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Design Calculation for A (G +10) Building (Encode Steel)

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Abstract: *The proposed steel building at Mumbai consisting of G+10 storeys, has a built-up area of about 165m^2. The typical floor height is 3m above GL and the total height of the building above GL is 33m.Withreference to given plan, the architectural drawings and structural drawings showing plan, elevation, sectional views and connection drawings are drawn by using AUTOCAD 2017.Design calculations (Dead Load, Live Load, Wind Load, Seismic Load) are calculated manually-As per IS codes which are mentioned in technical details. The rolled steel sections for beam and column has been chosen from IS 12778:2004. High tensile steel grade-E350BR has been used for steel sections. And, the analysis of structure is done by using STAAD.Pro V8i SS5.Design of beam and column are manually calculated-As per IS: 800-2007. And, spread sheet has been created to check the beam and column, whether it is safe or not. The connection designs are calculated-As per IS codes by using Welding-As per IS 9595-1996 and Fasteners-As per IS 3757-1985. Bracings are provided in the ground floor between the column to avoid soft storey failure. The material requirements are mentioned based on the design calculations. The total estimation of the building is 1.11cr.*

Keywords: Design Calculation, Analysing, AutoCAD, STAAD Pro

I. Introduction

In this a detailed design for G +10 residential structure. Design drawings showing various views and general arrangement. Detail drawings showing critical connections base plate details. Detailed bills of materials. General arrangement and structural design drawings showing plan, elevation and sectional views highlighting the structural system of the proposed structure. Detail drawings showing connection details of beams, columns, bracings, claddings, etc., in accordance with 'Design Scope'. All drawings should be drawn in AUTOCAD. Standard analysis software like STAAD. Pro. Design checks for the selected sections had been done using spreadsheets such as MS Excel. Connection design calculations and detailed sketches are attached in the appendices.

II. Drawings

The architectural drawings such as plan, section, elevation is drawn by using AUTO CAD 2017. The structural drawings like Beam Layouts and Column Layouts are drawn too.

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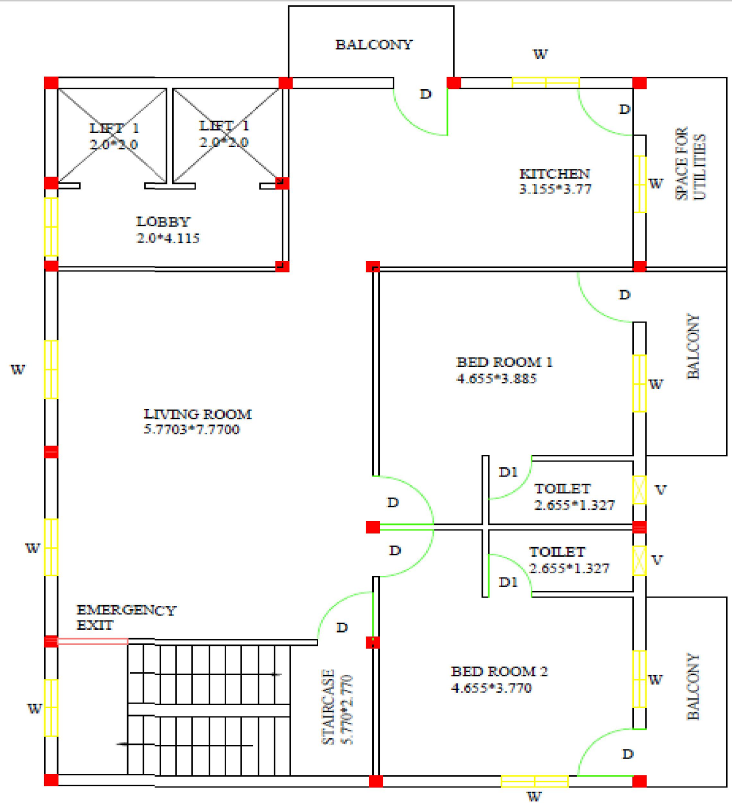


Figure: Plan Layout

III. Design Loads

3.1 Dead Load

The dead loads are the permanent loads acting axially on the expansion. The dead load of beam, column, brick wall, slab and staircase are calculated manually and attached in PDF format.

3.2 Live Load

Live load was computed using IS: 875 PART 2-1987

- Kitchen -2KN/M^2
- Bed room-2 KN/M^2
- Living room-2 KN/M^2
- Balconies-3 KN/M^2
- Stair case-3 KN/M^2
- Terrace- 1.5 KN/M^2

The live load of floor has been calculated manually and applied in the sections. The live load values are temporary loads acting on the structures rather than permanent loads.

3.3 Wind Load

For the purpose of determining approximate wind load on the structure, loads have been calculated in accordance with IS: 875 PART 3-1987, with a basic wind speed as 47 m/sec. Different intensity has been calculated in accordance with IS Code based on height of the storey.

- X - Windward side
- Z - Windward side

- X - Leeward / Sidewall face
- Z - Leeward / Sidewall face

3.4 Seismic Load

For the purpose of determining approximate seismic loads on the structure, loads have been calculated in accordance with IS: 1893-2002.The seismic load is considered for Mumbailocation which falls under Zone III.

- EQ X^{+VE}
- EQ X^{-VE}
- EQ Z^{+VE}
- EQ Z^{-VE}

Calculations are attached in PDF format.

3.5 Load Combination

Lateral load analysis is performed for this report and the load combinations are provided according IS 1893. It is also noted that the load combinations that includes the factor of 1.5DL are used to calculate uplift forces for the later loads.

- 1.5DL+LL
- 1.5DL+WL
- 1.5DL+EQ
- 1.5DL+SL

DL-Dead load, LL-Live load, WL-wind load, EQ-earthquake load, SL-seismic load.

IV. Structure Analysis

The model has been created and the materials had assigned to the model. And, the calculated loads were applied to the model. Then, the model was subjected to analysis by using STAAD. Pro V8i SS5. The 3D model of the building is,

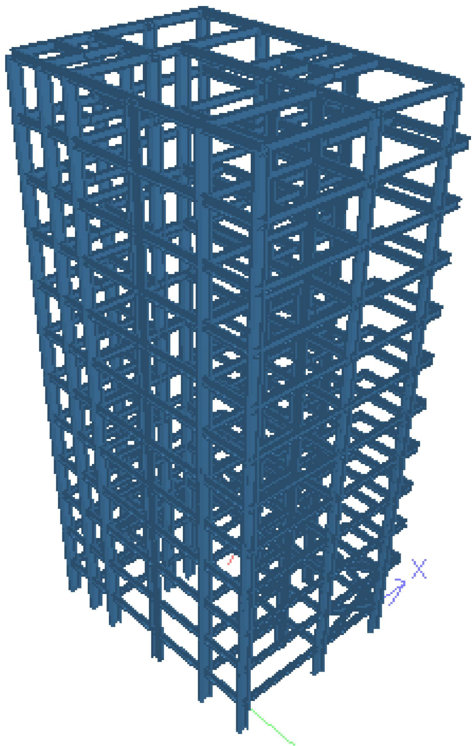


Figure: Structure Analysis

V. Design of Beams and Column

The sections are taken - AS per IS 12778 – 2004. And, the selected sections are connected by using welding – As per IS 9595 – 1996. The base plate connections are calculated and connected by using bolts – AS per IS: 5624 – 1993.Splicies are used to connect the columns. Seat angles and Cleat angles are used to connect the beam and the column. The calculations are manually calculated and attached in PDF format. Bracings are used in ground floor to avoid the soft storey failure. Spread sheet such as MS Excel has been created to check whether the beam is safe or not.

5.1 Materials

The required materials for construction have been mentioned below,

- Steel – High grade tensile steel (E350BR)
- Brick masonry
- RC

Apart from this the connection materials such as bolts, welding materials, Cleat angles and Seat angles are used for connections.

VI. Estimation for Materials

6.1 Steel

As per the grade E350BR, the amount of this material is Rs. **32/kg**. The split up of the materials in steel is mentioned below,

1. Beam and Column sections (I SECTIONS)
    - Weight- 237487.1778 kg = Rs. 75,99,589.70
2. Beam Splices, Column Splices
    - Bolt weight- 2243.8 kg = Rs. 71,801.60
    - Splice plate weight-16128.0kg = Rs. 5,16,096.00
3. Beam to Column Connections
    - Bolt weight- 3858.4kg = Rs. 1,23,468.80
    - Clip angles- 10140.0kg = Rs. 3,24,480.00
4. Bracing Connections
    - Bolt weight- 118.72kg = Rs. 3,800.00
    - Cleat angles- 314.00kg = Rs. 10,048.00
5. Base plate connections
    - Plate weight- 1413.0kg = Rs. 45,216.00
    - Anchor bolts- 117.56kg = Rs. 3,761.92
6. Welding(8 mm thick)- 39.24m = Rs. 17,658.00

TOTAL AMOUNT FOR STEEL = Rs. 87,15,920.02

6.2 RCSLAB

The amount required for 1 m^3 of concrete is Rs. 3547/m^3.Here we have used 24.7 $m^{3.}$

TOTAL AMOUNT FOR RC SLAB = Rs. 87,610.90

6.4 Brick Masonry

Brick Masonry consists of bricks and cement mortar. The priceof single red brick is Rs.7. The price of 43 grade OPC Cement is Rs.350/bag. The 1unit of M-sand is Rs.4500/unit.

Total no of bricks required-251281 nos =Rs. 15,07,686.00

Total no of cement bags is-634 bags =Rs. 2,21,900.00

Total unit of M-sand is-132.0776 units =Rs. 5,94,350.00

TOTAL AMOUNT FOR BRICK MASONRY= RS. 23,23936.00

TOTAL AMOUNT FOR STEEL	= Rs.	87,15,920.02
TOTAL AMOUNT FOR RC SLAB	= Rs.	87,610.90
TOTAL AMOUNT FOR BRICK MASONRY	= Rs.	23,23936.00
TOTAL AMOUNT	**=Rs.**	**1,11,27,466.92**

VII. Appendices

7.1 Load Calculations

Dead Load

A. Brick Masonary

$BW = \gamma_{bd} X\ t_k\ X\ (H - t_B)$

γ_{bd}- Brick density

t_k-Thickness of wall

H- Height of the wall

t_B-Thickness of beam

i) Brick wall BW_1 -230 Thickness

$BW_1 = \gamma_{bd} X\ t_k\ X\ (3-0.3)$

= 2100 X 0.23 X 2.7

= 1304.1 kg/m

BW_1 = 12793.221 n/m

BW_1 = 12.793 kn/m

ii) Brick wall BW_2 -230 Thickness (20% Reduction, due to openings)

BW_2= 20/100 X 12.793 kn/m

= 2.5586 kn/m

=12.793 – 2.5586

BW_2 = 10.2344 kn/m

iii) Brick wall BW_2 -115 Thickness

$BW_3 = \gamma_{bd} X\ t_k X\ (3-0.3)$

= 2100 X 0.115 X (2.7)

= 652.05 kg/m

= 6396.61 n/m

BW_3 = 6.396 kn/m

iv) Brick wall BW_2 -115 Thickness (20% Reduction, due to openings)

BW_4 = 20/100 X 6.396

= 1.2792 kn/m

= 6.396 – 1.2792

BW_4 = 5.1168 kn/m

B. Parapet Wall

v) BW_5 = 2100 X 0.23 X 1

= 483 kg/m

= 4738.23 n/m

BW_5 = 4.738 kn/m

vi) BW_6 = 2100 X 0.115 X 1

= 241.5 Kg/m

= 2369.115 n/m

BW_6 = 2.369 kn/m

C. Self Weight of Balcony

W= γ_{cd}X w

γ_{bd}- Concrete density

W-Width

W_1 = 25 x 1.5

W_1 = 37.5 kn/m

D. Self Weight of Slab

S_1 = (Density of slab X thickness + density of filling X thickness of filling + thickness of floor X thickness of floor finish)

S_1 = (Density of slab X thickness + density of filling X thickness of filling + thickness of floor X thickness of floor finish)

= 25 X 0.15 + 20

= 3.75 + 1 + 1

S_1 = 5.75 kn/m^2

Self weight of beam = 1 kn/m

Self weight of column = 1 kn/m

E. Weight of Lift Carrying 6 Persons

Totally there are two lifts. so, we need to calculate the weight of lift including 12person weight.

The total weight is = **13.734 kn/m.** This load is divided equally into 4 parts and given as point load in the column. The point load is = **3.4335 kn/m**

F. Weight of Staircase

Dead load of waist slab is = **8.3 kn/m**

Dead load of step is = **1.875 kn/m**

Total dead load acting is = 1**0.2 kn/m.** This load is divided equally into 4 parts and given as point load in the column.

Live Load

i) Kitchen = 2kn/m^2

ii) Bathrooms = 2kn/m^2

iii) Staircases = 3kn/m^2

iv) Bed rooms = 2kn/m^2

v) Balconies = 3kn/m^2

vi) Living room = 2 kn/m^2

vii) Lobbies = 3kn/m^2

viii) Garage = 2.5 kn/m^2

ix) Terrace = 1.5 kn/m^2

Wind Load

In accordance with IS: 875 PART 3-1987, with a basic wind speed as 47 m/sec. Different intensity has been calculated in accordance with IS Code based on height of the storey.

X - Windward side
Z - Windward side
X - Leeward / Sidewall face
Z - Leeward / Sidewall face

Vz = Vb x k1 x k2 x k3

Vz = Design wind speed m/s (47 m/s)
K1 = Probability factor
K2 =terrain, height and structure factor
K3 = topography factor.

By using this formula, the intensity of wind has been calculated and inserted in analysis software.

W.L. @ 10m is 0.961 kn/m^2
W.L. @ 12m is 1.026 kn/m^2
W.L. @ 15m is 1.092 kn/m^2
W.L. @ 18m is 1.138 kn/m^2
W.L. @ 21m is 1.184 kn/m^2
W.L. @ 24m is 1.232 kn/m^2
W.L. @ 27m is 1.284 kn/m^2
W.L. @ 30m is 1.305 kn/m^2
W.L. @ 33m is 1.329 kn/m^2

Seismic Load

For the purpose of determining approximate seismic loads on the structure, loads have been calculated in accordance with IS: 1893-2002.The seismic load is considered for Mumbai location which falls under Zone III.

Importance factor for residential building is = **1**
Response reduction factor is = **5**
Soil has been taken as **medium soil**

Vb = Ah x w
Ah = Z/2 x I/R x Sa/g

Z – Zone factor
I – Importance factor
R – Response Reduction
Sa/g – soil type

EQ X^{+VE}
EQ X^{-VE}
EQ Z^{+VE}
EQ Z^{-VE}

These are the earthquake load with the factor 1.

7.2 Design Calculations

Beam Design

Mmax = 160.125 kn-m
Vmax = 64.87 kn
∂max = 19.7 mm

fy = 350 n/mm^2
Fu = 490 n/mm^2

Section: **NPB 450 X 190 X 92.4**
A = 117.7 cm^2
Z_e = 1794.9 cm^3
Z_p= 2046.4 cm^3
Z_p/Z_e = 0.877
r_x= 18.65 cm
r_y= 4.21 cm

Section Classification
tf = 17.6 mm
bf = 190 mm
b = bf/2 = 190/2 = 95 mm
b/ tf = 5.3977 < 9ξ
Hence the section is plastic.
Neutral axis depth = (450 – 2(18)/11) = 37.636 <94
Hence the section is plastic.

Shear capacity
Vp = Av x fy x w/ √3
Av = h x tw = 450 x 11 = 4950mm^2
Vp = 4950 x 350/√3 = 1000.259 kn> Vmax
Hence the section is safe.
Moment capacity
Md = (β_b x Z_pXfy)/γm_0
= (1 x 2046.4 x 10^3 x350)/ 1.1
=651.127 kn-m >Mmax
Hence the section is safe.
∂ permissible = **span/300** = 4.82759/300 = 16.9 mm
Hence the section is safe.

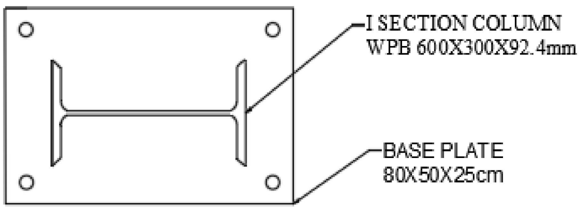
Column Design
Fy= 35.257 kn
M= 32.39 kn-m
As per IS 800: 200 **Table:11 (pinned joint)**
Leff = 1L = 3M
Assume design compressive strength
fcd = 250 n/mm^2
rmin = 7.05 cm
fy = 490 n/mm^2
Area required = (pd/fcd) = 35.257 x 10^3/250 = 141.028 mm^2
λ = Leff / γmin = 42.553

From Table 10 in IS 800: 2007
Interpolation,

λ – fcd
40 – 268 n/mm^2
42 -? (255.404) n/mm^2
50 – 242 n/mm^2
Pd = fcd X Ae = 36.017 kn

Base Plate Design
FY = 42.693 KN
M = 106.733 KN-M
As = 226.5 cm^2
Section: **WP 600 X 300 X 177.8**
tw = 13 mm
bf = 300 mm
D = 600 mm
tf = 25 mm
Assumed M20 grade concrete,
Bearing strength of concrete = **0.45 x fck**
=0.45 x 20 = 9 n/mm^2
Area of base plate = **p/ 0.45 x fck** = 4743.667 mm^2
L = 60 + 2a, B = 30 + 2B
Take a = b

W.K.T
L X B = A
47.43 = 1800 + 180a + 4a^2
By solving this,
a = b = 8.231 cm
substituting these values, we get
L = 76.462 CM, B = 46 .462 CM
Thickness of plate
ts = $\sqrt{}$ (2.5 x w(a^2-0.3b^2) x *γm0) / fy>tf*
w = p / A = 12.018 N/CM^2.
ts = 21.16 mm
Take ts = tf
Provide M_{20} bolts for base plate



Base Plate to Column Design
Welded Connection
Total length = 300+25+287+25+550+550+287+25+25+300
= 2374mm = 2.37m
Thickness of weld = 8mm

Reducing the end return,
= 2374-2(4+2)2a
= 2374-24x8
= 2182mm
Capacity of the weld = 0.7x8x410/√3x1.25
= 1.0584 kn/mm
Required length = 2000/1.0584
= 1889.04 < 2182mm
Length of weld for a single column = 2182mm
For 18 column = 39276mm = 39.276m

Beam to Beam Design
For **WPB 600X300X177.8**
$A=22650mm^2$
$t_f = 25mm$
$t_w = 13mm$
Area of web = {600-2(25)}x13
= 550x13
$= 7150mm^2$
Design of Web Splice:
Portion of load carried by web = 450x750/22650
= 142.05kn
Use two M20 bolts in double shear.
Slip resistance of M20 bot in single shear = 52.6 kn
Double shear = 2x52.6 = 105.2kn
Bearing resistance = 2.5x0.6x20x13x490/(1.25x1000)
= 152.88 kn
Shear force per bolt = 71.025 < 152.88 kn
Provide 150x150x8 Web Splice
Design of Flange Splice:
Portion of load carried by each flange = (450-142.05)/2
= 153.98 kn
For four M20 HSFG bolts grade of 8.8 in two rows in single shear.
Total slip resistance = 4x52.6
=210.4kn
Total bearing resistance (with $k_b = 0.5$)
= 4x2.5x0.5x20x13x490/(1.25x1000)
= 509.6kn
Total bot strength = 210.4 > 153.98 kn
Hence the connection is safe.
Provide an edge distance of 45mm and pitch= 60mm
Provide = 270x300x25 mm

Beam to column connection
Let us try 24mm diameter bolt of grade 4.6
Tensile stress area = $353mm^2$
Diameter f bot hole = $d_0 = 24+2 = 26mm$

Pitch, p = 2.5x24 = 60mm
Edge distance, e=40mm
K_b(least value) = 0.513
Strength of bolt in single shear,
$V_{dsb} = A_{nb} \times f_{ub}/(\sqrt{3}x\gamma_{mb}) = 353x400/(\sqrt{3}x1.25)$
= 65.22kn
Strength of bolt in single shear = 2x65.22 = 130.44kn
Strength of bolt in bearing, (for clip angle connection with beam web)
$V_{dpb} = 2.5k_b \times d \times t \times f_u/\gamma_{mb} = 2.5x0.513x24x7.4x410x10^{-3}/1.25$
= 74.07 kn
Strength of bolt in bearing, (for clip angle connection with column flange)
$V_{dpb} = 2.5k_b \times d \times t \times f_u/\gamma_{mb} = 2.5x0.513x24x10.6x410x10^{-3}/1.25$
= 107.01 kn
Strength of bolt in tension, $T_{db}= T_{nb}/\gamma_{mb}$
$T_{nb} = 0.9f_{ub}A_{nb}$ (should not greater than) $(f_{yb} \times \gamma_{mb} \times A_{sb})/ \gamma_{m0}$
$= 0.9x400x353x10^{-3}= 127.08$ kn
(should not greater than)$240x1.25x452x10^{-3}/1.10 = 123.27$ kn

Hence, strength of bolt in tension, Tdb = 123.27/1.25 = 98.61 kn
Provide two flange clips angle ISA 200X100mm, with 100mm leg connected to the column flange
Assume the gauge distance for 100mm leg, g = 60mm
Lever arm = 60+350+60 =470mm
$P=22x10^3/470=46.80Kn$

Consider, the effect of initial tension (assume tk of angle=15mm)
Maximum on bolts T=P(1+0.75(g-t/2)/a)
=46.80 x (1+0.75((60-15/2)/40
=92.87 KN
Provide two bolts to connect the flange clips leg with the column flange
Strength of bolt =101.66kN
Safe pull transmitted by the bolt =2x101.66=203.32kN>92.87
Assume tk of angle leg =15mm
Maximum moment in clip angle
M1=0.5P(g-(t/2)
=0.5x46.80 x ((60-(15/2) =1228.5kNmm
Moment capacity of 15 mm tk angle leg
$=1.2z_e$ (fy/γmo)
$=1.2x140 \times (15^2/6) \times (250/1.10) x10^3$
=1431.82kNmm>1228.5 kn-mm
Provide flange clips angle ISA200x100x15mm
Bolt connecting flange clips angle with beam flange
Horizontal shear $v=22x10^{3/}350$
=62.86kN
Number of bolt n=62.86/65.22
=0.964≈4
Provide 4mm dia bolt in two rows.
Web clip angle

Number of bolts required to connect web angle to beam ($v_{sd=}$65.22Kn)
Number of bolt n =220/65.22 =3.37≈4
Size of web clip angle
Size of each = pitch +2xedge distance =70+2x40=150mm
Provide two web clips angle 150x150x10
Edge distance l_e=40mm
$L_e=1.1t\sqrt{(\beta fo/fy)}$
$=1.1x15x\sqrt{(2x280/250)} = 33.67mm$
L_v = 60mm
ƞ=1.5
β=2.0
$F_{o=}0.7f_{ub=}0.7x400=280$mpa
$Q=L_{V/}2L_e\, x(T_{e-}(\beta ƞ\, F_o b_e t^4/27 l_e l_v^2)$
$T_{e=}$92.87/2 =46.435KN
$Q=60/2X33.67X(46.435-2X1.5X280X10^3x140x15^{4)}/27x33.67x60^2) = 39.75kN$
Total Tension on bolt =46.80+39.75=86.55Kn
Capacity of 24 mm bolt =98.61Kn>86.55kN

VIII. Conclusion

In this project, seen and studied how to design the steel building and how to draw the drawings using CADD and how to analyze the structure using STADD. Pro. The spread sheet has been designed for both beam and column to check whether the beam is safe or not. The estimation for required materials has been calculated and attached. And also calculated the amount need for RC Slab, Steel and brick masonry.

References

[1]. Devendra Dohare , Dr.SavitaMaru , Seismic Behavior of soft Storey Building, International Journal of Engineering Research and General Science Volume 2, Issue 6, October-November, 2014.
[2]. Susanta Banerjee, Sanjaya K Patro, PraveenaRao, Inelastic Seismic Analysis of Reinforced Concrete Frame Building with Soft Storey, International Journal of Civil Engineering Research. ISSN 2278-3652 Volume 5, November4 (2014).
[3]. Dr. Saraswati Setia ,Vineet Sharma, Seismic Response of R.C.C Building with Soft Storey, International Journal of Applied Engineering Research, ISSN 0973-4562 Vol.7 No.11 (2012).
[4]. Ghalimath. A. G, Hatti M.A, analytical review of soft storey, International Research Journal of Engineering and Technology (IRJET) Volume: 02 Issue: 06 | Sep-2015.
[5]. Vipin V. Halde, Aditi H. Deshmukh, Review on behaviour of soft storey in building, International Research Journal of Engineering and Technology (IRJET) Volume 2, Issue 8, November-2015.
[6]. AkshayShaji, Amrutha Binu, Dibi Divakaran, Swaraj, Angitha Sasidharan, Seismic analysis of soft storey buildings, International journal of scientific and engineering research volume 10, Issue 5, may 2019
[7]. B.LalithaChandrahas, P.Polu Raju, Behaviour of soft storey RC framed building under seismic loading, International journal of civil engineering and technology (IJCIET) Volume 8, Issue 4, april 2017
[8]. Surbhi Jain, Prof. M.C.Paliwal, Analysis of strength soft storey RC building via horizontal equivalent diagonal struts, International journal of engineering sciences and research technology (IJESRT)
[9]. Mahesh N Patel, Yogesh N Sonawane, Seismic analysis of multi-storeyed building, International journal of engineering and innovative technology (IJEIT)
[10]. T. Jayakrishna, K. Murali, Powar Satish, J. Seetunya, Seismic analysis of regular and irregular multi-storey buildings by using staad-pro, International journal of civil engineering and technology (IJCIET), Volume 9, Issue 1, January 2018