



IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 13 Issue: IV Month of publication: April 2025

DOI: https://doi.org/10.22214/ijraset.2025.69396

www.ijraset.com

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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)





International Journal for Research in Applied Science & Engineering Technology (IJRASET) ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538 Volume 13 Issue IV Apr 2025- Available at www.ijraset.com

V. MANUAL CALCULATION OF G + 1 RCC STRUCTURE

1) Manual Calculation of Slab

TABLE I Sample of two-way slab

Step	Slab Mark	S2	S2	S3
No.				
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
	ax=	0.0462	0.0435	0.035
	-qx=	0.0615	0.0579	0.045
	0V-	0.0013	0.0035	0.035
	-av-	0.0615	0.0033	-
	(from Table 26 of IS 456:2000)	0.0015	0.047	
2	Depth Calculation			R
2	$d = (\mathbf{I} \mathbf{x}/((\mathbf{I}/d) \mathbf{X} \mathbf{M} \mathbf{F}))$	125mm	110mm	65mm
	D = d + d'	145mm	130 mm	85mm
	Actual provided Depth	125mm	125 mm	125mm
3	Load Calculation	1251111	125 1111	12511111
5	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 L odd: in (KN/m^2)	1.2	1.2	1.2
	(as per IS 875 Part 1 of Dead Load)	1.2	1.2	1.2
	II = Imposed load = + Eloor			
	Due to occupancy Finish			
	Due to occupancy 1 misin	2	2	2
	• Imposed foad iff (KIV/III) $E^{1} = E^{1} = E^{1}$	15	15	15
	FIOOF FINISE III (KN/M)	1.0	1.5	1.5
	(as per 15 o / 5-part 2 Live Load) Total Load in (KN/m^2)			
	$\frac{1}{10} \frac{1}{10} \frac$	8 325	7 95	6 825
	Factored Load In (KN/m)	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: $(a/2) + (a/2) = a/2$	4.125	3.47	2.345
5	Moment Calculation: in (KNm)			
5	$M_{\rm HX} = \alpha_{\rm X} X W_{\rm H} X (I_{\rm e})^2$	9.81	6.24	1 97
	$-Mux = -\alpha v X Wu X (Le)^2$	13.05	8 31	2 53
	$M_{\rm HV} = \alpha_{\rm Y} X W_{\rm H} X (Le)^2$	7 43	5.02	1.97
	$-Muy = -\alpha y X Wu X (Le)^2$	9.98	6.74	1.77
	Mu = Maximum of above four	13.05	8 31	2 53
		13.03	0.31	2.33



6	Check for Depth in mm			
	Mu = Mulim			
	$= 0.133 \text{ fck } bd^2$			
	D required:	70.40	55.89	30.84
7	Aera of steel calculation (Ast) in mm ²			
	Steel along shorter span			
	$0.5 \text{ fck /fy} (1-\sqrt{1-(4.6 \text{ Mux / fck bd}^2)})$	211.13	134.59	71.68
	At Midspan Ast:	285.49	181.22	92.84
	• At support Ast:	150	156 mm^2	78
	Ast $Min = 0.12\%$ Ag	Yes	No	No
	Ast min <ast< th=""><th></th><th>(Provide</th><th>(Provide</th></ast<>		(Provide	(Provide
			min)	min)
	Distance for middle strip Width (in m)	3.09	3.09	3.09
	(0.75 X Le)			
	Edge strip width along either side (in m)	0.51	0.51	0.51
	(Lex/8)			
	Steel along Longer span			
	$0.5 \text{ fck} / \text{fy} (1 - \sqrt{1 - (4.6 \text{ Muy} / \text{fck bd}^2)})$			
	At midspan Ast:	158.28	107.59	71.68
	• At support Ast:	214.95	145.75	
	Distance for middle strip Width	3.65	3.65	3.65
	(0.75 X Le)			
	Edge strip width along either side	0.6	0.6	0.6
	(Lex/8)			
8	Spacing in (mm)			
	Assume 10 mm ǿ bar			
	Along shorter span			
	At midspan	300	500	1000
	At support	300	430	845.97
	Along Longer span			
	At midspan	300	500	1000
	At support	300	500	-
	Minimum spacing Check			
	It is minimum of following			
	• $3d = 3X \ 105$	315	315	195
	• 300 mm	300	300	300
	Therefore Provide	300	300	195
9	Check for deflection			
	Short span consideration			
	Ast provided =			
	{(17/4 X 10 ²) / (Ast x)} X 1000	212.27	261.79	402.768
	Fs = 0.58 fy	290	290	290
	Pt provided = $(100 \text{ X Astx provided}) / bd$	0.17	0.23	0.62
	Pt provided <pt assumed<="" th=""><th>Yes</th><th>Yes</th><th>yes</th></pt>	Yes	Yes	yes
	OR			
	d required= $le / ((L/d) X M.F)$	0.132	0.11	
	d required < d provided	Yes	Yes	



ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538

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		1010	and curculation of bla	0	
Sr	No.	Depth of Slab	Type of Slab	Steel along	Steel along
No		(in mm)		X axis	Y axis
1	S 1	D=145mm	Two way	10 mm ǿ @	10 mm ǿ @
			Two adjacent edges	300 mm c/c	300 mm c/c
			dis- continuous		
2	S2	D=130mm	Two Way	10 mm ǿ @	10 mm ǿ @
			Two adjacent edges	300 mm c/c	300 mm c/c
			Discontinuous		
3	S3	D=85mm	Two way	10 mm ǿ @	10 mm ǿ @
		Provide-125 mm	Two short edges	195 mm c/c	195 mm c/c
			Discontinuous		
4	S4	D=130mm	Two Way	10 mm ǿ @	10 mm ǿ @
		Provide-125 mm	One short edge	300 mm c/c	300 mm c/c
			Continuous		
5	S5	D=120mm	Two ways	10 mm ǿ @	Midspan –
			One long edge	300 mm c/c	10 mm ǿ @ 80
			discontinuous		mm c/c
					At edge-
					10 mm ǿ @
					300 mm c/c
6	S6	D=70mm	One way	10 mm ǿ @	10 mm ǿ @
		Provide-125 mm		180 mm c/c	300 mm c/c
7	S 7	D-240mm	Cantilever	10 mm ǿ @	10 mm ǿ @
		Provide-150mm		175 mm c/c	210 mm c/c
8	S 8	D-145mm	Cantilever	10 mm ǿ @	10 mm ǿ @
		Provide-150 mm		300 mm c/c	360 mm c/c

TABLE II Manual Calculation of Slab

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 + $(b/2)$ + $(b/2)$	1.19 m
	• Le= C.S + $(d/2)$ + $(d/2)$	4.235m
	Therefore Le :-	4.19 m
	Load Calculation	
	• Self-Weight – density of concrete X b X D X 1.5	2.588KN/m
	• Parapet wall – density of brick X b X H X 1.5	6.624KN/m
	• Slab Load – $qu = (qu / lx) X [1 - (1/(3 X \beta^2))]$	21.35KN/m
	Total load: -	30.562KN/m
	Factored Load (Wu): -	30.562KN/m



-		
2	Net BMD	
	Free bending moment Calculation	
	Assume beam as simply supported beam	
	$Mu = (Wu X Le^{2}) / (8)$	67.07KNm
	Diagram of free bending moment	
	+	
	• Fixed end moment diag.	
	Assume beam as fixed beam	
	$MA = MB = - (Wu X Le^2) / 12$	44.71KNm
	Diagram of Fixed End moment	
	44 71 KNm	
	_	
	Net BMD	
	Superimpose free bending moment diagram and fixed end moment diagram.	
3	Actual Reaction Calculation by using following equilibrium condition	
	\notin Fy = 0 (Upward + and Downward -)	
	$\notin M@a = 0$ (clockwise + and Anticlockwise -)	
	Therefore RA=	64.03 KN
	RB=	64.03 KN
4	Point of Contra flexure calculation	
	Contraflexure point near A support –	0.71 m
	Contraflexure point near B support -	0.71 m
5	Shear force Calculation	
	(At right of section take upward – and downward +)	
	SF @ BR: -	0
	SF @ BL: -	- 64.03KN
	SF @AR: -	64.03 KN
	SF @ AL: -	0
6	Point of Contra shear calculation	
-	Contra shear point near A support	1.75 m
	Contra shear point near B support	2.44 m
	PART 2] DESIGN OF FIXED BEAM	
	Depth Calculation	
	Mu = Mulim	
	(where Mu is maximum of Sagging and Haugging moment)	
	Therefore Mu :-	67.07 KNm
	$67.07 \times 10^6 = 0.133 \text{ fck } \text{bd}^2$	
	Therefore d reg =	331.1 mm
	Provide D	380 mm
	Area of steel calculation	
	Ast to resist sagging moment	
		1



Ast = $(0.5 \text{ fck} / (\text{fy})) \{1 - \sqrt{1} - ((4.6 \text{ Mus}) / \text{ fck bd}^2)\} \text{ X bd}$	
Ast :-	516.09 mm^2
No of bars calculation	
(Assume 16 mm \u00f8 Bar)	
No of Bars = (Ast) / $(\pi/4 \times 16^2)$	3 bars
• Ast to resist Haugging moment	
$\Delta st = (0.5 \text{ fck} / \text{fv}) X \sqrt{1 - \sqrt{1 - ((4.6 \text{ Muh}) / \text{fck} \text{ hd}^2)}} X \text{ hd}$	
Ast $-(0.5 \text{ teck}/19) \times (1^{-1} + ((4.0 \text{ Wull})/1\text{ teck}) \text{ out})) \times (0.5 \text{ teck}/19) \times (1^{-1} + ((4.0 \text{ Wull})/1\text{ teck}) \text{ out}))$	321.27 mm^2
Ast No of bars calculation	521.27 mm
(Assume 12 mm á bor)	
(Assume 12 mm 6 dar) No of Par = (Act) / $(\pi/4 \times 10^2)$	3 hars
No of Dat = $(Ast) / (1/4 \times 12)$	5 0415
VU = 04.05 KIN	0.78 N/mm^2
t v = vu/bd = (64.03 A10)/(230 A353)	0.701\/11111
$\tau c max = (From 15.456 : 2000)$	Voc
t c max > t v	105
shear reinforcement at centre $D_{1,0} = (A_{1,1}, A_{1,1}, A_{1,2}, A_{1,$	0.63.%
Pt % = (Ast / ba) X 100	0.03.70 0.51 N/mm ²
τ c for Pt % (SP 16 code)	0.31 N/IIIII 41 64 KN
vuc = (t c X b X d) / 1000	41.04 KN
vus = vu - vuc	22.30 KN
Vus /d	0.03 250 mm
Spacing from graph (SP 16 code)	550 mm
Smax is minimum of following	260
1] 0.75 d –	260 mm
2] 300 mm	300mm
Therefore smax –	260 mm
Provide spacing	260 mm
Provide 8 mm $å$ bar (a) 260 mm c/c	
Shear reinforcement at support	0.20.0/
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	2.00
1] 0.75 d	260 mm
2] 300 mm	300 mm
Smax :-	260 mm
Provide spacing	250 mm
Provide 8 mm & @ 250 mm c/c	



ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538

Volume 13 Issue IV Apr 2025- Available at www.ijraset.com

Manual Calculation of 1 Floor Slab						
Beam	Length	Depth	Steel in	Steel in	Shear Rein	forcement
No	(Le)	of	compression	tension	At Centre	At Midspan
		Beam	Zone	Zone		
B1	4.19 m	380 mm	3- 16 mm ǿ	3- 12 mm	8mm ǿ@260	8mm ǿ@250
				ǿ	mm c/c	mm c/c
B2	4.19 m	450 mm	4- 16 mm ǿ	4- 12 mm	8mm ǿ@200	8mm ǿ@190
				ǿ	mm c/c	mm c/c
B3	4.19 m	380 mm	3- 16 mm ǿ	3- 12 mm	8mm ǿ@260	8mm ǿ@260
				ǿ	mm c/c	mm c/c
B4	8.69 m	450 mm	5-16 mm ǿ	3-16mm ǿ	8mm ǿ@300	8mm
					mm c/c	ǿ@300mm
						c/c
B5	8.69 m	450 mm	5-16 mm ǿ	3-16 mm ǿ	8 mm ǿ @300	8 mmǿ@300
					mm c/c	mm c/c
B6	4.2 m	380 mm	3- 16 mm ǿ	3-12 mm ǿ	8mm ǿ@260	8mm ǿ@260
					mm c/c	mm c/c
B7	5.42 m	550 mm	5-16 mm ǿ	4-16 mm ǿ	8mm ǿ@170	8mm
					mm c/c	ǿ@140mm
						c/c
B8	2.51m	300 mm	2-12 mm ǿ	2-12 mm ǿ	8mm ǿ@200	8mm
					mm c/c	ǿ@200mm
						c/c
B9	3.51m	300 mm	3-12 mm ǿ	2-12 mm ǿ	8mm ǿ@200	8mm
					mm c/c	ǿ@200mm
						c/c
B10	4.21m	380 mm	3-16 mm ǿ	3-12 mm ǿ	8mm ǿ@260	8mm
					mm c/c	ǿ@260mm
						c/c
B11	3.51 m	450 mm	4-16 mm ǿ	3-16 mm ǿ	8mm ǿ@140	8mm ǿ@120
					mm c/c	mm c/c
B12	3.2 m	300 mm	4-12 mm ǿ	3-12mm ǿ	8mm ǿ@200	8mm
					mm c/c	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	8mmǿ@260
					mmc/c	mmc/c
B15	2.245	300mm	2-12mm ǿ	2-12mm ǿ	8mm ǿ@200	8mm
	m				mm c/c	ǿ@200mm
						c/c
B16	1.44 m	300mm	2-12mm ǿ	2-12mm ǿ	8mm ǿ@200	8mm
					mm c/c	ǿ@200mm
						c/c
MB	2.03 m	300mm	2-12 mm ǿ	2-12mm ǿ	8mm ǿ@200	8mm
					mm c/c	ǿ@200mm
						c/c

TABLE IV Manual Calculation of 1st Floor Slab



3) Manual Calculation of Column

C.	Column Mark	
SI Na	Column Mark	CI
1NO.		
1		
	Pt % assumed = 1.2 %	220
	Assumed b =	230 mm
	D=	300 mm
2	PART 1] ANALYSIS OF COLUMN	
	• Load Calculation (Pu)	
	Self Weight- 1.5 X 25 X 0.23 X 0.3X 3	7.76 KN
	Beam load =(RA of B1 beam) + (RA of B4 beam)	
	= 53.36 + 103.08	156.44 KN
	Therefore total load on column:-	164.2 KN
	Calculation of Eccentricities	
	Calculation ex	
	Equivalent Area = $(b X d) + (m-1) X Ast$	830.76 mm^2
1	Equivalent moment of inertia about X axis	
	$Ixx = (bd^3/12) + (m-1) X Ast X 100^2$	658.26 X10 ⁶
	As we know that direct stress = Bending Stress	mm^4
	(P/Ae) = [(PX ex)/Ixx) X (d/2)]	
	(1/10) [(1/10/)/1/(0/2)] ex :-	
	Calculation of ev	0.053m
	Equivalent area $=$ (b X d) + (m -1) X Ast	
	Equivalent moment of inertia about V axis	830.76 mm^2
	$L_{W} = (dh^3/12) + (m - 1) X A \text{ st} X 100^2$	0000000
	1yy = (db/12) + (dl-1) AAst A 100	$444 \ 94 \ \text{X} 10^6 \text{mm}^4$
	As we know that direct sitess – bending sitess $(D/A_0) = [((D X_0 x))/J_{WV}) X_0(b/2)]$	
	$(\mathbf{r}/\mathbf{A}\mathbf{e}) = [((\mathbf{r} \cdot \mathbf{A} \cdot \mathbf{e}\mathbf{y})/(\mathbf{i}\mathbf{y}\mathbf{y} \cdot \mathbf{y} \cdot \mathbf{A} \cdot (0/2)]$	$0.047 \mathrm{m}$
	ey	0.047 m
	• Moment calculation	7 72 KNm
	Mux = Pu X ex	7.72 KNm 8 70 KNm
	Muy = Pu X ey	0.70 KINIII
3	PART 21 DESIGN OF COLUMN	
5	• Pt / fck	0.06
	d'/D	0.15
		0.2
	• d / b	0.119
	• Pu / tck bd	0.119 41.4 KNm
	• Mux1x1	41.4 KINII 63 /8KNm
	• Muy1y1	17
1	• Puz / Ag	1/
	(From graph No 63 of SP 16 Code book)	1 172 V 106
1	• Puz	1.1/3 A 100
	• Pu/ Puz	0.14 Vac
	Check (Pu / Puz) < 0.2	res
	• $(Mux / Mux1x1)^{\alpha n} + (Muy / Muy1y1)^{\alpha n}$	0.33
	Check $(Mux / Mux1x1)^{\alpha n} + (Muy / Muy1y1)^{\alpha n} <1$	Yes
	• $Asc = (Pt Xb X d) / (100)$	828 mm ²
l		

TABLE V – SAMPLE OF MANUAL CALCULATION OF COLUMN



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

	Walluar Calcu		Joiumin
Column	Size of column	Longitudinal	Lateral Ties
Notation		Reinforcement	
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 VI

 Manual Calculation of 1st floor Column

TABLE VII Manual Calculation of Ground floor Column

Column	Size of column	Longitudinal	Lateral Ties
Notation		Reinforcement	
C1	230mm X 300mm	4-16 mm ǿ +	8 mm ǿ @190 mm c/c
		2-12 mm ǿ	
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	208.08 KN
	Mux=	12.69KNm
	Muz=	9.78 KNm
	Size of column:	230 X 300mm
	Fck	20 N/ mm2
	Fy	500 N/mm2
	Size of footing	1.2 m X 1.2 m
	Depth of footing	350 mm
	$\mathbf{d} = \mathbf{D} + \mathbf{d'}$	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:	42.569 KN
	Self-weight + Soil (18.9 + 42.569)	61.449 KN
	Total weight (P):	269.555 KN
4	Uplift pressure (σ) (P/A) +(Mux/) +(Muz/)	
	σ max:	264.89 KN/m2
	σ min:	109.48 KN/m2
	$\sigma \max > \sigma \min$	ok
5	Bending moment calculation	
	$Mux = WuLe^{2}/2$	47.680 KNm
	Muy=	47.680 KNm
	Pt %=	0.131 %
	Ast	393 mm ²
	Assume 10 mm ǿ bar	
	Spacing {(A\u00f6)/ Ast} X 1000	180 mm
	Provide	10 mm ǿ @180 mm c/c
6	Check for shear	
	Vu=	39.733 KN
	$Vuc = (\tau c Xb X d) / 1000$	99 KN
	Vuc > Vu	OK

TABLE IX Manual Calculation of Footing

internation of Footing.									
Sr No.	Size of column	Size of footing	Depth of	Steel along X axis	Steel along Y axis				
			footing						
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 @	10 mm ǿ@				
				200 mmc/c	200 mmc/c				
8	230 X 380 mm	1.2 X 1.2	350 mm	10 mm ǿ@ 10 mm ǿ@					
				200 mm c/c	200 mm c/c				



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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	10 mm ǿ@
				c/c	180 mm c/c
12	230 X 300 mm	1.2 X 1.2	350 mm	10 mm ǿ @	10 mm ǿ @
				300 mm c/c	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 - 4





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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	of slab]	Moment along X and Y axis			Reinforcement alon		along both ax	long both axis	
	М	S	Along X axis Along Y axis		Along x axis		Along Y axis				
			М	S	М	S	М	S	М	S	
S1	145	125	T10mm	T8 mm	T10mm	T8 mm	T10mm	T8 mm	T10mm	T8 mm	
0	mm	Mm	ǿ@	ǿ@	ǿ@	ǿ@	ǿ@	ǿ@	ǿ@	ǿ@	
			300mm	300mm	300mm	300mm	300mm	300mm	300mm	300mm	
			c/c	c/c	c/c	c/c	c/c	c/c	c/c	c/c	
S2	130	125	T10mm	T8mm	T10mm	T8mm	T10mm	T8mm	T10mm	T8mm	
	mm	mm	ǿ@	ǿ@	ǿ@	ǿ@	ǿ@	ǿ@	ǿ@	ǿ@	
			300mm	300mm	300mm	300mm	300mm	300mm	300mm	300mm	
			c/c	c/c	c/c	c/c	c/c	c/c	c/c	c/c	
S 3	85	125	T10mm	T8 mm	T10mm	T8 mm	T10mm	T8 mm	T10mm	T8 mm	
	mm	Mm	ǿ@	ǿ@	ǿ@	ǿ@	ǿ@	ǿ@	ǿ@	ǿ@	
			300mm	300mm	300mm	300mm	300mm	300mm	300mm	300mm	
			c/c	c/c	c/c	c/c	c/c	c/c	c/c	c/c	
S4	130	125	T10mm	T8mm	T10mm	T8mm	T10mm	T8mm	T10mm	T8mm	
	mm	mm	ǿ@	ǿ@	ǿ@	ǿ@	ǿ@	ǿ@	ǿ@	ǿ@	
			300mm	300mm	300mm	300mm	300mm	300mm	300mm	300mm	
			c/c	c/c	c/c	c/c	c/c	c/c	c/c	c/c	
S5	120	125	T10mm	T8mm	T10mm	T8mm	T10mm	T8mm	T10mm	T8mm	
	mm	mm	ǿ @	ó @	ǿ @	ǿ @	ǿ @	ǿ @	ǿ @	ǿ @	
			300mm	300mm	300mm	300mm	300mm	300mm	300mm	300mm	
			c/c	c/c	c/c	c/c	c/c	c/c	c/c	c/c	
S6	70	125	T10mm	T8mm	T10mm	T8mm	T10mm	T8mm	T10mm	T8mm	
	mm	mm	ǿ@	ǿ@	ǿ@	ǿ@	ǿ@	ǿ@	ǿ@	ǿ@	
			300mm	300mm	300mm	300mm	300mm	300mm	300mm	300mm	
			c/c	c/c	c/c	c/c	c/c	c/c	c/c	c/c	
S 7	240	125	T10mm	T8mm	T10mm	T8mm	T10mm	T8mm	T10mm	T8mm	
	mm	mm	ǿ@	ǿ@	ǿ@	ǿ@	ǿ@	ǿ@	ǿ@	ǿ@	
			300mm	300mm	300mm	300mm	300mm	300mm	300mm	300mm	
			c/c	c/c	c/c	c/c	c/c	c/c	c/c	c/c	
S 8	145	125	T10mm	T8mm	T10mm	T8mm	T10mm	T8mm	T10mm	T8mm	
	mm	mm	ǿ@	ǿ@	ǿ@	ǿ@	ǿ@	ǿ@	ǿ@	ǿ@	
			300mm	300mm	300mm	300mm	300mm	300mm	300mm	300mm	
			c/c	c/c	c/c	c/c	c/c	c/c	c/c	c/c	



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	Comparison of 1 st floor beam calculation								
Beam No	No Size of beam		Top steel		Bottom steel		Increased	Shear	
							Pt%	t% reinforce	
								ment	
	М	S	М	S	М	S		M (Fe 415)	S (Fe 415)
B1	230X	300	3-12	4-10	3-16	5-8	0.62%	2L-	2L-
	380	Х	mm ǿ	mm ǿ	mm ǿ	mm ǿ		8mmǿ@	8mmǿ@150mmc/
		380	Ast-	Ast-	Ast-	Ast-		260mmc/c	с
			339.29	314.16	603.19	251.32			
B2	230 X	300	4-12	5-8	4-16 mm	5-8	0.89%	2L-	2L-
	450	Х	mm ǿ	mm ǿ	ø	mm ǿ		8mmǿ@	8mmǿ@195mmc/
		450	Ast -	Ast-	Ast-	Ast-		200mmc/c	с
			452.39	251.32	804.24	251.32			
B3	230X	300	3-12	5-8	3-16	5-8 mm ǿ	0.68%	2L-	2L-
	380	Х	mm ǿ	mm ǿ	mm ǿ	Ast-		8mmǿ@	8mmǿ@195mmc/
		380	Ast-	Ast-	Ast-	251.32		260mmc/c	c
			339.29	251.32	603.19				
B4	230X	300	3-16	5-8	5-16	5-8	1.25%	2L-	2L-
	450	Х	mm ǿ	mm ǿ	mm ǿ	mm ǿ		8mmǿ@	8mmǿ@195mmc/
		450	Ast-	Ast-	Ast-	Ast-		300mmc/c	c
			603.19	251.32	1005.31	251.32			
B5	230	300	3-16	4-10	5-16	5-8	1.2%	2L-	2L-
	Х	Х	mm ǿ	mm ǿ	mm ǿ	mm ǿ		8mmǿ	8mmǿ
	450	450	Ast-	Ast-	Ast-	Ast-		@300	@195
			603.19	314.16	1005.31	251.32		mmc/c	mmc/c
B6	230	300	3-12	5-8	3-16 mm	5-8 mm ǿ	0.08%	2L- 8mmǿ@	2L-
	Х	Х	mm ǿ	mm ǿ	ø	251.32		260 mmc/c	8mmǿ@150
	380	380	339.29	251.32	603.19				mmc/c
B7	230 X	300	4-16	5-8	5-16	5-8 mm ǿ	1.02%	2L-	2L-
	550	Х	mm ǿ	mm ǿ	mm ǿ	251.32		8mmǿ@	8mmǿ@195mmc/
		380	804.24	251.32	1005.31			190mmc/c	с
B8	230X	300	2-12	3-8	2-12	3-8 mm ǿ	0.24%	2L-	2L-
	300	Х	mm ǿ	mm ǿ	mm ǿ	Ast-		8mmǿ@	8mmǿ@150mmc/
		230	Ast-	Ast-	Ast-	150.79		260mmc/c	с
			226.19	150.79	226.19				
B9	230X	300	2-12	5-8	3-12	5-8	0.42%	2L-	2L-
	300	Х	mm ǿ	mm ǿ	mm ǿ	mm ǿ		8mmǿ@	8mmǿ@150mmc/
		380						200mmc/c	c
B10	230	300	3-12	4-12	3-16 mm	5-8	0.49%	2L-8mmǿ@	2L-
	Х	Х	mm ǿ	mm ǿ	ø	mm ǿ		260mmc/c	8mm@195mmc/c
	380	380							
B11	230X	300	3-16	5-8	4-16	5-8	0.96%	2L-	2L-
	450	Х	mm ǿ	mm ǿ	mm ǿ	mm ǿ		8mmǿ@	8mmǿ@150mmc/
		380						140mmc/c	c
B12	230X	300	3-12	3-8	4-12	3-10	0.64%	2L	2L-
	300	Х	mm ǿ	mm ǿ	mm ǿ	mm ǿ		8mmǿ@	8mmǿ@195mmc/
		230						260mmc/c	с
B13	230	300	3-12	3-8	4-12	3-10	0.64%	2L	2L-
	Х	Х	mm ǿ	mm ǿ	mm ǿ	mm ǿ		8mmǿ@	8mmǿ@195mmc/
	300	230						260mmc/c	c
B14	230X	300	3-12	5-8	5-12	5-8	0.96%	2L-	2L-
	300	Х	mm ǿ	mm ǿ	mm ǿ	mm ǿ		8mmǿ@	8mmǿ@150mmc/
		380						260mmc/c	с
B15	300	300	2-12	4-12	2-12	5-8 mm ǿ	0.05%	2L-	2L-
		Х	mm ǿ	mm ǿ	mm ǿ			8mmǿ@200mm	8mmǿ@150mmc/
		230						c/c	с
B16	230X	300	2-12	4-12	2-12	5-8 mm ǿ	0.05%	2L-	2L-
	300	Х	mm ǿ	mm ǿ	mm ǿ			8mmǿ@200mm	8mmǿ@150mmc/
		380						c/c	с

TABLE -XI Comparison of 1 st floor beam calculation



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	TABLE XII	
Comparion	of calcultion	of column

Column No	Size of column	Level		Main rein	Later	al Ties	Decreased Pt %		
			M Ast	Reinforcement	S Ast	Reinforcement	M (Ast - 100.53 mm ²)	S (Ast- 100.53 mm ²)	
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 ớ	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%



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Footing	Size	of footing		Increased in Pt			
No.							%
	М	S	М	No of	S	No of	
				bars		bars	
FC1	1.2 X1.2 X 0.35	0.9 X 0.85 X 0.3	10 mm ǿ@	16	10mmǿ@	12	0.04
	$V-0.504 \text{ m}^3$	$V - 0.229 m^3$	180mmc/c		285mmc/c		
FC2	1.3 X 1.3 X 0.35	1.05 X 0.9 X 0.3	10 mm	16	10 mm	12	0.04
	V-0.591m ³	V-0.283m ³	ǿ@180mmc/c		ǿ@300mmc/		
					c		
FC3	1.2 X 1.2 X 0.35	0.9 X 0.85 X 0.3	10 mm	16	10mmǿ@	12	0.04
	$V-0.504 \text{ m}^3$	$V - 0.229 m^3$	ǿ@180mmc/c		285mmc/c		
FC4	1.3 X 1.3 X 0.35	1.15 X 1.1 X 0.35	10 mm	18	10 mm ǿ@.	14	0.11
	$V-0.591m^{3}$	V-0.442m ³	ø@170mmc/c	-	220mmc/c		
FOS	10 X 10 X 0 25	1 X 0 05 X 0 2	10	20	10 / 0	16	0.40
FC5	1.8 X 1.8 X 0.35	1 X 0.85 X 0.3	10 mm	38	10 mmø @	16	0.49
	V-1.134m	v-0.255m	ø@100mmc/c		285mmc/c		
FC6	1.2 X 1.2 X 0.35	0.9X 0.85 X 0.3	10 mm	14	10mm ǿ@	12	0.01
	V- 0.504 m ³	$V-0.229m^3$	ǿ@200mmc/c		285 mmc/c		
FC7	1.2 X 1.2 X 0.35	0.9 X 0.85 X 0.3	10 mm	14	10 mm ǿ@	12	0.01
	$V - 0.504 \text{ m}^3$	$V-0.229m^{3}$	ø@200mmc/c		285 mmc/c		
ECO	12 X 1 2 X 0 25	1 V 0 95 V 0 2	10	1.4	10	12	0.01
FC8	$1.2 \times 1.2 \times 0.35$	$1 \times 0.85 \times 0.3$	10 mm	14	10 mm ø@	12	0.01
	v- 0.504 m	v-0.255m	ø@200mmc/c		285mmc/c		
FC9	1.2 X 1.2 X 0.35	0.9 X 0.85 X 0.3	8 mm	18	10 mm ǿ@	12	0.07
	V- 0.504 m ³	$V-0.229m^3$	ǿ@170mmc/c		285 mmc/c		
FC10	1.3 X 1.3 X 0.35	1.25 X 1.1 X 0.35	10 mm	20	10 mm ǿ@.	14	0.16
	V-0.591m ³	V-0.481m ³	ø@160mmc/c	-	220mmc/c		
FC11	10 1 0 1 0 1 0 25	1.05 X 0.0 X 0.2	10	16	10 / 0	10	0.1
FCII	$1.2 \times 1.2 \times 0.35$	1.05 X 0.9 X 0.3	10mm	16	10 mm ø@	10	0.1
	v- 0.504 m	v-0.283m	ø@180mmc/c		300mmc/c		
FC12	1.2 X 1.2 X 0.35	1.05 X 0.9 X 0.3	10mm	10	10 mmǿ@	10	0.05
	V- 0.504 m ³	V-0.283m ³	ǿ@300mmc/c		300mmc/c		
FC13	1.3 X 1.3 X 0.35	1.05 X 0.9 X 0.3	10 mm	10	10 mm ǿ@	12	0.11
	V-0.591m ³	V-0.283m ³	ø@160mmc/c		300mmc/c		
	Total -7.53m ³	Total- 3.481m ³					Average %
							reduced -0.1

TABLE XIII Comparison of calculation of footing

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.

IX. ACKNOWLEDGMENT

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.



ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538

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