear Minor         0.001     104               0.000E+00                      |
| Bend Major          0.147     105               3.350E+00                      |
| Bend Minor          0.029     104               3.350E+00                      |
| Sec. 9.3.1.3        0.365     105               3.350E+00                      |
| Sec. 9.3.2.2 (Z)    0.337     105               3.350E+00                      |
| Sec. 9.3.2.2 (Y)    0.392     105               3.350E+00                      |
|-------------------------------------------------------------------------------|
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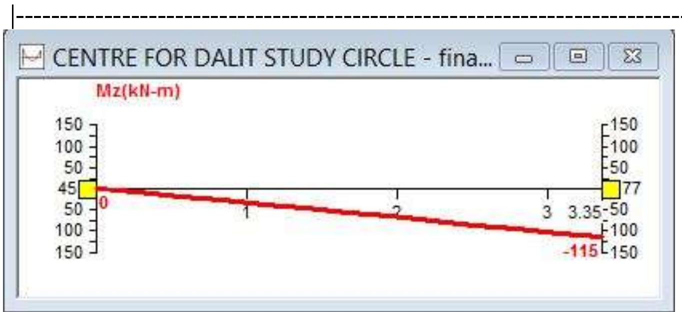


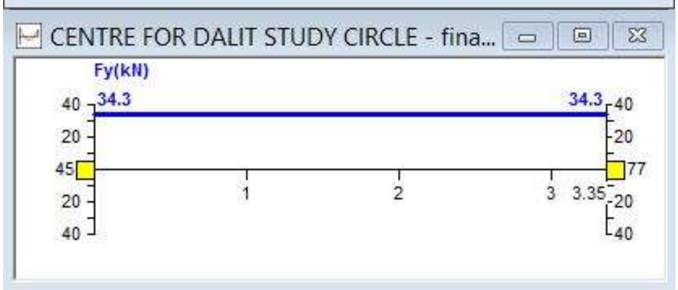


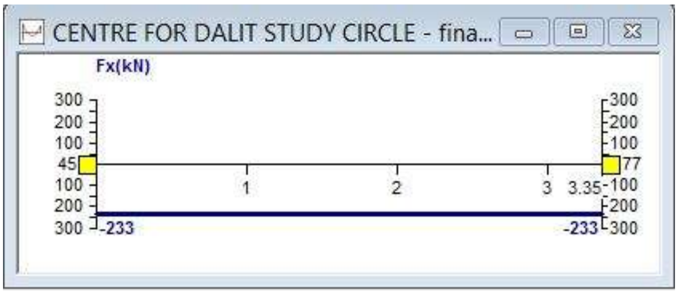

## 6. Conclusion

- In this project we have designed a steel structure building which consists of 9 floors building (2 cellar+ 1 stilt+ 6 floors). The building which is to be constructed at Borbanda in Hyderabad .
- In this project we preferred steel material rather than RCC and Speedfloor Technology is introduced . Speedfloor composite flooring system is suitable for use in all type of construction including: Steel frame structure, RCC frame Buildings, Poured insitu or precast concrete frames , light guage steel frames etc.,
- Limit state method came to existence due to the advancement on materials of the desired range of the strength and thus increasing the confidence levels. So research started in the direction of stressing the material beyond elastic limit to make the full strength of the material. By using limit state method, we design the steel beams and columns. We design only for primary structural members . Slab is 90mm thick with composite action.
- EPS is used in the building and construction industry and huge quantities are utilized to make insulation foam for walls, roofs and floor insulation.
- EPS has also found uses in road construction, bridges, swimming pools, retaining walls, basements and construction of soundproof rooms.
- Here, panels are first prefabricated in the factory. The raw materials are imported and used to manufacture the expanded polystyrene beads which are mould into EPS blocks.
- EPS panels are light weight and approximately 30% of regular brick walls. Typical designs are attached and they are manually checked as well.

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