

# APPLICATION OF COST ESTIMATION METHOD FROM WORK BREAKDOWN STRUCTURE

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**Abstract:** In every civil engineering project, whether it is residential, commercial, industrial, etc., cost estimation remained very challenging. Authors consider a Method of Cost Estimation from Work Breakdown Structure, which is developed, for software engineering projects. Method procedure is to prepare Work Breakdown Structure (WBS) as per given instruction aligning with Responsibility Assignment Matrix (RAM) then calculation of the duration of the processes and giving them the cost per hour or fixed cost. In this paper, the same method is applied for the Cost Estimation of the Civil Engineering Industrial Project. Work Breakdown Structure is prepared with great concern and have almost similar characteristics, which is asked in the method. We also discuss the suitability of the method in the Civil Engineering Industrial Project and limitation of the method, if any, with respect to the selected project type.

**Index Terms - Work Breakdown Structure; Responsibility Assignment Matrix; Cost Estimation; Scheduling; Project Management.**

## I. INTRODUCTION

Cost Estimation and schedule preparation is very much essential for the success of the project. Especially in Construction Projects civil, mechanical, electrical, etc. works have to be carried out simultaneously. Which makes this type of projects more complex. In addition, the high uncertainty of these projects make managers to look project plan with extreme care.

Cost Estimation is generally done by the probabilistic approach or the deterministic approach. In probabilistic approach is applied when the information available is very less and uncertainty exists in the estimation of the project. In this type of process, the simulation process is done on collected data to achieve accuracy in the result. The deterministic approach is applied when realistic data available of similar projects to create detailed estimate. Historical data with the combination of the professional experience gives more accurateness to the estimate.

To prepare cost estimate, Work Breakdown Structure is very helpful tool to get accuracy. A well detailed Work Breakdown Structure is must in acquiring higher accuracy. Work Breakdown Structure needs team effort. Project managers must have experience and need to follow the guidelines to prepare a good Work Breakdown Structure. A well-detailed Work Breakdown Structure will impact drastically positive in success of any project.

I am considering a Method of Cost Estimation from Work Breakdown Structure, which is developed, for software engineering projects. Here, the same method is applied for the Cost Estimation of the Civil Engineering Industrial Project to check whether it is appropriate for it or not. In this method, Work Breakdown Structure is made as per the given instruction in the literature. This Work Breakdown Structure is then combined with the Responsibility Assignment Matrix. Then it is transformed into duration Responsibility Assignment Matrix (RAM<sub>t</sub>) and then it is converted into cost estimation Responsibility Assignment Matrix (RAM<sub>§</sub>). [2]

### 1.1 Problem Statement

Every project is expected to complete within stipulated time and cost. High uncertainty in construction projects demands decent project plan and to prepare a project plan a well detailed work breakdown structure is must.

### 1.2 Scope of Project

Project purpose is to get the precision in cost estimation of construction project by applying simple method from Work Breakdown Structure.

### 1.3 Objectives

- Prepare a work breakdown structure of a construction project as per simple method.
- To Explore the suitability of the method in construction project.

## II. LITERATURE REVIEW

Sergio Sequeira and Eurico Lopes (2015) introduced stream lining procedures from project work breakdown structure (WBS) evaluating the duration processes and either the input cost hour or the fixed costs. The measures are made via hypothesis testing over the responsibility assignment matrix (RAM). Authors propose a method for project cost construction using a spreadsheet to create an early-stage budget allocation. In this paper they argue that the simulated cost results present superior accuracy while establishing the

applicability of the proposed simulation procedure. Generally, the precision is related with the WBS detailed design. The cost methodology approach offers a simplified decision tool for assessing the construction cost on the project managers' decision. They proposed methodology allows project managers to make quantitative estimates of costs with a qualitative approach using the RAM project environment. This approach also helps to improve the learning of organizational management. Finally, the use of responsibility matrix where the roles of functions are changed to an estimate of time and subsequently cost estimation / contracts provides a simple method to estimate all costs where other design characteristics are also easily accommodated.[2]

T. Rajani Devi and V.Shobha Reddy (2012) outline the importance of work breakdown structure in project's life cycle and timeline. WBS is created for the accuracy in project organization, assigning responsibility, showing control points and milestones. Accuracy in estimation of cost, schedule and risk, define scope of the project very well. WBS is the hierarchical distribution of all the elements of the project done to manage and control whole project by dividing it into smaller work packages. Work packages are broken down to the small chunks. Chunk sizes are depending upon the project type and management style. It is the final product of WBS. Size of chunks are generally determined by 8/80 rule or two weeks rule [3].

Jones, Charles (2008) has discussed the preparation of WBS for the scheduling of the project in his paper. In preparing the WBS, activity list, estimates etc will obviously be prepared by the team. Therefore, the importance of the same level of understanding of project team as project manager is highly required. So project manager will highly dependent on the team and vice versa. Therefore, project team has to have deep knowledge of the development steps of prepared schedule. Methodology described in preparing the estimates as: 1.Understanding the basics. 2. Creating the WBS. 3. Define the activities. 4. Identifying the predecessors. 5. Estimate the duration. 6. Identifying critical path [4].

Youngsoo Jung and Sungkwon (2004) proposed a flexible work breakdown structure (WBS) that optimizes the overhead effort by means of reducing the amount of data to be controlled. In order to have a flexible structure, the WBS numbering system needs to utilize standard classification codes and should not have a common strict hierarchy for all components. A case study is analyzed in this paper in order to examine the proposed concept. Practical implications are outlined as well. The proposed method is more suitable for general contractors who have to manage their own laborers, materials, subcontractors, and equipment, because it is generally true for general contractors that many different types of data from many different organizations should be controlled in an integrated way. However, the concept of flexible WBS can be applied to all project participants, including owners, construction managers, architects, and sub-contractors, for their own effective integrated cost and schedule control under any type of contract [5].

Shlomo Globerson (1994) has said that to manage the project proper there is a need to have a work breakdown structure. He considered WBS as the taxonomy of the project. In paper, he has discussed the impact of different type of WBS generated by different people on the project. He has explained his point by using different type of WBS of a restaurant project. What should be the size of work package is also considered. Impact of project manager on the WBS is very high as he is the in-charge of the project. Importance of the coordination between WBS and OBS is essential in the success of the project. Work packages should be coded correctly so everyone on site can understand the WBS properly. WBS is the fruit of the group efforts, as it cannot be done by a single person [6].

H. W. Lanford and T. M. McCann (1984) had designed article to make planning managers aware of a concept and practice that offers great promise of assisting in the development of plans, particularly budgets, and allowing improved visibility in the control phase. The work breakdown structure (WBS) concept pinpoints individuals and organizations responsible for budget preparation in large and complex organizations and provides the management team with information on responsibility, costs and schedules. This article has discussed the work breakdown structure concept of control. By reducing an end item to its basic components, bits and pieces, it has been shown how the workbox concept facilitates the preparation of budgets, the assignment of responsibility, and generally assists in both the planning and control of projects or systems. In addition to facilitating planning and control, the work breakdown structure adds visibility in the achievement of project objectives by enabling determinations of completion dates, costs, past performance indices, and the level of performance effectiveness necessary to complete work within budget restraints. The work breakdown structure has been widely applied in military acquisitions and is receiving increasing attention in the civilian sector. Parts of the work breakdown structure are being applied as the earned value concept. The advantages of the work breakdown structure concept make the concept a very attractive managerial tool [7].

### III. RESEARCH METHODOLOGY

Essential literatures relating to work breakdown structure, estimate schedule and cost in construction industry were reviewed in order to determine the significance of cost estimation and schedule preparation for construction projects.

Data collection is done by the interview of on field personnel having enough experience in their respective fields and by the on-site observation. Table-1 shows the respondents whose interview is taken while collecting the data for the Work Breakdown Structure.

Table 1 Respondents and Their Experience

Sr no	Interviewed Person	Experience
1	Project Manager	17+ Years
2	Project In charge	13+ Years
3	Planning Engineer	9+ Years
4	Senior Engineer	8+ Years
5	Site Engineer	3+ Years
6	Billing Engineer	5+ Years

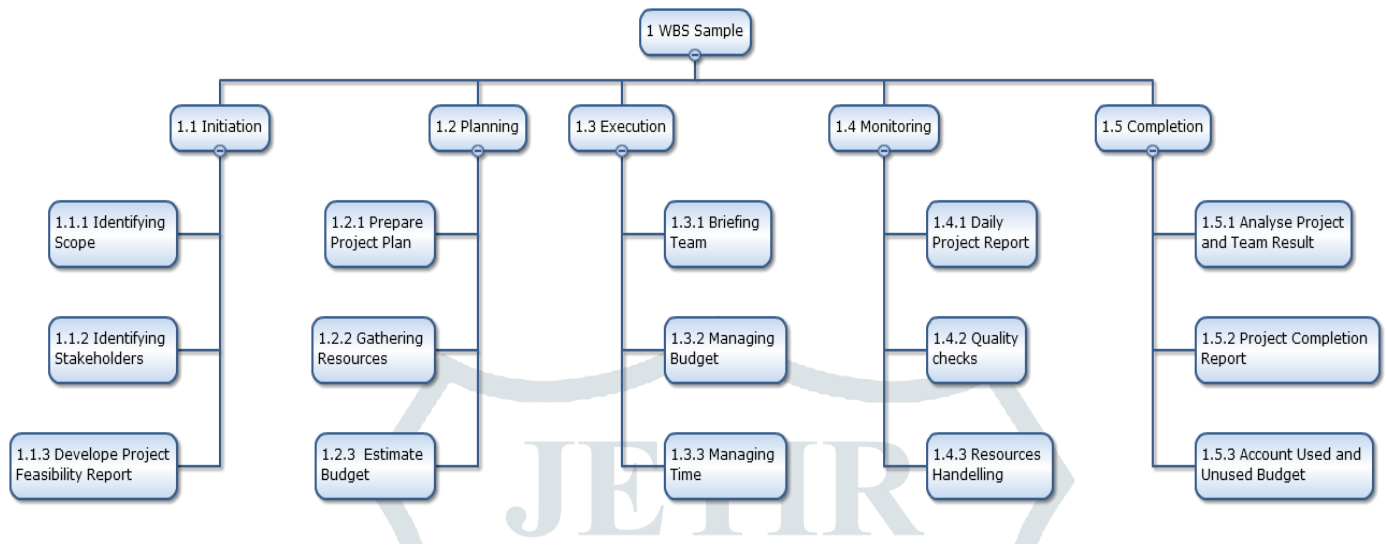
### 3.1 Methodology



**IV. DATA COLLECTION AND ANALYSIS**

**4.1 Work Breakdown Structure**

The Project Management Institute defines the WBS as, "Representing the sum total decomposition of all work that the project encompasses, from beginning to end." [1] A complex project is made manageable by first breaking it down into individual components in a hierarchical structure, known as the work breakdown structure, or the WBS.



**Fig. 1 Work Breakdown Structure**

Some widely used reasons for creating a WBS include:

- Assists with accurate project organization
- Helps with assigning responsibilities
- Shows the control points and project milestones
- Allows for more accurate estimation of cost, risk and time
- Helps explain the project scope to stakeholders

In this paper, authors have prepared the work breakdown structure by following Rolling Wave Project Planning Method. WBS is divided into three layers as shown in figure 1. These three layers are general for every construction project.

**4.2 Responsibility Assignment Matrix**

A Responsibility Assignment Matrix (RAM) describes the participation by various organizations, people and roles in completing tasks or deliverables for a project. It is especially useful in clarifying roles and responsibilities in departmental projects and processes.

In this paper, Authors have prepared Responsibility Assignment Matrix (RAM) by aligning it with Work Breakdown Structure (WBS). In RAM, Different responsible authorities are assigned for each work package as shown in figure 2.

While preparing the RAM letter such as P, A, R, I and S are used to assign the responsibility to work packages, which describes the role of that responsible person. The nomenclature used while preparing the RAM is indicated in PMI [1]. Table-2 shows the details of it.

Table 2 Corresponding Function to RAM Letter : Standard PMI [1]

RAM Letter Abbreviation	Function	Meaning
P	Participant	Usually a meeting
A	Accountable	Must be consulted
R	Review Required	Responsible for the Execution
I	Input required	Must provide Information
S	Sign-off Required	Approval Responsible

WBS	Roles														
	Owner	Project Coordinator	Project Manager	Planning Engineer 1	Planning Engineer 2	Junior Engineer 1	Junior Engineer 2	Store Incharge	Quality Engineer	Accountant	R/F Contractor	Concreting Contractor	Shuttering Contractor	Excavation Contractor	
1 Initiation	S	I	A	R											
1.1 Identifying Scope		I	A	R	R										
1.2 Identifying Stake holders		R	P												
1.3 Develop Project Feasibility Report		I	A	R	R										
2 Planning		A	I	R	R										
2.1 Prepare Project Plan	S	I	I	R	R										
2.2 Gathering Resources		I	R												
2.3 Estimate Budget		A	A	R	R										
3 Execution		S													
3.1 Briefing Team		I	R	P	P	P	P	P	P	P					
3.2 Work Execution		S			A	R	R	P		I					
3.3 Managing Time and Cost		S		A		R	R	P							
4 Monitoring		S	A			P									
4.1 Daily Project Report				R	R										
4.2 Quality Checks			S			A			R						
4.3 Resources Handelling			A	R											
5 Completion	S														
5.1 Analyse project and Team Result		I	R	P	P										
5.2 Project Completion Report			R	R	R	P	P								
5.3 Account Used and Unused Budget	S									R					

Fig 2 Responsibility Ssignment Matrix

4.3 Estimation of Time Duration

Every work package will need some time to complete. Project manager will assign time to responsible person. In this time, that work package should be completed.

Every work package is given a time duration, which requires to complete the work package. Time is allotted discussing with project manager and planning engineer who have vast experience in their respective field. Somewhere I used historical data of similar projects as well.

WBS	Roles														
	Owner	Project Coordinator	Project Manager	Planning Engineer 1	Planning Engineer 2	Junior Engineer 1	Junior Engineer 2	Store Incharge	Quality Engineer	Accountant	R/F Contractor	Concreting Contractor	Shuttering Contractor	Excavation Contractor	
1 Initiation	1h	1h	2h	16h											
1.1 Identifying Scope		4h	8h		16h										
1.2 Identifying Stake holders		4h	4h												
1.3 Develop Project Feasibility Report		4h	8h	16h											
2 Planning		8h	8h	24h	24h										
2.1 Prepare Project Plan	1h	4h	8h	24h	24h										
2.2 Gathering Resources		4h													
2.3 Estimate Budget		2h	2h	16h	16h										
3 Execution		1h													
3.1 Briefing Team		2h	4h	4h	4h	4h	4h	4h	4h	4h					
3.2 Work Execution		2h			4h	48h	48h			4h					
3.3 Managing Time and Cost		2h		4h											
4 Monitoring		1h	1h			1h									
4.1 Daily Project Report				2h	4h										
4.2 Quality Checks			1h			1h			4h						
4.3 Resources Handelling			2h	4h				2h							
5 Completion	1h														
5.1 Analyse project and Team Result		8h	8h	2h	2h										
5.2 Project Completion Report			16h	16h	16h	16h	16h								
5.3 Account Used and Unused Budget	1h									8h					
<b>Duration Time</b>	<b>4</b>	<b>51</b>	<b>73</b>	<b>128</b>	<b>110</b>	<b>70</b>	<b>68</b>	<b>6</b>	<b>8</b>	<b>16</b>					

Fig 3 RAM Changed to Duration Time Estimation - RAMt

From Fig-3, we can see that each work packages have time duration and responsibilities assigned. Now hourly cost of those personnel is calculated and multiplied it with the total numbers of hours they have worked. Calculation of that is shown in Fig-4.

WBS	Roles															TOTAL
	Owner	Project Coordinator	Project Manager	Planning Engineer 1	Planning Engineer 2	Junior Engineer 1	Junior Engineer 2	Store Incharge	Quality Engineer	Accountant	R/F Contractor	Concreting Contractor	Shuttering Contractor	Excavation Contractor		
Hourly Cost (INR)		500	300	200	200	100	100	80	100	130	304896.9	194768.6	53175.2	110900.4		
Duration Time	4	51	73	128	110	70	68	6	8	16						
Estimated Cost	0	25500	21900	25600	22000	7000	6800	480	800	2080	304896.9	194768.6	53175.2	110900.4	<b>775901.083</b>	

Fig 4 Project Cost Estimation

Hence, we get the total estimated cost for the project by the following formula,



$$\text{Cost Estimation} = \text{Hour Estimation Cost} \times \text{Duration Time} \quad (4.3.1)$$

Fig-3 shows the Duration Responsibility Assignment Matrix (RAMt) and Fig-4 shows the total project cost.

## V. CONCLUSION

For the successful running and completion of the project, proper methodologies are must. Cost Estimates and schedule preparation is done at pre-construction stage. Ultimately, accuracy in these estimates gives idea to the stakeholders to arrange and manage the finance. Estimation of schedule and cost becomes challenging at pre-construction stage. Most of the project face difficulties if these are not done well.

Method used in this paper for the cost estimation is very effective and gives more accuracy. But it will depend upon the preparation of the Work Breakdown Structure. Higher the accuracy in WBS will enhance the accurateness of the estimates. This method uses Work Breakdown Structure with Responsibility Assignment Matrix. This will give you the cost of working personnel only. So, in civil engineering projects, a separate BOQ should be prepared for the material cost and equipment cost. By one method, we can get both cost estimation as well as schedule of the project.

## VI. SUGGESTIONS

- Work Breakdown Structure Should be as detailed as possible.
- A separate BOQ will be needed for cost of materials and equipment.

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