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Compare the Analysis and Design by Limit State Method of G+1 RCC Bunglow by using STAAD Pro and Manual Calculation

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Abstract: In today's world, the importance of structural engineering is increasing day by day. Structural Engineer is not only responsible for designing a durable, serviceable structure but it's more important to design an economic structure. With rising construction costs and limited resources, designing a cost-effective building is essential. The process of manual analysis and design of RCC structure becomes more complex for heavy structure so the use of software's is necessary, for the effective use the theoretical concepts of analysis and design must be known. Similarly, the knowledge of IS codes is also mandatory.

So for the detailed study this project includes the comparative study of analysis and design of G+1 RCC Bungalow by manual calculation and by using STAAD Pro software. We at initial stage manually designed a G+1 RCC Bungalow by limit state methods using IS Codes, SP 15 Code and after that we have designed the same Bungalow by using a STAAD Pro software and finally compared the results.

Keywords: RCC design, STAAD Pro, Limit state method, IS code, SP 16

I. INTRODUCTION

With the increase in growth of population the residential, commercial and infrastructure development is increasing significantly. In today's day construction industry has immense pressure to design safe, serviceable and durable structure. And it is most important for structural Engineer to design the structure economically. Now with the advancement in the technology there are various analysis and design platform like STAAD Pro, E-Tabs etc. which streamline the analysis and design process. The report focuses on the Analysis and Design of G+ 1 RCC Bungalow by using limit state method by using STAAD Pro and manual calculation. The main objective of the project is to compare the results of structural design by STAAD Pro and manual calculation for the structural element like Slab, Beam, column and Footing. The comparative result shows the difference in the Load, Maximum Moment, Reaction and the reinforcement detailing.

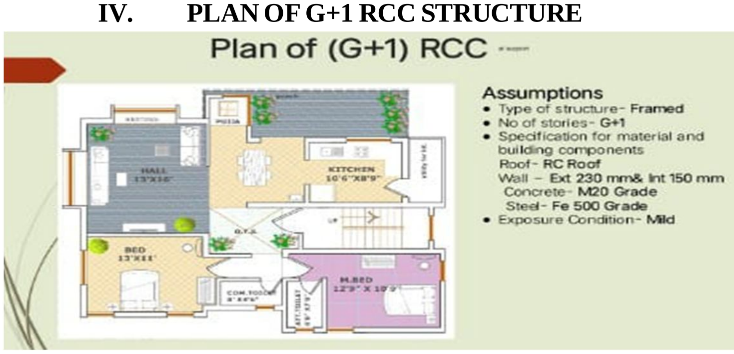
II. OBJECTIVE

1) To study analysis and design of RCC Structure in detail
2) To study the STAAD Pro software for the analysis and design purpose
3) To compare the analysis and design of G+1 RCC bungalow using STAAD Pro software and Manual calculation

III. SCOPE

Project can be extended for the analysis and design of G+1 RCC structure for other loading combination (dead load + Wind load) and (Dead load + Live load + Wind Load)

IV. PLAN OF G+1 RCC STRUCTURE



V. MANUAL CALCULATION OF G + 1 RCC STRUCTURE

1) Manual Calculation of Slab

TABLE I Sample of two-way slab

Step No.	Slab Mark	S2	S2	S3
1	Given: -			
	Span;			
	a) Short Span: (Lx) m	3.36	3.36	2.28
	b) Long Span : (Ly) m	3.96	3.96	2.39
	Aspect Ratio:	1.23	1.17	1.04
	Assumed Pt %= 0.3%			
	(Assume Pt% for M20 and Fe 500 between 0.2% to 0.5%)			
	Therefore M.F			
	(As per the Graph of Modification factor for Tension	1.2	1.2	1.2
	Reinforcement on page 38 of IS 456:2000)			
	L/D Ratio	26	26	26
	Grade of Concrete: in (N/mm^2)	20	20	20
	Grade of Steel: (N/mm^2)	500	500	500
	Width of Support (b):	230	230	230
	αx=	0.0462	0.0435	0.035
	-αx=	0.0615	0.0579	0.045
	αy=	0.0462	0.0035	0.035
	-αy=	0.0615	0.047	-
	(from Table 26 of IS 456:2000)			
2	Depth Calculation			R
	d = (Lx/((L/d) X M.F))	125mm	110mm	65mm
	D= d +d'	145mm	130 mm	85mm
	Actual provided Depth	125mm	125 mm	125mm
3	Load Calculation			
	Dead Load			
	DL = self-weight + Waterproofing load			
	• Self-Weight=25 X D X 1 in (KN/m^2)	3.625	3.25	2.125
	• Waterproofing Load: in (KN/m^2)	1.2	1.2	1.2
	(as per IS 875 Part 1 of Dead Load)			
	LL = Imposed load + Floor			
	Due to occupancy Finish			
	• Imposed load in (KN/m^2)	2	2	2
	• Floor Finish in (KN/m^2)	1.5	1.5	1.5
	(as per IS 875-part 2 Live Load)			
	Total Load: in (KN/m^2)			
	Factored Load in (KN/m^2)	8.325	7.95	6.825
		12.48	11.92	10.23
4	Effective Length Calculation			
	It is Minimum of following			
	• Le= C.S + (b/2) +(b/2) in m	4.19	3.59	2.51
	• Le = C.S + (d/2) + (d/2) in m	4.125	3.47	2.345
	Effective length:	4.125	3.47	2.345
5	Moment Calculation: in (KNm)			
	Mux = αx X Wu X $(Le)^2$	9.81	6.24	1.97
	-Mux = -αy X Wu X $(Le)^2$	13.05	8.31	2.53
	Muy = αy X Wu X $(Le)^2$	7.43	5.02	1.97
	-Muy = -αy X Wu X $(Le)^2$	9.98	6.74	
	Mu = Maximum of above four	13.05	8.31	2.53

6	Check for Depth in mm Mu = Mulim = 0.133 fck bd^2 D required:	 70.40	 55.89	 30.84
7	Aera of steel calculation (Ast) in mm^2 Steel along shorter span 0.5 fck /fy (1-√1- (4.6 Mux / fck bd^2)) • At Midspan Ast: • At support Ast: Ast Min = 0.12% Ag Ast min< Ast Distance for middle strip Width (in m) (0.75 X Le) Edge strip width along either side (in m) (Lex/8) Steel along Longer span 0.5 fck / fy (1-√1- (4.6 Muy / fck bd^2) • At midspan Ast: • At support Ast: Distance for middle strip Width (0.75 X Le) Edge strip width along either side (Lex/8)	 211.13 285.49 150 Yes 3.09 0.51 158.28 214.95 3.65 0.6	 134.59 181.22 156 mm^2 No (Provide min) 3.09 0.51 107.59 145.75 3.65 0.6	 71.68 92.84 78 No (Provide min) 3.09 0.51 71.68 3.65 0.6
8	Spacing in (mm) Assume 10 mm ǿ bar Along shorter span • At midspan • At support Along Longer span • At midspan • At support Minimum spacing Check It is minimum of following • 3d = 3X 105 • 300 mm Therefore Provide	 300 300 300 300 315 300 300	 500 430 500 500 315 300 300	 1000 845.97 1000 - 195 300 195
9	Check for deflection Short span consideration Ast provided = {(π/4 X 10^2) / (Ast x)} X 1000 Fs = 0.58 fy Pt provided = (100 X Astx provided) /bd Pt provided <Pt assumed OR d required= le / ((L/d)X M.F) d required < d provided	 212.27 290 0.17 Yes 0.132 Yes	 261.79 290 0.23 Yes 0.11 Yes	 402.768 290 0.62 yes

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TABLE II
Manual Calculation of Slab

Sr No	No.	Depth of Slab (in mm)	Type of Slab	Steel along X axis	Steel along Y axis
1	S1	D=145mm	Two way Two adjacent edges dis- continuous	10 mm ø @ 300 mm c/c	10 mm ø @ 300 mm c/c
2	S2	D=130mm	Two Way Two adjacent edges Discontinuous	10 mm ø @ 300 mm c/c	10 mm ø @ 300 mm c/c
3	S3	D=85mm Provide-125 mm	Two way Two short edges Discontinuous	10 mm ø @ 195 mm c/c	10 mm ø @ 195 mm c/c
4	S4	D=130mm Provide-125 mm	Two Way One short edge Continuous	10 mm ø @ 300 mm c/c	10 mm ø @ 300 mm c/c
5	S5	D=120mm	Two ways One long edge discontinuous	10 mm ø @ 300 mm c/c	Midspan – 10 mm ø @ 80 mm c/c At edge- 10 mm ø @ 300 mm c/c
6	S6	D=70mm Provide-125 mm	One way	10 mm ø @ 180 mm c/c	10 mm ø @ 300 mm c/c
7	S7	D-240mm Provide-150mm	Cantilever	10 mm ø @ 175 mm c/c	10 mm ø @ 210 mm c/c
8	S8	D-145mm Provide-150 mm	Cantilever	10 mm ø @ 300 mm c/c	10 mm ø @ 360 mm c/c

2) Manual Calculation of Beam

TABLE III- SAMPLE OF MANUAL CALCULATION OF BEAM

Sr No.	Beam Mark	B1
1	PART A] ANALYSIS OF BEAM Effective length calculation (Le) Le minimum of following • Le= C. S + (b/2) + (b/2) • Le= C.S + (d/2) + (d/2) Therefore Le :- Load Calculation • Self-Weight – density of concrete X b X D X 1.5 • Parapet wall – density of brick X b X H X 1.5 • Slab Load – qu = (qu / lx) X [1- (1/(3 X $ß^2$))] Total load: - Factored Load (Wu): -	 1.19 m 4.235m 4.19 m 2.588KN/m 6.624KN/m 21.35KN/m 30.562KN/m 30.562KN/m

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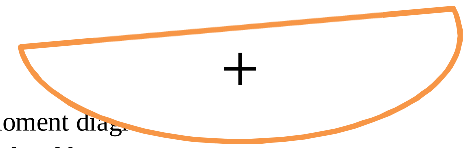
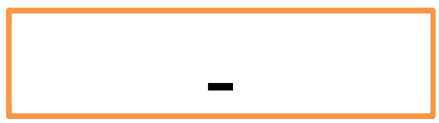
2	Net BMD • Free bending moment Calculation Assume beam as simply supported beam $Mu= (Wu\ X\ Le^{2}) / (8)$ Diagram of free bending moment  • Fixed end moment diag Assume beam as fixed beam $MA= MB= - (Wu\ X\ Le^{2}) / 12$ Diagram of Fixed End moment 44.71 KNm  Net BMD Superimpose free bending moment diagram and fixed end moment diagram.	 67.07KNm 44.71KNm
3	Actual Reaction Calculation by using following equilibrium condition € Fy = 0 (Upward + and Downward -) € M@a = 0 (clockwise + and Anticlockwise -) Therefore RA= RB=	 64.03 KN 64.03 KN
4	Point of Contra flexure calculation Contraflexure point near A support – Contraflexure point near B support -	 0.71 m 0.71 m
5	Shear force Calculation (At right of section take upward – and downward +) SF @ BR: - SF @ BL: - SF @AR: - SF @ AL: -	 0 - 64.03KN 64.03 KN 0
6	Point of Contra shear calculation Contra shear point near A support Contra shear point near B support	 1.75 m 2.44 m
	<u>PART 2] DESIGN OF FIXED BEAM</u> • Depth Calculation Mu = Mulim (where Mu is maximum of Sagging and Haugging moment) Therefore Mu :- $67.07\ X\ 10^{6} = 0.133\ fck\ bd^{2}$ Therefore d req = Provide D • Area of steel calculation Ast to resist sagging moment	 67.07 KNm 331.1 mm 380 mm

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	Ast = (0.5 fck / (fy)) {1- √1- ((4.6 Mus)/ fck bd^2)} X bd	
	Ast :-	516.09 mm^2
	No of bars calculation	
	(Assume 16 mm ǿ Bar)	
	No of Bars = (Ast) / (п/4 X 16^2)	3 bars
	• Ast to resist Haugging moment	
	Ast = (0.5 fck / fy) X {1- √1 – ((4.6 Muh) / fck bd^2)} X bd	
	Ast: -	321.27 mm^2
	No of bars calculation	
	(Assume 12 mm ǿ bar)	
	No of Bar = (Ast) / (п/4 X 12^2)	3 bars
	• Shear Reinforcement Calculation	
	Vu= 64.03 KN	
	τ v = Vu/bd = (64.03 X10^3)/ (230 X 335)	0.78 N/mm^2
	τ c max = (From IS 456 : 2000)	
	τ c max > τ v	Yes
	shear reinforcement at centre	
	Pt % = (Ast / bd) X 100	0.63 %
	τ c for Pt % (SP 16 code)	0.51 N/mm^2
	Vuc = (τ c X b X d) / 1000	41.64 KN
	Vus = Vu – Vuc	22.38 KN
	Vus /d	0.63
	Spacing from graph (SP 16 code)	350 mm
	Smax is minimum of following	
	1] 0.75 d –	260 mm
	2] 300 mm	300mm
	Therefore smax –	260 mm
	Provide spacing	260 mm
	Provide 8 mm ǿ bar @ 260 mm c/c	
	Shear reinforcement at support	
	Pt%= (Ast / bd) X 100	0.39 %
	τ c for Pt %	0.44 N/mm2
	Vuc=	35.926 KN
	Vus = Vu -Vuc	28.09 KN
	Vus / d	0.79
	Spacing	250mm
	Smax is minimum of following	
	1] 0.75 d	260 mm
	2] 300 mm	300 mm
	Smax :-	260 mm
	Provide spacing	250 mm
	Provide 8 mm ǿ @ 250 mm c/c	

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TABLE IV
Manual Calculation of 1st Floor Slab

Beam No	Length (Le)	Depth of Beam	Steel in compression Zone	Steel in tension Zone	Shear Reinforcement At Centre	At Midspan
B1	4.19 m	380 mm	3- 16 mm ǿ	3- 12 mm ǿ	8mm ǿ@260 mm c/c	8mm ǿ@250 mm c/c
B2	4.19 m	450 mm	4- 16 mm ǿ	4- 12 mm ǿ	8mm ǿ@200 mm c/c	8mm ǿ@190 mm c/c
B3	4.19 m	380 mm	3- 16 mm ǿ	3- 12 mm ǿ	8mm ǿ@260 mm c/c	8mm ǿ@260 mm c/c
B4	8.69 m	450 mm	5-16 mm ǿ	3-16mm ǿ	8mm ǿ@300 mm c/c	8mm ǿ@300mm c/c
B5	8.69 m	450 mm	5-16 mm ǿ	3-16 mm ǿ	8 mm ǿ @300 mm c/c	8 mmǿ@300 mm c/c
B6	4.2 m	380 mm	3- 16 mm ǿ	3-12 mm ǿ	8mm ǿ@260 mm c/c	8mm ǿ@260 mm c/c
B7	5.42 m	550 mm	5-16 mm ǿ	4-16 mm ǿ	8mm ǿ@170 mm c/c	8mm ǿ@140mm c/c
B8	2.51m	300 mm	2-12 mm ǿ	2-12 mm ǿ	8mm ǿ@200 mm c/c	8mm ǿ@200mm c/c
B9	3.51m	300 mm	3-12 mm ǿ	2-12 mm ǿ	8mm ǿ@200 mm c/c	8mm ǿ@200mm c/c
B10	4.21m	380 mm	3-16 mm ǿ	3-12 mm ǿ	8mm ǿ@260 mm c/c	8mm ǿ@260mm c/c
B11	3.51 m	450 mm	4-16 mm ǿ	3-16 mm ǿ	8mm ǿ@140 mm c/c	8mm ǿ@120 mm c/c
B12	3.2 m	300 mm	4-12 mm ǿ	3-12mm ǿ	8mm ǿ@200 mm c/c	8mm ǿ@200mm c/c
B13	6.86 m	mm	mm ǿ	mm ǿ		
B14	3.2 m	300 mm	5-12 mm ǿ	3-12 mm ǿ	8 mm ǿ@260 mmc/c	8mmǿ@260 mmc/c
B15	2.245 m	300mm	2-12mm ǿ	2-12mm ǿ	8mm ǿ@200 mm c/c	8mm ǿ@200mm c/c
B16	1.44 m	300mm	2-12mm ǿ	2-12mm ǿ	8mm ǿ@200 mm c/c	8mm ǿ@200mm c/c
MB	2.03 m	300mm	2-12 mm ǿ	2-12mm ǿ	8mm ǿ@200 mm c/c	8mm ǿ@200mm c/c

3) Manual Calculation of Column

TABLE V – SAMPLE OF MANUAL CALCULATION OF COLUMN

Sr No.	Column Mark	C1
1	Given Pt % assumed = 1.2 % Assumed b = D=	 230 mm 300 mm
2	PART 1] ANALYSIS OF COLUMN • Load Calculation (Pu) Self Weight- 1.5 X 25 X 0.23 X 0.3X 3 Beam load =(RA of B1 beam) + (RA of B4 beam) = 53.36 + 103.08 Therefore total load on column:- • Calculation of Eccentricities Calculation ex Equivalent Area = (b X d) + (m-1) X Ast Equivalent moment of inertia about X axis Ixx = $(bd^3/12)$ + (m-1) X Ast X 100^2 As we know that direct stress = Bending Stress (P/Ae) = [(PX ex)/ Ixx) X (d/2)] ex :- Calculation of ey Equivalent area = (b X d) + (m-1) X Ast Equivalent moment of inertia about Y axis Iyy = $(db^3/12)$ + (m-1) X Ast X 100^2 As we know that direct stress = bending stress (P/Ae) = [((P X ey)/ Iyy) X (b/2)] ey :- • Moment calculation Mux = Pu X ex Muy = Pu X ey	 7.76 KN 156.44 KN 164.2 KN 830.76 mm^2 658.26 X10^6 mm^4 0.053m 830.76 mm^2 444.94X$10^6$$mm^4$ 0.047 m 7.72 KNm 8.70 KNm
3	<u>PART 2] DESIGN OF COLUMN</u> • Pt / fck • d' / D • d' / b • Pu / fck bd • Mux1x1 • Muy1y1 • Puz / Ag (From graph No 63 of SP 16 Code book) • Puz • Pu/ Puz Check (Pu / Puz) < 0.2 • $(Mux / Mux1x1)^{\alpha n} + (Muy / Muy1y1)^{\alpha n}$ Check $(Mux / Mux1x1)^{\alpha n} + (Muy / Muy1y1)^{\alpha n} < 1$ • Asc = (Pt Xb X d) / (100)	 0.06 0.15 0.2 0.119 41.4 KNm 63.48KNm 17 1.173 X 106 0.14 Yes 0.33 Yes 828 mm^2

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	No of bars = (Asc / (п/4 X 12^2))	8 nos
	• Lateral Ties	
	Diameter of lateral ties be greater of following	
	1] (1/4th of larger diameter of main bar)	3 mm
	2] 5 mm	5 mm
	Provide spacing as 5 mm	
	Practically provide 8 mm ǿ bar	
	Spacing of Lateral ties be minimum of following	
	1] least lateral dimension of column	230 mm
	2] 16 X smaller diameter of main bar	190 mm
	3] 300 mm	300 mm
	It is minimum of following	190 mm
	Provide 8 mm ǿ @ 190 mm c/c	

TABLE VI
Manual Calculation of 1st floor Column

Column Notation	Size of column	Longitudinal Reinforcement	Lateral Ties
C1	230mm X 300mm	8-12 mm ǿ	8 mm ǿ @190 mm c/c
C2	230mm X 380 mm	10- 12 mm ǿ	8 mm ǿ @190 mm c/c
C3	230mm X 300mm	8-12 mm ǿ	8 mm ǿ @190 mm c/c
C4	230mm X 300mm	8-12 mm ǿ	8 mm ǿ @190 mm c/c
C5	230mm X 380 mm	10- 12 mm ǿ	8 mm ǿ @190 mm c/c
C6	230mm X 380 mm	10- 12 mm ǿ	8 mm ǿ @190 mm c/c
C7	230mm X 380 mm	10- 12 mm ǿ	8 mm ǿ @190 mm c/c
C8	230mm X 380 mm	10- 12 mm ǿ	8 mm ǿ @190 mm c/c
C9	230mm X 300mm	8-12 mm ǿ	8 mm ǿ @190 mm c/c
C10	230mm X 300mm	8-12 mm ǿ	8 mm ǿ @190 mm c/c
C11	230mm X 300mm	8-12 mm ǿ	8 mm ǿ @190 mm c/c
C12	230mm X 300mm	8-12 mm ǿ	8 mm ǿ @190 mm c/c
C13	230mm X 300mm	8-12 mm ǿ	8 mm ǿ @190 mm c/c

TABLE VII
Manual Calculation of Ground floor Column

Column Notation	Size of column	Longitudinal Reinforcement	Lateral Ties
C1	230mm X 300mm	4-16 mm ǿ + 2-12 mm ǿ	8 mm ǿ @190 mm c/c
C2	230mm X 380 mm	10- 12 mm ǿ	8 mm ǿ @190 mm c/c
C3	230mm X 300mm	8-12 mm ǿ	8 mm ǿ @190 mm c/c
C4	230mm X 300mm	8-12 mm ǿ	8 mm ǿ @190 mm c/c
C5	230mm X 380 mm	10- 12 mm ǿ	8 mm ǿ @190 mm c/c
C6	230mm X 380 mm	10- 12 mm ǿ	8 mm ǿ @190 mm c/c
C7	230mm X 380 mm	10- 12 mm ǿ	8 mm ǿ @190 mm c/c
C8	230mm X 380 mm	10- 12 mm ǿ	8 mm ǿ @190 mm c/c
C9	230mm X 300mm	8-12 mm ǿ	8 mm ǿ @190 mm c/c
C10	230mm X 300mm	8-12 mm ǿ	8 mm ǿ @190 mm c/c
C11	230mm X 300mm	8-12 mm ǿ	8 mm ǿ @190 mm c/c
C12	230mm X 300mm	8-12 mm ǿ	8 mm ǿ @190 mm c/c
C13	230mm X 300mm	8-12 mm ǿ	8 mm ǿ @190 mm c/c

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TABLE VIII
Manual Calculation of Footing.

Sr No.	Particulars	Footing of Column C1
1	Given: - Assumed suitable data Total Factored load on footing Mux= Muz= Size of column: Fck Fy Size of footing Depth of footing d = D +d'	 208.08 KN 12.69KNm 9.78 KNm 230 X 300mm 20 N/ mm2 500 N/mm2 1.2 m X 1.2 m 350 mm 350- 50 = 300 mm
2	Factored self-Weight of footing 1.5 X1.2 X0.35 X25	 18.9KN
3	Factored soil weight (1.2^2- 0.069) X 1.15 X 18 X1.5: Self-weight + Soil (18.9 + 42.569) Total weight (P):	 42.569 KN 61.449 KN 269.555 KN
4	Uplift pressure (σ) (P/A) +(Mux/) +(Muz/) σ max: σ min: σ max > σ min	 264.89 KN/m2 109.48 KN/m2 ok
5	Bending moment calculation Mux = $WuLe^2/2$ Muy= Pt %= Ast Assume 10 mm ǿ bar Spacing {(Aǿ)/ Ast} X 1000 Provide	 47.680 KNm 47.680 KNm 0.131 % 393 mm^2 180 mm 10 mm ǿ @180 mm c/c
6	Check for shear Vu= Vuc = (τc Xb X d)/ 1000 Vuc > Vu	 39.733 KN 99 KN OK

TABLE IX
Manual Calculation of Footing.

Sr No.	**Size of column**	**Size of footing**	**Depth of footing**	**Steel along X axis**	**Steel along Y axis**
1	230 X300 mm	1.2 X 1.2	350 mm	10 mm ǿ 180 mm c/c	10 mm ǿ 180 mm c/c
2	230 X300mm	1.3 X 1.3	350 mm	10 mm ǿ 180 mm c/c	10 mm ǿ 180 mm c/c
3	230 X300 mm	1.2 X 1.2	350 mm	10 mm ǿ 180 mm c/c	10 mm ǿ 180 mm c/c
4	230 X300mm	1.3 X 1.3	350 mm	10 mm ǿ@ 170 mm c/c	10 mm ǿ 170 mm c/c
5	230 X380mm	1.8 X 1.8	350 mm	10 mm ǿ@ 100 mm c/c	10 mm ǿ 100 mm c/c
6	230 X300 mm	1.2 X 1.2	350 mm	10 mm ǿ@ 200 mm c/c	10 mm ǿ 200 mm c/c
7	230 X 380 mm	1.2 X 1.2	350 mm	10 mm ǿ @ 200 mmc/c	10 mm ǿ@ 200 mmc/c
8	230 X 380 mm	1.2 X 1.2	350 mm	10 mm ǿ@ 200 mm c/c	10 mm ǿ@ 200 mm c/c

9	230 X 300mm	1.2 X 1.2 m	350 mm	8 mm ǿ @170 mmc/c	8 mm ǿ@ 170 mmc/c
10	230 X 300 mm	1.3 X 1.3 m	350 mm	10 mm ǿ@160mmc/c	10 mm ǿ@160mmc/c
11	230 X 300 mm	1.2 X 1.2 m	350 mm	10 mm ǿ @ 180 mm c/c	10 mm ǿ@ 180 mm c/c
12	230 X 300 mm	1.2 X 1.2	350 mm	10 mm ǿ @ 300 mm c/c	10 mm ǿ @ 300 mm c/c
13	230 X 300	1.3 X 1.3 m	350 mm	10 mm ǿ@160mmc/c	10 mm ǿ@160mmc/c

VI. ANALYSIS AND DESIGN IN STAAD PRO

A. Steps in analysis and design in STAAD Pro

Step 1) Create the STAAD Pro Page
Step 2) Create the model of building (Refer fig 1)
Step 3) Assign the support (Refer Fig 2)
Step 4) Assign the member properties (Refer Fig -3)
Step 5) Check the orientation as per RCC plan
Step 6) Assign loading (Refer Fig- 4)
Step 7) Analysis (Refer Fig 5)
Step 8) Design (In RCDC)

B. Figures

FIGURE 1

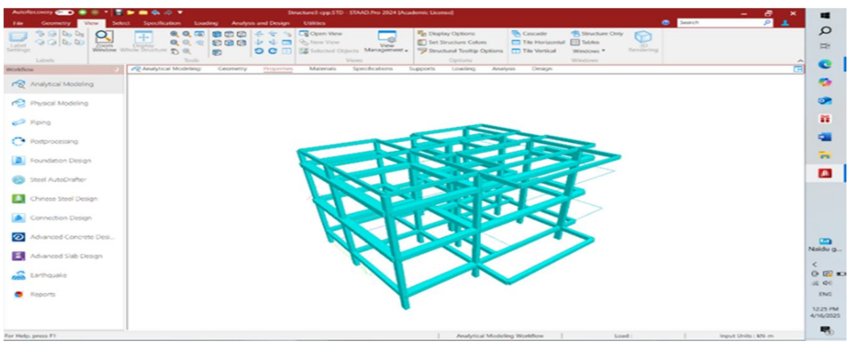


FIGURE 2

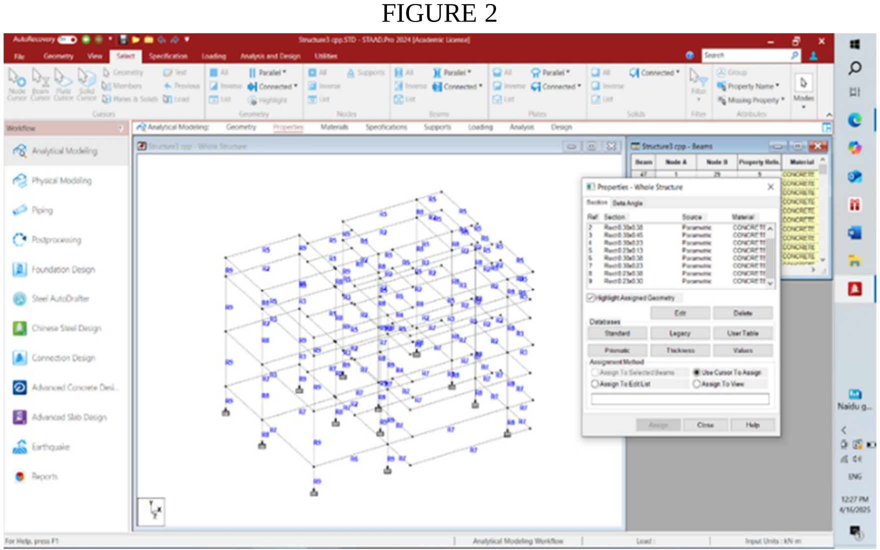
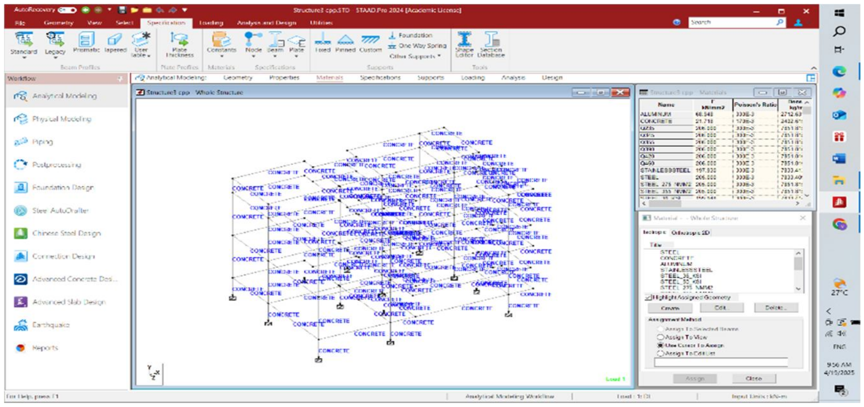


FIGURE 3



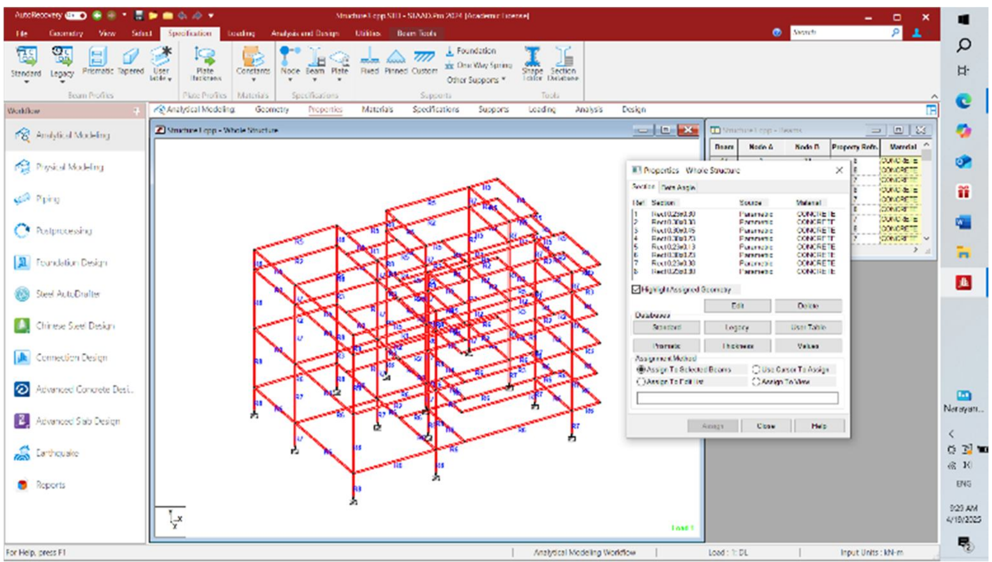


FIGURE – 4

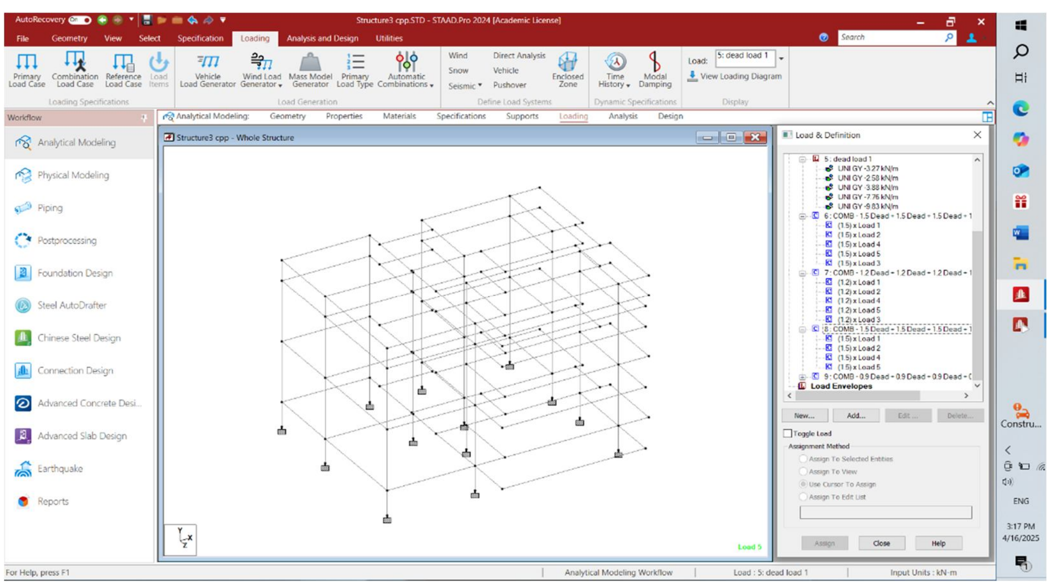
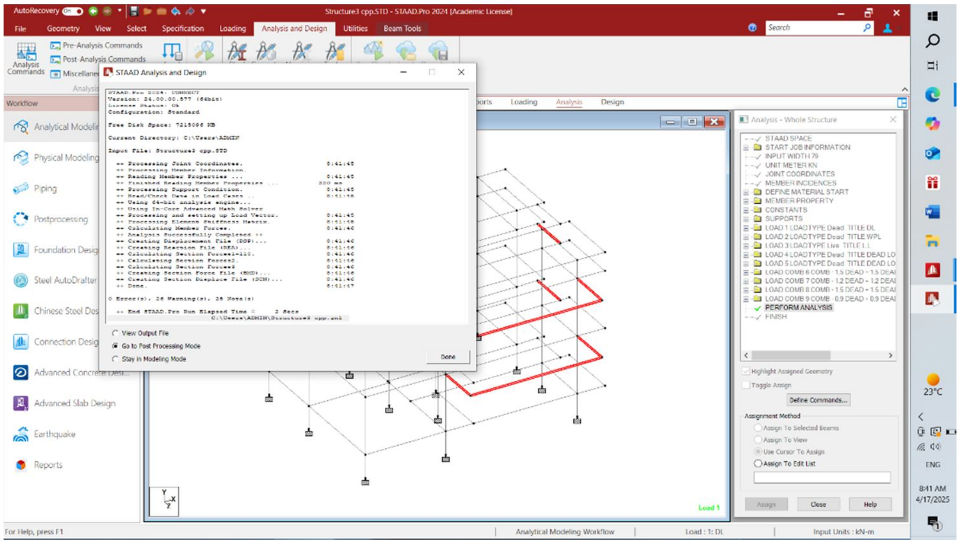


FIGURE 5



VII. COMPARISON OF MANUAL AND STAAD PRO CAALCULATION

Comparison of Manual calculation of slab where, S- Software & M- Mannual

TABLE NO -X

Slab No	Depth of slab		Moment along X and Y axis				Reinforcement along both axis			
	M	S	Along X axis		Along Y axis		Along x axis		Along Y axis	
			M	S	M	S	M	S	M	S
S1 ()	145 mm	125 Mm	T10mm ǿ@ 300mm c/c	T8 mm ǿ@ 300mm c/c	T10mm ǿ@ 300mm c/c	T8 mm ǿ@ 300mm c/c	T10mm ǿ@ 300mm c/c	T8 mm ǿ@ 300mm c/c	T10mm ǿ@ 300mm c/c	T8 mm ǿ@ 300mm c/c
S2	130 mm	125 mm	T10mm ǿ@ 300mm c/c	T8mm ǿ@ 300mm c/c	T10mm ǿ@ 300mm c/c	T8mm ǿ@ 300mm c/c	T10mm ǿ@ 300mm c/c	T8mm ǿ@ 300mm c/c	T10mm ǿ@ 300mm c/c	T8mm ǿ@ 300mm c/c
S3	85 mm	125 Mm	T10mm ǿ@ 300mm c/c	T8 mm ǿ@ 300mm c/c	T10mm ǿ@ 300mm c/c	T8 mm ǿ@ 300mm c/c	T10mm ǿ@ 300mm c/c	T8 mm ǿ@ 300mm c/c	T10mm ǿ@ 300mm c/c	T8 mm ǿ@ 300mm c/c
S4	130 mm	125 mm	T10mm ǿ@ 300mm c/c	T8mm ǿ@ 300mm c/c	T10mm ǿ@ 300mm c/c	T8mm ǿ@ 300mm c/c	T10mm ǿ@ 300mm c/c	T8mm ǿ@ 300mm c/c	T10mm ǿ@ 300mm c/c	T8mm ǿ@ 300mm c/c
S5	120 mm	125 mm	T10mm ǿ @ 300mm c/c	T8mm ǿ @ 300mm c/c	T10mm ǿ @ 300mm c/c	T8mm ǿ @ 300mm c/c	T10mm ǿ @ 300mm c/c	T8mm ǿ @ 300mm c/c	T10mm ǿ @ 300mm c/c	T8mm ǿ @ 300mm c/c
S6	70 mm	125 mm	T10mm ǿ@ 300mm c/c	T8mm ǿ@ 300mm c/c	T10mm ǿ@ 300mm c/c	T8mm ǿ@ 300mm c/c	T10mm ǿ@ 300mm c/c	T8mm ǿ@ 300mm c/c	T10mm ǿ@ 300mm c/c	T8mm ǿ@ 300mm c/c
S7	240 mm	125 mm	T10mm ǿ@ 300mm c/c	T8mm ǿ@ 300mm c/c	T10mm ǿ@ 300mm c/c	T8mm ǿ@ 300mm c/c	T10mm ǿ@ 300mm c/c	T8mm ǿ@ 300mm c/c	T10mm ǿ@ 300mm c/c	T8mm ǿ@ 300mm c/c
S8	145 mm	125 mm	T10mm ǿ@ 300mm c/c	T8mm ǿ@ 300mm c/c	T10mm ǿ@ 300mm c/c	T8mm ǿ@ 300mm c/c	T10mm ǿ@ 300mm c/c	T8mm ǿ@ 300mm c/c	T10mm ǿ@ 300mm c/c	T8mm ǿ@ 300mm c/c

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TABLE -XI
Comparison of 1 st floor beam calculation

Beam No	Size of beam		Top steel		Bottom steel		Increased Pt%	Shear reinforcement	
	M	S	M	S	M	S		M (Fe 415)	S (Fe 415)
B1	230X 380	300 X 380	3-12 mm ǿ Ast-339.29	4-10 mm ǿ Ast-314.16	3-16 mm ǿ Ast-603.19	5-8 mm ǿ Ast-251.32	0.62%	2L-8mmǿ@260mmc/c	2L-8mmǿ@150mmc/c
B2	230 X 450	300 X 450	4-12 mm ǿ Ast – 452.39	5-8 mm ǿ Ast-251.32	4-16 mm ǿ Ast-804.24	5-8 mm ǿ Ast-251.32	0.89%	2L-8mmǿ@200mmc/c	2L-8mmǿ@195mmc/c
B3	230X 380	300 X 380	3-12 mm ǿ Ast-339.29	5-8 mm ǿ Ast-251.32	3-16 mm ǿ Ast-603.19	5-8 mm ǿ Ast-251.32	0.68%	2L-8mmǿ@260mmc/c	2L-8mmǿ@195mmc/c
B4	230X 450	300 X 450	3-16 mm ǿ Ast-603.19	5-8 mm ǿ Ast-251.32	5-16 mm ǿ Ast-1005.31	5-8 mm ǿ Ast-251.32	1.25%	2L-8mmǿ@300mmc/c	2L-8mmǿ@195mmc/c
B5	230 X 450	300 X 450	3-16 mm ǿ Ast-603.19	4-10 mm ǿ Ast-314.16	5-16 mm ǿ Ast-1005.31	5-8 mm ǿ Ast-251.32	1.2%	2L-8mmǿ @300 mmc/c	2L-8mmǿ @195 mmc/c
B6	230 X 380	300 X 380	3-12 mm ǿ 339.29	5-8 mm ǿ 251.32	3-16 mm ǿ 603.19	5-8 mm ǿ 251.32	0.08%	2L- 8mmǿ@ 260 mmc/c	2L-8mmǿ@150 mmc/c
B7	230 X 550	300 X 380	4-16 mm ǿ 804.24	5-8 mm ǿ 251.32	5-16 mm ǿ 1005.31	5-8 mm ǿ 251.32	1.02%	2L-8mmǿ@190mmc/c	2L-8mmǿ@195mmc/c
B8	230X 300	300 X 230	2-12 mm ǿ Ast-226.19	3-8 mm ǿ Ast-150.79	2-12 mm ǿ Ast-226.19	3-8 mm ǿ Ast-150.79	0.24%	2L-8mmǿ@260mmc/c	2L-8mmǿ@150mmc/c
B9	230X 300	300 X 380	2-12 mm ǿ	5-8 mm ǿ	3-12 mm ǿ	5-8 mm ǿ	0.42%	2L-8mmǿ@200mmc/c	2L-8mmǿ@150mmc/c
B10	230 X 380	300 X 380	3-12 mm ǿ	4-12 mm ǿ	3-16 mm ǿ	5-8 mm ǿ	0.49%	2L-8mmǿ@260mmc/c	2L-8mm@195mmc/c
B11	230X 450	300 X 380	3-16 mm ǿ	5-8 mm ǿ	4-16 mm ǿ	5-8 mm ǿ	0.96%	2L-8mmǿ@140mmc/c	2L-8mmǿ@150mmc/c
B12	230X 300	300 X 230	3-12 mm ǿ	3-8 mm ǿ	4-12 mm ǿ	3-10 mm ǿ	0.64%	2L 8mmǿ@260mmc/c	2L-8mmǿ@195mmc/c
B13	230 X 300	300 X 230	3-12 mm ǿ	3-8 mm ǿ	4-12 mm ǿ	3-10 mm ǿ	0.64%	2L 8mmǿ@260mmc/c	2L-8mmǿ@195mmc/c
B14	230X 300	300 X 380	3-12 mm ǿ	5-8 mm ǿ	5-12 mm ǿ	5-8 mm ǿ	0.96%	2L-8mmǿ@260mmc/c	2L-8mmǿ@150mmc/c
B15	300	300 X 230	2-12 mm ǿ	4-12 mm ǿ	2-12 mm ǿ	5-8 mm ǿ	0.05%	2L-8mmǿ@200mm c/c	2L-8mmǿ@150mmc/c
B16	230X 300	300 X 380	2-12 mm ǿ	4-12 mm ǿ	2-12 mm ǿ	5-8 mm ǿ	0.05%	2L-8mmǿ@200mm c/c	2L-8mmǿ@150mmc/c

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TABLE XII
Comparion of calcultion of column

Column No	Size of column	Level	Main reinforcement				Lateral Ties		Decreased Pt %
			M Ast	Reinforcement	S Ast	Reinforcement	M (Ast - 100.53 mm²)	S (Ast- 100.53 mm²)	
C1	230 X 300	0 to 7.2m	904.78	8-12mmǿ	452.39	4-12 mm ǿ	T-8 @190	T-8 @175	0.75
C2	230 X 380	0 to 7.2m	1130.97	10-12 mm ǿ	678.58	6-12 mm ǿ	T-8 @190	T-8 @175	0.75
C3	230 X 300	0 to 7.2m	904.78	8-12 mm ǿ	452.39	4-12 mm ǿ	T-8 @190	T-8 @175	0.75
C4	230 X 300	0 to 7.2m	904.78	8-12 mm ǿ	452.39	4-12 mm ǿ	T-8 @190	T-8 @175	0.75
C5	230 X 380	0 to 7.2m	1130.97	10-12 mm ǿ	678.58	6-12 mm ǿ	T-8 @190	T-8 @175	0.75
C6	230 X 380	0 to 7.2m	1130.97	10-12 mm ǿ	452.39	4-12 mm ǿ	T-8 @190	T-8 @175	1.13
C7	230 X 380	0 to 7.2m	1130.97	10-12 mm ǿ	452.39	4-12 mm ǿ	T-8 @190	T-8 @175	1.13
C8	230 X 380	0 to 7.2m	1130.97	10-12 mm ǿ	678.58	6-12 mm ǿ	T-8 @190	T-8 @175	0.75
C9	230 X 300	0 to 7.2m	904.78	8-12 mm ǿ	452.39	4-12 mm ǿ	T-8 @190	T-8 @175	0.75
C10	230 X 300	0 to 7.2m	904.78	8-12 mm ǿ	678.58	6-12 mm ǿ	T-8 @190	T-8 @175	0.37
C11	230 X 300	0 to 7.2m	904.78	8-12 mm ǿ	678.58	6-12 mm ǿ	T-8 @190	T-8 @175	0.37
C12	230 X 300	0 to 7.2m	904.78	8-12 mm ǿ	678.58	6-12 mm ǿ	T-8 @190	T-8 @175	0.37
C13	230 X 300	0 to 7.2m	904.78	8-12 mm ǿ	678.58	6-12 mm ǿ	T-8 @190	T-8 @175	0.37

Average percentage reduced is 0.69%

TABLE XIII
Comparison of calculation of footing

Footing No.	Size of footing		Steel along				Increased in Pt %
	M	S	M	No of bars	S	No of bars	
FC1	1.2 X1.2 X 0.35 V- 0.504 m^3	0.9 X 0.85 X 0.3 V- 0.229m^3	10 mm ǿ@ 180mmc/c	16	10mmǿ@ 285mmc/c	12	0.04
FC2	1.3 X 1.3 X 0.35 V-0.591m^3	1.05 X 0.9 X 0.3 V-0.283m^3	10 mm ǿ@180mmc/c	16	10 mm ǿ@300mmc/c	12	0.04
FC3	1.2 X 1.2 X 0.35 V- 0.504 m^3	0.9 X 0.85 X 0.3 V- 0.229m^3	10 mm ǿ@180mmc/c	16	10mmǿ@ 285mmc/c	12	0.04
FC4	1.3 X 1.3 X 0.35 V-0.591m^3	1.15 X 1.1 X 0.35 V-0.442m^3	10 mm ǿ@170mmc/c	18	10 mm ǿ@ 220mmc/c	14	0.11
FC5	1.8 X 1.8 X 0.35 V-1.134m^3	1 X 0.85 X 0.3 V-0.255m^3	10 mm ǿ@100mmc/c	38	10 mmǿ @ 285mmc/c	16	0.49
FC6	1.2 X 1.2 X 0.35 V- 0.504 m^3	0.9X 0.85 X 0.3 V- 0.229m^3	10 mm ǿ@200mmc/c	14	10mm ǿ@ 285 mmc/c	12	0.01
FC7	1.2 X 1.2 X 0.35 V- 0.504 m^3	0.9 X 0.85 X 0.3 V- 0.229m^3	10 mm ǿ@200mmc/c	14	10 mm ǿ@ 285 mmc/c	12	0.01
FC8	1.2 X 1.2 X 0.35 V- 0.504 m^3	1 X 0.85 X 0.3 V-0.255m^3	10 mm ǿ@200mmc/c	14	10 mm ǿ@ 285mmc/c	12	0.01
FC9	1.2 X 1.2 X 0.35 V- 0.504 m^3	0.9 X 0.85 X 0.3 V- 0.229m^3	8 mm ǿ@170mmc/c	18	10 mm ǿ@ 285 mmc/c	12	0.07
FC10	1.3 X 1.3 X 0.35 V-0.591m^3	1.25 X 1.1 X 0.35 V-0.481m^3	10 mm ǿ@160mmc/c	20	10 mm ǿ@ 220mmc/c	14	0.16
FC11	1.2 X 1.2 X 0.35 V- 0.504 m^3	1.05 X 0.9 X 0.3 V-0.283m^3	10mm ǿ@180mmc/c	16	10 mm ǿ@ 300mmc/c	10	0.1
FC12	1.2 X 1.2 X 0.35 V- 0.504 m^3	1.05 X 0.9 X 0.3 V-0.283m^3	10mm ǿ@300mmc/c	10	10 mmǿ@ 300mmc/c	10	0.05
FC13	1.3 X 1.3 X 0.35 V-0.591m^3	1.05 X 0.9 X 0.3 V-0.283m^3	10 mm ǿ@160mmc/c	10	10 mm ǿ@ 300mmc/c	12	0.11
	Total -7.53m^3	Total- 3.481m^3					Average % reduced -0.1

VIII. CONCLUSION

Thus, we can say from the comparative study for a given G+1 RCC bungalow using STAAD Pro and manual calculation steel quantity is reduced for the structural element which is as follows: -

1) For slab percentage of steel is reduced by 0. 67%
2) For beam percentage of steel is reduced by 0.62%
3) For column percentage of steel is reduced by 0.69%
4) For footing percentage of steel is reduced by 0.11%
5) For footing volume of concrete is reduced by 46%

From above conclusion it proves that STAAD Pro gives optimize analysis and design of given structure. Due to optimize analysis and design of STAAD Pro economy can be achieved.

Through this project we studied manual and software analysis and design by limit state method of RCC Structure in detail.

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We take this opportunity to thank all who have contributed in successful completion of this major project work. I sincerely wish to express my gratitude to my major project guide Mr. S.S. Ingale , Mr. KP Mali sir for full support, expert guidance, encouragement and kind cooperation throughout the major project work. I am greatly indebted to her guiding us throughout the major project.

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