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ANALYSIS BY STAAD-PRO AND DESIGN OF STRUCTURAL ELEMENTS BY MATLAB

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ABSTRACT

The analysis and design of multi storey building is carried out usually in the software packages which are very strong in analysis. The different software like STAAD-PRO, Etabs, etc is used for such purposes. The programming tools like C+, JAVA, etc are also used in many structural elements for different methods of calculations. The high level programming tools like MATLAB is used for many complicated problems in various fields. In the present paper the STAAD-PRO is used for the purpose of analysis and design of a building. The building was analyzed for the seismic behavior. Shear force, bending moment, deflections are calculated using the software, the reinforcement details are also available through the design. The coding of STAAD editor is also included in this paper. The design of slab, beam, column and footing are carried out by the programming of MATLAB. The objective of this study was to check the programming language for these structural elements.

Contribution/ Originality: This study contributes in the existing literature that MATLAB program and STAAD editor files is provided. The flowchart of the program is also provided. The results of the STAAD is provided in graphs.

1. INTRODUCTION

For high performance numerical computation and visualization MATLAB is a good software with high level programming language [1]. The formulation and obtaining the solution for the minimum cost design for bridge superstructure and for this the high level programming language i.e. MATLAB is used [2]. The finite element approach is used for analysis of dam in which time history method is used to study the dynamic behavior. The gravity dam for earthquake analysis was studied by STAAD-PRO in the investigation [3].

STAAD-PRO and Etabs are the software which are used for the multi storied buildings. Shear force, bending moments, reinforcement and deflection are the parameters found out after analysis and design is carried out [4]. Most engineering software tools use typical menu-based user interfaces, and they may not be suitable for learning tools because the solution processes are hidden and students can only see the results. An educational tool for simple beam analyses is developed using a pen based user interface with a computer so students can write and sketch by hand. The geometry of beam sections is sketched, and a shape matching technique is used to recognize the sketch [5]. The structural analysis and design of the structural frame considered was done using the STAAD-Pro software which is very user friendly and effective. First a typical frame is selected from the structure.

The frame was analyzed and designed according to the PEB concept and then by the CSB concepts [6].

The power tool for Computerized Structural engineering STAAD. Pro is the most popular structural engineering software product for 3D model generation, analysis and multi-material design. It has an intuitive, user-friendly, visualization tools, powerful analysis and design facilities and seamless integration to several other modeling and design software products [7]. The seismic design of steel frame is carried out by the STAAD-PRO. RCC frame and steel frame is compared by analyzing in the STAAD-PRO [8]. The modeling and analysis of aqueduct structure is carried out by STAAD-PRO. Seismic static loading is applied on the aqueduct in terms of self weight and other types loading [9]. Computer aided design of a twin reinforced concrete multi-storey tower is presented in this work and it entails the use of Midas Gen software for modeling, analyzing and designing of a 25 storey twin tower and comparing the results with STAAD Pro software

and manual design [10]. A study of one R.C. buildings, of G + 2 storey institutional building (designed according to IS 456:2000) are analyzed. Analysis and redesigning by changing the main reinforcement of various frame elements and again analyzing [11]. RC –Design suite is a reinforced concrete design program that has numerous applications for the design of concrete structures. It contains modules for the design of beams, columns, footings and slabs. For this project the students utilized this program only for the design of floor slab and combined footings. Design of beams and columns are carried out in STAAD- III package itself [12].

Seventy nine soil samples were collected from three different sites in Iraq (Mosul, Baghdad and Basrah) to investigate their effect on the foundation of the buildings. The results of the tests were used in a hypothetical building and analyzed by STAAD Pro.v8i model. Soil in Mosul region includes many types such as clayey (expansive clayey), gypsum and silty clay. The results indicated that the bearing pressure under the foundation was lower than that calculated. Similar results were obtained when using the relatively worse bearing pressure values [13]. A research presents the dynamic time history analysis and response spectrum method of a concrete gravity dam by using STAAD-PRO. Here Finite Element Approach is used to analyze the dam. A concrete gravity dam model is prepared in STAAD-PRO to perform the time history analysis and response spectrum analysis and a comparison is done between both these methods [14].

2. METHODOLOGY

A research presents the main features and organization of STAADPRO, a computer program that has been developed for the static and seismic stability evaluations of concrete gravity dams. STAADPRO is based on the gravity method using rigid body equilibrium and beam theory to perform stress analyses, compute crack lengths, and safety factors. Seismic analyses could be done using either the pseudo-static or a simplified response spectrum method [15]. The Curtain Wall is designed using STAADPRO to resist and handle all the imposed loads on it as well as keep air and water from penetrating in the building. The loads imposed on the curtain wall are transferred to the building structure through structural interface (i.e. brackets) which attaches the mullions to the building [16].

The main aim of a research is to study which section of the large span cantilever structures are more safe and economical among the three sections of pipe, angle and tube. On the study the inference is that by comparing the output of STAAD.Pro (structural analysis and design) analysis results of different sections and it is concluded that the steel take off for pipe section is 3% less than tube section in weight and 14% less than angle section in weight [17]. A six storey RC building in zone III on medium soil is analyzed using the software STAAD –

PRO. It is assumed that no parking floor for the building. Seismic analysis is performed using Equivalent lateral force method given in IS 1893:2002 and also by dynamic analysis [18].

The analysis and design of a building is carried out in STAAD-PRO for the following data:

- Floor to floor height for ground floor = 3.4m
- Floor to floor height for above floors = 4m
- Plinth height = 0.6m
- Depth of foundation below ground level = 1.8m
- Thickness of slab at each floor = 0.125m
- External wall thickness = 0.23m
- Internal wall thickness = 0.15m
- Sizes of column = 450 x 600
- Sizes of beam = 230 x 380
- Live load on floors = 3kN/m^2 (for earthquake 25% of live load)
- Live load on roof = 3kN/m^2 (for earthquake roof live load = 0)
- Floor finish = 0.75kN/m^2
- Roof treatment = 0.75kN/m^2
- Site location at seismic zone = III
- Building resting on = medium soil
- Density of wall = 20kN/m^2
- Density of concrete =25kN/m^2
- Grade of concrete = 25N/mm^2
- Grade of steel = 415N/mm^2 (main reinforcement)
- Grade of steel = 250N/mm^2 (secondary reinforcement)
- Dead load
- External member load for ground floor = (0.23 x 1 x 1) x 20 x (4 – 0.38)
- Internal member load for ground floor = (0.15 x 1 x 1) x 20 x (4 – 0.6 – 0.38)
- For first floor and above
- External member load = (0.23 x 1 x 1) x 20 (4 – 0.38)
- Internal member load = (0.75 x 1 x 1) x 20 (4-0.38)
- Parapet load = 0.23 x 1 x 1 x 20
- Floor Dead load = 1 x [125 + 75 / 1000] x 1 = 5kN/m^2

2.1. STAAD-PRO Input File

The analysis and design of a structure considering earthquake resistance parameters is carried out in STAAD-PRO by the coding as detailed in the Appendix-A. This program gives in detail about the analysis of structure including the load conditions and combinations, design of structure by IS code method & earthquake provisions are included.

3. MATLAB PROGRAMMING

Matlab is a very useful CAE tool for numerical analysis. In the dissertation, the computational algorithms for several vibration control systems are implemented with Matlab and used for diverse simulation studies. Matlab has many embedded tools which simplify matrix operations encountered in the vibration control [19].

One of the interesting engineering application is space truss, a three dimensional element, particularly used as roof for industrial and commercial structure spanning large distances. Analysis of space truss can be performed by much commercial FEA software available in the market. A research concerns the current growth of MATLAB based program which analyze the space truss step by step as done in Finite Element Analysis [20].

The MATLAB programming for footing, column, beam and slab is completed once the analysis in STAAD-PRO is done.

3.1. Design of Footing

Problem: Design a rectangular footing of uniform thickness bearing a vertical load of 1616 kN having a base size of 230 mm X 600 mm. Assuming safe bearing capacity of soil is 150 kN/m^2. Using M25 grade of concrete and Fes 415 steel.

The programming in MATLAB is detailed in Appendix-B giving all the commands and syntax to design the footing so that any design can take place accordingly.

3.2. Design of Column

Problem: Design a column size of 450 mm X 600 mm subjected to an axial load of 2500 kN under the service dead load and live load. The column has an unsupported length of 4 m and effectively held in position in both ends. Using M25 grade of concrete and Fes 415 steel. The programming in MATLAB is detailed in Appendix-C giving all the commands and syntax to design the column so that any design can take place accordingly.

3.3. Design of Beam

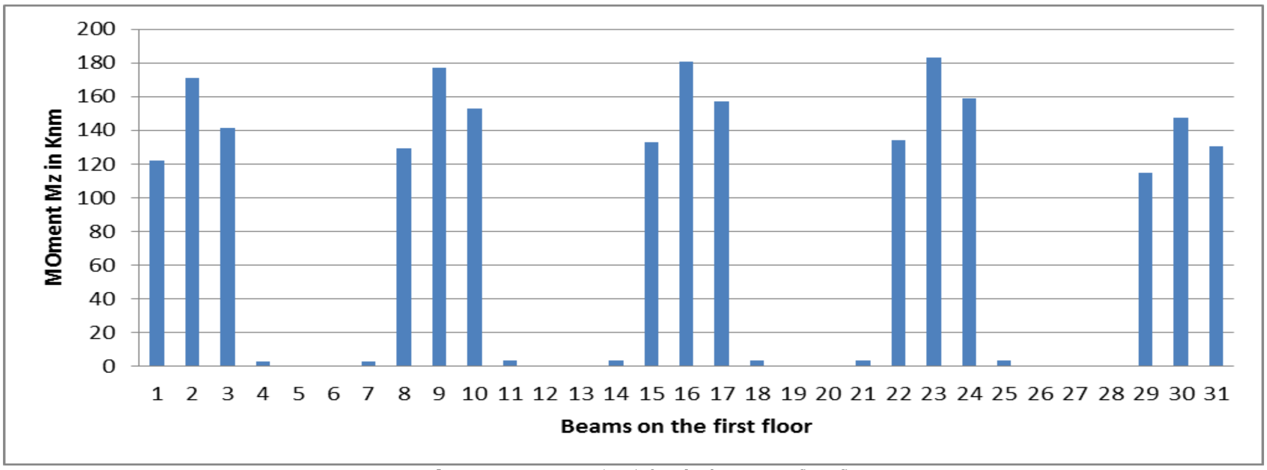
Problem: Design a rectangular beam for simply supported span of 4m subjected to superimposed ultimate load of 41.11 kN/m and size of beam is limited to 230 mm X 380 mm. Use of M25 grade of concrete and Fe415 grade of steel. The programming in MATLAB is detailed in Appendix-D giving all the commands and syntax to design the beam so that any design can take place accordingly.

3.4. Design of Slab

Problem: Design of a two way continuous slab is subjected to uniformly distributed load of 3 kN/m2 for a room size of 4 m X 4 m. Use of M25 grade of concrete and Fe415 grade of steel. The programming in MATLAB is detailed in Appendix-E giving all the commands and syntax to design the slab so that any design can take place accordingly.

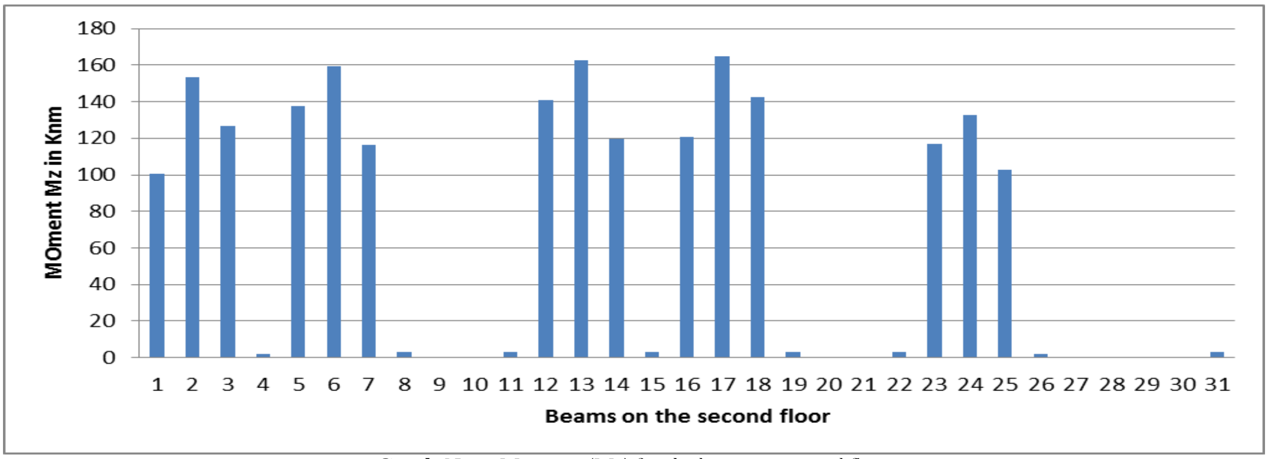
4. RESULTS & DISCUSSION

The following graphs show the results in terms of deflection, shear force and moment of the beams on First, second, third, fourth floor and fifth floor.



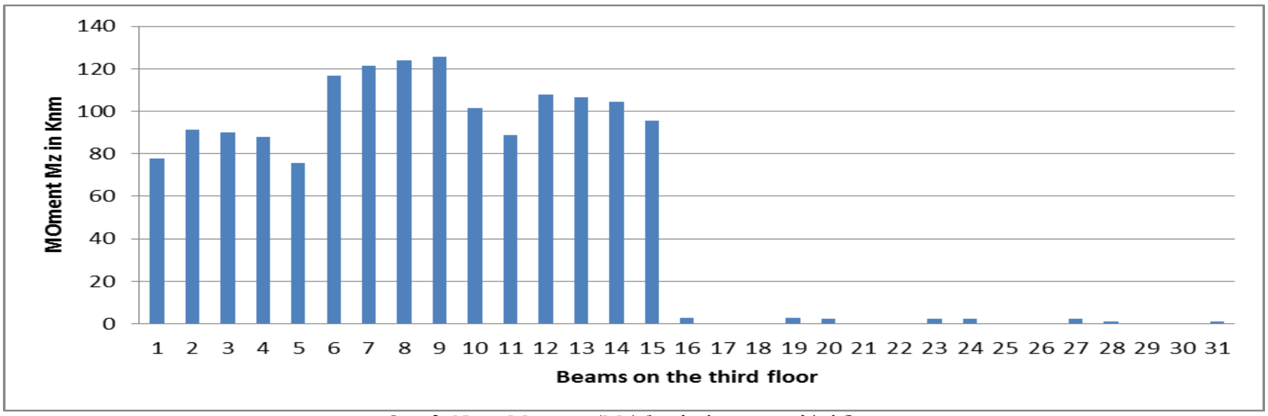
Graph-No.1. Moments (Mz) for the beams on first floor

From the above graph it is clear that the maximum moment in the beam is 182 kNm in case of beam on the first floor while the minimum moment is noted to be 0.5 kNm in the Z direction of beam locally.



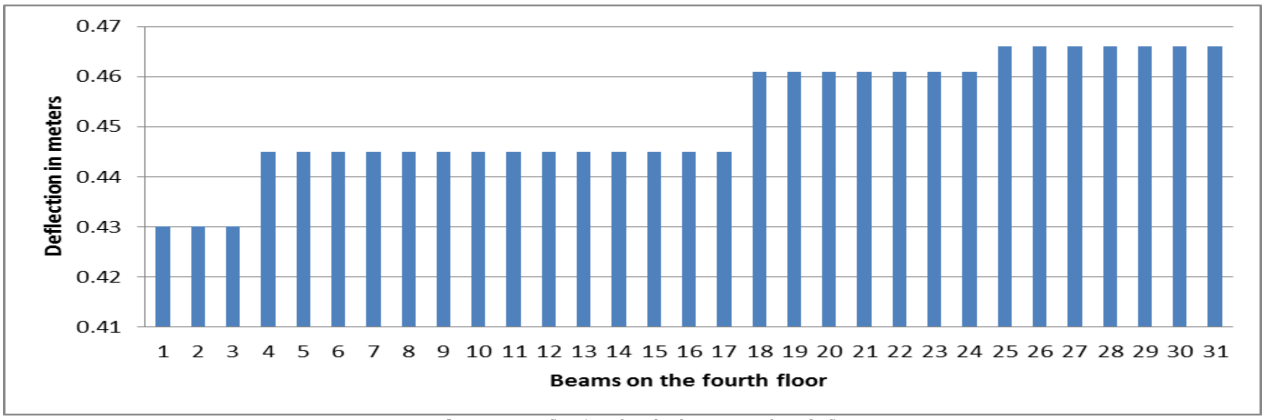
Graph-No.2. Moments (Mz) for the beams on second floor

From the above graph it is clear that the maximum moment in the beam on the second floor found to be 162 kNm which is lower than the moment on the beam of second floor while the minimum moment on the beam of second floor found to be 0.5 kNm in most of the beams.



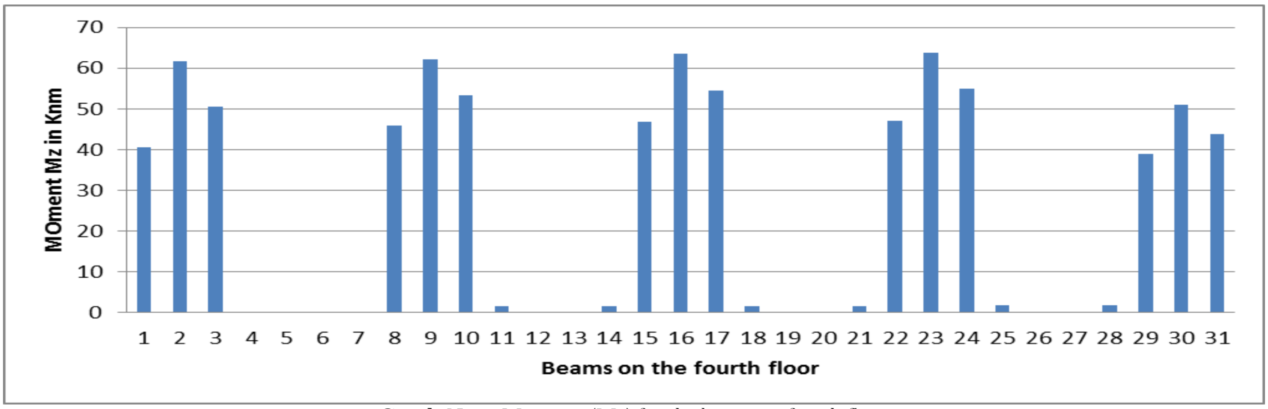
Graph-No.3. Moments (Mz) for the beams on third floor

From the above graph it is clear that the moment in the beams of third floor is 122 kNm which is lower than the moment on the beams of first and second floor while the minimum moment is observed to be 0.25 kNm.



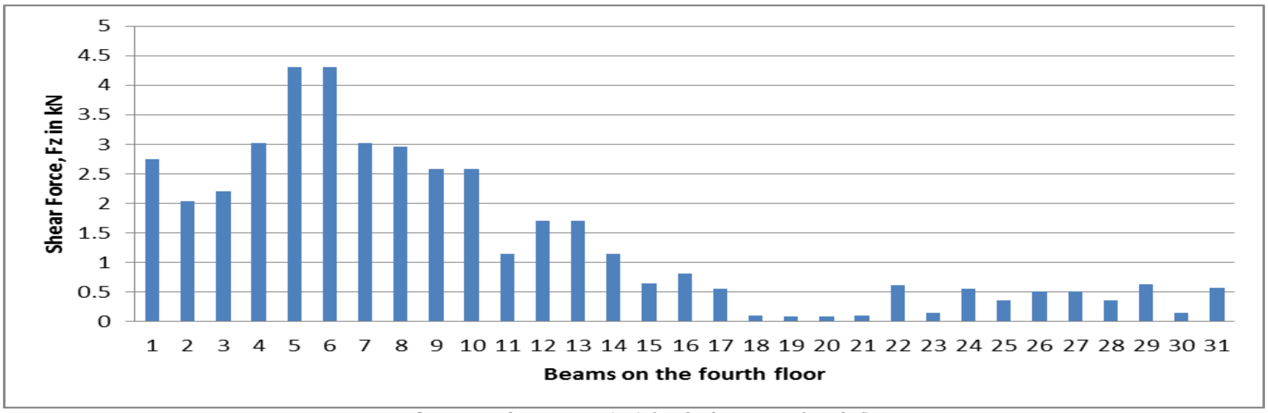
Graph-No.4. Deflection for the beams on fourth floor

From the above graph it is clear that the maximum deflection on the fourth floor found to be 0.465 m and it is more than the deflections of first and second floor while the minimum deflection found to be 0.43 m in other beams.



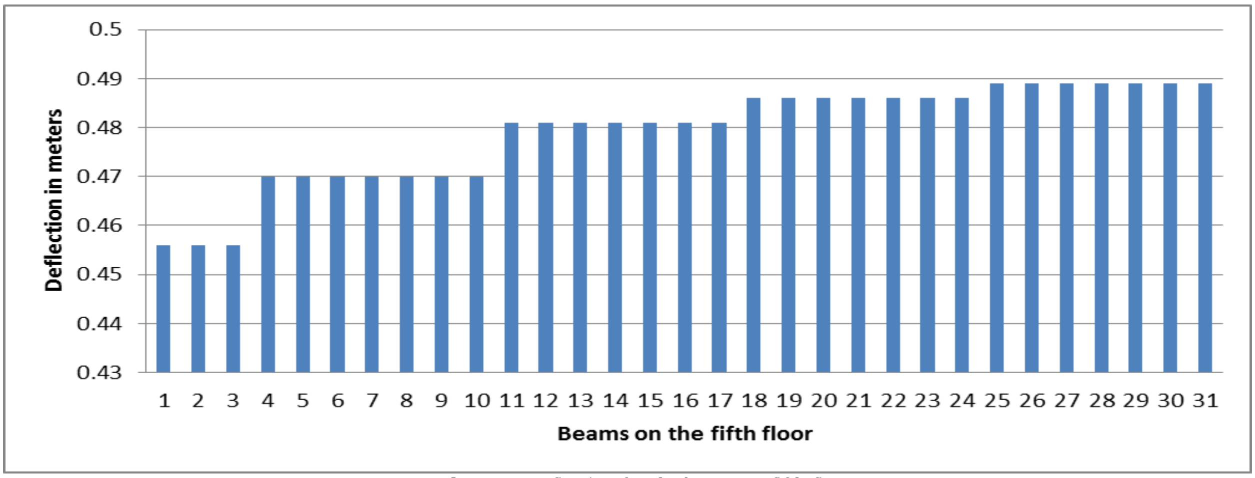
Graph-No.5. Moments (Mz) for the beams on fourth floor

The beams on the fourth floor have lower moments than that of first, second and third floor and maximum moment found to be 65 kNm while other beams have moment of 0.1 kNm and it is clear that the moment on the beams are decreases as the height of floor increases.



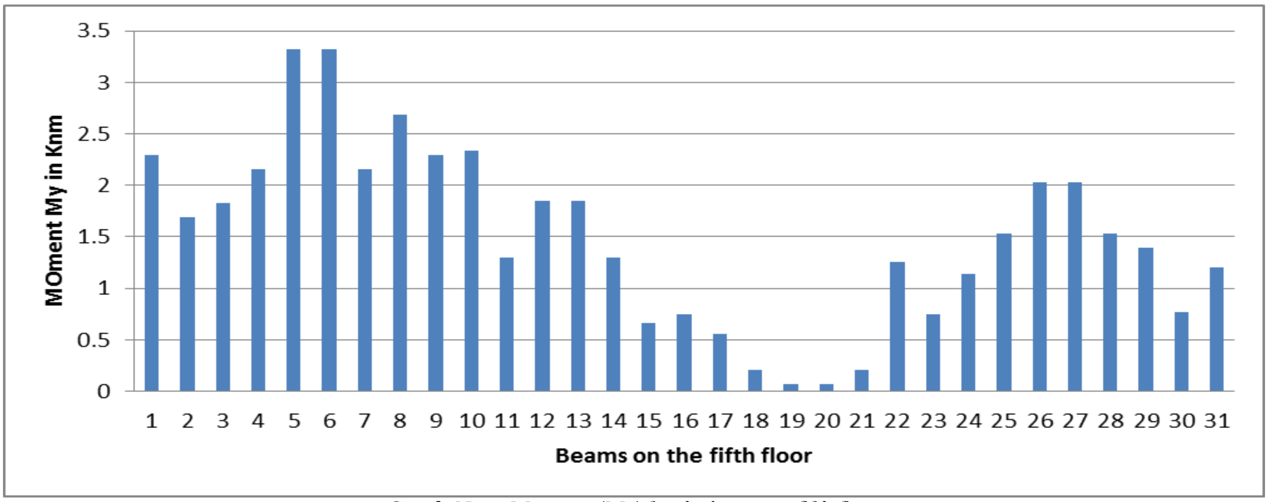
Graph-No. 6. Shear Force (Fz) for the beams on fourth floor

The shear force on the beams on fourth floor found to be maximum as 4.25 kN in the Z direction locally while the minimum shear force is 0.1 kN in other beams of fourth floor.



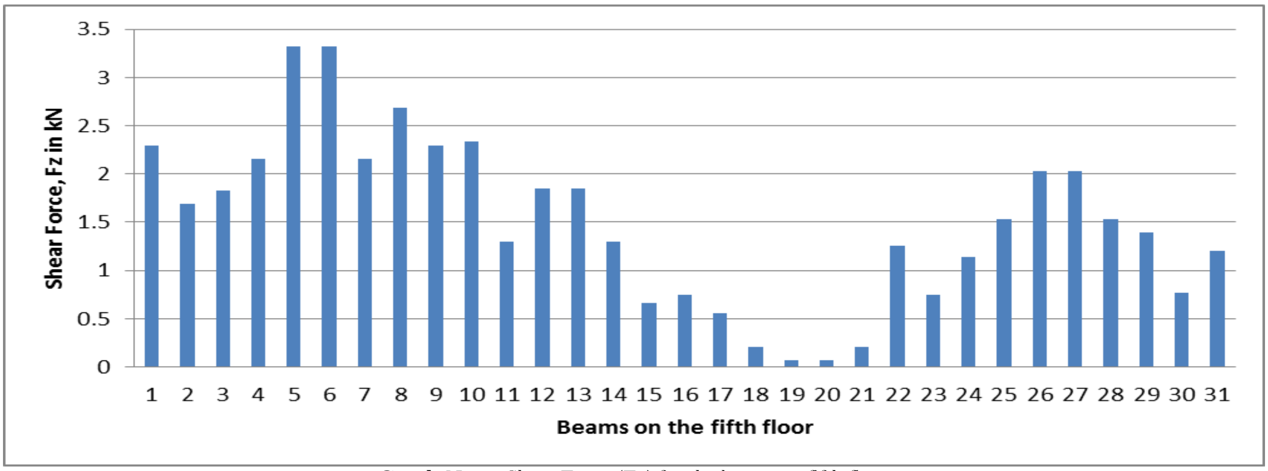
Graph-No.7. Deflection for the beams on fifth floor

The deflection on the highest floor is maximum i.e 0.488 and it is higher than the deflections of first, second, third and fourth floor while the minimum deflection found to be 0.455.



Graph-No.8. Moments (My) for the beams on fifth floor

The moments on the fifth floor in Y direction is found to be 3.25 kNm and observed that the moment on the top floor as 3.25 kNm which is much lower than the moments on the remaining floors.



Graph-No. 9. Shear Force (Fz) for the beams on fifth floor

The shear force on top floor i.e fifth floor found to be 3.25 kN which is also lower than that of on the remaining floors.

5. ADVANTAGES & LIMITATIONS

The advantage of the present work includes programming code of design members of structures like beam, slab, column and footing. Most of the cases the design is carried out on the MS-Excel sheet but the programming in MATLAB are also a good option. The present paper also discusses the STAAD-PRO programming part which also not detailed in other work and earthquake resistant design is also given in that part.

The limitations of the present work involves programming in only one language, other languages need to checked for more faster results. Also design and analysis is carried out in STAAD-PRO, other software tools need to be checked for faster results. Also reinforcement detailing is not provided.

6. CONCLUSION

The analysis and design of a structure in STAAD-PRO software is completed, the maximum shear force and bending moment in the column, beam and slab is noted. The noted values are programmed in MATLAB software so that the required area of reinforcement and size for footing, column, beam and slab is properly designed. The advantages of user friendly software like STAAD-PRO for analysis and MATLAB programming for the design of structural elements are found out.

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Appendix A (STADD-Programme)

STAAD SPACE

START JOB INFORMATION

ENGINEER DATE 15-Apr-15

END JOB INFORMATION

INPUT WIDTH 79

UNIT METER KN

JOINT COORDINATES

1 0 0 0; 2 4 0 0; 3 8 0 0; 4 12 0 0; 5 0 0 4; 6 4 0 4; 7 8 0 4; 8 12 0 4;
9 0 0 8; 10 4 0 8; 11 8 0 8; 12 12 0 8; 13 0 0 12; 14 4 0 12; 15 8 0 12;
16 12 0 12; 17 0 0 16; 18 4 0 16; 19 8 0 16; 20 12 0 16; 21 0 1.8 0;
22 4 1.8 0; 23 8 1.8 0; 24 12 1.8 0; 25 0 1.8 4; 26 4 1.8 4; 27 8 1.8 4;
28 12 1.8 4; 29 0 1.8 8; 30 4 1.8 8; 31 8 1.8 8; 32 12 1.8 8; 33 0 1.8 12;
34 4 1.8 12; 35 8 1.8 12; 36 12 1.8 12; 37 0 1.8 16; 38 4 1.8 16; 39 8 1.8 16;
40 12 1.8 16; 41 0 5.8 0; 42 4 5.8 0; 43 8 5.8 0; 44 12 5.8 0; 45 0 5.8 4;
46 4 5.8 4; 47 8 5.8 4; 48 12 5.8 4; 49 0 5.8 8; 50 4 5.8 8; 51 8 5.8 8;
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58 4 5.8 16; 59 8 5.8 16; 60 12 5.8 16; 61 0 9.8 0; 62 4 9.8 0; 63 8 9.8 0;
64 12 9.8 0; 65 0 9.8 4; 66 4 9.8 4; 67 8 9.8 4; 68 12 9.8 4; 69 0 9.8 8;
70 4 9.8 8; 71 8 9.8 8; 72 12 9.8 8; 73 0 9.8 12; 74 4 9.8 12; 75 8 9.8 12;
76 12 9.8 12; 77 0 9.8 16; 78 4 9.8 16; 79 8 9.8 16; 80 12 9.8 16; 81 0 13.8 0;
82 4 13.8 0; 83 8 13.8 0; 84 12 13.8 0; 85 0 13.8 4; 86 4 13.8 4; 87 8 13.8 4;
88 12 13.8 4; 89 0 13.8 8; 90 4 13.8 8; 91 8 13.8 8; 92 12 13.8 8;
93 0 13.8 12; 94 4 13.8 12; 95 8 13.8 12; 96 12 13.8 12; 97 0 13.8 16;
98 4 13.8 16; 99 8 13.8 16; 100 12 13.8 16; 101 0 17.8 0; 102 4 17.8 0;
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113 0 17.8 12; 114 4 17.8 12; 115 8 17.8 12; 116 12 17.8 12; 117 0 17.8 16;
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133 0 21.8 12; 134 4 21.8 12; 135 8 21.8 12; 136 12 21.8 12; 137 0 21.8 16;
138 4 21.8 16; 139 8 21.8 16; 140 12 21.8 16;

MEMBER INCIDENCES

32 1 21; 33 2 22; 34 3 23; 35 4 24; 36 5 25; 37 6 26; 38 7 27; 39 8 28;
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DEFINE MATERIAL START
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POISSON 0.17
DENSITY 23.5616
ALPHA 1e-005
DAMP 0.05
END DEFINE MATERIAL
MEMBER PROPERTY AMERICAN
36 TO 47 49 50 87 TO 98 100 101 138 TO 149 151 152 189 TO 200 202 203 240 -241 TO 251 253 254
291 TO 302 304 305 PRIS YD 0.23 ZD 0.6
32 TO 35 48 51 83 TO 86 99 102 134 TO 137 150 153 185 TO 188 201 204 -
236 TO 239 252 255 287 TO 290 303 306 PRIS YD 0.23 ZD 0.45
52 TO 82 103 TO 133 154 TO 184 205 TO 235 256 TO 286 307 TO 336 -
337 PRIS YD 0.38 ZD 0.23
CONSTANTS
BETA 90 MEMB 33 34 37 38 41 42 45 46 49 50 84 85 88 89 92 93 96 97 100 101 -
135 136 139 140 143 144 147 148 151 152 186 187 190 191 194 195 198 199 202 -
203 237 238 241 242 245 246 249 250 253 254 288 289 292 293 296 297 300 301 -
304 305
MATERIAL CONCRETE ALL
SUPPORTS
1 TO 20 PINNED
****
DEFINE 1893 LOAD
ZONE 0.16 RF 5 I 1 SS 1 DM 0.05 DT 1.5
JOINT WEIGHT
****
1 WEIGHT 2.195
2 WEIGHT 2.195
3 WEIGHT 2.195
4 WEIGHT 2.195
5 WEIGHT 2.926
6 WEIGHT 2.926
7 WEIGHT 2.926
8 WEIGHT 2.926
9 WEIGHT 2.926
10 WEIGHT 2.926
11 WEIGHT 2.926
12 WEIGHT 2.926
13 WEIGHT 2.926
14 WEIGHT 2.926
15 WEIGHT 2.926
16 WEIGHT 2.926
17 WEIGHT 2.195

18 WEIGHT 2.926

19 WEIGHT 2.926

20 WEIGHT 2.195

21 WEIGHT 81.089

22 WEIGHT 101.54

23 WEIGHT 101.54

24 WEIGHT 81.089

25 WEIGHT 102.813

26 WEIGHT 78.526

27 WEIGHT 78.526

28 WEIGHT 102.813

29 WEIGHT 102.284

30 WEIGHT 77.844

31 WEIGHT 77.844

32 WEIGHT 102.284

33 WEIGHT 102.812

34 WEIGHT 78.384

35 WEIGHT 78.384

36 WEIGHT 102.812

37 WEIGHT 81.066

38 WEIGHT 104.058

39 WEIGHT 104.058

40 WEIGHT 81.066

41 WEIGHT 105.104

42 WEIGHT 152.706

43 WEIGHT 152.706

44 WEIGHT 105.104

45 WEIGHT 154.341

46 WEIGHT 192.095

47 WEIGHT 192.095

48 WEIGHT 154.341

49 WEIGHT 153.271

50 WEIGHT 188.666

51 WEIGHT 188.666

52 WEIGHT 153.271

53 WEIGHT 154.328

54 WEIGHT 191.543

55 WEIGHT 191.543

56 WEIGHT 154.328

57 WEIGHT 105.062

58 WEIGHT 156.526

59 WEIGHT 156.526

60 WEIGHT 105.062

61 WEIGHT 105.4

62 WEIGHT 152.831

63 WEIGHT 152.831

64 WEIGHT 105.4

65 WEIGHT 154.584

66 WEIGHT 191.36

67 WEIGHT 191.36

68 WEIGHT 154.584

69 WEIGHT 153.637

70 WEIGHT 188.434

71 WEIGHT 188.434

72 WEIGHT 153.637

73 WEIGHT 154.575

74 WEIGHT 190.848

75 WEIGHT 190.848

76 WEIGHT 154.575

77 WEIGHT 105.363

78 WEIGHT 156.609

79 WEIGHT 156.609

80 WEIGHT 105.363

81 WEIGHT 105.518

82 WEIGHT 152.796

83 WEIGHT 152.796

84 WEIGHT 105.518

85 WEIGHT 154.57

86 WEIGHT 191.274

87 WEIGHT 191.274

88 WEIGHT 154.57

89 WEIGHT 153.685

90 WEIGHT 188.419

91 WEIGHT 188.419

92 WEIGHT 153.685

93 WEIGHT 154.561

94 WEIGHT 190.761

95 WEIGHT 190.761

96 WEIGHT 154.561

97 WEIGHT 105.487

98 WEIGHT 156.569

99 WEIGHT 156.569

100 WEIGHT 105.487

101 WEIGHT 104.562

102 WEIGHT 152.904

103 WEIGHT 152.904

104 WEIGHT 104.562

105 WEIGHT 154.365

106 WEIGHT 192.465

107 WEIGHT 192.465

108 WEIGHT 154.365
109 WEIGHT 153.082
110 WEIGHT 188.755
111 WEIGHT 188.755
112 WEIGHT 153.082
113 WEIGHT 154.351
114 WEIGHT 191.902
115 WEIGHT 191.902
116 WEIGHT 154.351
117 WEIGHT 104.503
118 WEIGHT 156.752
119 WEIGHT 156.752
120 WEIGHT 104.503
121 WEIGHT 13.782
122 WEIGHT 17.138
123 WEIGHT 17.138
124 WEIGHT 13.782
125 WEIGHT 18.929
126 WEIGHT 22.197
127 WEIGHT 22.197
128 WEIGHT 18.929
129 WEIGHT 19.29
130 WEIGHT 22.813
131 WEIGHT 22.813
132 WEIGHT 19.29
133 WEIGHT 18.934
134 WEIGHT 22.19
135 WEIGHT 22.19
136 WEIGHT 18.934
137 WEIGHT 13.81
138 WEIGHT 18.745
139 WEIGHT 18.745
140 WEIGHT 13.81
****
LOAD 4 LOADTYPE Seismic TITLE LOAD CASE 4 EQX
1893 LOAD X 1
LOAD 5 LOADTYPE Seismic TITLE LOAD CASE 5 -EQX
1893 LOAD X -1
LOAD 6 LOADTYPE Seismic TITLE LOAD CASE 6 EQZ
1893 LOAD Z 1
LOAD 7 LOADTYPE Seismic TITLE LOAD CASE 7 -EQZ
1893 LOAD Z -1
****
LOAD 1 LOADTYPE Dead TITLE DL
SELFWEIGHT Y -1 LIST 32 TO 337

```
MEMBER LOAD
52 TO 55 58 62 65 69 72 76 79 TO 82 UNI GY -17.02
56 57 59 TO 61 63 64 66 TO 68 70 71 73 TO 75 77 78 UNI GY -6.44
103 TO 106 109 113 116 120 123 127 130 TO 133 UNI GY -17.02
107 108 110 TO 112 114 115 117 TO 119 121 122 124 TO 126 128 129 UNI GY -8.15
154 TO 157 160 164 167 171 174 178 181 TO 184 UNI GY -17.02
158 159 161 TO 163 165 166 168 TO 170 172 173 175 TO 177 179 180 UNI GY -8.15
205 TO 208 211 215 218 222 225 229 232 TO 235 UNI GY -17.02
209 210 212 TO 214 216 217 219 TO 221 223 224 226 TO 228 230 231 UNI GY -8.15
256 TO 259 262 266 269 273 276 280 283 TO 286 UNI GY -17.02
260 261 263 TO 265 267 268 270 TO 272 274 275 277 TO 279 281 282 UNI GY -8.15
FLOOR LOAD
YRANGE 3 19 FLOAD -5 GY
LOAD 2 LOADTYPE Live  TITLE LL
FLOOR LOAD
YRANGE 3 19 FLOAD -3 GY
LOAD 3 LOADTYPE Roof Live  TITLE RLL
FLOOR LOAD
YRANGE 20.8 23 FLOAD -3 GY
LOAD 21 LOADTYPE Wind  TITLE WLX
MEMBER LOAD
55 62 69 76 83 87 91 95 99 106 113 120 127 134 138 142 146 150 157 164 171 -
178 185 189 193 197 201 208 215 222 229 236 240 244 248 252 259 266 273 280 -
287 291 295 299 303 310 317 324 331 UNI GX 10.144
LOAD 22 LOADTYPE Wind  TITLE WLX-
MEMBER LOAD
58 65 72 79 86 90 94 98 102 109 116 123 130 137 141 145 149 153 160 167 174 -
181 188 192 196 200 204 211 218 225 232 239 243 247 251 255 262 269 276 283 -
290 294 298 302 306 313 320 327 334 UNI GX -10.144
LOAD 23 LOADTYPE Wind  TITLE WLZ
MEMBER LOAD
52 TO 54 83 TO 86 103 TO 105 134 TO 137 154 TO 156 185 TO 188 205 TO 207 236 -
237 TO 239 256 TO 258 287 TO 290 307 TO 309 UNI GZ 7.608
LOAD 24 LOADTYPE Wind  TITLE WLZ-
MEMBER LOAD
80 TO 82 99 TO 102 131 TO 133 150 TO 153 182 TO 184 201 TO 204 233 TO 235 -
252 TO 255 284 TO 286 303 TO 306 335 TO 337 UNI GZ -7.608
****************************************
LOAD COMB 8 COMBINATION LOAD CASE 8 (1.5D.L.+1.5L.L.+1.5RLL)
1 1.5 2 1.5 3 1.5
LOAD COMB 9 COMBINATION LOAD CASE 9 (1.5D.L.+1.5EQX)
1 1.5 4 1.5
LOAD COMB 10 COMBINATION LOAD CASE 10 (1.5D.L.-1.5EQX)
1 1.5 5 1.5
LOAD COMB 11 COMBINATION LOAD CASE 11 (1.5D.L.+1.5EQZ)
```

1 1.5 6 1.5

LOAD COMB 12 COMBINATION LOAD CASE 12(1.5D.L.-1.5EQZ)

1 1.5 7 1.5

LOAD COMB 13 COMBINATION LOAD CASE 13 (1.2DL+1.2LL+1.2EQX)

1 1.2 2 1.2 4 1.2

LOAD COMB 14 COMBINATION LOAD CASE 14 (1.2D.L. +1.2LL-1.2EQX)

1 1.2 2 1.2 4 1.2

LOAD COMB 15 COMBINATION LOAD CASE 15(1.2D.L. +1.2LL+1.2EQZ)

1 1.2 2 1.2 6 1.2

LOAD COMB 16 COMBINATION LOAD CASE 16(1.2DL.L. +1.2LL-1.2EQZ)

1 1.2 2 1.2 7 1.2

LOAD COMB 17 COMBINATION LOAD CASE 17(0.9D.L.+1.5EQX)

1 0.9 4 1.5

LOAD COMB 18 COMBINATION LOAD CASE 18 (.9D.L.-1.5EQX)

1 0.9 5 1.5

LOAD COMB 19 COMBINATION LOAD CASE 19(0.9D.L.+1.5EQZ)

1 0.9 6 1.5

LOAD COMB 20 COMBINATION LOAD CASE 20(0.9DL-1.5EQZ)

1 0.9 7 1.5

LOAD COMB 25 1.5(DL+WLX)

1 1.5 21 1.5

LOAD COMB 26 1.5(DL-WLX-)

1 1.5 22 1.5

LOAD COMB 27 1.5(DL+WLZ)

1 1.5 23 1.5

LOAD COMB 28 1.5(DL-WLZ-)

1 1.5 24 1.5

LOAD COMB 29 1.2(DL+LL+WLX)

1 1.2 2 1.2 21 1.2

LOAD COMB 30 1.2(DL+LL-WLX-)

1 1.2 2 1.2 22 1.2

LOAD COMB 31 1.2(DL+LL+WLZ)

1 1.2 2 1.2 23 1.2

LOAD COMB 32 1.2(DL+LL-WLZ-)

1 1.2 2 1.2 24 1.2

****

PERFORM ANALYSIS PRINT STATICS LOAD

LOAD LIST 8

START CONCRETE DESIGN

CODE INDIAN

FC 25000 ALL

FYMAIN 415000 ALL

FYSEC 250000 ALL

DESIGN BEAM 52 TO 82 103 TO 133 154 TO 184 205 TO 235 256 TO 286 307 TO 337

DESIGN COLUMN 32 TO 51 83 TO 102 134 TO 153 185 TO 204 236 TO 255 287 TO 306

END CONCRETE DESIGN
FINISH

Appendix-B (MATLAB Programming on Design of Footing)

Flowchart: Calculate size of footing ⟶ Calculate design of section ⟶ Calculate depth for one way shear ⟶ Check for two way shear ⟶ Design of reinforcement ⟶ check for development length ⟶ check for transfer of load at base

(Note: If any check do not satisfy then revise the section of footing)

MATLAB programming:

```
% for m25 & fe415
% xumax/d=0.48, ru=3.45
% 1) size of footing
% load on column
w=1616;
% p=10% of w
p=w+(10*w)/100
% area of footing=load/bearing capacity
% bearing capacity
bc=150;
a=p/(1.5*bc)
% ratio of b/l for column
b=230;l=600;
% ratio of b/l
r=b/l
% length of footing
l1=sqrt(a/r)
% breadth of footing
b1=a/l1
% providing footing of size 2x4.6
l2=4.6;b2=2;
% net upward pressure
po=(w/(l2*b2))
if po<bc
      disp('ok')
   else
      disp('change size of footing')
   end
% design of section
% a) design on the basis of b.m compression
% b.m moment at section x-x
m1=(po*b2*(l2-(l/1000))^2)/8
% taking 1.5 as safety factor
m1u=1.5*m1
%b.m moment at section y-y
m2=(po*l2*(b2-(b/1000))^2)/8
m2u=1.5*m2
% since m1u>m2u then considering m1u for design
ru=3.45;
d=sqrt((m1u*10^6)/(ru*b2*1000))
% providing depth of 400
d1=400;
% assuming 50mm cover
% therefore total depth
td=d1+50
% b)depth on basis of one way shear
% assuming under reinforced section
% depth of footing
otd=(po*b2*1000)/((sc*1000)+po)
% taking overall depth
otd1=680;
% c) check for two way shear action
% for two way shear action/ punching shear action along ABCD
% perimeter of ABCD
p=2*((l+otd1)+(b+otd1))
% area of ABCD
ar=((l/1000+otd1/1000)*(b/1000+otd/1000))
% punching shear
tau=100;
ps=tau*1.5*((l2*b2)-ar)
tauv=(ps*10^3/(p*otd1))
fck=25;
tauc=0.25*sqrt(fck)
ks=0.5+(b/1000+l/1000)
% adopting ks=1
ks1=1
h=ks1*tauc
if (h>tauv)
      disp('ok')
   else
      disp('check')
   end
% 5) design of reinforcement
% for mu1
fy=415;
a1=(1-sqrt(1-((4.6*m1u*10^6)/(fck*b2*1000*otd1^2))))
ast1=(0.5*fck*b2*a1*1000*d)/fy
% no of bars
% assuming 12mm dia bars
nob1=(ast1/(0.785*12*12))
% these are to be distributed uniformly in width b=2
a2=(1-(sqrt(1-((4.6*m2u*10^6)/(fck*l2*1000*d^2)))))
ast2=0.5*(fck/fy)*a2*l2*1000*d
% no of bars
nob2=ast2/(0.785*12^2)
% providing 10 bars
% check for development length
fi=12;
ld=47*fi
% providing 60mm side cover ,available length
al=0.58*(b2*1000-b)-60
if (al>ld)
    disp('ok')
```

```
with p=0.3%
% shear stress for m25 grade concrete
sc=0.36;
% for td>=300mm
k=1;
% therefore permissible shear stress
ps=k*sc
c=(po*b2*1.5)/(b2)
c1=c/ps
  else
    disp('check')
  end
% check for transfer of load at base
% adopting sqrt(a1/a2)=2
z=2;
% bearing stress
sb=0.45*fck*z
% actual bearing stress
abs=(1.5*l*1000)/(b*l)
if (abs<sb)
     disp('ok')
  else
     disp('check')
  end
```

Appendix-C (Programming in MATLAB-Design of Column)

Flowchart: check the column is short or slender → check for minimum eccentricity → calculation of area of steel

MATLAB programming:

```
% design of column
% given data
l=4000;b=450;D=600;w=2500000;fck=25;fy=415;s=
1.5;
% step 1) To check the column is short or slender
% by refering table no 28 of page 94
lex=0.65*l
ley=0.65*l
% refering clause no 25.1 of I.S 456 :2000
 x=lex/D
 y=ley/D
if x>12
disp('column is long')
elseif y>12
disp('column is long')
else
disp('column is short')
end
% step 2) to check minimum eccentricity
% refering clause no 25.4
ex=(l/500)+(D/30)
ex1=20;
if ex>ex1
exmin=ex
else
exmin=ex1
end
ey=(l/500)+(b/30)
ey1=20;
if ey>ey1
eymin=ey
else
eymin=ey1
end
% step 3) calculation of area of
steel
% refering clause no 39.3 of I.S.
456 : 2000
asc=(w*s-
0.4*fck*b*D)/(0.67*fy-0.4*fck)
% asumming 32mm dia bars
bars=asc/(0.785*32^2)
% providing 5-32mm dia bars
pt=(5*0.785*32^2*100)/(450*60
0)
% check
if pt<0.8
disp('repeat')
elseif pt>6
disp('repeat')
else
disp('hence ok')
end
```

Appendix-D (Programming in MATLAB-Design of Beam)

Flowchart: determination of max bending moment → Calculation of mu_{lim} and ast_{lim} → Determination of Mu_2, A_{st2},A_{sc},$A_{s\,t}$ → check for min & max tension & compression steel →

(Note: If any check do not satisfy then revise the section of Beam)

MATLAB programming:

```
% design of beam
% given data
l=4000;w=41.11;b=230;D=380;fck=25;fy=415;
% 1)determination of max bending moment
mumax=(w*l*l)/12
% assume
cover=35;
d=D-cover
% for m25 & fe415
xumax=0.48*d
% 2)determination of mulim and astlim
mulim=0.36*xumax*(d-0.42*xumax)*b*fck
 if mulim<mumax
disp('it is doubly reinforced beam')
else
disp('it is singly reinforced beam')
end
astlim=mulim/((0.87*fy)*(d-(0.42*xumax)))
% 3) determination of mu2, ast2,asc,ast
mu2=mumax-mulim
% calculating from the table
fsc=346.4;
fcc=0.446*fck
asc=mu2/((fsc-fcc)*(d-cover))
ast2=mu2/(0.87*fy*(d-cover))
ast=astlim+ast2
% 4) check for min & max tension & comp steel
%  a) in compression
minasc=(0.2*b*D)/100
maxasc=(4*b*D)/100
if minasc<asc
disp('hence ok')
elseif asc<maxasc
disp('hence ok')
else
disp('check again')
end
%  b) In tension
minast=(0.85*b*d)/fy
maxast=(4*b*D)/100
if minast<ast
disp('ok')
elseif ast<maxast
disp('ok')
else
disp('check again')
end
```

Appendix-E (Programming in MATLAB-Design of Slab)

Flowchart: Design constant and limiting depth of N.A. ⟶ Calculation of load and moment ⟶ Calculation of effective depth ⟶ Calculation of area of steel (Short span) ⟶ Calculation of area of steel (Long span)

MATLAB programming:

```
% 1) design constant and limiting depth of N.A.
% given
% fck=25;fy=415;xumax/d=0.479;ru=2.761;
a=20*1.68
l=4000;
d=l/a
% providing nominal cover of 20mm & 8mm dia bars
td=d+20+8/2
% providing overall depth of 180mm
% i) weight of slab per sqm
ws=0.18*1*1*25000
```

```
% ii)super imposed load
sl=3000;
tl=ws+sl
wu=1.5*tl
% taking effective depth=150mm
ly=6+0.15
lx=5+0.15
r=ly/lx
% from table
alpx=0.072;
alpy=0.056;
mux=alpx*wu*(lx)^2
muy=alpy*wu*(lx)^2
% 3)computational of eff depth
ru=2.76;
d=sqrt(mux*1000/ru*1000)
d=sqrt((mux*1000)/ru*1000)
d=sqrt((mux*1000)/(ru*1000))
% available depth for short span
adsh=180-20-(8/2)
% available depth for long span
adlp=adsh-8
% 4) computation of steel reinforcement for short span
fck=20;
c1=1-((4.6*mux*1000)/(fck*1000*(adsh)^2))
fy=415;
astx=(0.5*fck*(1-sqrt(c1))*1000*adsh)/fy
% spacing
sx=(1000*(0.785*8^2))/astx
% use 8mm dia bars@ 120mm c/c
% 5) computation of reinforcement for long span
astx=(0.5*fck*(1-sqrt(c1))*1000*adsh)/fy
c2=1-((4.6*muy*1000)/(fck*1000*(adlp)^2))
asty=(0.5*fck*(1-sqrt(c2))*1000*adlp)/fy
%provide 8mm dia. bars
% spacing
sy=(1000*(0.785*8^2))/asty
% hence provide 8mm dia. bars @ 150mm c/c
```