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Comparison of Rate Analysis of Actual Project Vs CPWD, PWD (Maharashtra and Telangana) and Indian Railways for Excavation of Soft Rock

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ABSTRACT: In the construction industry, the frequent increase in labour, material, and equipment costs has resulted in an inflation and a huge delay in the completion of the project, which directly affects the cost and quality of the overall project. In terms of cost estimation, economic and financial analysis, performance analysis, project cost-benefit analysis, engineers and managers involved in urban planning projects have new challenges to address. The construction industry is a labour-intensive industry, with total construction costs accounting for 30–40 per cent of the labour costs, 50–80 per cent of the construction materials used and 10–20 per cent of the machinery (tools and plants) used in the field. Rate Analysis is carried out to determine the rate of a specific item. We have tried to compare the rate analysis and to identify the missing parameters that contribute to the inaccuracy of the rate analysis due to imprecise rate analysis and frequent changes in working conditions on site. A comparison of various organisations, such as the Central Public Works Department, the Public Works Department and the Indian Railways, is made on a similar platform to compare the different item descriptions for the rate analysis with the Actual Project, which consists mainly of labour costs, material costs and machinery costs with different relevant taxes and standard charges. The study also emphasises the development of an improved accurate rate analysis that includes all the parameters and factors responsible for a completely inaccurate rate analysis.

KEYWORDS: Rate Analysis, unit pricing, labour cost, material cost, machinery cost, cost estimates, concrete

I. INTRODUCTION

Estimation of the project cost is necessary for evaluation of required investments in any project. *An estimate is a probable cost of the work, arrived by mathematical calculations based on the measurement of quantities of various items of work involved in the work.* A contractor's estimate is completely based on completion of work and making profit. Therefore, the estimation of any construction work may be defined as the process of determining the quantity and cost of the various items needed in connection with the work. This shall be drawn up by measuring the quantity from the dimensions on the drawings for the various items needed to complete the project and multiplied by the unit cost of the item concerned. The cost is accurately estimated with great importance. Estimating construction projects are an extremely complex process because of the inherent interaction, interdependence and lack of standard norms. In framing a correct estimate, it is important to ensure that the dimensions of all the elements are properly determined and that any work or part of it is omitted. As the nature of the project is clear and all quantities, quality of material, manufacturing, logistics, etc. are well understood, the precision of an estimate can be improved. The reasons for exceeding the estimate are inaccuracy in preparing estimates and the omission of items, modifications in concepts and improper rates, etc. although the increase in the rate is one of the main reasons. These rates are calculated based on the Schedule of Rates (SOR) prepared by concerned departments or organizations. The SOR breaks up all work done to build any structure into a series of item of works and provides approved rates for costing of each item of work. The rates include labour rates (based on minimum wages), rates for materials used, rates for transportation of materials, hiring charges of machines, royalty payments for freely available natural resources and rates for maintenance of structures. These rates are thus calculated from Rate Analysis carried out for each of the item of work. In order to determine the rate of a particular item, the factors affecting the rate of that item are studied carefully and then finally a rate is decided for that item. This process of determining rate per unit of any work like earthwork, concrete work,

brickwork, plastering, painting etc. is known as “Analysis of Rates or Rate Analysis”. The rates of materials, labour and machinery vary from place to place and hence the rates of different items of works also vary from place to place. This rates further help in determining cost of particular work and in turn cost of the project. The research carried out mainly focuses on Rate Analysis hence shall be further discussing essential elements of rate analysis.

II. LITERATURE REVIEW

The basic elements for preparing any estimate are Standard Specifications, Analysis of Rates, and Schedule of rate for elements like materials, labour and machinery utilized for construction works. To get the work done as per requirements keeping all the standards in mind, required material quantities, specific manpower needs, proper utility-based machinery availability and its duration of utilization are to be observed with care and are quantified for each unit of work this is called “Rate Analysis”.

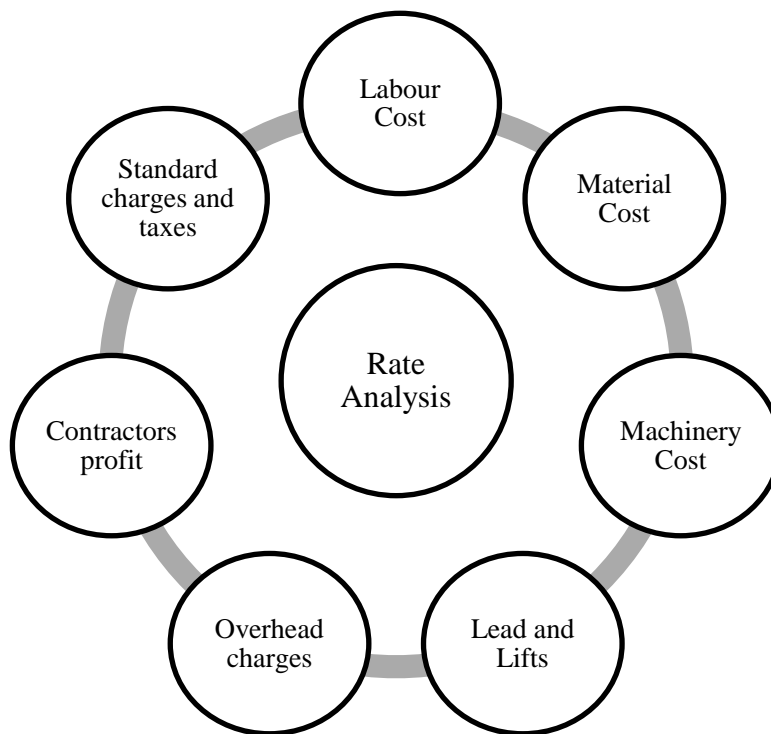


Figure no.1. Elements of Rate Analysis

A. Factors affecting Analysis of Rates

It is important that estimators, architects, engineers and contractors have a clear realistic understanding of all the factors involved in construction cost. The various factors influencing the price of an item of work that can be grouped into the five key components on of which the unit price is built. These are the following:

1. Specifications of works

The specifications describe the products, materials and works required by the construction contract. They do not include cost, quantity or drawing information, and should therefore be read alongside other information, such as quantity, schedule and drawings. Specifications are precisely written documents that cover the construction documents and describe the materials as well as the installation methods. It describes the project to be constructed, complements the drawings and forms part of the contract, and describes the quality of the materials, their methods of manufacture and installation, and the workmanship and manner of construction. They also provide additional information not shown in the drawings, including a description of the final result. The primary function of the project specifications is to provide detailed information on the materials and working methods for a specific construction project. They cover various components related to the project, including general conditions, scope of work, quality of materials and

standards of workmanship. The drawings, together with the project specifications, define the project in detail and clearly define exactly how it is to be constructed. For example, ceramic tiles and vitrified tiles are to be used for flooring. Hence, the specifications of both vary according to their manufacturing process, use, texture, characteristic etc. the ceramic tiles are mixture of earthen clay whereas vitrified tiles are mixture of silica and clay. The installation of ceramic tiles is easier than vitrified tiles. The texture of ceramic tiles is coarser than of vitrified tiles. The porosity of vitrified tiles is low compared to ceramic tiles. The various aspects of specifications like quality, chemical properties and physical properties differs for both the tiles.

2. Constructional operation method

Adequate selection of construction methods to be used during the execution of a construction project is a major determinant of high productivity, but sometimes this selection process is carried out without the care and systematic approach it deserves, with negative consequences. Construction methods are the means used to convert resources into constructed products. The selection of construction methods affects not only the selection of activities and their sequence of activities, but also their duration. In construction, this process is highly iterative and requires the construction team to examine a variety of data sources as well as to draw on its own experience base for constructing. For example, the excavation carried out for soft rock can be done by both the methods; manual means and mechanical means. When the excavation is carried out by manual means, the labour and time requirement is more as compared to the mechanical means which in turn requires very few labours and is completed in short time with use of machineries. Hence, if 1 m³ of excavation by manual method takes 1 hours by employing 2 labours then by mechanical method it will only take up to 20 minutes with the use of excavator and a crew member for operating the machine. Hence, looking towards the resources and time constraints of a project construction methods are to be wisely chosen.

3. Quantity of materials and market rates

As a generalization, the cost of materials in the unit price of an item of work is almost fifty per cent of the overall price. Any savings or excess amounts spent on materials would therefore reduce or increase the total cost of work and would have an impact on the cost of the materials listed below. The calculation of the quantity of materials needed must be precise. Reasonable provision shall be made for waste and extra material for runs, etc. where the measurements are net. Any error in these calculations is expected to be reflected in the unit price calculated. If the products on the site of work are found to be in excess of the requirement, they must also be disposed of at a cost. And when these materials are used in other works, transport charges may be added to other works, transport charges may be high and double handling may increase the amount of waste.

4. Cost of labour and their wages

Labour is the most unknown factor in determining the estimated cost of any work unit. A straightforward approach to calculating labour costs is to assume the hourly or daily performance of a worker and to calculate the total number of man-hours or days needed for the job. They are multiplied by wages per man-hour or per day of labour. Uncertainty in labour costs is due the output of different craftsmen may vary considerably depending on their skill. The production of an individual craftsman often varies from day to day depending on such different items as weather and domestic life. Efficient site organization and management will increase labour production, whereas weak or slack organization will reduce labour production. Higher salaries, bonus bonuses and the provision of other services, such as safe and healthy labour camps, shortened working hours, increased efficiency. Past experience coupled with a study of the peculiarities of the proposed work should make it possible for the estimator to determine the realistic labour costs involved.

5. Equipment cost

Due to the shortage of labour, the use of the plant is increasing and is likely to continue to do so. However, it cannot be assumed that the use of a mechanical plant is justified in all circumstances. In fact, the cost of work will depend on the estimator's decision in relation to two basic questions. Whether the plant can be used and, if the plant can be used, the weather is cheaper to buy or hire the plant. There may be ample opportunity for a large workplace to use mechanical plants and the cost of work would rise if human labour is used instead. However, if a plant cannot move in sufficient space or if there is a small amount of work, it can be impracticable or wasteful to use plants extensively. The purchase of a plant would only be economic if the plant was to operate for a large part of its life each year at its maximum capacity. It is cost-effective to buy only general-purpose machines that can be used to carry out certain construction operations. To minimize its costs, it must operate as close as possible to its peak performance, whether a plant is owned

or hired. The workforce and other plants must be combined in order to achieve this. This challenging task and the efficiency of the site management will depend on the cost of the plant.

6. Transportation cost

When a location of construction project is far away from available resources, it increases the project cost. Cost of transportation for workmen, equipments, materials, tools etc. increases with distance and adds to the project cost.

7. Overhead charges

All costs which cannot be explicitly traced to any particular contract are included in this heading. Examples of such costs include office expenses, including construction of office sheds, rents, lighting and heating, stationery, postal services, telephone accounts, staff salaries, etc. Similarly, the costs of small plants, such as iron baskets, ladders, ropes, etc., are also included. A 10% provision is made as an overhead charge in the rate analysis. This percentage figure will vary from firm to firm depending upon the size of the firm and efficiency of its site organization and management.

8. Contractor's profit

The profit margin that a contractor can expect depends on the factors involved. If he has contracts almost to his capacity, he will only be willing to undertake a relatively high degree of further work. Another contractor, who needs work to fully occupy his workers and equipment, can expect only a profit margin. The cost of a work is another factor that will depend on the profit margin. The lower the work cost, the lower the profit percentage. The percentage of small jobs varies from 15% to 5% of larger jobs. The report of the Council and Cost Committee, published by the Government of India in 1957, suggested that the 10% allowance be suitable for contractor actual overhead expenses and 10% of primary costs as the contractor's profit is reasonable.

B. Analysis of Rates

Having identified the different cost components associated with labour, material, plants and equipments and overheads, the analysis of rate can be performed using any one of the following methods or as a combination thereof.

1. Operational Estimating

As per Jha (2011), the operational estimating procedure is quite common, especially with contracting organizations as it fits well with the construction schedule. In civil engineering projects, it is quite common to have resources not working on a continuous basis, due to any number of reasons such as lack of front availability, inclement weather and so on. The operational estimation method recognizes and takes into account the idle time of resources, especially the plant and equipment. Initially, items falling within a group are identified in a bill of quantity and the total scope is determined. The time available for the total workload of this operation is set out in the construction schedule prepared at the time of the tender. The estimator will pick the resources used in the operation and use the length of the operations and the unit cost of each resource to calculate the total cost of the operation.

2. Unit Rate Analysis

As per Jha (2011), the unit rate estimating methods is most commonly used for building works, especially where the traditional bill of quantities is issued by the owner along with the other tender documents. The method involves selection of the required resources such as labour, material, and equipments and selection of their output or usage rates. The output rate is expressed as work quantity per hour and the usage rate is the time taken to do a fixed quantity of work. Thus, by definition, the unit of output rate and the unit of usage rate would be depending on unit of measurement. The unit cost of resources could be in terms of Rupees per unit measurement. Thus, by combining the output or usage rate of the resources with the cost of the resources the cost for an item can be obtained and the sum of the unit cost for all the resources will be estimate of the total direct cost for the item.

III. METHODOLOGY

The precise study of the different SORs shall be carried out in order to understand the rate analysis of the work object. SORs of various organizations such as the Central Public Works Department, the Maharashtra and the Telangana State Public Works Department and Indian Railways have been carefully studied. It was observed, after the study, the item of work differs accordingly. Labours, materials and machines descriptions used differed according to the prerequisites of the item description. Also, the variation in terms of labour output constants, material constants and equipment constants as well as rates is observed. The study carried out by the researchers helped to explain the principles of rate analysis, its use in the construction sector, its factors influencing the industry and the elements of rate analysis. The basic elements required for the analysis of rates are labour costs, material costs and machine costs, with the addition of various standard charges and taxes commonly applicable to organizations or departments. At the end of the study, a clear understanding of the variations in the Rate Analysis of all organizations was achieved. Furthermore, in order to make a comparison of these rate analysis on a similar platform, it was necessary to identify the work item as per the requirement. The decision was taken to compare selected items of work, which could be similar to those carried out on the construction site. The identified few project items of work consisted mainly of the most important parts of each structure. The items of works such as excavation, concreting for foundations, slabs, beams, columns, brickwork, plastering, painting, tilling etc. were sorted out. Therefore, the main activity considered for the study is Excavation as these items represent the majority of the construction costs for any construction project. The substructure is the lower part of the building that is built below the ground level. The function of the substructure is to transfer the loads from the superstructure to the underlying soil. The substructure is therefore in direct contact with the soil support. The substructure includes Excavation and Foundation for any building. Excavation of rock or soil is an important aspect of a construction project. The excavation techniques or the methods of excavation of rocks differ from those in for soil, rock and murrum.

The Actual Project chosen for rate analysis was building works for Girls Hostel (Ground Floor + 4 storey) at Army Law College, Kanhe, Pune. The site has 2 phases, the first was renovation of the old structures and the second is construction of new structures for accommodation of students. It consisted of Boys and Girls Hostel (Ground plus Four Storey) and Academic Block. To carry out rate analysis on site, the various components involved in rate analysis were observed carefully on the actual project site. The main elements of rate analysis such as material cost, labour cost, equipment cost was closely monitored. The key objective of the research study is to develop a precise rate analysis. Hence, all the elements involved in rate analysis are studied carefully and provision for addition of those missing elements in the rate analysis is carried out.

According to the rate analysis carried out for the actual project, from the Maharashtra PWD SSR, the item no 21.14 excavation for soft rock up to depth 1.5 m was identified having the following description “*Excavation for foundation in Soft rock and old cement and lime masonry foundations including removing the excavated materials up to a distance of 50 meters beyond the building area and stacking as directed including dewatering preparing the bed for the foundation and necessary back filling with available earth murrum, ramming, watering including shoring and strutting etc. complete (lift up to 1.5m) By Mechanical Means*”

Table 1. Rate Analysis of Actual Project Excavation of Soft Rock up to 1.5 m

Sr. No	Description	Quantity	Rate (in Rs)	Unit	Amount (in Rs)
A	LABOUR				
	Mazdoor - Unskilled Heavy Male	0.250	500	Day	125.00
	Mazdoor - Unskilled Heavy Female	0.250	300	Day	75.00
	Excavator - Unskilled Heavy	0.250	750	Day	187.50
	Breaker - Semi Skilled	0.250	850	Day	212.50
	TOTAL				600.00
B	MACHINE				
	Excavator PC200	1.000	1550	Hour	1550.00
	Breaker	1.000	1650	Hour	1650.00
	Dumper	1.000	1500	Hour	1500.00
	TOTAL				3200.00



Sr. No	Description	Quantity	Rate (in Rs)	Unit	Amount (in Rs)
	GRAND TOTAL				3800.00
C	STANDARD OVERHEAD		%AGE	AMT	TOTAL
	Scaffolding		0	0.00	3800.00
	Sundries		0	0.00	3800.00
	Water Charges		0	0.00	3800.00
	Laboratory Testing Charges		0	0.00	3800.00
	Formwork		0	0.00	3800.00
	Overhead Charges		10	380.00	4180.00
	Contractors Profit		10	418.00	4598.00
	Goods and Service Tax (GST)		18	827.64	5425.64
	Labour Amenities		1	54.26	5479.90
	Corporation area charges		5	273.99	5753.89
	Total Rate per 1 Cum (in Rs)				575.39

Table 1. shows the rate analysis of this excavation item for 10 cum, showing labour costs and cost of equipment along with transport (lead) costs and other miscellaneous cost details. These details shall be discussed in the preceding sections.

1. Labour Cost

The various types of labours are employed in the excavation activity with variation in categories such as Mazdoors (both Male and Female), Excavator and Breaker. The quantity of these labour required for 10 cum are deduced on the basis of the actual observations on project which is also termed as labour constants. From the available data the labour constants for Mazdoors (both Male and Female), Excavator and Breaker are 0.25 each on per day basis. The daily wages of all the above labours is considered from the available data actual project which is Rs. 850 per day for a Breaker and Rs. 750 per day for Excavator. For Mazdoor (including both male and female mazdoor) is Rs. 500 and Rs. 300 respectively. After multiplying all the labour constants with their respective rates, the total labour cost obtained is Rs. 600

2. Machinery Cost

Herein a PC-200 excavator having a bucket capacity 1 cum is used for excavation of soft rock and a breaker for breaking the soil. Also, a dumper is utilized for removing excess soil or rock from the excavated area. Here again the productivity norms for machinery are used as per observation on actual project. The excavator, breaker and the dumper have a constant of 1 per hour each. The rate of excavator is Rs. 1550 per hour whereas the rate breaker is Rs. 1650 per hour. Also, the dumper has a rate of 1500 per hour. The total cost of the machineries is Rs. 3200.

Apart from the labour costs and machinery cost, various standard charges and taxes are also applicable on the total cost. These charges comprise of Labour amenities about 1% of the total cost. The Overhead charges about 10% of the total cost are considered. The goods and service tax and corporation area charges of about 18 % and 5 % respectively are also considered here.

Considering all the above cost the total cost for 1 cubic meter of excavation of Soft rock up to 1.5 m is Rs. 523.08 including GST.

The various rate analysis carried out by different organizations in the construction projects were intended to set an optimal cost per unit for the item of work. A detailed explanation description, as well as each and every parameter responsible for rate analysis, are discussed and defined for the item of work. The items in substructure like earthwork, concreting for foundations are selected and a detailed discussion of all the components in involved in rate analysis is carried out.

IV. RESULTS AND DISCUSSION

The rate analysis of all the organizations as compared to actual project differs. There is variation in costs of the elements involved in rate analysis. The variations in labour cost, material cost and machinery cost as well as lead charges and various standard taxes for all the items of work selected is discussed here with a comparative table. Table 2. shows the comparison of rate analysis for one cubic meter of excavation showing labour costs, material costs and machinery cost with other miscellaneous cost details.

1. Labour Cost

After the comparison between the labour cost of all the organizations it is observed that the labour cost of Maharashtra PWD is Rs. 375.45. The cost of CPWD is Rs. 208.62 whereas labour cost of Railways is Rs. 146.26. The cost of Telangana PWD is Rs. 35.23 and of the Actual project is Rs. 60.

2. Material cost

The next important aspect after labour cost is material cost. The material cost of Maharashtra PWD is Rs. 70.25. It is observed that only Maharashtra PWD is using materials for blasting in excavation. Rest of the organizations excludes material cost.

Table 2. Comparison of costs involved in rate analysis for per cubic meter of excavation

Sr. No	Description	Rate per Cum (in Rs)				
		Maharashtra PWD	CPWD	Railways	Telangana PWD	Actual Project
1	Labour Cost	375.45	208.62	146.26	35.23	60.00
2	Material Cost	70.25	0.00	0.00	0.00	0.00
3	Machinery Cost	13.36	54.81	84.00	122.04	320.00
4	Grand Total(A)	459.06	263.43	230.26	157.27	380.00
6	Water Charges	-	1% of A	1% of A	-	-
7	Total cost (B)	459.06	266.06	232.56	157.27	380.00
8	Contractors Profit	-	15% of B	15% of B	13.615 % of B	10% of B
9	Overhead charges	10% of B				10% of B
10	Total cost (C)	504.97	305.97	267.45	178.68	459.80
11	GST	-	12% of C	12% of C	-	18% of C
12	Total cost (D)	504.97	348.96	305.02	178.68	542.56
13	Additional cess	-	1% of D	1% of D	-	-
14	Total cost (E)	504.97	352.45	308.07	178.68	542.56
15	Labour Amenities	1% of E	-	-	-	1% of E
16	Total cost (F)	510.02	352.45	308.07	178.68	547.99
17	Corporation Area Charges	-	-	-	-	5% of F
18	Rate Per Cubic Meter (in Rs.)	510.02	352.45	308.07	178.68	575.39

3. Machinery Cost

Apart from material and labour cost, the machinery cost is next important aspect of rate analysis. The machinery cost of Maharashtra PWD is Rs. 13.36 The cost of CPWD is Rs. 54.81 whereas machinery cost of Railways is Rs. 84. The cost of Telangana PWD is Rs. 122.04 and of the Actual project is Rs. 320. The equipments used in Maharashtra PWD, CPWD, Telangana PWD and Actual Project consists of Excavators of various types along with breakers, dumpers and tippers for removal and disposal of earth material.

4. Standard Charges and Taxes

After all the costs such as labour cost, material cost and machinery cost along with lead charges are added up together in order to achieve a total cost, the various standard charges and taxes are applied to the calculated total cost. The total

cost of Maharashtra PWD consists of Overhead charges and Labour amenities and Additional Cess but provision for contractor's profit and GST is absent whereas in CPWD and Railways the provisions for Labour Amenities is missing. The contractor's profit and overhead charges are incorporated in Telangana PWD whereas rest of the charges are waived off. The total cost Actual project cost includes all the standard charges and taxes. Therefore, the final rate per cubic meter for the item of work for Maharashtra PWD and Telangana PWD is Rs. 510.02 and Rs. 178.68 respectively. The cost per cubic meter for CPWD and Railways is Rs. 352.45 and Rs 308.07 respectively. The rate for the Actual Project inclusive of all the standard charges and Taxes is Rs. 575.39.

V. CONCLUSION

In this fast-growing construction sector, the Rate Analysis plays an important role in computing the rates of construction activities. Nowadays, cost overruns are typical in most of the construction projects. The construction projects require high capital investments and take years to complete, as a result it subjects to price escalation. The literature study thus carried out showed up the factors affecting the rates of the items. Through the literature study eight factors were identified.

The study of the various concepts required for rate analysis from the available literature has received a considerable approach to understand the procedure and requirements. The methods involved in Analysis of rates which included Unit Pricing method and Operational Estimating method were discussed. In some of the organizations, the rate analysis of items of work are not improved from decades. The analysis of data gathered from Schedule of Rates and Standard Rate Analysis of various organizations illustrated the variation in the item descriptions as well as the basic three heads of rate analysis i.e. Labour cost, Material cost and Machinery cost. The rate analysis also differed for particular organization / department in terms of standard charges and taxes applied on the items of work.

The comparison of rate analysis of various organizations including CPWD, PWD (Maharashtra and Telangana) and Indian Railways with the Actual project proved the variation in cost of the selected items of work which is excavation. The main contribution of this study focuses on the actual condition and factors that affects the rate analysis carried on actual project which helped to develop a comparative between organizations and analyse the cause for variation.

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