Cost Analysis and Control of Highway Engineering Testing and Inspection

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Abstract: This paper discusses the cost of road engineering tests and inspections. Firstly, the object of cost analysis is clarified, including the unit price of all testing projects in highway delivery, completion acceptance, and construction control. Secondly, the basis of testing cost analysis is introduced, covering relevant laws and regulations, fee management regulations, technical standards, and norms. Next, the composition of testing costs and specific analysis methods are analyzed, including calculating direct cost fees and other costs. Finally, the costing methods of different testing projects are illustrated through examples, the main factors affecting the unit price are pointed out, and suggestions for establishing a standardized testing fee system are put forward. This paper provides theoretical support and practical guidance for the reasonable control and effective management of highway engineering testing costs.

Keywords: Highway Engineering; Testing; Inspection; Fees; Criteria

1. Introduction

The quality inspection of highway engineering is vital to ensure the quality and safety of engineering construction [1-3]. With the increasing scale and complexity of highway construction projects, the requirements for highway engineering testing are becoming increasingly stringent [4-5]. It is essential to carry out a cost analysis of scientific testing to control the cost of testing and improve the efficiency of testing work [6]. This paper aims to systematically explore the basis, object, cost composition, and analysis method of testing cost analysis, as well as the factors affecting the unit price of testing. The detailed analysis of highway engineering test and inspection costs reveals the critical role of scientific and reasonable cost control in inspection work.

This paper first clarifies the basis of testing cost analysis, including laws and regulations, technical standards, and relevant provisions, to provide a theoretical basis for the subsequent analysis [7]. Subsequently, the object and content of test cost analysis are elaborated in detail, emphasizing the importance and application scope of cost analysis in road traffic engineering. Then, the composition and analysis methods of test cost are discussed in depth. By introducing the concepts of cumulative cost and direct cost expense, various costs, such as the depreciation of testing instruments and ancillary equipment, maintenance cost, transport usage cost, testing gauge cost, labor cost, etc., are analyzed, and the corresponding calculation methods are proposed [8]. In addition, we introduced the concepts of other costs and overheads and their roles in cost analysis. Finally, by illustration, we detail the costing methods for different test items and emphasize the impact of market price changes on cost analysis. We point out that a standardized test fee system should be established based on a contract signed between the test trustee and the commissioning unit. The relevant fees should be adjusted promptly to ensure the accuracy and reasonableness of the cost analysis.

In summary, this paper provides an essential reference for managing and controlling highway engineering testing costs, which helps improve the economic efficiency and management level of testing work.

2. Analysis of Testing Costs

2.1 Basis for Testing Cost Analysis

The testing cost analysis is based on laws,

regulations, fee management regulations, budget estimates, budgeting methods, technical standards, assessment standards, construction technical specifications, testing protocols, and exceptional technical standards [9]. On the testing cost item division, concept, and its cost analysis, here reference to the Ministry of Urban and Rural Construction (construction standard (2013) No. 44) issued 'on the issuance of the cost of construction and installation project cost item composition of the notice' in the relevant content. In the actual preparation, reference can also be made to the cost standards of test and inspection of highway projects in other provinces; at the same time, relevant test and inspection units and experts in the province should also be consulted and referred to, and in-depth investigations and studies should be carried out on the various test and inspection items, to strive for reasonableness and accuracy.

2.2 Testing Cost Analysis Object and Content

The object of cost analysis is the highway delivery, completion acceptance, and construction control process of testers traveling to the site testing or site to send samples to the laboratory for testing and inspection of the project [10-11]. It mainly includes the unit price of roadbed pavement, bridge and tunnel, traffic engineering, and other projects. The content of the cost analysis should consist of the basis of cost analysis, cost composition, analysis methods, and the conditions for testing cost unit price.

3. Testing Cost Components and Analysis Methods

The total testing costs are divided into direct cost fees and other costs [12]. Among them, direct costs include depreciation of testing equipment and ancillary equipment, maintenance costs, office space and facilities, living space and facilities, labor costs, vehicle organization costs, transport facilities, communication costs, travel costs, other temporary facilities, costs of consumables for testing and inspection materials, and auxiliary materials. Other costs include overheads (fees and management fees), profits, taxes, etc. The composition of the cost of road test inspection is shown in Figure 1.

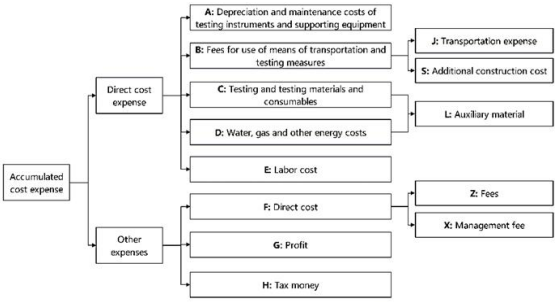

Figure 1. Schematic Diagram of the Cost Components of Road Engineering Test and Inspection Testing

3.1 Cost Analysis Methodology

3.1.1 Accumulated costs

Accumulated cost = direct cost charge + other costs, direct cost charge = A + B + C + D + E; other costs = F + G + H, overheads = Z + X.

3.1.2 Direct cost

(1) Depreciation and maintenance costs of testing and inspection instruments and ancillary equipment. It is the depreciation and maintenance cost of testing and inspection instruments and ancillary equipment x number of shifts x number of working days, which includes depreciation, routine maintenance, upgrading, and updating of testing and inspection instruments and their ancillary equipment.

(2) Office space and facilities costs, living space and facilities costs. It refers to the cost of the office and living room and other office and living facilities required by the test and inspection personnel to complete the contract testing project based on the requirements of the project duration.

(3) Labour costs. It is paid to the personnel directly engaged in testing and inspection at the site for the testing price. This cost includes the basic salary of the testing personnel, overtime pay, allowances, subsidies and bonuses, and wages paid under exceptional circumstances.

(4) Vehicle organization costs. This mainly refers to the test and inspection personnel traveling to the project site and returning to complete the established contract testing project using accessible vehicles, such as fuel, repair, maintenance, parking, road, and bridge costs.

(5) Traffic facilities costs. This refers mainly to the test and inspection personnel traveling to the site and returning to complete the testing project at the cost of public transport,

including the testing process requiring personnel and other non-supporting equipment; transport costs are also included.

(6) Other temporary facilities costs. Refers to the testing process due to safety and environmental protection, civilized construction, and temporary facilities for the costs incurred by the measures taken.

For example, test and inspection personnel are divided into test engineers and test inspectors, test inspectors at 220 yuan / d, test and inspection engineers at 300 yuan / d, test and inspection personnel per capita salary of 260 yuan / d, bonuses, overtime and overtime pay, allowances and subsidies in the project completion of the amount of 5 percent of the Calculation of bonuses for the basic salary of 25 percent, overtime and overtime pay for overtime work according to the actual overtime work calculated according to the actual project. The situation is set. Currently, the cost of meals for a 1d business trip (provincial testing project) is RMB 100/d/person; accommodation cost is about RMB 200/d, and outing subsidy is RMB 80/d, which is a total of RMB 705/d. Labor cost = unit price of labor cost × number of people required × number of working days.

3.1.3 Other costs

Other costs are overheads, profits, taxes, and direct costs related to on-site testing. Overheads refer to the costs (fees and management fees) that do not occur directly from the testing process [13]. Still, they are related to the requirements of testing implementation and indirectly incurred by the testing unit for the effective organization of the testing work. Fees refer to the national laws and regulations by the provincial government and the relevant provincial authorities and must be paid, or accrued expenses, including social insurance premiums, housing funds, and other fees, should be listed but not included, according to the actual occurrence of accrued. Management fees refer to the testing unit that organizes production and business management costs [14].

Profit is the profit the testing unit makes for completing the contracted testing project. Taxes refer to the taxes and fees paid by the enterprise by the regulations. Other costs concerning the 'Engineering Survey and Design Fee Standards' (2002), using the proportion of technical work (22%) fee collection method, and according to the technical difficulty of the testing project, engineering complexity, and other factors and then consider the determination of a comprehensive additional adjustment coefficient (μ), the cost analysis is often taken as 0.3 to 0.5, that is:

Other costs = direct cost fee × μ;

Total cost = direct cost fee × (1 + μ).

3.2 Calculation of Proposed Unit Price

3.2.1 Calculation of testing fee for traveling testing items

Based on the actual test results, calculate and determine the cumulative cost of a test item (A+B+C+D+E) and the total number of tests completed (n) within one business trip.

Proposed unit price = cumulative cost of a test item within one traveling time / total number of tests. Calculation formula:

$$\text{Proposed unit price} = \frac{A+B+C+D+E}{n} \times (\mu + 1) \quad (1)$$

By traveling 1 time to test, the test volume is often less than the whole shift, so there is a phenomenon of reduced testing efficiency, which leads to the formulation of the unit price being sometimes large. For example, bridge and culvert particular project testing rebound method to travel 1 time 1 d test l piece of beam 10 test area analysis of 100 yuan/test area, 1-time test 5 pieces of beam 50 test area analysis of 30 yuan/test area, so the preparation of several proposed unit price to be supplemented by explaining the cost of testing units and commissioned by the unit to be negotiated with the use of the unit can be used to adjust the formula (1).

3.2.2 Calculation of test fee for indoor test items

According to the actual investigation in the room to carry out a single test of the cost of (A + B + C + D + calendar, then the proposed unit price of the test = (A + B + C + D + E) x (μ, + 1). The cost analysis of the test fee for the indoor test project does not need to consider the cost of traveling accommodation, food, and transport, so the price is relatively simple.

3.3 Examples

3.3.1 Project overview

The bridge project is a municipal bridge in the province 450 km away from the provincial capital city; the superstructure adopts 2×25 m prestressed T-beam + 1×90 m medium bearing

box arch + 2×25 m prestressed T-beam, medium bearing box arch is equal cross-section variable height suspension chain line hingeless arch, the net span diameter is 90 m, sagittal height is 22.5 m, sagittal span ratio is 1/4, the arch axis coefficient is 1.988. the subordinate structure is 0#, 6# platforms for the U-type abutment, pile foundation; 1 #, 4 #, 5 # pier (approach bridge part) using column pier, pile foundation; 2 #, 3 # pier (central bridge part) using gravity pier, expanding the foundation; piles are embedded rock pile design. Now, on this bridge project, inspection in the static load test costing and analysis of unit price.

3.3.2 Cost analysis

According to the Specification for Testing and Evaluation of Bearing Capacity of Highway Bridges (JTG/T J21-2011), for the bridge holes (or piers) with the same span diameter in multi-hole bridges, 1-2 representative holes can be selected for the loading test. According to the bridge load calculation, the static load test adopts 6 sets of 24 t loading trucks for equivalent loading. 3 persons carried out the static load test inspection and review work, and the cost analysis of the inspection cost was as described:

The number of test spans for static load test detection is 1 span, the depreciation cost of static strain measurement and collection device and displacement transducer is 380 yuan, and the total service cost of the inspectors is 505 yuan/person × 3 persons = 1515 yuan, the total labor cost is 1515 yuan, the cost of living room is 400 yuan for 2 rooms, the cost is 400 yuan, and the vehicle organization cost includes round trip toll fee of 360 yuan, round trip fuel cost of 500 yuan, other costs 100 yuan, the Total 960 yuan. Auxiliary materials 200 yuan. 1 24t loading truck for 1000 yuan/shift, other temporary facilities costs 6000 yuan, direct costs total 10075 yuan, other costs 10075 × 0.3 = 3022.5 yuan, the cost of a total of 130975 yuan, the proposed unit price of 13097.5 yuan/piece (cost of a total / 1 span). The negotiated fee between the testing and commissioning units can be considered when there are many testing projects simultaneously. The cost analysis of pile foundation testing for on-site testing projects of highway engineering is carried out, and the results are shown in Table 1.

It should be noted that the main factors affecting the unit price of the analysis method are the depreciation and maintenance costs of the testing instruments and ancillary equipment. Different instruments and equipment, other methods of operation, and various skill levels of users all have different fluctuations, which is also a significant factor in the competition among testing organizations in the market. Secondly, the testing conditions and the number of tests are other important factors affecting the unit price. These objective factors should be thoroughly investigated and verified in the actual cost analysis and fee collection and used as the basis for a fee adjustment. Therefore, the test commissioned and commissioning units of the test fee are appropriate for taking the quotation as a contract agreement to form a standardized testing fee system.

Table 1. Cost Analysis of Highway Engineering Site Inspection Projects

Project name	Bridge static load test program
Depreciation and maintenance of test and inspection instruments and ancillary equipment	1380 RMB
labour cost	1515RMB
Office accommodation and facilities, living accommodation and facilities	400 RMB
Vehicle organization costs	960RMB
Supplementary material	200 RMB
Other temporary facilities	6000RMB
Total direct costs	10455 RMB
Other costs	3136.5 RMB
Total cost	13591.5 RMB

Furthermore, market price changes are also factors affecting unit prices. They should be adjusted according to the market price of auxiliary materials, labor costs, etc., which is also one of the essential reasons for unit price analysis. Highway engineering testing and inspection costs of the composition and cost analysis also allow us to establish further and improve the government guidance and market regulation and the mutual role of the test and inspection fee market system.

4. Conclusions

The detailed analysis of highway engineering tests and inspection costs shows that scientific and reasonable cost control is vital in

inspection work. This paper systematically discusses the object, basis, cost composition, and analysis method of testing cost, proposes calculating direct cost fees and other costs, and illustrates the cost accounting method of different testing projects through specific examples. The main factors affecting the unit price of testing include the depreciation and maintenance costs of testing instruments and ancillary equipment, testing conditions and the number of tests, etc., which play a crucial role in market competition and actual operation. Therefore, the test commissioned and commissioning units should take the quotation and sign a contract to form a standardized testing fee system. In addition, with the changes in market prices, the relevant costs need to be adjusted in time to ensure the accuracy and reasonableness of the cost analysis. This study provides an essential reference for managing and controlling highway engineering testing costs, which helps improve the economic efficiency and management level of testing work.

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