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Direct Cost Analysis of an 18.2 km section of Dhaka-Sylhet Highway in Bangladesh: A Case Study

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Abstract

Proper budgeting is a significant pillar for the effective implementation of large-scale construction projects like highways, bridges, and metro rail systems, as lack of expertise can result in cost overruns, funding challenges, and delays. This study examines a real case of preparing the direct construction cost for an 18.2 km section of the Dhaka-Sylhet National Highway from the contractor's perspective in 2024. A unit rate analysis (URA) methodology is employed, integrating contract documents, field data, and 2024 market rates to estimate direct costs, including materials, equipment, and labor for highway construction, validated through expert reviews and historical benchmarks. The cost analysis reveals that materials expenditure accounts for over four-fifths of the total direct cost, establishing it as the dominant budget factor, while equipment represents a secondary but operationally important component, and labor constitutes a relatively marginal expense. This study develops a practical per-kilometer cost benchmark for national highway projects, offering valuable reference data for budget engineers, contractors, and policymakers to enhance planning efficiency and mitigate common budgetary issues. Additionally, the detailed case study methodology supports meaningful international cost comparisons and provides a reliable framework for budgeting in Bangladesh's future mega infrastructure projects.

Keywords: *Direct Costs; Budget; Unit Rate Analysis; Contractor; Highway Construction*

1 Introduction

When preparing a construction budget, contractors generally divide costs into two main categories: direct costs and indirect costs. Direct costs are those specifically linked to the physical implementation of the project, such as materials, equipment, and labor. On the other hand, indirect costs cover a broad spectrum of supportive and administrative expenses that are necessary for project execution but are not associated with particular construction tasks. These may include the development of site camps and stackyards, construction of semi-permanent site offices and accommodations, utilities, office and residential furnishings, consumables, transportation for site personnel, communication systems, legal and consultancy fees, both domestic and international travel, staff wages, bonuses and allowances, bank guarantees, insurance premiums, interest on bank loans, corporate overheads, and contingency funds, among other items. While both categories are vital for preparing a complete budget, this study solely concentrates on direct costs.

2 Objectives of the Study

2.1 Primary Objective: To develop a standardized framework for estimating direct construction costs, comprising materials, equipment, and labor, in highway infrastructure projects using the Unit Rate Analysis (URA) method, validated through real project data and expert input.

2.2 Secondary Objective: This study aims to quantify the proportional distribution of material, equipment, and labor costs in highway construction, identifying the major cost drivers and their operational implications. It further analyzes the cost structure of key material components and equipment usage to highlight areas of high expenditure and potential opportunities for optimization. By establishing a reliable per-kilometer direct cost benchmark for national highway projects in Bangladesh, the research enables data-driven planning and effective cross-project comparisons. Ultimately, it offers practical insights for budget engineers, contractors, and policymakers to improve cost predictability, enhance procurement strategies, and mitigate common budgetary risks in large-scale infrastructure development.

3 Literature Review

Highway construction costs in developing economies have been widely examined, with studies consistently identifying trends in resource allocation. Prior research has shown that material costs typically represent 60–75% of total project expenditures (Amoatey et al., 2015). In our analysis, materials accounted for 83.6% of the direct cost; however, this figure would fall within the expected range when indirect costs are factored in, reaffirming the predominant role of materials in highway construction. Notably, aggregates constituted 43.7% of material expenses, which closely aligns with the 35–50% aggregate share reported in Asian highway projects by (Zhang et al., 2021). The fixed equipment costs (6.65%) and fuel costs (6.66%) reinforces the observations of (Jha and Iyer, 2020), who highlighted the impact of fuel price volatility on project budgets. Furthermore, the concentration of equipment uses in dump trucks and excavators, together comprising 37.4% of total equipment costs, supports findings by (Rokooei et al., 2021), who emphasized the dominance of earthmoving machinery in driving construction equipment expenses. The relatively low contribution of labor costs (3.1%) reflects modern trends in highway construction, consistent with (Chen et al., 2019), and contrasts with earlier findings by (Memon et al., 2016), which reported labor shares of 8–12%, indicating a broader industry shift toward mechanization. Our observation that structural works command the largest portion of labor spending also aligns with the framework proposed by (O'Connor et al., 2020) for identifying labor-intensive components in infrastructure development.
Despite these valuable insights, detailed and validated disaggregated cost analyses from the contractor's perspective remain scarce in the Bangladeshi context. This study fills that gap by introducing a comprehensive Unit Rate Analysis (URA)-based framework grounded in real-world project data from the Dhaka–Sylhet highway corridor. It contributes a nuanced understanding of material, equipment, and labor cost structures and establishes a practical per-kilometer cost benchmark for future highway projects in Bangladesh.

4 Study Area and Project Details

The project name is "South Asia Sub-regional Economic Cooperation: Dhaka - Sylhet Corridor Road Investment Project" and total length is 210 km. The project is divided into 6 packages and 13 lots, Lot No. DS-7 under WP 4 is one of them which we have taken into consideration for study. The contract is titled "Improvement of Dhaka Sylhet National Highway (N2) into 4 Lane Highway with Service Lanes on Both Sides from SM Spinning Mill to Sayestaganj Bypass BM Filling Station (Ch. 116+400 to 134+600 km)" (see Figure 1).

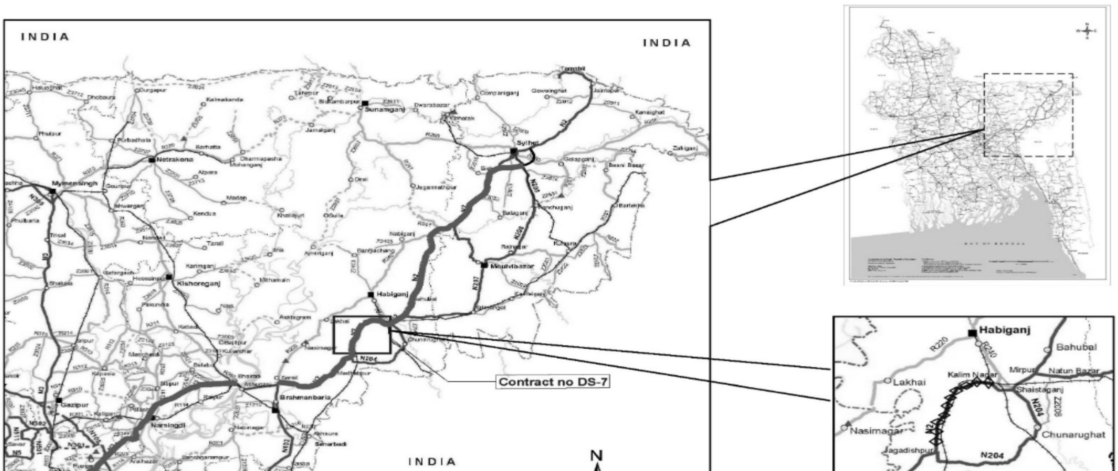

Figure 1. Location map of DS-7

This project involves the upgradation of the existing two-lane highway into a six-lane facility, including service lane on both sides. As part of the widening and improvement works, the existing two-lane pavement will be fully removed down to the subbase level, and complete reconstruction will be carried out. Recovered materials from the existing pavement may be reused in the construction of subbase and base (Type-2) layers, provided they meet the specification requirements in terms of gradation, strength, and durability. The scope of works includes Road pavement (18.20 Km), Culvert (42 nos.), Bridge (02 nos.), Overpass (02 nos.), Slope & embankment protection, Misc. works items of Sign Signal, Guide Post, Road Marking etc. Project Duration is 4 years, and commencement date was 1st August 2023.

5 Methodology

This study presents a systematic and practical approach for estimating direct costs (materials, equipment, and labor) for the Dhaka-Sylhet National Highway project, Bangladesh. The methodology integrates contract documents with practical field data through a structured process. Primary data sources include contract documents (BOQ, drawings, technical specifications, etc.) and approved mix designs for all pavement layers, concrete works, and other ancillary works. Secondary data consists of historical cost data from two similar recently completed highway projects and current market rates (as of October 2024), including delivery to the construction site. A comprehensive Unit Rate Analysis (URA) is developed for each BOQ item based on material quantities derived from specifications and drawings, equipment requirements using standard productivity rates, and labor inputs from current subcontractor agreements. The URA results are validated through cross-referencing with completed and similar project data and expert review conducted by the Project Manager, Quantity Survey Engineer, Material Engineer, Planning Engineer, and Senior Field Engineers. Material quantities are based on technical specifications and include standard wastage allowances. Pricing relies on verified supplier quotations (delivered to site) for both local and imported materials. Equipment rental costs include operator wages, maintenance, and standard usage of 8 hours per day, while fuel consumption is estimated considering equipment capacity, anticipated idle time, and site-specific conditions. Labor rates are benchmarked against prevailing subcontractor agreements and validated using data from two reference highway projects. For each BOQ item, the required quantities of resources (materials, equipment, fuel, and labor) are calculated per unit (please see Figure 2). These resources are multiplied by the total quantity of that BOQ item to compute aggregate resource requirements. This process is repeated across all BOQ items, and cumulative resource totals are compiled and presented in the Results section. This methodology ensures reliable cost estimation by combining rigorous analysis of contract documents with practical field data and market realities. The URA based approach provides transparency in cost breakdown while maintaining alignment with project specifications and local construction practices.

Improvement of the Dhaka - Sylhet National Highway (N2) Contract No. DS-7					
UNIT RATE ANALYSIS (URA) FORMAT					
Pay Item No.:	2/8/1				
Work Item:	Improved Subgrade				
Estimated Quantity:	1 Cubic Metre				
Ref. No.	**Equipment Costs**	No. of Units	No. of Days	Local Currency(BDT)	
				Unit Rate	Amount
i	Excavator [0.90 cum bucket capacity]	1.00	0.0031	11,000.00	34.10
ii	Bull Dozer [90 HP]	1.00	0.0006	22,000.00	13.20
iii	Water Tanker [6000 litre]	1.00	0.0050	3,600.00	18.00
iv	Vibratory Roller [8-10 ton]	1.00	0.0009	8,000.00	7.00
v	Motor Grader [3.70 m blade]	1.00	0.0025	9,300.00	23.25
vi	Dump Truck (14 cum capacity)	1.00	0.0056	8,600.00	48.38
Subtotal (1)					**143.93**
Ref. No.	**Labor Costs**	Qty	Unit	Local Currency(BDT)	
				Unit Rate	Amount
i	Labor Subcontractor	1.00	LS	12.00	12.00
Subtotal (2)					**12.00**
Ref. No.	**Materials Costs**	Qty	Unit	Local Currency(BDT)	
				Unit Rate	Amount
i	Sand [FM=0.8]	1.30	cum	490.00	637.00
Subtotal (3)					**637.00**
Ref. No.	**Fuel [Diesel] Costs**	No. of Days	Avg. Consumption/ Day	Local Currency(BDT)	
				Unit Rate	Amount
i	Excavator [0.90 cum bucket capacity]	0.0031	144	109.00	48.66
ii	Bull Dozer [90 HP]	0.0006	200	109.00	13.08
iii	Water Tanker [6000 litre]	0.0050	45	109.00	24.53
iv	Vibratory Roller [8-10 ton]	0.0009	128	109.00	12.21
v	Motor Grader [3.70 m blade]	0.0025	126	109.00	34.34
vi	Dump Truck (14 cum capacity)	0.0056	111	109.00	68.06
Subtotal (4)					**200.88**
Direct Cost: (1)+(2)+(3)+(4)					**993.81**

Figure 2. Example of Unit Rate Analysis Format

6 Results

Table 1. Direct Cost Summary

SL No.	Direct Cost Particulars	Amount (BDT)	Percentage (%)
1	Material Cost	6,686,369,395.00	83.6%
2	Equipment Cost	1,063,883,749.00	13.3%
3	Labor Cost	248,178,370.00	3.1%
	Total Direct Cost =	7,998,431,514.00	100%

Direct Cost per Kilometer:

Total Direct Cost/ Total Length = (7,998,431,514 BDT/ 18.2 km)
= 439,474,259 BDT/km

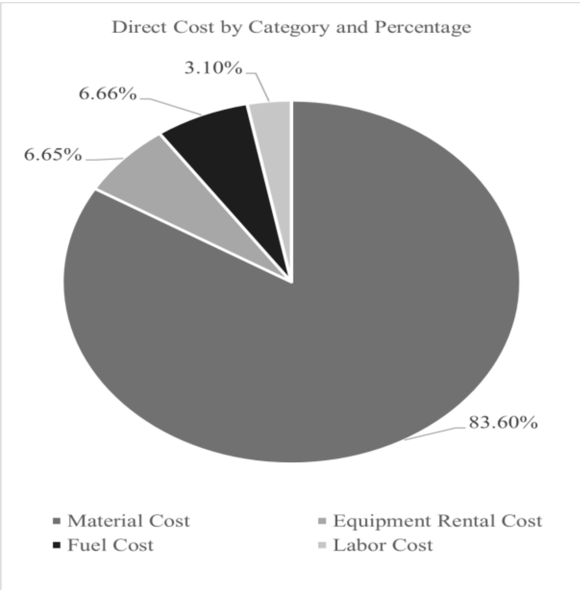

Figure 3. Breakdown of Direct Cost

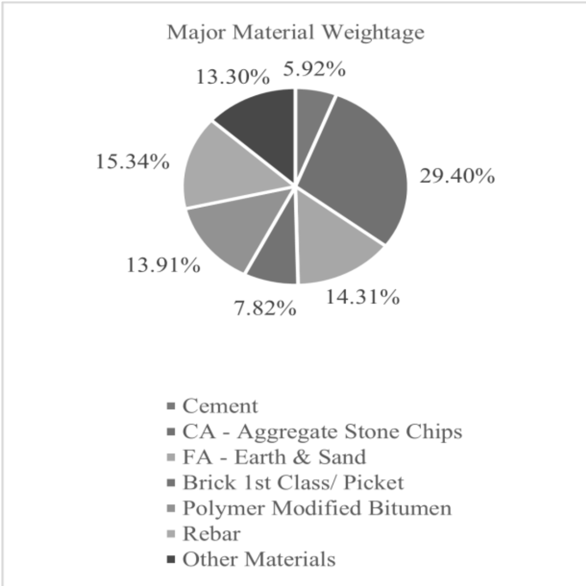

Figure 4. Material Cost Distribution

Table 2. Construction Material Cost Summary

Sl no.	Major Material Name	Unit	Total Quantity Required	Unit Rate (BDT)	Amount (BDT)
1.	Cement	kg	46,045,453.57	8.60	395,990,900.70
2.	Aggregate Stone Chips	Ton	517,293.21	3,800	1,965,714,190.40
3.	Earth & Sand [FM>= 0.5]	cum	210,796.14	420	718,514,680.80
4.	Sand [FM=0.8]	cum	294,916.98	490	144,509,320.20
5.	Sand [FM=1.2]	cum	40,903.92	600	24,542,352.00
6.	Sand [FM>=2.2]	cum	97,953.86	706	69,155,426.57
7.	Brick 1st Class/ Picket	nos	47,522,131.00	11	522,743,441.00
8.	Bitumen [PG-80/100]	kg	524,006.65	75	39,300,498.75
9.	Polymer Modified Bitumen	kg	9,790,284.00	95	930,076,980.00
10.	Rebar	kg	11,151,977.00	92	1,025,981,884.00
11.	Expansion Joint	LM	645	60,000	38,700,000.00
12.	Formwork	kg	1,110,936.40	125	138,867,050.00
13.	Scaffolding	Ton	674.31	120,000	80,916,600.00
14.	PC Strand	Ton	448	150,000	67,200,000.00
15.	Guard Rail (Double Flex)	LM	17,044.00	4,500	76,698,000.00
16.	Guard Rail (single Flex)	LM	37,932.00	3,200	121,382,400.00
				subtotal=	6,360,293,724.42
17.	Other minor remaining 41 items material cost				326,075,670.58
				Total Material Cost=	6,686,369,395.00

Table 3. Breakdown of Plant and Equipment Expenses

SL No.	Major Plant & Equipment	Used (No. of Days) (i)	Hire Charge Rate (Day wise) in BDT (ii)	Total Equipment Charge (BDT) (iii) = (i) x (ii)	Avg. Fuel Consump-tion/ day (litre) (iv)	Total Fuel Cost (BDT) [1 litre Disel = 109 BDT] (v) = (i) x (iv) x 109	Total Equipment Cost (BDT) (vi) = (iii) + (v)
1	Excavator	5,228	11,000	57,508,000	144	82,058,688	139,566,688
2	Payloader	2,090	16,500	34,485,000	128	29,159,680	63,644,680
3	Bull Dozer	1,142	22,000	25,124,000	200	24,895,600	50,019,600
4	Motor Grader	2,825	9,300	26,272,500	126	38,798,550	65,071,050
5	Vibratory Roller	1,748	8,000	13,984,000	128	24,388,096	38,372,096
6	Dump Truck	11,886	8,600	102,219,600	111	143,808,714	246,028,314
7	Rotary Rig	514	100,000	51,400,000	315	17,648,190	69,048,190
8	Crane	1,345	30,667	41,247,115	137	20,084,885	61,332,000
9	Transit Mixture	1,110	8,000	8,880,000	56	6,775,440	15,655,440
10	Water Tanker	9,076	3,600	32,673,600	45	44,517,780	77,191,380
11	Cone Crusher	454	38,000	17,252,000	176	8,709,536	25,961,536
12	Brick Crusher	625	30,000	18,750,000	64	4,360,000	23,110,000
13	Wet Mix Plant	698	25,000	17,450,000	144	10,955,808	28,405,808
14	WMM Paver	698	35,000	24,430,000	112	8,521,184	32,951,184
15	Concrete Batching Plant	438	26,500	11,607,000	192	9,166,464	20,773,464
16	Asphalt Batching Plant	274	78,000	21,372,000	990	29,567,340	50,939,340
17	Bitumen Distributor	77	13,000	1,001,000	50	419,650	1,420,650
18	Paver Finisher	274	30,000	8,220,000	143	4,270,838	12,490,838
19	Tandem Roller	211	8,000	1,688,000	117	2,690,883	4,378,883
20	Pneumatic Tyre Roller	211	8,000	1,688,000	90	2,069,910	3,757,910
			Subtotal=	517,251,815		512,867,236	1,030,119,051
21	Other Minor remaining 26 different equipment=			14,284,003		19,480,695	33,764,698
	Total Plant & Equipment Cost=			531,535,818		532,347,931	1,063,883,749

Table 4. Labor Cost Overview

SL No.	Description	Labor Cost (BDT)
Bill No. 1	General & Site Facilities	3,018,500.00
Bill No. 2	Earthworks	29,744,558.40
Bill No. 3	Pavement Works	21,600,681.04
Bill No. 4	Foundation Works	30,785,673.60
Bill No. 5	Structures	98,413,726.40
Bill No. 6	Incidentals	64,615,230.72
	Total =	248,178,370.00

7 Discussion

The analysis of direct costs for the 18.2 km section of the Dhaka–Sylhet National Highway provides critical insights into budget allocation trends in major infrastructure projects in Bangladesh. As detailed in Table 1, the total direct cost amounts to BDT 7,998,431,514 translating to a unit cost of approximately BDT 439.47 million per kilometer. Among the three major components, material costs dominate at 83.6% (BDT 6,686 million), significantly surpassing equipment costs (13.3%, BDT 1,064 million) and labor costs (3.1%, BDT 248 million). This 4:1 ratio between material and non-material costs clearly underscores the centrality of material procurement and supply chain efficiency in highway construction. A closer examination of the material cost structure reveals a high concentration among a few major components. As shown in Figure 4, six materials collectively account for 86.7% of total material expenditure. The aggregate materials coarse aggregate (29.4%) and fine aggregate (14.31%) alone contribute 43.71% of the total, highlighting the inherently material intensive nature of highway construction, the strategic importance of aggregate sourcing and pricing control, and the project's susceptibility to supply chain disruptions affecting aggregate supply (see table 2). Other key materials include reinforcement steel (15.34%) and polymer modified bitumen (13.91%), which together constitute nearly 30% of total material costs. These figures emphasize the need for accurate forecasting, material standardization, and procurement strategies tailored to high value inputs. As shown in Figure 3 and Table 3, the equipment cost is split nearly equally between two main segments: fixed operational expenses (rentals, operator wages, and maintenance), representing 6.65% of the total direct cost (BDT 531.5 million), and fuel costs, which constitute 6.66% (BDT 532.3 million). This near balance underscores the critical and potentially unstable impact of fuel, particularly due to its sensitivity to international energy price fluctuations. Among the different equipment types, dump trucks and excavators stand out in both usage and cost, with 11,886 operating days (BDT 246.0 million) for dump trucks and 5,228 operating days (BDT 139.6 million) for excavators. Combined, these two types make up 37.4% of total equipment expenses (BDT 385.6 million). Their prominence reflects the operational demands of large-scale earthworks and materials transport in highway development. Lastly, labor expenditures, as presented in Table 4, show a concentration in structural work, which alone accounts for BDT 98,413,726.40 across six work categories. Although labor represents a relatively small share of overall direct costs, this component remains essential for quality assurance, safety, and timely execution, especially in complex structural elements.

8 Conclusion

The cost analysis shows that materials overwhelmingly dominate project expenses, highlighting the need for efficient procurement and supply chain management. Equipment costs, divided almost equally between operations and fuel, point to opportunities for savings through improved utilization and fuel efficiency. Although labor constitutes a smaller share, it remains vital for ensuring quality and safety. The established per-kilometer cost benchmark and detailed cost composition provide a practical reference for optimizing resource allocation and controlling direct costs in future highway projects across Bangladesh and similar developing regions.

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