Design of RCC Ductile Frame Structure

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Abstract: Ductility can be defined as the ability of material to undergo large deformation before failure. It is beneficial to the user of the structures as in case of overloading, it provide warning to the occupant and this gives notice to the occupants and provide sufficient time taking preventive measures. Ductility increases with compressive steel content, concrete compressive strength and ultimate concrete strain. In case for ductility decreases in tension steel content, steel yield strength and axial load.

Importance:1) stress relieving, a low temperature treatment, to Reduce or relieve internal stresses remaining after casting.

2) When ductile reinforcement is provided, overall strength is Improved.

3) Resist major catastrophic earthquake without collapse.

4) Increases in the transverse (shear) reinforcement.

5) The top and bottom reinforcement shall consist of at least Two bars throughout the member length.

6) The positive steel at a joint face must be at least equal to Half the negative steel at the face.

Key words: Ductile design IS codes (456-2000), (1893-1984 & 2002),(13920-1993), and STADD PRO software.

INTRODUCTION

The requirements of any RCC building structure are that it should be designed as a ductile structure which can resist severe earthquake shock without collapse.

PROBLEM STATEMENT:

A G+10 RCC structure is selected for ensuring a ductile design. STADD PRO version v8i software used for analysis.

A) **Assumption**: 1) Structures are located in seismic zone 3, 4 and 5 is selected

B) **Size of the component of the structure**:
Column size: - 600mm x 600mm.
Beam size: - 350mm x 500mm.
Slab size: - 120mm thickness.
Shear wall size: - 3500mm x 33000mm on four sides.
Total plinth area of the building size: - 196 m^2
14m x 14m =196m^2
Foundation area of building size: - 18m x 18m =324m^2.

C) **Loads on the components:**
After putting input data, the loads on the components are
Column: - 0.6 x 0.6 x 33+4.5=13.5 m^3
Beam: - 0.35 x 0.5x 2.9 = 0.5075 m^3
Slab: - 0.12 x 3.15^2 = 1.1907 m^3
Shear wall: - 0.25 x 3 x37.5 = 28.125 m^3
Mat foundation: - 18 x18 x0.5 = 162 m^3

Analysis and design as been performed using software STADD PRO version.V8i, mat foundation is also designed using STADD Foundation V8i (Release 5.3), Total Concrete quantity works out to be so many cubic meters, (Beam= 269.5cu.m, Column=297 cu.m, Slab=209.44 cu.m), (Shear wall =95.7cu.m), Mat foundation= 162 cu.m.

Reinforcing quantity works out as per design.
(Column=131797N, Beam =158541N, slab=173200N shear wall= 72470N) and Mat foundation=490620N.
Area 2100sq.ft, (196m^2) from the above codes input.
Response reduction=3, with ordinary shear wall with (OMRF) Ordinary Moment Resistant Force.
Damping ratio=0.05%, Foundation depth =5m,
Zone=3.

METHODOLOGY:

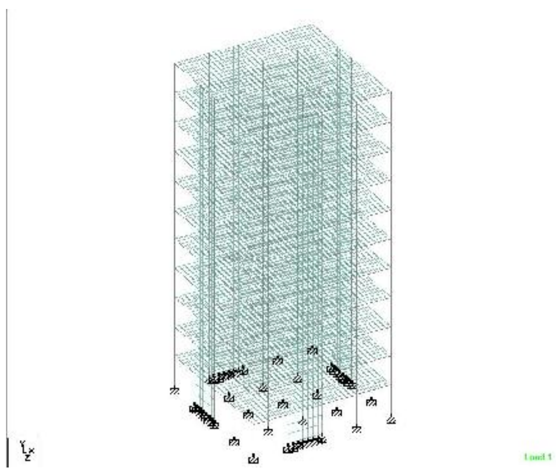
As for this method is used from STADD software using the IS Codes (concrete IS:456-2000 & Ductile design 13920-1993 and 1893-1984 , 2002) for all building can approval more than G+6 storey high and reinforcing bar of grade fe415 are fe500 both are used.

PROCEDURE

Final Stage

After initial design was accepted foundation design is performed using mat foundation as per IS codes we accepted the mat foundation design quantity (reinforcing steel =490620 N) and (concrete = 162 cu.m).

Figures and Tables:



(Fig 1: shows 3D view of G+10 building structure made of columns, beams, slabs and shear walls.

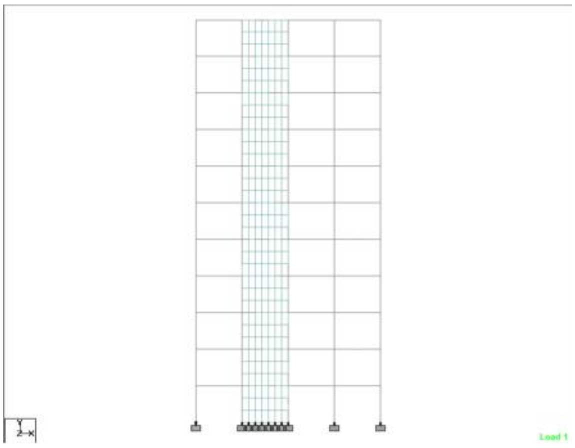


Fig 2: shows front elevation showing columns and beam frames, shearwall, fixed supports.

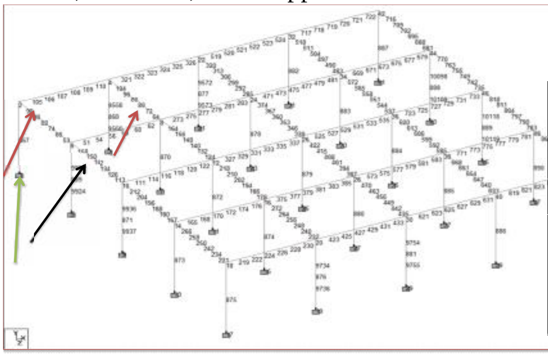


Fig 3: shows layout of the typical plan

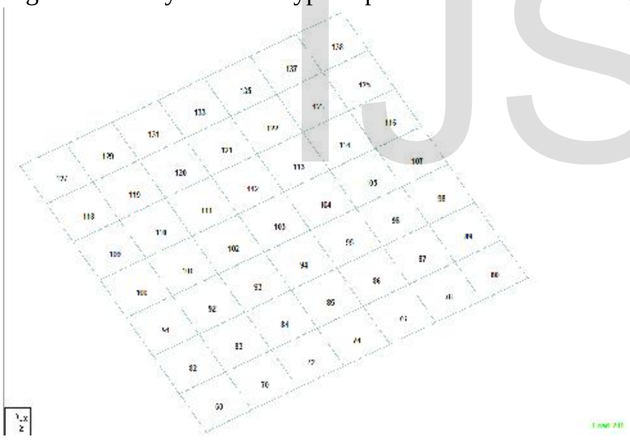


Fig 4: shows enlargement of partial typical floor framed with finite elements.

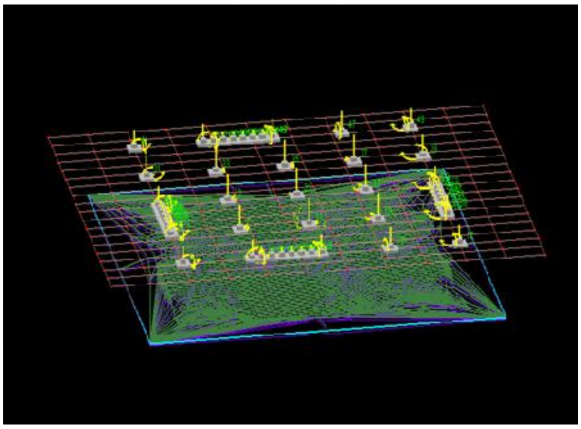


Fig: 5 show the layout of mat foundation.

UNITS: PRIMARILY IN STADD PRO (M K S) UNITS ARE INPUT.

Table: 1 Foundation Job Details

Job Name : MAT-FDN

Included Support	X (m)	Y (m)	Z (m)
1	0.000	0.000	0.000
2	3.500	0.000	0.000
3	0.000	0.000	3.500
4	3.500	0.000	3.500
5	0.000	0.000	7.000
6	3.500	0.000	7.000

Table: 2 support reactions (from structural analysis)

No de	L/C	Force-X kN	Force-Y kN	Force-Z kN	Moment-X kNm	Moment-Y kNm	Moment-Z kNm
1	1	-21.133	-477.171	0.155	-0.191	-0.041	55.82
1	2	21.13	477.171	-0.155	0.199	0.041	-55.832
1	3	0.155	-477.171	-21.133	-55.832	0.041	0.191
1	4	-0.155	477.171	21.13	55.832	-0.041	-0.191
1	5	4.765	955.095	4.765	4.898	0.000	-4.898
1	6	1.103	104.042	1.103	1.1092	0.000	-1.092

Table: 3(a). Properties Details and Soil Details

Boundary	Subgrade Modulus	Soil Height Above Mat	Soil Density	Soil Pressure
FDN-5	24000.000kN/ m2/m	4.500 m	18.000 kN/m3	80.997 kN/m^2

Table: 3(b). Properties Details and Soil Details

Region	Thickness(m)	Material
FDN-5	0.500	Concrete

Table: 4 Mat Dimensions

Boundary Name : FDN-5

Node No	X Coor(m)	Y Coor(m)	Z Coor(m)
13	-2.000	-5.000	-2.000
14	16.000	-5.000	-2.000
15	16.000	-5.000	16.000
16	-2.000	-5.000	16.000

Table no: 5 STADD space input file: G+10.STD

A. MEMBER END FORCES STRUCTURE TYPE = SPACE

B. -----------------

C. ALL UNITS ARE -- KN METE (LOCAL)

D.

E. MEMBER LOAD JT AXIAL SHEAR-Y SHEAR-Z TORSION MOM-Y MOM-Z

F.

G. 4 1687 -0.54 19.55 -0.28 4.02 0.06 -13.83

H. 1688 0.54 -19.55 0.28 -4.02 0.08 23.60

I. 5 1687 -0.41 -28.90 0.10 0.09 -0.26 6.15

J. 1688 0.41 33.96 -0.10 -0.09 0.21 -21.86

K. 6 1687 -0.16 -11.22 0.02 0.06 -0.04 1.50

L. 1688 0.16 11.22 -0.02 -0.06 0.03 -7.11

M. 101 1687 -0.57 -40.11 0.12 0.15 -0.30 7.65

N. 1688 0.57 45.17 -0.12 -0.15 0.24 -28.97

O. 201 1687 -0.86 -60.17 0.18 0.22 -0.45 11.48

P. 1688 0.86 67.76 -0.18 -0.22 0.36 -43.46

Q. 202 1687 -1.81 -100.57 0.06 -0.32 -0.46 58.53

R. 1688 1.81 108.17 -0.06 0.32 0.43 -110.71

S. 203 1687 -1.57 -83.24 0.00 -0.38 -0.31 54.84

T. 1688 1.57 87.79 0.00 0.38 0.31 -97.60

U. 204 1687 -1.64 -93.92 0.07 -0.19 -0.42 48.63

V. 1688 1.64 99.99 -0.07 0.19 0.38 -97.10

W. 205 1687 0.58 13.89 0.25 0.61 -0.32 -40.08

X. 1688 -0.58 -6.30 -0.25 -0.61 0.20 45.13

Y. 206 1687 0.83 31.23 0.19 0.55 -0.17 -43.77

Z. 1688 -0.83 -26.67 -0.19 -0.55 0.07 58.25

AA. 207 1687 0.27 -2.35 0.22 0.55 -0.31 -30.26

BB. 1688 -0.27 8.42 -0.22 -0.55 0.20 27.57

CC. 208 1687 0.19 -72.67 0.58 -5.89 -0.48 29.96

DD. 1688 -0.19 80.26 -0.58 5.89 0.19 -68.19

EE. 209 1687 0.44 -55.33 0.52 -5.94 -0.32 26.27

FF. 1688 -0.44 59.89 -0.52 5.94 0.06 -55.08

GG. 210 1687 -0.04 -71.59 0.48 -4.64 -0.43 25.77

HH. 1688 0.04 77.67 -0.48 4.64 0.19 -63.09

II. 211 1687 -1.42 -14.02 -0.26 6.17 -0.31 -11.51

JJ. 1688 1.42 21.61 0.26 -6.17 0.44 2.61

KK. 212 1687 -1.18 3.32 -0.33 6.11 -0.15 -15.20

LL. 1688 1.18 1.24 0.33 -6.11 0.32 15.72

MM. 213 1687 -1.33 -24.67 -0.19 5.00 -0.29 -7.41

NN. 1688 1.33 30.75 0.19 -5.00 0.39 -6.45

OO.

PP. 2031 1 1688 -0.88 -37.69 0.34 -0.70 -0.12 52.78

QQ. 1493 0.88 37.69 -0.34 0.70 -0.04 -71.63

RR. 2 1688 0.88 37.69 -0.34 0.70 0.12 -52.78

SS. 1493 -0.88 -37.69 0.34 -0.70 0.04 71.63

TT. 3 1688 -0.19 -22.32 0.82 -5.61 0.01 23.89

UU. 1493 0.19 22.32 -0.82 5.61 -0.42 -35.05

VV. 4 1688 0.19 22.32 -0.82 5.61 -0.01 -23.89

WW. 1493 -0.19 -22.32 0.82 -5.61 0.42 35.05

XX. 5 1688 -0.34 -35.86 3.22 -0.62 -0.61 22.58

YY. 1493 0.34 40.92 -3.22 0.62 -1.00 -41.78. PAGE NO. 5758.

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Equations:

From The ductile project total equations and all FORMULAS are from STADD PRO SOFTWARE.

Top of Mat Longitudinal Direction

Zone:- 1

Governing Moment (M_{GOV}) = 88.492(kN-m/m)

Effective Depth = 0.417 (m)

D= Diameter ; C C= Clear cover
db= diameter of bar

Limit Moment of Resistance (M_{umax}) = $R_{umax} \times B \times d_e^2$ = 718.696 (kNm)

B=width of beam , de= effective depth,
Mumax=ultimate moment maximum
M_{GOV}<= M_{umax} hence OK

Steel Required

Calculated Area of Steel = 600.000 (mm2)

Minimum Area of Steel = 600.000 (mm2)

Provided Area of Steel = 600.000 (mm2)

Reinforcement Details

Bar No= N/A (N=Number of bars / A= unit width,)

Maximum Spacing(S_{max})(User Specified) = 300.000(mm)

Minimum Spacing(S_{min})(User Specified) = 50.000(mm)

Actual Spacing (S) = N/A

S_{min}<= S <= S_{max}

Zone:- 2

Governing Moment (M_{GOV}) = 505.304(kN-m/m)

Ef fective Depth = $D - (cc + 0.5 \times d_b)$ = 0.417 (m)

Limit Moment of Resistance (M_{umax}) = $R_{umax} \times B \times d_e^2$ = 718.696 (kNm)

M_{GOV}<= M_{umax} hence OK

Steel Required

Calculated Area of Steel = 3847.213 (mm2)

Minimum Area of Steel = 600.000 (mm2)

Provided Area of Steel = 3847.213 (mm2)

Reinforcement Details

Bar No= 16

Maximum Spacing(S_{max})User Specified = 300.000(mm)

Minimum Spacing(S_{min})User Specified = 50.000(mm)

Actual Spacing (S) = 50(mm)

S_{min}<= S <= S_{max}

Zone:- 3

Governing Moment (M_{GOV}) = 1093.485(kN-m/m)

Effective Depth = $D - (cc + 0.5 \times d_b)$ = 0.417 (m)

Limit Moment of Resistance (M_{umax}) = $R_{umax} \times B \times d_e^2$ = 718.696 (kNm)

M_{GOV}<= M_{umax} hence OK

Steel Required

Calculated Area of Steel = 7685.901 (mm2)

Minimum Area of Steel = 600.000 (mm2)

Provided Area of Steel = 7685.901 (mm2)

Reinforcement Details

Bar No= 25

Maximum Spacing(S_{max})User Specified = 300.000(mm)

Minimum Spacing(S_{min})User Specified = 50.000(mm)

Actual Spacing (S) = 60(mm)

S_{min}<= S <= S_{max}

CONCLUSIONS:

1) In the above work, only 16mm dia and 32mm dia bars Have been used for the mat foundation. This work Can be extended by trials of 20mm and 25mm bars Also.
2) By the above method, optimization of the structure Also can be done.

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