

## RATE ANALYSIS AND BUDGETING OF ROAD PAVEMENT

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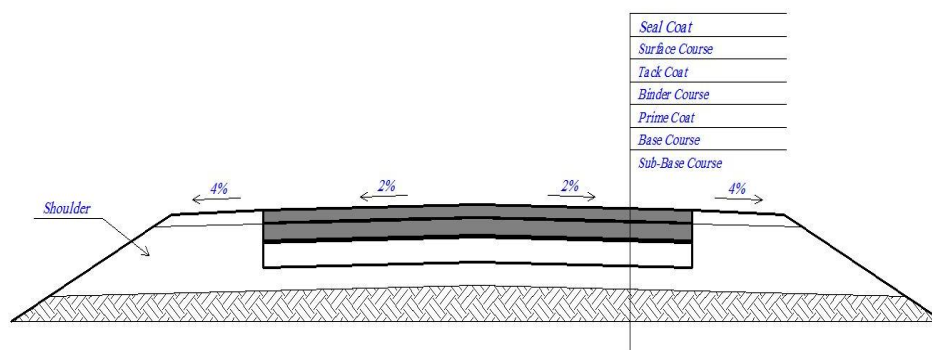
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**Abstract-** Pavement of road is important for its complexity and cost. Rate analysis and budgeting are parts of construction management, prepared by project managers in the planning phase for controlling and reporting of cost overrun and underrun. Rate analysis and budgeting are challenging tasks for construction project managers. Road pavement work often faces delay and cost overrun due to inaccurate rate analysis and allocated budget. Objective of this term paper is accuracy in rate analysis and allocation of budget for road pavement. Analysis of rates and budgeting are prepared based on scope of work, design, specification, updated rates, availability of resources and factors affecting them. In this paper, the information is collected about required documents, tools and techniques for analysis of rates and budgeting, factors affecting rate analysis and budget, and methods of Analogous Cost Estimation, Parametric Cost Estimation, Bottom-up Cost Estimation and Three point Cost Estimation. Bottom-up Cost Estimation method is good practice for accurate rate analysis and budgeting of road pavement work.

**Keywords—** Road Pavement, Rate Analysis, Budgeting, delay, Cost Overrun

### I. INTRODUCTION

Pavement work is important part of road construction project for its complexity and Cost than other works of the project. There are two basic types of pavements. Flexible Pavements consisting of various layers of granular materials and provided with a layer of bituminous materials (PC) on top and Rigid Pavement consisting of a cement concrete pavement laid on a well prepared granular sub base. This research paper [1] is about rate analysis and budgeting of flexible pavement (hot mix asphalt surface). The purpose of the term paper is discussion on accuracy in rate analysis and budgeting of road pavement work. Road pavement work is important part in the road construction project, because of its complexity and cost. Rate analysis and budgeting is crucial for road pavement to prevent delay and cost overrun. Typical layers of a conventional flexible pavement (Fig 2) includes seal coat, surface course, tack coat, binder course, prime coat, base course and sub-base course. [2]



*Fig. 1: Typical Layers of Flexible Pavement of Road*

The determination of rate per unit of a particular item of work, from the cost of quantities of materials, the cost of labourers and other miscellaneous petty expenses require for its completion is known as the analysis of rate [3]. Cost estimation is an essential component of infrastructure projects. Accurate estimation will assist project managers to choose adequate alternatives and to avoid misjudging of technical and economic solutions Major difficulties which arise while conducting cost estimation during the conceptual phase are lack of preliminary information, lack of database of road works costs, and lack of up to date cost estimation methods [4].

Additional difficulties arise due to larger uncertainties as result of engineering solutions, socio-economical, and environmental issues. Budgeting is the process of aggregating the estimated costs of individual activities or work packages to establish an authorized cost baseline [5].

## II. LITERATURE REVIEW

Sodiko (2005) discussed that during cost estimation of highway, major problems faced are lack of preliminary information, lack of database of road works costs, missing of data, lack of an appropriate cost estimation methods, and the involvement of uncertainties. The models of Road Construction Cost (RCC), Multiple Regression (MR), and Artificial Neural Network (ANN) were discussed. In conclusion, ANN could be an appropriate tool to help solve problems which come from a number of uncertainties such as cost estimation at the conceptual phase. NRRD India [1] discussed cost analysis of Cement Concrete Roads and Asphalt (Bituminous) Roads. The topics of Types of road pavement, Initial Cost, Maintenance Cost, Life Cycle Cost Analysis and per Km Cost Estimation of both types of pavement were discussed [4].

Shaikh (2013) discussed in his thesis to predict the parametric cost estimation in construction building projects in Gaza Strip using Fuzzy Logic Model. Fuzzy Logic Model was developed to predict the parametric cost estimation. It is a computerized system which uses MATLAB program as a tool box. The results revealed the ability of Fuzzy Model to predict cost estimate to an acceptable degree of accuracy reached to 88%. The fuzzy logic model will provide more accurate estimates, save time, minimize error, and hopefully to have better chance to win bids [6].

DRISI (2017) investigated best practices for cost estimating, including improved the methods for determining both capital and support costs. Capital costs include the costs of construction, and support costs include preconstruction costs for such tasks as design and surveying, as well as maintenance costs throughout the life cycle of a facility. The complete essential and specific required document for accurate rate analysis and budgeting of road pavement works, were not obtained from the papers, therefore some relevant personnel experience or observations discussed in the form of figures and tables [7].

### A. UNIT OF MEASUREMENTS

Before starting rate analysis and budgeting, it is important to modify unit for item of the work. Each unit used in measurements (such as staff hours, staff days, or weeks for time measures; meters, liters, tons, kilometers, or cubic yards for quantity measures; or lump sum in currency form) is defined for each of the resources [5]. The method of measuring work performed under a contract deserves serious consideration. The most common method is by unit cost, which breaks work down by quantity or time, while other methods include lump sum and force account. Lump sum is an amount the department agrees to pay the contractor for completing the prescribed work, regardless of the actual effort. Force account is paid based on the actual labour, equipment and materials needed to complete the prescribed work plus profit and overhead.

### B. REQUIREMENTS

For the purpose of analysis, the details about all the operations involved in carrying out the work should be available. The amount and type of additional details supporting the cost estimate vary by application area. Regardless of the level of detail, the supporting documentation should provide a clear and complete understanding of how the cost estimate was derived. Applicable agreement information and costs relating to products, services, or results that have been or will be purchased are included when determining the budget.

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Supporting detail for cost estimates may include:

- Documentation of the basis of the estimate (i.e., how it was developed),
- Documentation of all assumptions made,
- Documentation of any known constraints,
- Documentation of identified risks included when estimating costs,
- Indication of the range of possible estimates (e.g., US\$10,000 (±10%) to indicate that the item is expected to cost between a range of values), and
- Indication of the confidence level of the final estimate. [5]

**C. ELEMENTS OF RATE ANALYSIS**

The calculation of equipment or labour are required to execute unit amount of an item of work, these things are required for the purpose of eliminating cost of construction, material planning, labour and equipment allocation in the scheduling etc. Obtaining the cost of unit amount of an item is called *rate analysis* (Fig 2). To obtain the rate of an item, generally the cost of material, cost of labour, cost of equipment, plant tools etc., overhead cost and profit are considered.

Rates include direct and indirect cost estimates of materials, labor, equipment, engineering, support staff, insurance, bonds, taxes, allowances, contingencies, and profit [6]. Overhead costs include general office expenses, rents, taxes, supervision and other costs are indirect expenses and not productive expenses on the job. A reasonable profit, usually 10% for the contractor is also included in the analysis of rate. Total direct cost of material, labors and equipment calculated and 1% for water charges and total of 15% for overhead and net profit added to the direct cost for all work items.

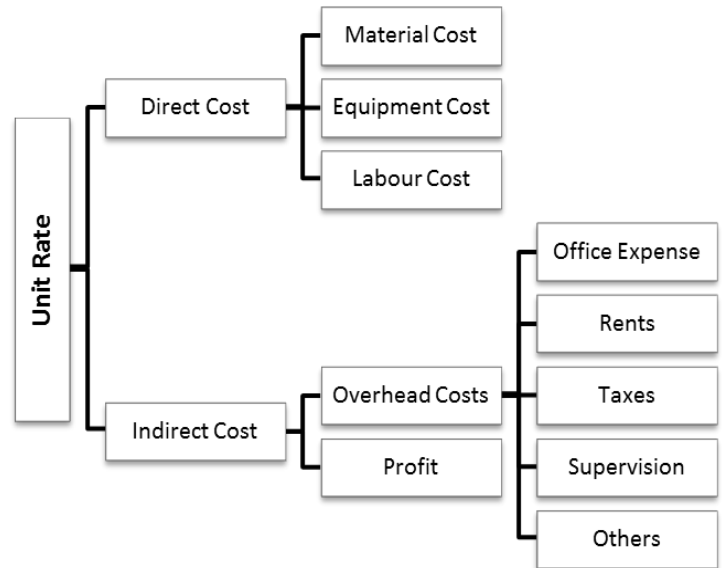


Fig. 2: Elements of Rate Analysis [6]

**D. BUDGETING**

Determine Budget is the process of aggregating the estimated costs of individual activities or work packages to establish an authorized cost baseline. The key benefit of this process is that it determines the cost baseline against which project performance can be monitored and controlled. Cost estimation, project schedule, and risk register are essential to be provided before allocation of budget. [5].

At various stages in the project management, we need to know how much is cost of executing unit amount of the work.

- Requirements for budgeting are:-
- Work Breakdown Structure (WBS)
- Project Contract or initial budget
- Resource Requirements
- Resource cost estimate
- Activity duration estimation
- Historical information
- Market conditions
- Donor and organization policies
- Chart of accounts structure (COA). [8]

**III. METHODS OF RATE ANALYSIS AND BUDGETING**

AASHTO's Cost Estimating covers conceptual (parametric) estimating, historical bid-based estimating, cost-based estimating and risk-based estimating. These are explained tools and techniques and method of rate analysis as below [5, 7]:

#### A. EXPERT JUDGMENT

Expertise should be considered from individuals or groups with specialized knowledge or training in the following topics:

- Previous similar projects;
- Information in the industry, discipline, and application area; and
- Cost estimating methods.

#### B. ANALOGOUS COST ESTIMATING

Analogous cost estimating uses values, or attributes, of a previous project that are similar to the current project. Values and attributes of the projects may include but are not limited to: scope, cost, budget, duration, and measures of scale (e.g., size, weight). Comparison of these project values, or attributes, becomes the basis for estimating the same parameter or measurement for the current project.

#### C. PARAMETRIC COST ESTIMATING

Parametric estimating uses a statistical relationship between relevant historical data and other variables (e.g., square footage in construction) to calculate a cost estimate for project work. This technique can produce higher levels of accuracy depending on the sophistication and underlying data built into the model. Parametric cost estimates can be applied to a total project or to segments of a project, in conjunction with other estimating methods.

#### D. BOTTOM-UP COST ESTIMATING

Bottom-up estimating is a method of estimating a component of work. The cost of individual work packages or activities is estimated to the greatest level of specified detail. The detailed cost is then summarized or “rolled up” to higher levels for subsequent reporting and tracking purposes. The cost and accuracy of bottom-up cost estimating are typically influenced by the size or other attributes of the individual activity or work package.

#### E. THREE POINT COST ESTIMATING

The accuracy of single-point cost estimates may be improved by considering estimation uncertainty and risk and using three estimates to define an approximate range for an activity’s cost:

- Most likely (*cM*). The cost of the activity, based on realistic effort assessment for the required work and any predicted expenses.
- Optimistic (*cO*). The cost based on analysis of the best-case scenario for the activity.
- Pessimistic (*cP*). The cost based on analysis of the worst-case scenario for the activity.

Depending on the assumed distribution of values within the range of the three estimates, the expected cost, *cE*, can be calculated using a formula. Two commonly used formulas are triangular and beta distributions. The formulas are:

- Triangular distribution.  $cE = (cO + cM + cP)/3$
- Beta distribution.  $cE = (cO + 4cM + cP)/6$

Cost estimates based on three points with an assumed distribution provide an expected cost and clarify the range of uncertainty around the expected cost. For detailed rate analysis of Sub-Base Course, Base Course, Prime Coat, HMA Binder Course, Tack Coat, HMA Wearing Course and Seal Coat the following spreadsheet can be used. The quantities and rates of materials, labours and equipment vary from place to place and therefore, the rates of different items of work also vary from place to place [3], therefore the Quantities of material, number of skilled and unskilled labours, and number of equipment couldn’t be specified in this spreadsheet (TABLE 1, 2)

Table 1: Particulars of Schedule of Unit Rate for Pavement Items [3]

<b>1. Direct Cost</b>									
<b>1.1. Construction material</b>						<b>1.2. Labors</b>			
No	Material	Unit	Qty.	Unit Rate	Amount	Labor Type	No	Daily Wage	Total Wage
1					0	Skilled Labor			0
2					0	Unskilled Labor			0
3					0				0
4					0				0
<b>Total Amount of Construction Material</b>					<b>0.00</b>	<b>Total wage of Labors</b>			<b>0.00</b>
<b>1.3. Equipment</b>									
<b>Machinery Rent</b>					<b>Fuel Consumption</b>				
No	Type of Machinery	No	Daily Rent	Total Rent	Daily Fuel/ Lit	Total Fuel Lit	Rate	Amount of Fuel	
1	Loader			0				0	
2	Dump Truck			0				0	
3	Grader			0				0	
4	Water Tanker			0				0	
5	Roller			0				0	
6	Low bed Truck			0				0	
	etc.			0				0	
<b>Total Amount of Rent</b>				<b>0.00</b>	<b>Total Amount of Fuel</b>			<b>0.00</b>	
<b>Total Direct Cost</b>									<b>0.00</b>
<b>2. Indirect Cost</b>									
Tax (%)		Supervision (%)			Travels (%)				
Office Expenses (%)		Rents (%)			Net Profit (%)				
<b>Total Indirect Cost</b>									<b>0.00</b>
<b>Total Unit Rate (Direct Cost + Indirect Cost) of Work Item</b>									
<b>Total Quantity of Work Item</b>									
<b>Total Amount of Work Item</b>									

Expenses of Construction material, Skilled/Unskilled Labours, Construction plants/equipment, and other indirect expenses are allocated monthly, based on work schedule. These expenses are different in each month.

Table 2: Sample Schedule of Summery of Budget [3]

No	Description	Monthly Expenses					Total Expenses
		M - 1	M - 2	M - 3	M - 4	M - n	
1	Construction Material						<b>0.00</b>
2	Skilled and Unskilled Labours						<b>0.00</b>
3	Construction Equipment Rent						<b>0.00</b>
4	Fuel Consumption						<b>0.00</b>
5	Maintenance of Equipment						<b>0.00</b>
6	Subcontractors and suppliers						<b>0.00</b>
7	Supervision						<b>0.00</b>
8	Monthly office expenses						<b>0.00</b>
9	Rents						<b>0.00</b>
<b>Total Monthly Expenses</b>		<b>0.00</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>

#### IV. FACTORS AFFECTING RATE ANALYSIS AND BUDGETING

Organizational culture and structure can influence cost management. Market conditions describe what products, services, and results are available in the regional and global markets. Currency exchange rates for project costs are sourced from more than one country [5]. The preparation of any type of cost estimate depends on the experience of the estimator, the tools used, the time spent, and the information available [6]. The rate of a particular item of work depends on the following:-

- Specification of works and materials, quality of materials, proportions etc.
- Quantity of materials and their rates, number of different types of labourer and their rates.
- Location of the construction site and its distances from the sources of materials and the rate of transport.
- Profits and miscellaneous and overhead expenses of contractor.
- Availability of construction material, labour and equipment.

The following factors affecting allocation of budget for road pavement activities.

- Construction schedule
- Method of payments received from client
- Organization’s policy, objectives and vision
- Key stakeholders for provision of information
- Project contract
- Market conditions
- Money exchange rates

#### V. CONCLUSIONS

The purpose of the paper is discussion on accuracy in rate analysis and budgeting of road pavement work. Road pavement work is important part in the road construction project, because of its complexity and cost. Rate analysis and budgeting is crucial for road pavement to prevent delay and cost overrun. More than 40 papers, journals, books and topics were searched and summarized in the literature review. From the research it concludes that for the accurate rate analysis and budgeting of road pavement works, it is important to have access to quantity estimation, detailed specification, updated rates of material and labours, software, and estimator’s skills. Units of measurements should be specified for each item of the work. Factors (Specification, Site location, Quantity of work, Availability of resources, profit, miscellaneous expense, and overhead), which influence the rate analysis and budgeting of the pavement work should be considered. For analysis of rates the methods of (1) Analogous Cost Estimating (2) Parametric Cost Estimating (3) Bottom-up Cost Estimating and (4) Three Point Cost Estimating discussed. Analogous Cost Estimating is based on the data of previous similar project. This method is not more accurate, because road construction projects are not similar in all aspects. Parametric Cost Estimating is based on square footage (area estimation). Bottom-up cost estimation method is detailed cost estimation of each component and activity of the works. This method is applicable and accurate for rate analysis of road pavement works. Allocation of budget is prepared based on the detailed cost estimation (bottom-up cost estimation). Budgeting helps the organization to plan upcoming expense. It controls and reports project expenses, cost overrun and underrun during the construction period. Required documents (WBS, work plan, unit rates, contracts, market conditions and donor and organization’s policies) are important to be available and factors have affects should be specified during budgeting.

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