ANALYSIS AND DESIGN OF BEAMS USING SPREAD SHEET TOOL

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ABSTRACT

The manual design and analysis of beams for even a small structure is laborious and time consuming. The use of sophisticated design software involves high cost and software skill. This paper deals with the development of simple tool using spread sheet for analysis and design of beams for small buildings. In the first step the structural beam layout, grouping of beams and loading diagrams are manually done. Based on this, a excel spread sheet has been developed for to calculate the bending moment and shear force. For analysis of design moments and Reinforcements another spread sheet is developed. A sample analysis and design is presented and it shows the satisfactory result. This analysis and design of beams using spread sheet tool reduces the complexity of calculation and time.

KEYWORDS: Beams, Spread Sheet, Bending moment, Shear Force.

1.0INTRODUCTION

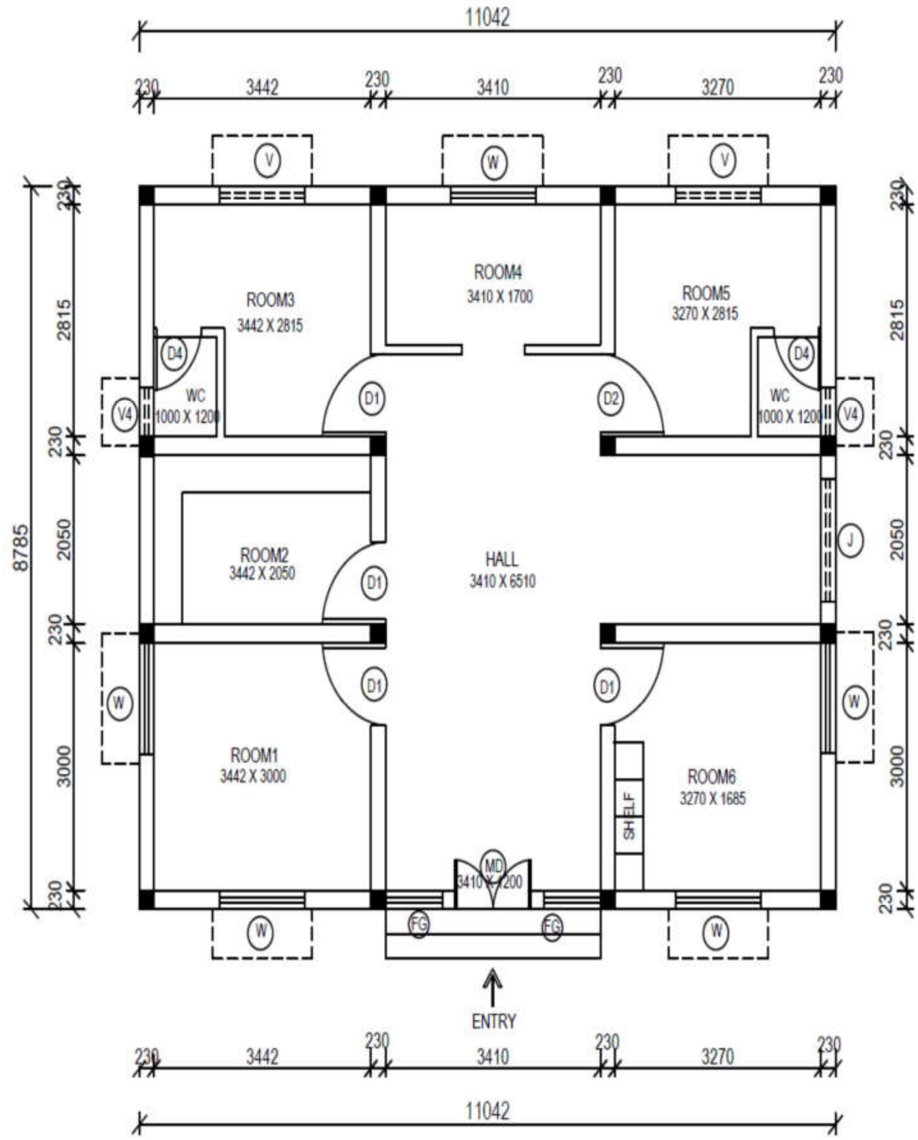
A RCC beam is a flexural structural member that carries lateral loads. The loads carried by a beam are transferred to column which is then transferred to foundations. Generally, Beams are subjected to bending moment and shear force. The common types of concrete beams are singly reinforced rectangular beams, doubly reinforced rectangular beams and flanged beams. For simple structures the singly reinforced rectangular beams are used. In this paper a single storey building with less than 4m span is taken. Due to the well known advantages, the limit state method is used for design of beams in this proposed building. The computer program has been developed to do the analysis in moment distribution method (exact method) to find the bending moment and shear. Section 2 presents the detailed building plan, the structural layout and grouping of beams. The analysis of beam is presented in section 3 and design is given in section 4. Finally it is concluded.

1.1 SAMPLE STRUCTURE

A single storey small office building is taken as a sample structure in this paper. The plan of the sample building is shown in figure.1. The structural layout has been developed for the sample structure and it is shown in figure 2. It consists of single span beams and three span continuous beams. From the beam layout, the beams are grouped into 4 categories based on loads, end conditions and span. The loads are uniformly distributed. The beams are simply supported at discontinuous ends and continuous over intermediate support with unequal span. The highest variation in span is RB3 and RB4 which has longest span 3230mm and the lowest is 2280mm. This is 29.4% of the longest span. The grouping of beams is done and is tabulated in table 1.

Table.1. Grouping of Beams

Category No.	Type of beam	Beam Mark
1	3 Span continuous beams simply supported at ends	RB1
2	Single span simply supported beam	RB2
3	3 Span continuous beams simply supported at ends	RB3
4	3 Span continuous beams simply supported at ends	RB4



GROUND FLOOR PLAN

Figure. 1. Building Plan

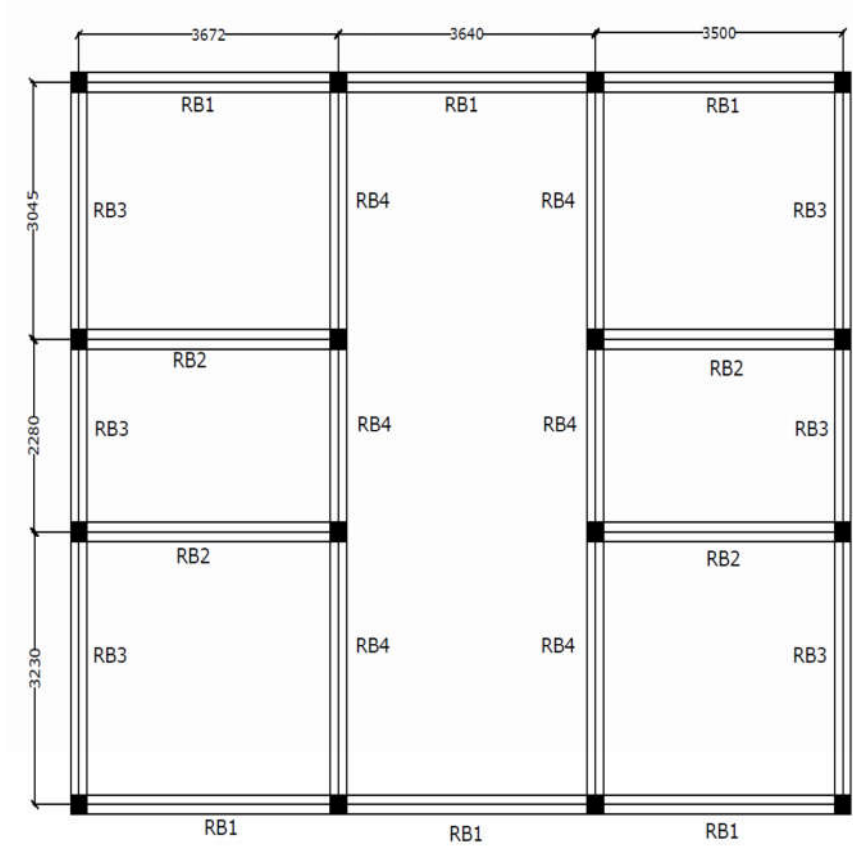


Figure. 2. Structural Layout Beams

2.0ANALYSIS OF BEAMS IN SAMPLE STRUCTURE

The structural layout shows that the maximum span is less than 4000mm, so that singly reinforced rectangular beams are more suitable for the proposed structure.

2.1 LOADING DIAGRAM

Initially the loading diagram is developed from simple manual calculation of loads transferred from the slab and wall. The corresponding loading diagram is given in figure.3. The beam members are simply connected except at the continuous ends of a continuous beam. Accordingly, beams RB2 is treated as single span simply supported beam. Beams are continuous in RB1, RB3, and RB4 and simply supported at ends.

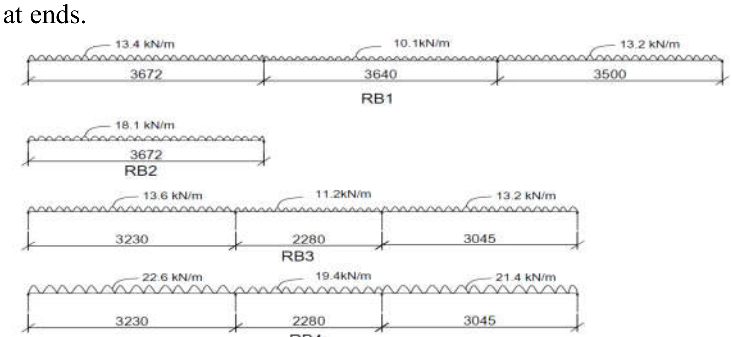


Figure. 3. Loading Diagram

2.2 ANALYSIS OF BEAM MEMBER

Calculations of exact bending moments in single spans beams will not pose any problem. For single span beams with uniformly distributed loads for various end conditions, the shear and bending moment are directly computed by IS coefficients method. Difficulty arises in determination of bending moments in continuous beams. Codes prescribe coefficients continuous beams with approximately equal spans (span not exceeding 15% of the longest and carrying UDL).

In practice, the analysis of a multispan continuous beam can be simplified by assumptions and approximations of considering number of independent single span beams or group of typical multispan beams. The exact analysis of a continuous beam manually is extremely laborious and subjected to human errors. For analysis of these beams, Excel spread sheet has been developed. The data are taken from the loading diagram shown in figure 3 for the spread sheet. The developed spread sheet is shown in figure.4. Out of four categories, RB2 has single span and analysis could be done by applying Moment coefficient. But, for the others which have 3 different spans with different loadings, the Excel spread sheet helps to determine the internal forces. The input data are span, loads, end conditions for each span. The input consists of span, loads, and end conditions are edited for each continuous beam RB1, RB3 AND RB4. After entering the input data, the internal forces shear, bending moments, reaction at supports are displayed automatically. The sample Excel spread sheet snapshot for RB1 is shown below in Figure.4.

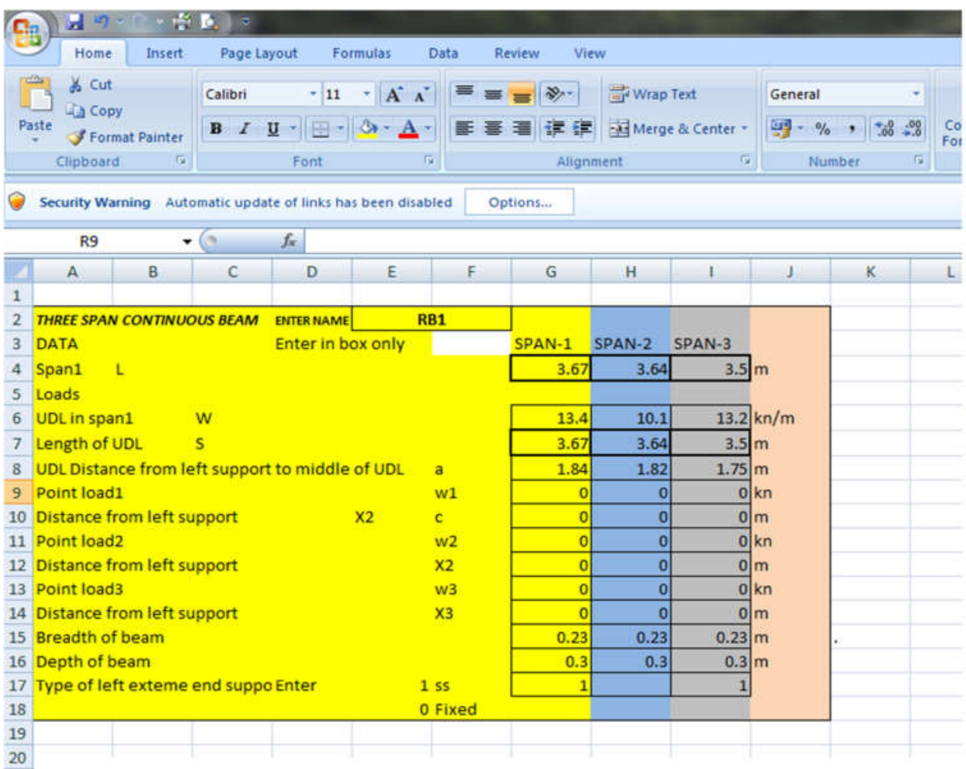


Figure. 4. Excel Spread Sheet: Input Parameters

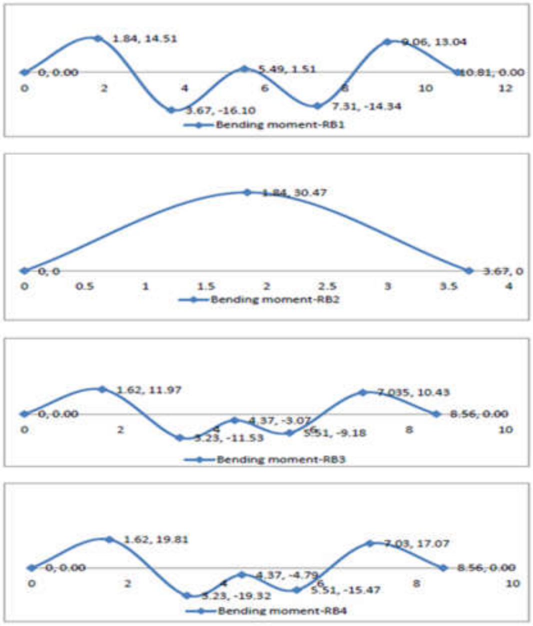


Figure.5. Bending Moment Diagram

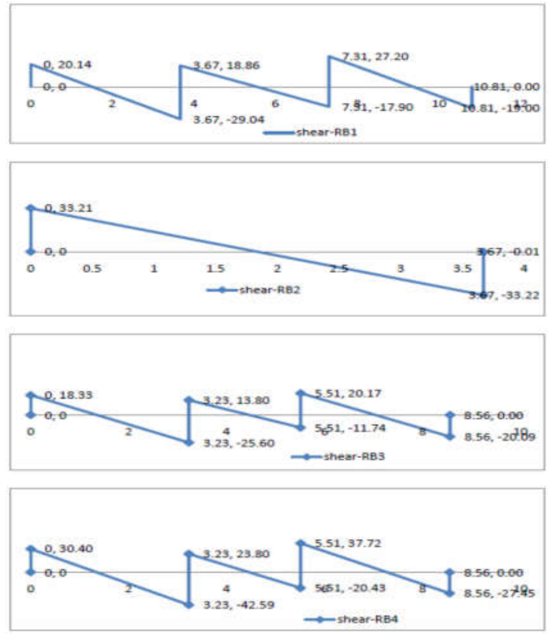


Figure.6. Shear Force Diagram

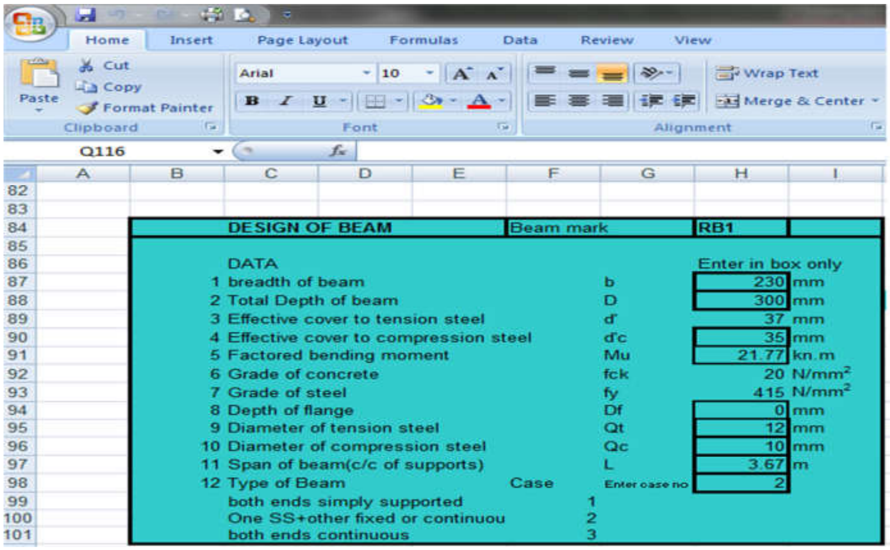
The bending moment and shear force diagrams are generated corresponding to the input parameters. The magnitudes of BM and SF are shown in Figure.5 and Figure.6 respectively.

It is observed that the maximum BM normally occurs at penultimate support and end span in the continuous beams. The maximum sagging moment occurs at mid span of the single span simply supported beam. The maximum shear occurs at the supports. This data are given as input for the design of beams.

3.0DESIGN OF BEAMS

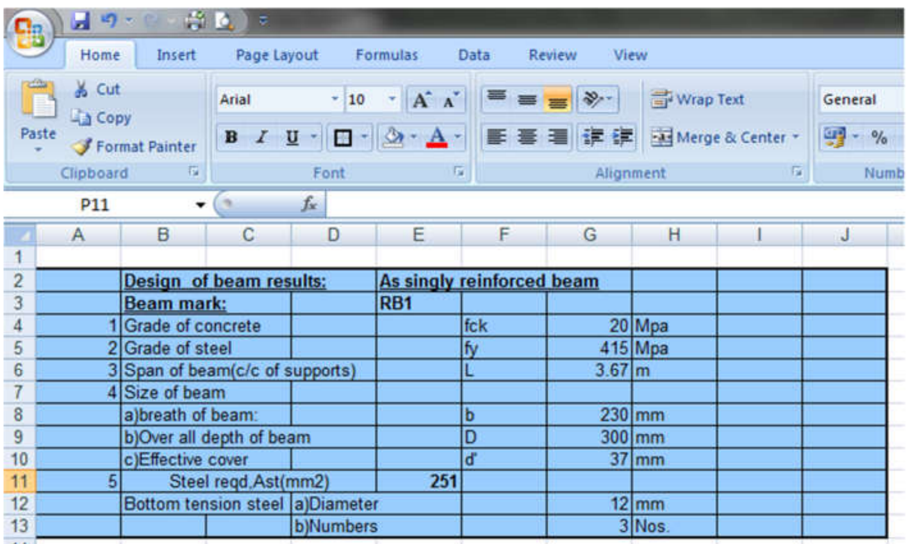
3.1 INPUT PARAMETERS

For the analysis of design of beams, an excel spread sheet has been developed. The output values of the previous section are given as input to this developed spread sheet. The inputs are Trail section, design moment, effective cover. The grade of concrete is kept as M20 and Fe415 for steel. The beam is designed for limit state for flexure. The input details are shown in below figure.7.



DESIGN OF BEAM		Beam mark	RB1		
DATA			Enter in box only		
1	breadth of beam	b	230	mm	
2	Total Depth of beam	D	300	mm	
3	Effective cover to tension steel	d'	37	mm	
4	Effective cover to compression steel	d'c	35	mm	
5	Factored bending moment	Mu	21.77	kn.m	
6	Grade of concrete	fck	20	N/mm^2	
7	Grade of steel	fy	415	N/mm^2	
8	Depth of flange	Df	0	mm	
9	Diameter of tension steel	Qt	12	mm	
10	Diameter of compression steel	Qc	10	mm	
11	Span of beam(c/c of supports)	L	3.67	m	
12	Type of Beam Case	Enter case no	2		
	both ends simply supported	1			
	One SS+other fixed or continuou	2			
	both ends continuous	3			

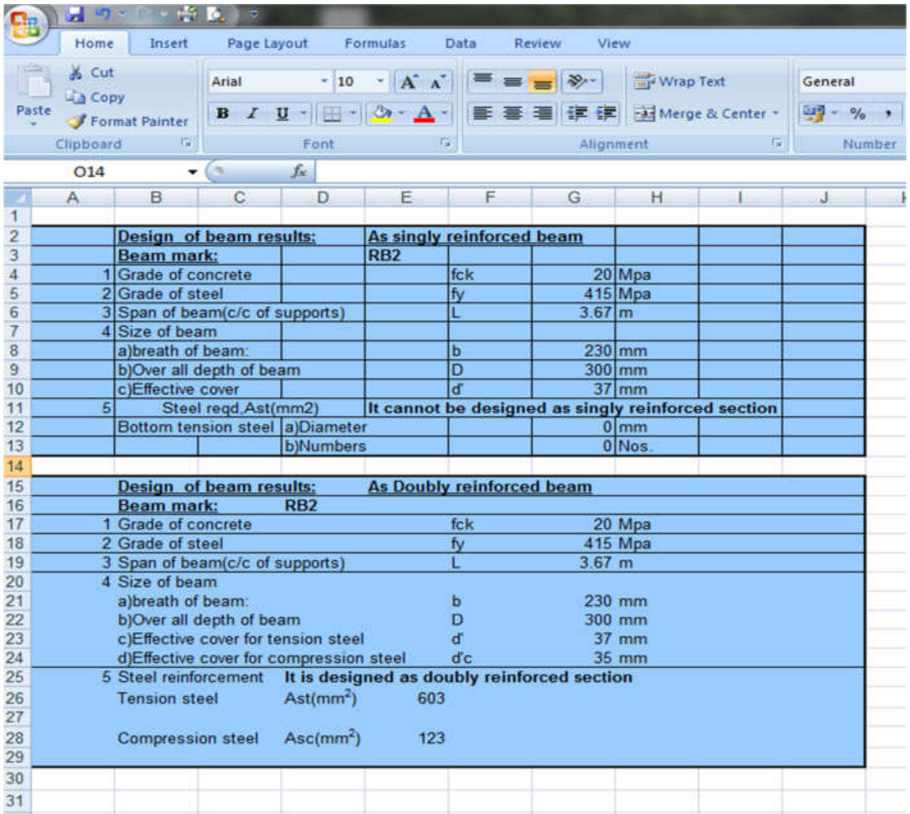
Figure.7. RB1 Input Parameter



Design of beam results:		As singly reinforced beam			
Beam mark:		RB1			
1	Grade of concrete		fck	20	Mpa
2	Grade of steel		fy	415	Mpa
3	Span of beam(c/c of supports)		L	3.67	m
4	Size of beam				
	a)breath of beam:		b	230	mm
	b)Over all depth of beam		D	300	mm
	c)Effective cover		d'	37	mm
5	Steel reqd.Ast(mm2)	251			
	Bottom tension steel	a)Diameter		12	mm
		b)Numbers		3	Nos.

Figure.8. RB1 Design Results

The section of each beam has been designed and the design results are obtained. The sample output results of beam RB1 is displayed in Figure.8. Except RB2, All the three beams have been designed as singly reinforced beam and the required area of steel for the design BM is displayed as shown in Figure.8. RB2 is designed as doubly reinforced beam since it exceeds the limiting percentage of steel as shown in Figure. 9. The results are consolidated in table: 2.



	Design of beam results:	**As singly reinforced beam**			
	Beam mark:	RB2			
1	Grade of concrete		fck	20	Mpa
2	Grade of steel		fy	415	Mpa
3	Span of beam(c/c of supports)		L	3.67	m
4	Size of beam				
	a)breath of beam:		b	230	mm
	b)Over all depth of beam		D	300	mm
	c)Effective cover		d'	37	mm
5	Steel reqd,Ast(mm2)	It cannot be designed as singly reinforced section			
	Bottom tension steel	a)Diameter		0	mm
		b)Numbers		0	Nos.

	Design of beam results:	**As Doubly reinforced beam**			
	Beam mark:	RB2			
1	Grade of concrete		fck	20	Mpa
2	Grade of steel		fy	415	Mpa
3	Span of beam(c/c of supports)		L	3.67	m
4	Size of beam				
	a)breath of beam:		b	230	mm
	b)Over all depth of beam		D	300	mm
	c)Effective cover for tension steel		d'	37	mm
	d)Effective cover for compression steel		d'c	35	mm
5	Steel reinforcement	It is designed as doubly reinforced section			
	Tension steel	Ast(mm²)	603		
	Compression steel	Asc(mm²)	123		

Figure.9. RB2 Design Results

Table: 2 Design moments and Reinforcements (Mu & $Ast_{required}$)

Category	**Details**	**Support 1**	**Mid span1**	**Support 2**	**Mid span2**	**Support 3**	**Mid span3**	**Support 4**
Beam RB1	Moments	0.00	14.51	-16.09	1.51	-14.35	13.04	0.00
	Mu, kN.m	0.00	21.77	-24.14	2.27	-21.53	19.56	0.00
	$Ast_{required}$, mm^2	123	251	282	123	248	223	123
Beam RB2	Moments	0.00	30.47	0.00	-	-	-	-
	Mu, kN.m	0.00	45.71	0.00	-	-	-	-
	Ast_{reqd}& Asc_{reqd},mm^2	123	621 123	123	-	-	--	-
Beam RB3	Moments	0.00	11.97	-11.53	-3.07	-9.18	10.43	0.00
	Mu, kN.m	0.00	17.96	-17.29	-4.61	-13.77	15.65	0.00
	$Ast_{required}$, mm^2	123	203	195	123	153	175	123
Beam RB4	Moments	0.00	19.81	-19.32	4.79	-15.47	17.07	0.00
	Mu, kN.m	0.00	29.72	-28.98	7.19	-23.21	25.61	0.00
	$Ast_{required}$, mm^2	123	367	347	123	269	301	123

4.0CONCLUSION

The exact analysis of a continuous beam manually is extremely laborious and subjected to human errors.. This paper analyses the design of beams using excel spread sheet tool. The bending moment and shear force diagrams are plotted using spread sheet which considerably reduces the design time. By using the results the RCC beams are designed as per IS 456:2000. The results are compared with sample problems and obtained satisfactory results. Spread sheet is open source software and easily get trained by the users. The spread sheet can also used to design flanged beams apart from rectangular beams.

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