Simplified Quantification Method on Rebar Work

Seok Heon Yun

Abstract: ***It is important to calculate quantity in a very detailed manner, but it is also important to calculate it as efficiently as possible within the margin of error as possible. Currently, the quantity takeoff is carried out in a very complex process and needs to be improved in efficiency. In this study, we investigated the research cases of quantity takeoff process, and analyzed current approximate cost estimate status and problems. In order to draw up an efficient QTO method of rebar work, overseas cases are surveyed. The error level in simplified rebar QTO method on the domestic cases are analyzed and applicability of the simplified QTO method for rebar work is reviewed. The purpose of this study was to analyze the error level of QTO of rebar works by using the simplified calculation method, and to analyze the applicability of rebar construction in Korea. According to an analysis of existing case sites, the average quantity of rebar compared to the volume of concrete was 12.23% and the standard deviation was 1.32.nd the standard deviation. The actual deviation of these mean values is analyzed to be within 1.5%. The results showed that the error occurred within 3 to 6% of the surcharge rate applied when calculating quantity of rebar, and that there was little difference between the detailed and simplified results.***

Keywords : Rebar, Simplified Quantity Takeoff, Construction Cost, Cost Estimation

I. INTRODUCTION

Quantity takeoff(QTO) in construction is a very important task in determining expected construction costs. However, it takes a lot of time and effort to calculate so many construction elements in great detail and during the bidding phase, the contractors should precisely calculate the quantity to analyze the adequacy of the construction cost. In fact, the cost of preparing these bidding targets is very large, reaching 1% of the construction cost. Although it is important to calculate the quantity in great detail, it is also important to calculate it within the margin of error as efficiently as possible. The most complex and difficult type of work for quantity takeoff is rebar work. For rebar construction, quantities should be calculated by taking into account the exact shape of rebar placed in various forms for each element and should be calculated precisely considering the joint and settlement of rebar that appears in construction. While accurately calculating these quantities, additional surcharges of 3 to 6% are applied in consideration of the errors in actual quantities. In this study, we will consider ways to simplify the process of quantity extraction of rebar construction, analyze the errors that may occur if simplified rebar quantity takeoff is applied, and analyze the actual applicability of the simplified calculation method of rebar work.

II. LITERATURE REVIEW

The research related to estimates and quantity output was conducted mainly in the 1980s, and recently, with the advent of the BIM concept, the development of quantity production and estimation technology in the BIM environment is mainly carried out. Looking at the overall trend of research, from the basic study of existing estimates to the latest BIM related research trends, is as follows

A. Related Study

Carr defined the estimate as an accurate reflection of the reality of the project, showing the level of detail associated with the decision. In other words, it said that estimates are a process to review the future and to predict project costs and resource needs, and estimates can be classified as cost assessment, view, forecast activities[1]. Garold classified the impact factors related to the accuracy of the estimate of the construction project into four categories: the capacity of the estimator, the readiness of the estimate, the understanding of the project per unit, and the considerations in estimating the project. In addition, it was intended to provide a methodology for calculating the appropriate reserve ratio for the project by calculating the weight for each classification to measure the quality level of the estimate [2]. Akintola presented 20 items, including lack of time to prepare the estimate, poor bidding documents, lack of understanding of project requirements, lack of ability of the estimator, incorrect building information, lack of guidance required for the estimate, and lack of historical construction performance data. The most important of them were the lack of time to prepare the estimate, followed by poor bidding documents and poor analysis of the estimate team's bidding documents [3]. Kamal classified the problems faced by the estimator preparing the estimate in the implementation design phase into 20 categories: Short contract terms, poor drawings and specifications, uncertainty of project scope, changes in material prices, changes in the owner's needs, errors in workload judgement, insufficient estimate preparation time, lack of experience with past performance data, omission of work items, lack of computational errors [4].

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Although BoQ is an important contract document in the process of calculating construction costs and implementing contracts, current BoQs differ a lot in the BoQ framework (classification of the BoQ work item, description of the item, detail construction name, specifications, terminology, etc.) depending on the project, author or time of preparation for the same work. This makes it difficult to achieve consistency and objectivity in the work content of BoQ items, and the lack of compatibility between BoQs for the same type of construction results in economic additional costs and time. Therefore, BoQ is an important element in the management of construction cost information, but due to the lack of uniformity of the BoQ component, there are many limitations in the collection, analysis, accumulation and utilization of construction performance data. Current BoQs tend to list items according to the amount produced without taking into account the importance of the cost of a particular work or simply categorizing detailed items into different classes, without considering the association between the types and specifications of the construction work required to complete a single object. This results in less time and effort spent on calculating the cost of items that are less important to each item in BoQ, thereby reducing the efficiency of creating BOQ. In addition, it is difficult to review or change the calculation results by distributing the detailed work items involved to different types of construction, and may cause the calculation results to be less accurate [5].

After analyzing the problems of the current BoQs, Cho proposed the improvement of the BoQ preparation system by presenting the 'Quantity Estimation Standard' that sets the direction of improvement of the details system and standardize methods of construction and preparation of details [6]. Park's study established a new type of details and process integration control system model that embraces the country's historical-oriented construction management method without damaging the basic system of existing process-centered and cost-centered management in order to improve the limits of practical application caused by differences from the general-purpose schedule control computer system developed in a foreign activity-oriented environment after the introduction of the schedule control method[7]. Considering the correlation between the cost items, Moon proposed a cost calculation model to determine the appropriate construction cost reflecting the construction characteristics by calculating the expected cost and variance of the construction project and adjusting the construction cost in the process of calculating the equivalence risk[8]. Jung Sook developed a text recognition algorithm and system that can recognize different expressions for the same work item to address the difficulty of developing a single-unit accumulation system and building a DB due to differences in work item and standard expression of BoQ, foreign language notation and errors in additional information presentation [9].

To secure the relationship between BoQ and Quantity Statement, Song analyzed their problems and proposed the use of QDB (Quantity Database), which includes site-specific information, based on the product breakdown structure (PBS), which is a common application between them, and verified its efficiency through case analysis [10]. Heng-quan Zhang et al used the approximate comprehensive evaluation method according to the characteristics of BoQ, which distinguishes quantity from unit price, and analyzed the unit price adjustment coefficients of unequal bidding programming model established based on the time value of capital to present a rough mathematical model [11]. Odeyinka used secondary data extracted from recently completed construction projects in Northern Ireland to assess the reliability of BoQ in construction projects [12]. Qingli et al analyzed the characteristics of the BoQ evaluation, and analyzed the characteristics of the BoQ evaluation and the methods and procedures of cost estimates that depend on the current construction cost management system, and the contents of the cost plan [13]. One of the most important documents in project management, the BoQ preparation standards, were not available and, therefore, different in structure or language from person to person, found it very difficult to collect and manage the information contained in BoQ and presented an intelligent system for retrieving and structured BoQ data called i-BoQ as a way to address this[14].

As seen in the study case, studies related to estimates and construction costs were conducted mainly before the 2000s, and more recently, studies have been conducted on estimates and cost control methods using BIM. In Korea, traditional BoQ documents have long been used, and there have been no major changes in technology development or construction cost management systems. However, a request for a change in the construction cost management system has recently been made with the introduction of BIM, and efforts have been required to improve the specification and Quantity Statement system. In this study, we would like to propose an improvement of the existing method of quantity takeoff as a way to improve existing BoQ methods while maintaining connectivity with BIM.

B. Current Status of BoQ and Quantity Statements

BoQ is used as an important contract document as well as handling cost information in the bidding and contract execution process for construction projects. BoQ is also used as a foundation for construction planning and management, with construction management system based on BoQ being established and operated at construction sites.

In current BIM based cost estimation process, the BIM model with property information is established, and the unit price information of the cost database is applied to the quantity calculated from the model to prepare BoQ. Although BIM-based quoting automation has the advantage of ensuring accuracy of the output results and making it easier to change the quantity according to the design change, the current use of BIM-based estimates is less efficient than expected.

Because it is not possible to obtain all of the quantities required by BoQ from the model in a BIM-based estimate, it is inevitable to use them in parallel with the existing quantity calculation method.

The unit price information of the database for labor cost calculation as well as materials plays an important role in the BIM estimate, and the previously mentioned items in the current BoQ are excessively subdivided without a structured system, the lack of uniformity of BoQ items, the various expressions of items make it difficult to accumulate performance construction costs in the database and the reliability of unit cost information. As a result, databases are often used as a one-time basis for each project, and the linkage between databases and modeling is not smooth.

The BIM model has location or site information in property information, but currently BoQ does not utilize element or location information, which makes it difficult to verify the basis for the detailed calculation of BoQ.

Detailed modelling and input of attribute information are required to produce detailed levels of estimation information, such as current BoQ, which results in excessive BIM modeling work, thus reducing the efficiency of BIM estimates. Therefore, it is required that the active use of BIM estimates should involve the improvement of the current BoQ framework.

III. REVIEW CRITERIA SIMPLIFIED CALCULATION METHOD OF REBAR WORK

A. Approximate Cost Estimate and Cost Influence Factors

Approximate cost estimates can be used to ensure the adequacy of construction costs not only in the planning stage but also in the basic design stage, and can be used in part in detailed estimates such as the builder's bidding estimate. Because the Approximate cost estimate does not need to calculate all the specific figures, it is sufficient to use the method of calculating quantities with simplified method as long as the accuracy can be obtained.

However, if the quantity for calculating the construction cost is calculated by abbreviation, it may not be possible to apply special circumstances for the construction or the site concerned. Therefore, it is always necessary to calibrate the simplified calculation results in this approach. Although the construction cost impact factors to be considered in the Simplified cost estimate vary widely and cannot list all the factors for all conditions, the factors that have a significant impact can be defined and applied to improve the accuracy of the resulting values. Generally, the factors affecting the construction cost are as in Figure 1. As shown in the figure, the study was able to identify 13 factors affecting construction costs by reviewing existing design drawings, examples of quantity calculation cases and research data. However, these factors also require consideration of how to reflect the various characteristics of a building in detail.

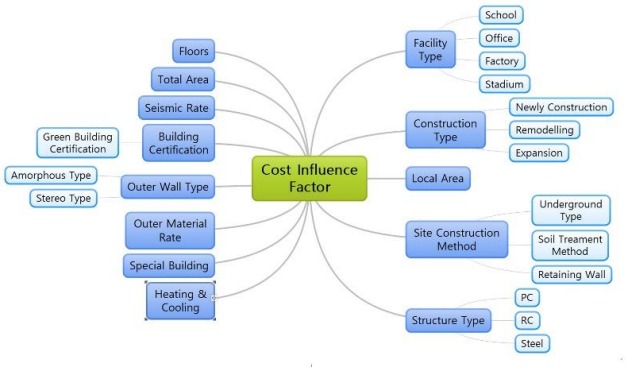

Fig. 1. Construction Cost Influence Factors

There are many factors that affect construction costs, but the most basic factors can be area and scale. In most cases, the cost per unit area is used as an approximate cost estimate method in Korea.

The analysis of construction cost per unit area of public construction projects over the past three years is as shown in Figure 2. As you can see in the figure, the cost per unit area is helpful in understanding the approximate pattern. There is a limit to calculating the exact cost of construction.

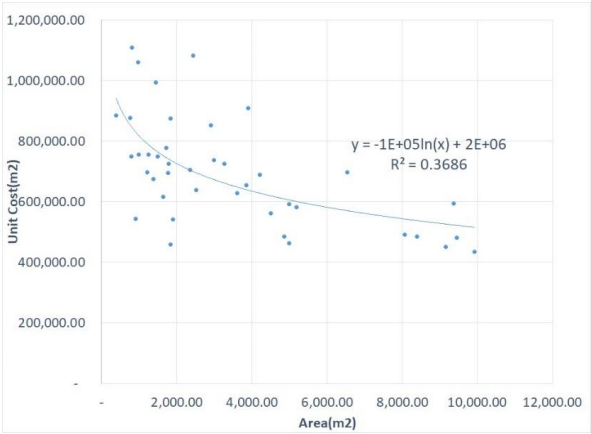

Fig. 2. Construction Cost per Unit Area

B. Applicability Analysis of Simplified Quantity Takeoff Method in Rebar Work

Although the construction cost of main structure is larger than that of finishing work, there are not many types of construction in structure construction. The main structure construction work consists mainly of formwork, rebar and concrete work. Quantity of formwork and concrete can be easily calculated by area and volume of structures alone, but for rebar it is very complex to calculate the quantity, with each type of rebar used to be subdivided into each area, with joints and settlements to be considered depending on the location of the rebar and the loss rate due to the rebar form manufacturing.

Although the quantity of rebar construction is calculated by various methods overseas, the calculation process is very complicated in Korea, with most of the numbers being calculated precisely in the prescribed manner. If a precise quantity of rebar is not calculated, it can be calculated as a proportion of the weight of

rebar to the volume of concrete, and it is known that the amount of rebar produced is not significantly different from the results produced by the actual precise quantity. The criteria used in the simple calculation of rebar quantities overseas are as shown in Table I.

Table I: Sample Table

	Average Values for typical concrete frames
Heavy industrials	130kg/m3
Commercial	100kg/㎥
Institutional	90kg/㎥
Residential	85kg/㎥

Table II shows the quantity of rebar according to the site in a detailed proportion.

Table II: Standard Method of Reinforcements Measurement (Element Base)[15]

Concrete Building Element	**Weight of reinforcement (kg/㎥)**
Bases	90-130
Beams(lightly loaded)	100-150
Beams	150-300
Columns(lightly loaded)	110-200
Columns	200-450
Footings	70-100
Plate slabs	95-135
Retaining walls	110-150
Slabs-one way	75-125
Slabs-two way	67-135
Stairs	130-170

Although the calculation of rebar quantity based on this simple equation is not used in Korea, it is deemed that the difference between the results produced by the brief equation and the results produced in detail is not significant. In this study, we are going to analyze the quantity of rebar based on the simple ratio and examine the adequacy of the method of calculating the quantity of rebar by simple formula.

Figure 3 shows an analysis of the ratio of the quantity of rebar to the volume of concrete in the past three years in case of a regular office building. The overall average value is 12.23%, and with the exception of some anomalies, it is deemed that the approximate output value and error do not appear to be significant. The standard deviation of 1.32 is considered to be within 2% of the mean error, which can be included within the loss rate or premium rate considered for rebar manufacturing.

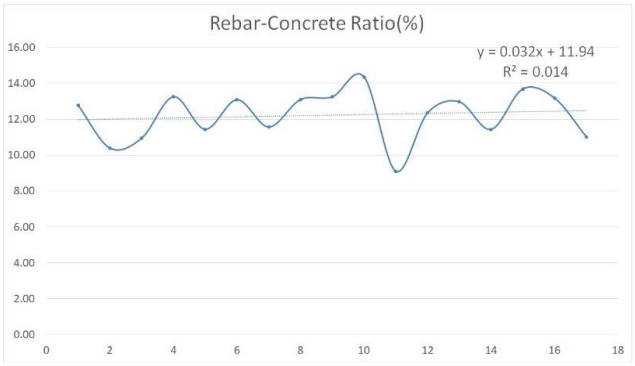

Fig. 3. Rebar-Concrete Quantity Ratio

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IV. CONCLUSION

Quantity statement BoQ of structure work are very important criteria for managing construction costs. However, the composition of quantity statement and BoQ are very complex, and the task burden on the quantity takeoff of rebar work is very heavy. On the other hand, for rebar work, the error rate in the calculation results is not small, reflecting the loss rate of the site cutting operation and the extra quantity for the work is 3% to 6%. In other countries, a simple method is used to calculate the quantity of rebar based on the volume of concrete. In this study, we want to analyze the application of a simple calculation method to calculate the rebar quantity as a percentage of concrete volume.

For this purpose, 10 cases of public office buildings were selected over the past three years to analyze the quantity of rebar work on them. The results showed that the quantity of rebar averaged 12.23% and the standard deviation of 1.32% compared to the volume of concrete, and the actual deviation from the average value was analyzed to be within 1.5%. This is an error that occurs within the 3 to 6% premium rate, indicating that the difference between the detailed and abbreviated results is very small. Of course, it is necessary to take into account the characteristics of the structure or the specificity of the structure, which can be calculated by reflecting additional characteristic changes.

In addition, it is deemed that the correct quantity of rebar can be obtained more simply if different abbreviations can be applied by dividing them into foundation, beam, column, and slab, as in the case of overseas. This simple method of quantity calculation can be expected to increase work efficiency of quantity calculation, and it is expected to reduce burden and cost of preparing bidding documents for construction work when preparing BoQ.

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