



IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 6 Issue: XI Month of publication: November 2018

DOI: http://doi.org/10.22214/ijraset.2018.11095

www.ijraset.com

Call: 🕥 08813907089 🔰 E-mail ID: ijraset@gmail.com



## **Automated Excel Sheets for Various RC Elements**

Nitin Tiwari<sup>1</sup>, Rashmi Sakalle<sup>2</sup>, Aman Katare <sup>3</sup>, Manjeet Kumar Sharma<sup>4</sup>, Mayank Shrivastava<sup>5</sup>, Mohd Shoab Khan<sup>6</sup>, Mohd Altamish Khan<sup>7</sup>, Prajjwal Gholap<sup>8</sup>

<sup>1, 2</sup> Assistant Professor, <sup>3, 4, 5, 6,7, 8</sup>UG Student, Department of Civil Engineering, Truba Institute of Engineering and Information Technology, Bhopal M.P, India

Abstract: In this paper EXCEL spreadsheet software has used in analyzing and calculating rebar's of different RC elements like beams, columns and slabs. Five different types of EXCEL spreadsheet like simply supported beam, cantilever beam, short column and long column, one way and two-way slab has calculated in this project work. Different characteristics conditions like effective span, nominal cover, and effective length of compression members has applied in our study. Apart from the inclusion of various characteristics properties, different checks have assigned to the RC elements. Reference has been taken from RCC code IS 456:2000.

Keywords: MS Excel, IS 456:2000, Analysis, Design, Beam, Column, Slab.

## I. INTRODUCTION

This study shows that, with the help of MICROSOFT excel we can create a program or a software, which can calculated reinforcement bars and distribution, bars only by given dimensions and assigning properties of the reinforced elements. For the study, a huge amount of documented data is required.

It will recorded by going through different papers and extracting the values from the same. Reinforced concrete (RC) (known as reinforced cement concrete or RCC) is a composite material in which concrete's relatively low tensile strength and ductility are counteracted by the inclusion of reinforcement having higher tensile strength or ductility.Excel sheets are are design sheets with inbuilt cell-based structure and the simple boundary that is easy to use, for the first time users also. It helps in analysis as well as design of civil engineering structures, which effectively utilizes MS EXCEL environment.

It has mainly used in teaching civil engineering concepts and providing useful applications. It focuses on concepts related to construction management and structural engineering varying from a simple cost estimating problem, structural design and analysis to advanced applications.

Typical civil engineering problems has used to present the programming concepts. Excel has used to enhance the concept and efficiency of structural analysis and design when design sheet is used.

## **II. OBJECTIVE**

- A. To develop a computerized programme to reduce paper work and time.
- *B.* This increases the efficiency and reduction in workload.
- C. To use structural engineering concepts in design sheets.
- D. To enhance the concept and efficiency of structural analysis and design when design sheet is used.

## III. CODING

MICROSOFT EXCEL is a spreadsheet developed for Windows, Android and IOS. It features calculation, tabular forms, pivot tables. It is a very widely applied spreadsheet for these type of functions, especially since 1993.

There are three activities must be performed to achieve that goal.

- A. Coding of the RC elements using MICROSOFT EXCEL..
- B. The calculations to decide the explanatory.
- C. Result has checked in the OUTPUT.

IS 456:2000 RCC code is used in this paper as reference to various characteristic properties of reinforced elements like effective span, nominal cover, effective length of compression members, exposure conditions, etc.



International Journal for Research in Applied Science & Engineering Technology (IJRASET)

ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887 Volume 6 Issue XI, Nov 2018- Available at www.ijraset.com

## **IV. METHODOLOGY**

For the study, a large amount of documented data is required and RCC code IS 456:2000 is taken as a reference for different characteristic properties like effective cover, effective span, effective length of compression members, nominal cover and exposure conditions, etc.

The study shows automated calculation of rebar for following RC elements:

MS EXCEL is extensively used in calculating the rebars of the above mentioned RC elements.

#### A. Beams

The procedure of the method for calculation of rebars of both simply supported as well as cantilever beam can be precised as follows: 1.)given span of beam, grade of concrete, live load, grade of steel, width of support, cover need and size of main rebars 2.) to check if the simply supported beam is singly or doubly using Mu< Mu<sub>lim</sub> then it is singly else doubly reinforced beam 3.) determine area of steel by using clause G.1.1-b (annex G) for singly reinforced bean and clause G.1.2 for doubly reinforced beam 4.) calculation of rebars using formula (AST<sub>calculated</sub>/ast<sub>one bar</sub>).

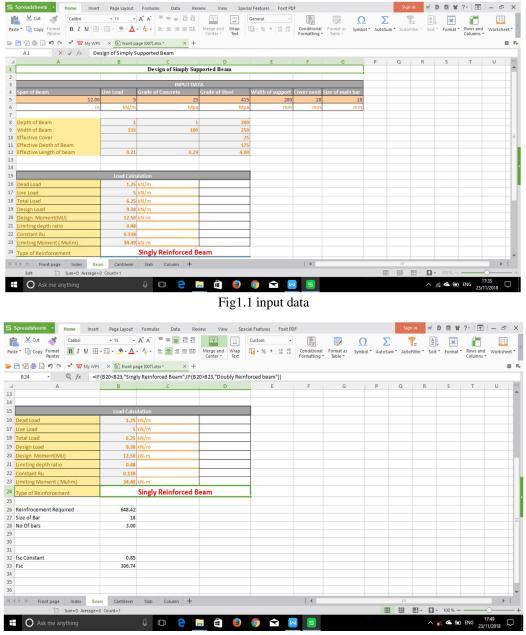


Fig1.2 checks for singly and doubly reinforced



## International Journal for Research in Applied Science & Engineering Technology (IJRASET) ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887

Volume 6 Issue XI, Nov 2018- Available at www.ijraset.com

Spreadsheets - Home Insert	Page Layout	Formulas Data Rev	riew View Spo	cial Features Foxit PD	F			Sign in	# D 🖾 1	r ?•   🛧	– 8 ×
🚔 💥 Cut <	• 11 · •	A <sup>+</sup> A <sup>−</sup> <sup>=</sup> = = = = = =		General +			Ο Σ	7-	A.		m
	• 🔂 • 🖄 • 🗛 •	• 🍫 • 🗄 🗄 🗏 🖽	Merge and Wrap Center • Text	₩ • % • +.0 .00 .00 +.0	Conditional Formatting		Symbol * AutoSu	m * AutoFilter	* Sort * Format	<ul> <li>Rows and Columns *</li> </ul>	Worksheet *
📂 💾 😰 🖶 🔍 🍠 🍽 📌 😾 My WPS	× 🗐 front pa	age (007).xlsx * × +									B 6.
A28 - 🕲 fx No	Of bars										
A	В	С	D	E	F	G	Р	Q	R S	Т	U -
19 Design Load	9.38	kN/m									<b>^</b>
20 Design Moment(MU)	12.50	kN-m									
21 Limiting depth ratio	0.48										
22 Constant Ru	0.138										
23 Limiting Moment ( Mulim)	34.49	kN-m									
24 Type of Reinforcement		Singly Reinforced B	eam								
25											
26 Reinfrocement Required	648.42										
27 Size of Bar	18										
28 No Of bars	3.00										
29											
30											
31											
32 fsc Constant	0.85										
33 Fsc	306.74										
34 35											
36											
37											
38											
39											
40											
41											
42											
43					1.4						· · · · ·
Id d ▶ ▶ Front page Index Bean		Slab Column 🕂			4		-				
Sum=3 Average=3	Count=2					_		III	• 100 % •		)+
Ask me anything			<b>.</b> 🗎 🥹	o 🔁 🦻	9 5				^ 🌾 🗲 🐕	ENG 23/11	:52  /2018 □

Fig1.3 no. Of rebars

## B. Columns

The procedure of the method for calculation of rebar's of column for both shorter and longer span is précised as follows: 1.)given data axial load(P), length of column(L), grade of concrete(fck), grade of steel(fy), dia of rebar's 2.) check effective length of compression members using table 28 of IS 456:2000. 3.)determine whether short column or long column using clause 25, 3.)verify that the eccentricities are not less than the corresponding minimum eccentricities as per clause clause 39.2, 4.) calculation of reinforcement bars and distribution bars.

5 Spreads	heets • Home Insert Pa	ige Layout Formulas	Data Review	View Special Features	Foxit PDF				Sig	in in 💡	001	?*   🛧   — 🗗	p ×
<b>K</b>	Cut 💉 Calibri 👻	11 • A <sup>+</sup> A <sup>−</sup> ≡		General	*			2	Σ	7- 1	<u>2</u>	i 🗐 🔲	
Paste * 👔 🕻	Copy Format B I U H - H -	• <u>•</u> • <u>A</u> • <u></u> • ≡	≝ ≝ ≣ 😫 Merge Cente	and Wrap	00 .00 Con	ditional For	mat as Symb	bol * Auto	Sum * Aut	oFilter * S	ort * Format *	Rows and Worksh	neet *
<b>- P</b> • <b>a</b> #		(007).xlsx *		er • Text	Form	latting * la	ible *					Columns +	
C42		00*C25/100	<u> </u>										
A A	B	C	D	E	F	G	H	i	J	К	L	M	
1													-
2					DESIGN	OF CC	DLUMN						
3													
4	INPUT DATA:-												
5	Axial Load	Length of colomn(L)	Grade of concrete(fck	) Grade of Steel(fy)	Dia of Rebars								
6	1500		2										=
7	KN	m											
8													
9	OUTPUT DATA:-												
10													
11	Ultimate Axial Load(Pu)	2250	KN										_
12	Effective Length(Le)	4.8	m	One hinged, one fixed					EFFE	CTIVE	LENGTH	OF COMPRI	ES:
13													+
14										of End R		Theoritical value	of
15	DESIGN STEPS								of com	pression i	members	Effective Length	<u> </u>
16	Cross Section Design Assume 1% Reinforcement	-						1	Effectively	h al d ha a		0.5	+
18		234497.1339	000	-									+
	Gross Area(Ag)  Area of Concrete(Ac)	234497.1339		(99% of Ag)					both ends		nst rotation in		+
20	Area Of Steel In Compression(A	232152.1626		(1% of Ag)					ootnenus				+
21		1							Effectively	held in n	osition at	0.7	+-
	Front page Index Beam	Cantilever Slab	Column +		1	•	_	111				•	1
							-				<b>•</b> 100 % —	18:15	
	Ask me anything	Ļ (	ı 🤁 📃 i	🗄 🥹 🌍 🖆	3 😡 🛛	5 🗠	6			/	N 🌾 🐔 🗐	ENG 23/11/2018	$\Box$
				Fig2.1inpu	ut data								



## International Journal for Research in Applied Science & Engineering Technology (IJRASET)

ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887 Volume 6 Issue XI, Nov 2018- Available at www.ijraset.com

te * 🚡 Co	py Format B I U ⊞ • ⊞ •	<u>*</u> • <u>A</u> • ∳• ≡		Merge a Center			ditional Fe	ormat as Symb Table •	ol * Auto	Sum * Auto	Filter * S	ort * Format *	Rows and Work	kshe
8 🛿 🖨	्रि 🄊 (भ 📌 😾 My WPS 🛛 👰	front page (007).xlsx *	× +											1
E12	- 🔍 fx One hinge	d, one fixed												
А	В	С	D		E	F	G	Н	1	J	K	L	М	
	KN	m		Mpa	Mpa	mm	1							
	OUTPUT DATA:-													
	Ultimate Axial Load(Pu)	2250	KN											
	Effective Length(Le)	4.8	m		One hinged, one fixed	•				EFFEC	TIVE I	ENGTH	OF COMPR	RE
					Both end fixed									
					One hinged, one fixed					Degree	of End Re	straint	Theoritical valu	e c
	DESIGN STEPS				Both end hinge					of comp	pression n	nembers	Effective Leng	zth
	Cross Section Design													_
	Assume 1% Reinforcement								1	Effectively	held in p	osition	0.5	_
	Gross Area(Ag)	234497.1339	mm 2							and restrain	ned again	st rotation in		
1	Area of Concrete(Ac)	2344.971339	mm <sup>2</sup>		(99% of Ag)					both ends				_
	Area Of Steel In Compression(A	232152.1626	mm <sup>2</sup>		(1% of Ag)									_
									2	Effectively	held in p	osition at	0.7	_
	Shape Of Column									both Ends,	Restraine	d against		
	If Square Column									rotation at	one end			
	Side of Square Column(a)	485.00												
2	SIDE(provided)	485.00	mm							Effectively			1	_
											out not re	strained agai	nst	_
	Minimum Eccentricity ecalculat	28.17								rotation				_
▶ M	e (min) Front page Index Beam C		mm Column +		1	1	4		111		_	l		•

Fig2.2 different end conditions

-	~	1 → A <sup>+</sup> A <sup>-</sup> =		General	• •.0 .00 G	enditional Fo	irmat as Sum		Σ defum X Aut			Rows and Worksh	1
ite u	Copy Format Painter B I U H • H •	<u></u>	Cent	er * Text	,00 +.0 Fo	rmatting * 1	ormat as Symi Table 🔻	DOI AU	JLOSUM AUL	orniter 50	on Format	Columns *	nee
- 2	🛛 🖓 (*) 📌 🖤 My WPS 🛛 🄅		× +										1
C29													
Α	В	С	D	E	F	G	Н			K	L	М	
	1 Area of Concrete(Ac)	2344.971339		(99% of Ag)	_	-			both ends	-			_
	Area Of Steel In Compression(A	232152.1626	mm²	(1% of Ag)	_	-							_
				_		-		2	Effectively			0.7	_
	Shape Of Column			_		-			both Ends,		d against		_
	If Square Column Side of Square Column(a)	485.00				-			rotation at	one ena			-
	2 SIDE(provided)	485.00		_		_		3	Effectively	hold in n	cition at	1	-
	2 SIDE(provided)	465.00						5			strained agai		-
	Minimum Eccentricity ecalculat	28.17	mm						rotation	butnotte	Strained agai		-
	e (min)		mm									-	-
	СНЕСК	OK	€ calculated ≥€ minimum										
	3	UN	- Concernent - Minimum										
	Slenderness Ratio	9.6											
	CHECK1	Short Column											
	CHECK2	ОК											
	4												
	Calculation of Asc												
	Asc	2352.25											
	Use 20mm Dia BARS	24	mm <sup>2</sup>										
	5 Number Of BARS	5.20											
	BARS provided	5	Nos			_							
▶ )			1			1.4							
	Front page Index Beam C	Cantilever Slab	Column +			•		111					•

Fig 2.3 checks for short and long column



## International Journal for Research in Applied Science & Engineering Technology (IJRASET) ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887 Volume 6 Issue XI, Nov 2018- Available at www.ijraset.com

		11 • A <sup>+</sup> A <sup>−</sup> ≡ <u>•</u> • <u>A</u> • A <sub>0</sub> • ≡	≡ ≡ ∰ Merge Cente	and Wrap	General	•.0 0.0 0.0 0.0	Conditional F Formatting *	ormat as	Ω Symbol * A	∑ RutoSum * Au		AZ Format	<ul> <li>Rows and Columns +</li> </ul>	Worksheet *
- 🖰 😨	] 🖶 🗋 🄊 (™ 💙 🖤 My WPS 🛛 🗸			i iext			ronnatting	abie					Columns	
B3														
⊿ / 22	B Shape Of Column	С	D	1	E	F	G	Н	1	J bash made			M	
22	If Square Column									rotation a	, Restraine	against		
23	Side of Square Column(a)	485.00		1						rotation a	t one end		+	
25	2 SIDE(provided)	485.00		1					3	Effectivel	y hold in n	orition at	1	
26	zobelpionaca	405.00							5			estrained aga		
27	Minimum Eccentricity ecalculat	28.17	mm	1						rotation			T	
8	e (min)		mm	1										
29	СНЕСК	ОК	e calculated >e minimum	1										
0	3													
31	Slenderness Ratio	9.6		1										
32	CHECK1	Short Column												
33	CHECK2	ОК												
14	4													
15	Calculation of Asc													
6	Asc	2352.25												
7	Use 20mm Dia BARS		mm <sup>2</sup>						_					
8	5 Number Of BARS	5.20												
9	BARS provided	5	Nos						_		-			
10 11											-			
12	Distribution Reinforcement	F03	mm <sup>2</sup>					-			-			
13	Distribution Reinforcement	582							_		-			
14													-	
( ( ) )	Front page Index Beam	Cantilever Slab	Column +				∢	1			-			) ► I
	Sum=592.2022514 Averag	and a second	Contraction and the second								<u> </u>	<b>•</b> 100 %		
	Ask me anything	۵ ( <b>ا</b>				_			_	COC3	- 10 E		18:1	0

Fig 2.4 calculation of rebars and distribution reinforcement

## C. Slabs

The third case demonstrates the automated calculation of rebars of two-way slab using designsheets. The design steps mainly includes: 1) given data like shorter span, longer span, live load, grade of concrete and steel, cover condition, width of support, size of primary and secondary rebars, floor finishing(=1KN/m2). 2) finding thickness of slab 3)finding effective span 4) check for one way and two way slab using clause as per IS 456:2000 5) calculation of shorter and longer span reinforcements.

S Spreadsh	eets • Home Insert Page Layout	Formulas I	Data Re	eview View	Special Features Foxit PDF			Sign in	# D 🖾 1	r ?-   🛧	– a ×
H X 0	ut 🔏 Calibri 🗸 11	- A <sup>+</sup> A <sup>-</sup> = =	= = =	<b>T</b>	General 👻	<b>F</b>		-		<b>1</b>	III
Paste *	opy Format Painter	• ~ = =			• · · · · · · · · · · · · · · · · · · ·	Conditional Forma Formatting • Table	- L3 Z4 - Band	* AutoFilter *	Sort * Format	<ul> <li>Rows and Columns</li> </ul>	
	I Q II Q II V My WPS × Ø front		× +			romating - labo				Columns	
C15	<ul> <li></li></ul>	n as two way sta	D , Desigi		F G	Н	L	1		K	L
A 1	в	L	U		ign of Simply Supported		1	J	_	K	
2			1		agn or simply supported	5160		IS 456:2000			
3					User Data Table						
4 Paramet	e Shorter Span	Longer Span	Live load	Garde of Concrete	Grade of Stee Cover Co	ndition width of su	pport Size of Main Reb	a Size of Seco	ndary Rebai Fl	oor Finishi	ng Load
5 Value	4	1 12	2	20	415 Mild		150 1	5	8	1	
6	1	1									
7 S.No	Calculating Parameter	notation	unit	Value							
8 1	Thickness of shorter span	dx	mm	. 170							
9 2	Thinkness of Longer span	dy	mm	485	1						
10 3	Effective Cover	d.	mm	30							
11 4	Overall Depth	D	mm	200							E
12 5	Effective length of Shorter Span		m	4.15							
L3 6	Effective length of Longer Span		m	12.15							
4 7	Longer/shorter span depth	_	2.93	ĭ							
15 8	Type of Slab	Design as one y	ray slab								
16 9	Self Wt. Of Slab Wo		kN/m	5.00							
.7 10	Wt. of Floor Finish Wf		kN/m	1.00							
18 11	Live Load on slab WI		kN/m	2.00							
19 12	Total Factored Load		kN/m	12.00							
20 13	Design moment in shorter Span	ļ	kN-m	25.83375							
21 14	Design moment in Longer Span		kN-m	221.43375							
22											
23	Calculation of Shorter Span Reinforceme	ent		Calculation of Dis	tribution Reinforcement						
4 4 4 4	Front page Index Beam Cantilever		ımn +			∢					▶
	1							III -	🖸 🕶 100 % ·		-0
0	Ask me anything	↓ (_)	9	📄 🖨 🍯	) 🌖 숙 🧧				^ 🎻 📤 9		<sup>18:32</sup>
			<b>T</b> '	2.1.	t data in user	1 / / 11					

Fig 3.1 input data in user data table



## International Journal for Research in Applied Science & Engineering Technology (IJRASET) ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887 Volume 6 Issue XI, Nov 2018- Available at www.ijraset.com

aste *	X a ∏⊇ a	ut Calibri • 11 Depy Format Painter Calibri • 11 B I U H • H • • • • •	· A <sup>+</sup> A <sup>-</sup> ≡ ≡ <u>A</u> · A <sub>0</sub> · ≡ ≡			General	*.0 .00 Cond	itional Format as atting * Table *	Ω Σ Symbol ▼ AutoSum	AutoFilter * So	rt * Format	<ul> <li>Rows an</li> <li>Column</li> </ul>		shee
	12 🚍	🗋 🄊 🍽 📌 W My WPS 🛛 🗐 fro	nt page (007).xisx *	× +										
	C15	- ℚ fx =IF(C14<2,"De	sign as Two way Sla	b","Desig	n as one way slab")									
4	А	В	С	D	E	F			1	j		K	L	
		e Shorter Span			Garde of Concrete					Size of Seconda	ry Rebai Fl	oor Finish	ing Load	
Va	lue		4 12	2	20	415	Mild	150	16		8	1		
					x									
S.1	No	Calculating Parameter	notation	unit	Value									
1	1	Thickness of shorter span	dx	mm	170									
	2	Thinkness of Longer span	dy	mm	485									
D	3	Effective Cover	ď	mm	30									
1	4	Overall Depth	D	mm	200									
2	5	Effective length of Shorter Span		m	4.15									
3	6	Effective length of Longer Span		m	12.15									
4	7	Longer/shorter span depth		2.93										
5	8	Type of Slab	Design as one v	av slab										
5	9	Self Wt. Of Slab Wo		kN/m	5.00									
7	10	Wt. of Floor Finish Wf	i i i i i i i i i i i i i i i i i i i	kN/m	1.00									
	11	Live Load on slab WI	1 IIII	kN/m	2.00									
9	12	, Total Factored Load	-i	kN/m	12.00									
D	13	Design moment in shorter Span	1	kN-m	25.83375									
1	14	Design moment in Longer Span	l l	kN-m	221.43375									
2														
		Calculation of Shorter Span Reinforce	ment		Calculation of Dist	ribution Reinf	orcement							
4	15	Ast	445.31		Ast(ds)	240.00								
5	16	Spacing	300.00	mm	Spacing	210.00	mm							
5														
<	bi .	Front page Index Beam Cantile	ver Slab Colu	mn +			1	4			-			•
11	P1		Ver Slap Colu				1			·····································	100.01			1
		1								113 El • El	<b>→</b> 100 % -			

Fig 3.2 check for type of slab

ite * 👔	Cut Station - 11 Copy Format Painter B I U ⊞ - ⊞ - 11		and a second sec	Merge and Wrap Center * Text	General	condi	itional Format as stting * Table *	Ω Σ Symbol * AutoSum *	AutoFilter * Sort * Fi	ormat * Rows a Column		
B23	■ Q ♥ ♥ ♥ ♥ Wy WPS × ● fr Q fx =IF(\$C\$15="DI			r Calculation of Main F	leinforcemen	t"."Calculation of	of Shorter Span R	einforcement")				
A	В	С	D	E	F	G	н	1	J	K	L	
S.No	Calculating Parameter	notation	unit	Value								
1	Thickness of shorter span	dx	mm	170								
2	Thinkness of Longer span	dy	mm	485								
3	Effective Cover	ď	mm	30								
4	Overall Depth	D	mm	200								
5	Effective length of Shorter Span	_	m	4.15								
6	Effective length of Longer Span		m	12.15								
7	Longer/shorter span depth	_	2.93									
8	Type of Slab	Design as one	way slah									
9	Self Wt. Of Slab Wo		kN/m	5.00								
10	Wt. of Floor Finish Wf		kN/m	1.00								
11	Live Load on slab WI		kN/m	2.00								
12	Total Factored Load		kN/m	12.00								
13	Design moment in shorter Span	Î	kN-m	25.83375								
14	Design moment in Longer Span		kN-m	221.43375								
	Calculation of Shorter Span Reinforce			Calculation of Distr		orcement						
15		445.3		Ast(ds)	240.00							
16	Spacing	300.0	)0 mm	Spacing	210.00	mm						
		-										
										-		
										++		
► H	Front page Index Beam Cantil	ever Slab Co	olumn +			1.	4					Þ

Fig 3.3 calculation of shorter and longer span reinforcements

## V. CONCLUSION

MS-EXCEL sheet is a very helpful tool for calculation of rebars of various RC elements such as beams, columns, slabs. These excel sheets can be used in conjunction with the analytical softwares like STAAD and ETABS for the design of reinforced concrete elements. These are efficient and help in quick design of buildings and other structures on various projects. While standard software like STAADPRO were used in the frame analysis but self created excel sheets for design of columns, beams and slabs.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)



ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887 Volume 6 Issue XI, Nov 2018- Available at www.ijraset.com

## REFERENCE

- [1] Santosh Kumar P.T. (2014) "Trends and recent advances in civil engineering (TRACE-24th-25th january 2014), International Journal of Engineering Research and Applications (IJERA) ISSN:2248-9622
- [2] Varsha S Danavandi, Shaik Kabeer Ahmed (2017) "Developing civil engineering design software using MS EXCEL" ISSN:2349-0697, VOLUME-4, ISSUE-5,2017
- [3] Mahesh Kumar (2015) "quick design of buildings and other projects on MS EXCEL"
- [4] Suryam Tiwari, Vijay Shrivastav (2018) "Microsoft Excel Spreadsheet using VBA programming packages"-IJIRST-International Journal for Innovative Research in Science and Technology, Volume 4, Issue 11, April 2018, ISSN-(2349-6010).
- [5] Ima Rahamanian, Yves Lucet, Solomon Tesfamariam(2014)"Optimal design of reinforced concrete beams", Computers and concrete, Volume 13, No.4(457-482).
- [6] Fernandes R. J, Javeli F. M, Patil S. B (2017) "Analysis and Design of Reinforced Concrete Beams and Columns using open STAAD", International Journal of Soft Computing and Engineering(IJSCE) ISSN:2231-2307, Volume-7 Issue-3.
- [7] Richard Lawrene Emberley(2013)" behaviour of RC columns under fire exposures using a spreadsheet-based numerical model" Worcester Polytechnic Institute, may 2013
- [8] Poonam Gare, Dr. S.S. Angalekar(2016) "Design of Structural Element Employing Optimization Approach" International Journal of Innovative Research in Science, Engineering and Technology, Volume-5, Issue-7 july 2016











45.98



IMPACT FACTOR: 7.129







# INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Call : 08813907089 🕓 (24\*7 Support on Whatsapp)