Waste Minimization of Steel Using BBS Module

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Abstract-*Today, in modern times, attempts are made to integrate various departments in a project to avoid duplication of information, avoid errors, keep track of the money and efficient management. The major material used in construction project is steel. Cost of the project mainly comprises of the cost of steel. The total cost of the project increases due to wastage of steel. Thus, the wastage of steel is caused due to human and technical errors. To reduce the wastage of steel and minimize the cost, one of the attempts made is "Bar bending schedule". Bar bending schedule gives the optimized rebar schedule, so that the wastage of steel due to the errors can be reduced. Rebar schedule is prepared by comparing the drawings, inputting the data obtained. Thus, the rebar schedule is prepared by bar bending schedule in the form of optimized rebar schedule. Here we have obtained very minimum scrap value of steel of a residential building using the "Bar bending schedule model".*

Keywords*-*Steel, Bar Bending Schedule, Minimize wastage, scrap, cut-off lengths

I. INTRODUCTION

Today, in modern times, attempts are made to integrate various departments in a project to avoid duplication of information, avoid errors, keep track of the money and efficient management. One of the attempts made is "Bar bending schedule".

Bar bending schedule is used to communicate the design requirement of reinforcement steel to the fabricator and execution team and to enumerate the weight of each size of steel. It is a list of reinforcement steel bars, which includes size and number of bars, cutting length of bars, weight of steel and a sketch representing the shape of bar to be bent. Generally, civil engineers who are familiar in RCC structure are employed to prepare Rebar bending schedule. When compared to common quantity take offs, preparation of Rebar schedule needs excessive time for calculation. These calculations include cutting length, deduction of bend allowance within cutting length and summary of weight of each size separately. Insertion of any omitted items or revisions in the drawing may lead to repeated calculations and consume ample time.

This Reinforcement Bar Bending Schedule software is made to win these difficulties and optimize productivity with an integrated solution within Microsoft Excel. It can be used in various stages of construction such as estimation, steel procurement, and execution, billing and steel reconciliation.

It gives the most effective way for obtaining cutting lengths of the steel bars while taking into consideration the bending effect, temperature effect etc. on the steel bars. The optimum output received for the cutting lengths of steel reduces the scrap and the cut-off lengths which occur while working with steel.

II. OBJECTIVES OF STUDY

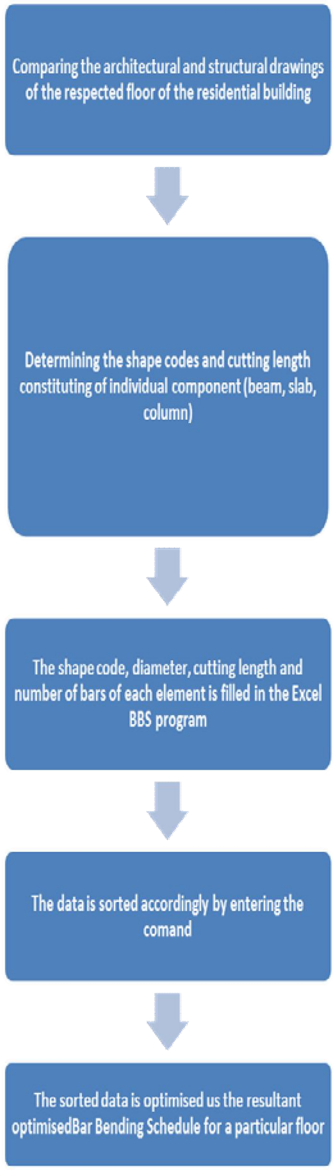
The objective of the project is to prevent the wastage of steel and to finish the project in the most economical way as possible. Reducing the scarp and the cut-off lengths which occur while working with steel will minimize extra demands of steel and its wastage. By minimizing the wastage of steel, it indirectly reduces the cost of the project. To fulfil the objective of the project, we are making the use of an excel program known as "Bar bending schedule".

III. SCOPE OF STUDY

In today's time importance is given in completing the project efficiently with minimum cost and wastage of materials. This excel program helps us to pace up with this requirement.

In the field of civil engineering importance is given to practical field knowledge rather than theoretical book knowledge. This project will introduce us to practical field work which goes on in construction of a project. Through this project, the required field experience is achieved. This project will introduce us to a new program for creating an optimized bar bending schedule which will be beneficial in future.

IV. METHODOLOGY



Methodology Flow Chart

1. Comparing the architectural and structural drawings of the respected floor of the residential building

The architectural drawings and structural drawings are compared and thoroughly studied. After examining both drawings and bar bending schedules, if faced any difficulties the field engineer and have dialogue with design engineer.
Reinforcement drawings are revised several times because of technical errors as well as human errors. Such changes may affect speed and the cost of construction. Hence the number of revisions should be reduced.

2. Determining the shape codes and cutting length constituting of individual component (beam, slab, column)

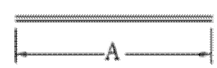
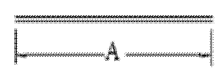
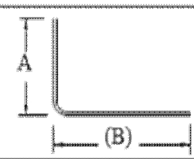
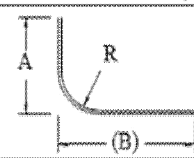
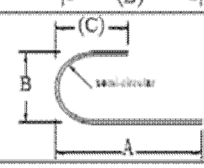
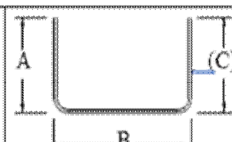
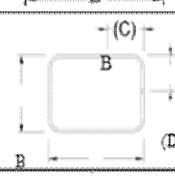
The shape code and cutting length are determined of all the individual components such as beams, columns, slab. The shape codes are given in "BS 8666:2005 Scheduling, dimensioning, bending and cutting of steel reinforcement for concrete."

Cutting Length:

We must remember than steel is ductile in nature and is subject to elongation. Hence, the length of a bar is increased when bends or hooks are introduced. Hence, certain deductions are needed to offset this increase in length.
Cutting Length = True Length of a bar – Deductions

The schedules of beam, slab and column is referred for the number of bars and then the shape code is determined. The next step is to calculate the cutting lengths.

Table-1:- Shape codes

Shape Code	Shape Diagram	Total Length of Bar, L measured along centre line
00		A
01 New		A Stock Lengths See Note 4.
11		A+(B)-0.5r-d Neither A nor B shall be less than P in Table 2.
12		A+(B)-0.43R-1.2d Neither A nor B shall be less than P in Table 2 nor less than (R+6d).
13		A+0.57B+(C)-1.6d B shall not be less than 2(r+d). Neither A nor C shall be less than P in Table 2 nor less than (B/2+5d) See Note 3.
21		A+B+(C)-r-2d Neither A nor (C) shall be less than P in Table 2.
New 51		L=2A+B+max(21d, 240) 2(A+B+(C))-2.5r-5d (C) and (D) shall be equal and not more than A or B nor less than P in Table 2. Where (C) and (D) are to be minimised the following formula

3. The shape code, diameter, cutting length and number of bars of each element is filled in the Excel BBS program

The shape code, diameter, cutting length and number of bars of each element calculated is filled in the Excel BBS program. The data is entered in proper order and then the cutting length is obtained. All the shape codes of beams, column, slab is inserted in the excel program. The cutting length is determined and the weight of the bars are obtained.

Table-2:- Data input excel sheet

1			BBS Ref:																
2	Serial No	Sorted Order	Bar Mark	Description of Elements	ø of Bars	N0of Elmts	N0of Bars	Total №	Cutting length	Code	A	B	C	D	E	F	Shape	Weight (Kg)
3	1	325	B272	BMR CONT	T12	1	2	2 №	3810	200	608	2890	358				608 2890 358	6.767
4	2	326		TMR CONT	T12	1	2	2 №	3810	200	608	2890	358				608 2890 358	6.767
5	3	246		TER L	T16	1	2	2 №	1730	111	844	913					844 913	5.463
6	4	398		TER R	T12	1	1	1 №	1500	111	358	1163					358 1163	1.332
7	5	520		STIRRUPS	T8	1	17	17 №	1650	501	142	642	80				642 80 142	11.080
8																		
9	6	199	B68	BMR CONT	T16	1	2	2 №	3440	100	3444						3444	10.864
10	7	101		BER L+M	T20	1	2	2 №	3180	100	3180						3180	15.690
11	8	347		TMR CONT	T12	1	2	2 №	3210	100	3208						3208	5.701
12	9	32		TER L+M	T25	1	2	2 №	3080	100	3075						3075	23.747
13	10	521		STIRRUPS	T8	1	17	17 №	1650	501	142	642	80				642 80 142	11.080

4. The data is sorted accordingly by entering the command

The inserted data is sorted by entering the sorting command. The sorting command has 2 types- 1. The data is sorted according to the cutting length, 2. The data is sorted according to the bar bending. The (1) is selected as the goal of this project to minimise the scrap and get optimised use of the available steel.

Table-3:- Sorted data excel sheet

1			BBS Ref:															
2	Serial No	Sorted Order	Bar Mark	Description of Elements	ø of Bars	Sort Total	No.	Cutting length	Code	A	B	C	D	E	F	Shape	Weight (Kg)
3	173	1		TER L+M	T32		2 №	3020	100	3015						3015	38.149
4	381	2	B106	BMR CONT	T25		3 №	8370	100	8370						8370	96.799
5	29	3	B271	BMR CONT	T25		2 №	8340	200	1375	5730	1375				1375 5730 1375	64.301
6	358	4	B87	BMR CONT	T25		3 №	8270	200	1375	5660	1375				1375 5660 1375	95.643
7	294	5	B41	BMR CONT	T25		3 №	8240	111	925	7385					925 7385	95.296
8	463	6	B275	BMR CONT	T25		3 №	7780	200	1375	5170	1375				1375 5170 1375	89.976
9	179	7	B48	BMR CONT	T25		3 №	6300	111	1375	4990					1375 4990	72.860
10	190	8	B276	BMR CONT	T25		3 №	5170	100	5170						5170	59.791
11	170	9	B62	BMR CONT	T25	4	2 №	4570	111	1375	3265					1375 3265	35.235
12	172	10		TMR CONT	T25		2 №	4570	111	1375	3265					1375 3265	35.235
13	530	11	1	CB1,CB53	T25	322	8 №	4220	100	4220						4220	130.145

5. The sorted data is optimised which gives us the resultant optimised Bar Bending Schedule for a floor

The optimised command is given after the data is sorted. The optimised bar bending schedule is obtained for that floor. This schedule obtained contains scrap and off-cuts. This is the final rebar sheet according to which the contractor can commence the respected project. The scrap obtained should be well within the limits. The limit for scrap production of a given floor is 1%.

Table-4:- Optimized data excel sheet

1	BBS Ref:								
2	Dia	Length	Nos	Cut Lengths. (Read this list together with sorted BBS to correlate with BBS.)			Scrap	Off-cut	
3	32	12000	1	3020	3020		0	5960	2
4	25	12000	3	8370	3280		350	0	6
5	25	12000	1	8340	3280		380	0	2
6	25	12000	1	8340	3270		390	0	2
7	25	12000	1	8270	3270		460	0	2
8	25	12000	2	8270	3080		650	0	4
9	25	12000	2	8240	2910		850	0	4
10	25	12000	1	8240	2030		0	1730	2
11	25	12000	3	7780	4220		0	0	6
12	25	12000	3	6300	5170		530	0	6
13	25	12000	2	4570	4570		0	2860	4
14	25	12000	159	4220	4220		0	3560	318
15	25	12000	1	4220			0	7780	1
16	20	12000	2	10640	1160		200	0	4
17	20	12000	6	10640	1100		260	0	12
18	20	12000	8	10640			0	1360	8
19	20	12000	5	7780	4220		0	0	10
20	20	12000	4	7690	4220		90	0	8
21	20	12000	2	6020	5230		750	0	4
22	20	12000	1	5230	5230		0	1540	2
23	20	12000	1	5230	4880	1750	140	0	3
24	20	12000	1	4880	4880	2210	30	0	3
25	20	12000	1	4880	4220	2540	360	0	3
26	20	12000	4	4220	4220	3530	30	0	12

V. CASE STUDY

Introduction:

The analysis was to be conducted on a 15-floored residential project of Paranjape Schemes (Construction) Ltd named Swapna Samrat.

Fig-1 Swapna Samrat

About Swapna Samrat

Swapna Samrat, is a project of 41 limited edition 2 & 3 BR homes. Located on Karve Road, the project offers amenities like a rooftop swimming pool and intricately designed landscaped garden.

It constitutes 2 symmetrical wings, A and B, each of which is 15 a storeyed residential building. Every alternate floor provides the same architecture providing a distinct odd and even architecture.

Introduction to BBS module

Many methods have been introduced to control the wastage of steel. On such method is preparing an optimised cutting length sheet by use of the BBS module.

Information about the BBS Module:

Product name: BAR BENDING SCHEDULE PROGRAM IN MICROSOFT EXCEL.

Version: 4.3.

Developed by: Shivaprasad Sreedhara Panicker.

Official website: www.BendingSchedule.com

Bar bending schedule is used to communicate the design requirement of reinforcement steel to the fabricator and execution team and to enumerate the weight of each size of steel. It is a list of reinforcement steel bars, which includes size and number of bars, cutting length of bars, weight of steel and a sketch representing the shape of bar to be bent. Generally, civil engineers who are familiar in RCC structure are employed to prepare Rebar bending schedule. When compared to common quantity take offs, preparation of Rebar schedule needs excessive time for calculation. These calculations include cutting length, deduction of bend allowance within cutting length and summary of weight of each size separately.

In this program, all calculations are done automatically, besides it generates a real dimensional shape of the bar. Dimensions demonstrated in the shapes are linked to bar bending data. Any changes in the bar bending data will be reflected in the cutting length, weight of steel and dimension within the demonstrated shape picture.

VI. RESULT

Table-5:- Result table for the optimized rebar sheet of the second (even) floor.

Summary	Less than length 40 X diameter is considered as scrap						
Dia	Unit Wt	Stock Weight	Finish Weight	Scrap Weight	Off-cuts Weight	% Scrap	% Off-cuts
32	6.32	76	38	0	38	0.0%	98.7%
25	3.86	8281	6013	26	2241	0.4%	37.3%
20	2.47	24334	17666	27	6642	0.2%	37.6%
16	1.58	3752	3461	20	271	0.6%	7.8%
12	0.89	2110	1994	13	103	0.7%	5.2%
10	0.62	496	461	6	29	1.3%	6.4%
8	0.4	11267	11243	23	1	0.2%	0.0%
Overall		**50315**	**40875**	**115**	**9326**	**0.3%**	**22.8%**

Terminologies:

1. Off cuts are the lens which remain from the main steel bar of 12 meter after the required cutting length is cut from them. Off cuts can be used for some other member if required.
2. Scrap is the useless portion of the 12-m long steel bar after the cutting length of the required section is cut from it. (Length < 40*dia)

Result:

1. The scrap percentage of this floor is 0.3 %. This is well within the permissible limit which is 1%.

2. The weight of steel to be ordered for one floor is 50,315 tonnes. As all the even floors are built structurally and architecturally same, the weight of steel require for all the even floors is the same. Therefore theoretically, the weight of all the even floors which are 7 in number out of the total 15 floors is 7*50315= 3,52,205 tonnes.

Discussion:

1. As steel falls in the A category of the materials, the organisation needs to hose an appropriate order pattern to avoid excess capacity. The most common and efficient method used is JIT (Just in Time) technique. Just in Time is an inventory strategy companies employ to increase efficiency and decrease waste by receiving goods only as they are needed in the production process, thereby reducing the inventory cost. Therefore, the estimation of weight of steel required and the scrap generated is

removed separately for every floor and not the whole building itself. The rebar sheet is prepared for the floor which is to be constructed and the weight of the steel is ordered accordingly.

2. As the module uses permutation and combination to derive numerous combinations for all the cutting lengths of the floor, if rebar is prepared for a building as a whole the scrap value will reduce drastically to less than 0.1% as the possibilities of combinations increases many folds. But as the total steel required for the entire building cannot be ordered at once for numerous reasons one of which being the storage capacity of the site, the materials are ordered in batches floor wise.

VII. CONCLUSION

1. There is considerable profit gained in the total cost of the project because of the optimized use of steel. Optimization of steel reduces its wastage and thus avoids overuse of steel. This reduces the total cost of project.
2. A systematic process can be adopted for the cutting of steel unlike the traditional times where the steel bars were haphazardly cut and utilized. This becomes possible because of the optimized rebar sheet prepared using the BBS module.
3. Use of BBS module gives optimized output in comparatively less time. This does not affect the main schedule of the project.
4. It helps to optimize the data communication from engineer to the contractor and the contractor to his employees. This ensures the operation to be carried smoothly and leaves no space for miscommunication.
5. The BBS module is used along with Just in Time Technique to obtain 100% benefit in respective project.

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