CONSTRUCTION COST INDEX FOR APPLYING INDEX ADJUSTMENT RATE IN THE ROAD PROJECT

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ABSTRACT : Construction cost index is generally used to estimate the new project cost based on past construction data and to adjust contract cost when the price change of various articles and items of expenditure composing the contract occurs. In Korea, it is mostly used for adjustment of construction contract cost due to fluctuation of prices. However index adjustment rate which is used for adjustment of construction contract cost had some problems in calculating cost index of each expenditure item that could not reflect properly the change of construction cost. For supplementing these problems, the research of developing construction cost index has been executed. Through the precedent research, these problems were partially resolved but still remain. Therefore this research proposes method of making cost index that utilizes representative items of labor, material, and equipment by analyzing bill of quantity of road construction, through analysis and comparison of precedent study. By using this method, it is expected to solve problems which were not reflected in precedent studies.

Key words : Construction cost index, fluctuation of prices, adjustment of construction contract cost, index adjustment rate

1. INTRODUCTION

Most of construction projects have the characteristic that they are conducted over a long time. Due to their characteristic, the price change of various articles and items of expenditure composing the contract occurs while project is ongoing. In case that, the contract cost can be adjusted to alleviate the burden of contract's parties and to go on smoothly performing the construction contract.

As the method to reflect the rate of fluctuations in prices and to modify contract cost, item adjustment rate and index adjustment rate are used. When the time passes 60 days from the standard day and the calculated rate of fluctuations in prices by utilizing each way is more than 5%, the contract cost is able to be adjusted. Of two ways, index adjustment rate is generally used because it is more simple and convenient for applying escalation or de-escalation. However, there are some problems that don't reflect the fluctuation of construction prices. It is the reason why index adjustment is calculated by applying the arithmetical mean of overall construction labor wages, the items of irrelative construction and the arithmetical mean of whole construction equipment cost.

For supplementing these problems, the researches of developing construction cost index have been executed. Construction cost index is generally used to estimate the new project based on past construction data and adjust contract cost. In Korea, it is mostly used for modulation of construction contract cost due to fluctuation of prices. The method of making construction cost index is not differentiated by the purpose. However it requires precision of index for applying adjustment of contract cost. With reviewing the preceding studies, they are differentiated according to weight which is calculated from statistical data of overall industry or is analyzed from actual input cost of the project. In the research applied the weight of statistical data, Construction Association of Korea (CAK) (1993) presented construction cost index, Cho et al (2002) developed architecture construction cost index and Cho et al (2003) presented construction cost index. In the research utilized the weight of the actual input cost of the project, Park et al (2002) developed cost index of road construction project, Park et al (2003) presented cost index for site developing project, Kim et al (2003) developed cost index of construction labor, and Kim et al (2004) presented cost index of construction material. In this research, the method that applies weight analyzed by actual input cost of project was applied because it is considered more proper method for reflecting fluctuation of the construction cost.

Generally, when many items are analyzed, the cost index is more accurate. However it needs relatively more time and effort. To adjust contract cost, the method that analyzes the representative resource is applied (Jelen et al., 1998). Therefore, this research presents the most appropriate method of making cost index for applying escalation. The proposed method utilizes representative items of labor, material and equipment by analyzing bill of quantity of road construction, through analysis and comparison of precedent studies. By using this method, it is expected to solve problems of index adjustment rate which were not reflected in proceeding studies.

2. CALCULATION OF EACH ITEM'S COST INDEX

2.1 Basic resource of cost index

To make cost index, it requires the standard point of time, weight, equation and cost data. In this research, the standard point of time is set as May, 2000 and input cost ratio of each representative items of the expenditure and actual results of earned value of facility, highway (7.57 %) and general road (5.61%), is utilized as weight. Actual results of earned value of facilities reflect the effect of cost index of each facility and it has the influence for five years from standard time. In this research, to make cost index, equation utilizing each cost index of items of the expenditure is applied. For calculating labor, material, and equipment cost index, the applied cost data is following table 1. The road facilities were divided as highway and general road according to the facility breakdown system of CAK.

Table 1. Cost data of items of expenditure

Item	Cost data
Labor	Labor fee investigated and presented at the Construction Association of Korea (CAK,2003)
Material	Producer Prices Index of each item presented by Korea National Statistical Office (KNSO, 1999)
Equipment	Equipment cost investigated and presented at the Construction Association of Korea (CAK)

2.2 Labor cost index

Occupational categories of representative labors selected in the precedent study (Kim, 2003) was used to make labor cost index and input ratio of them in the project was analyzed like table 2 through analyzing bill of quantity of road construction.

Table 2. Input ratio of representative labor

Representative labor	Highway	General road
Carpenter	7.49 %	7.42 %
Steel frame worker	1.71 %	2.15 %
Steel worker	3.24 %	3.34 %
Steel reinforcing worker	11.46 %	9.31 %
Steel plater	3.00 %	3.64 %
Scaffolding man	3.03 %	4.50 %
Concrete worker	2.45 %	2.13 %
Coating worker	0.71 %	1.86 %
Powder dealer	3.12 %	2.85 %
Driller	1.26 %	0.65 %
Special worker	8.77 %	5.70 %
General worker	42.18 %	29.84 %
Welder	1.87 %	2.65 %
Trimmed stone worker	1.14 %	5.62 %
Sum	**91.44 %**	**81.67 %**

The process to make labor cost index is like figure 1. Labor cost index of each facility was calculated by summing up representative labor indexes that each basic labor cost index made by using labor fee presented at CAK (2003) times input ratio that was convert into 100%. Labor cost index of road construction was computed by applying the weighted average of each labor cost index of road facility. The actual result of earned value of each facility was utilized as the weight for labor cost index.

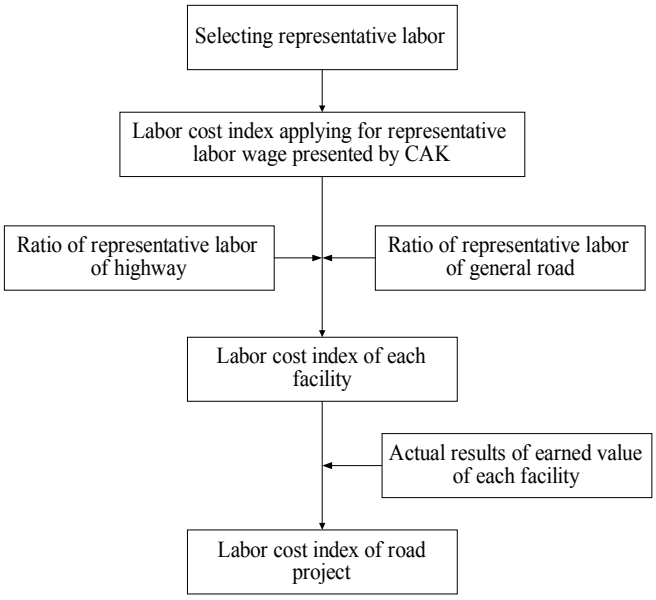

Figure 1. Process of calculating labor cost index

2.3 Material cost index

In this research, the representative items of material applied in the preceding research (Park, 2002) were used to make material cost index. Input cost ratio of representative materials was calculated like table 3 through analyzing bill of quantity of road construction.

Table 3. Input ratio of representative materials

Representative materials	Input Rate	
	Highway	General road
Cement	10.97 %	1.45 %
Steel reinforcing	10.85 %	6.84 %
Ready mixed concrete	2.09 %	12.00 %
Concrete manufacture	1.30 %	8.24 %
Packing material of asphalt	4.68 %	3.22 %
Stone materials	4.58 %	2.11 %
Steel materials	7.11 %	8.70 %
Wooden materials	2.83 %	3.55 %
Light oil	17.02 %	14.24 %
Sum	**61.42 %**	**60.35 %**

Material cost index of each road facility was calculated by adding representative material indexes that each producer price index presented at KNSO times input ratio that was convert into 100%. Material cost index of road construction was calculated by the same way of making labor index. The process of calculating material cost index is like figure 2.

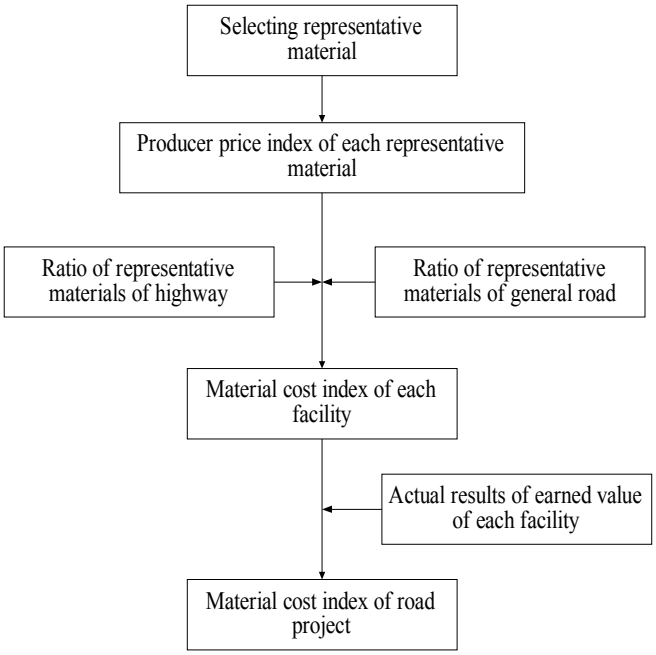

Figure 2. Process of calculating material cost index

2.3 Equipment cost index

The representative equipments were selected through the analysis of bill of quantity. There were several equipments which had large input ratio and were used in common. However, they were different in each road project and equipments that had large input ratio and use in common were determined as representative equipments. It needs to determine representative equipment by analyzing more data and questionnaire of the expert. The 12 chief domestic and foreign equipments of each road facility were selected and their input ratio was computed like table 4.

Cost data for making equipment cost index used representative equipment cost presented at CAK (2003). The process of calculating equipment cost index is like figure 3. Basic cost indexes of equipment were made on the basis of standard point of time. In case of equipment cost index, the ratio of domestic and foreign equipment was used as additional weight. Although ratio of foreign equipment in the project is lower than domestic equipment, the cost of foreign equipment has great effect on cost index. To reduce inappropriate effect, the ratio of domestic and foreign equipment (table 5) was utilized for calculating equipment cost index. Equipment cost index of each road facility was the sum of index that basic cost indexes time input ratio changed into 100%.

Table 4. Ratio of chief domestic and foreign equipment of each road facility

	Highway	Input ratio	General road	Input ratio
Domestic equipment	Excavator + Breaker (0.7㎥)	9.55 %	Excavator (0.7㎥)	1.68 %
	Dump Truck (Soil) (15 Ton)	12.94 %	Excavator + Breaker (0.7㎥)	6.73 %
	Tire Loader (Soil, RR, BR) (1.72㎥)	4.70 %	Dump truck (15 Ton)	39.47 %
	Tire Loader (Soil, RR, BR) (2.87㎥)	13.40 %	Tire loader (1.72㎥)	3.91 %
	Motor Grader 3.6	2.18 %	Motor grader 3.6	2.48 %
	Water Closet (5500L)	5.42 %	Water closet (5500L)	2.73 %
	Bulldoze (Soil, RR, BR) (32 Ton)	2.30 %	Crawler Bulldozer (32 Ton)	8.99 %
	Hydraulic Controlled Back-Hoe (1.0㎥)	3.02 %	Mobile Concrete Pump (80㎥/hr)	4.21 %
	Concrete Truck Mixer (6.0㎥)	12.03 %	Crane (truck) (10 Ton)	1.09 %
	Concrete Batch Plant (120.0㎥/hr)	7.01 %	Crane (truck) (25 Ton)	1.34 %
	Mobile Concrete Pump (80㎥/hr)	3.63 %	Crane (truck) (30 Ton)	5.39 %
	Crawler Drill (17㎥/hr)	3.52 %	Crawler Drill (17㎥/hr)	3.11 %
	Sum	**79.71 %**	**Sum**	**81.14 %**
Foreign equipment	Crawler Crane (40 Ton)	3.96 %	Crawler Loader (1.72㎥)	30.44 %
	Crawler Crane (70 Ton)	1.70 %	Crawler Crane (70 Ton)	1.20 %
	Crawler Crane (100 Ton)	4.10 %	Crawler Crane (100 Ton)	19.76 %
	Crawler Crane (150 Ton)	10.73 %	Crawler Crane (150 Ton)	6.60 %
	Motorized Vibration Roller (10 Ton)	16.92 %	Asphalt Finisher (3M)	1.33 %
	Concrete Spreader (7.95 m)	2.15 %	Water Jet (131 PS)	6.98 %
	Concrete Slipform Paver (215 HP)	1.92 %	Motorized Vibration Roller (10 Ton)	3.89 %
	Concrete Finisher (142HP)	6.22 %	Vibration Pile Hammer (60Kw)	0.74 %
	Portable Crusher (150 Ton/hr)	18.60 %	Concrete Finisher (142HP)	0.39 %
	Rubber Tire Roller (8~15 Ton)	9.26 %	Portable Crusher (150 Ton/hr)	6.19 %
	Rubber Tire Roller (15~25 Ton)	1.29 %	Rubber Tire Roller (8~15 Ton)	4.44 %
	Truck Tractor and Trailer (30 Ton)	2.52 %	Truck Tractor and Trailer (30 Ton)	0.86 %
	Sum	**79.39 %**	**Sum**	**82.82 %**

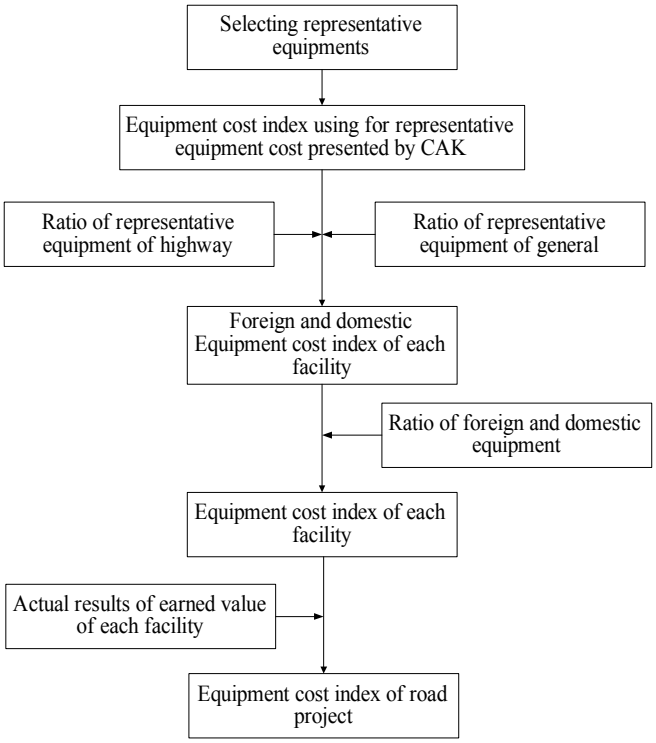

Figure 3. Process of calculating equipment cost index

Table 5. Ratio of domestic and foreign equipment of each facility

Road facility / Equipment	Highway	General road
Domestic equipment	81.57 %	76.85 %
Foreign equipment	18.43 %	23.15 %
Sum	**100 %**	**100 %**

3. COST INDEX OF ROAD CONSTRUCTION

3.1 The Calculation of Road Cost Index

In this research, road cost index is calculated by utilizing each cost index of labor, material and equipment because cost index about each item of bill of quantity was computed. To make road cost index, following equation (1) was applied.

$$IR = \sum(a \times ILi + b \times IMi + c \times IEi) \quad (1)$$

IR : Construction cost index of road
ILi : Labor cost index of road
IMi : Material cost index of road
IEi : Equipment cost index of road

In the equation (1), a, b and c is the input ratio of labor, material and equipment which is weighted by actual results of earned value of each facility. They reflect the effect of each item of bill of quantity. The ratio of labor, material and equipment was calculated like table 6.

Table 6. Ratio of labor, material and equipment

	Highway	General road	Weighted Value
Labor	43.87 %	42.28 %	42.95 %
Material	43.93 %	44.93 %	44.51 %
Equipment	12.20 %	12.79 %	12.54 %
Sum	**100 %**	**100 %**	**100 %**

From equation (1), the cost index of road construction from 1997 to 2004 was calculated like table 7. It was computed by using representative item of labor, material, and equipment.

Table 7. Construction cost index of road construction

Year / Month	1997	1998	1999	2000	2001	2002	2003	2004
1	91.1	108.2	97.5	98.7	104.3	107.9	126.7	132.8
2	91.3	109.8	97.4	98.6	104.3	108.4	127.1	134.6
3	91.2	107.3	97.4	98.5	105.0	109.3	128.0	135.8
4	91.4	108.1	97.6	98.4	105.6	110.4	127.7	136.5
5	93.5	100.4	98.2	100.0	106.5	116.5	128.7	138.2
6	93.8	100.2	98.0	99.3	106.5	117.0	128.5	138.2
7	93.1	100.1	97.2	99.6	106.4	117.8	129.5	138.2
8	93.0	99.9	97.5	102.0	106.2	118.1	129.6	139.2
9	96.0	99.0	98.3	103.2	108.2	124.5	129.7	139.3
10	96.1	100.0	99.1	104.3	108.1	125.4	129.9	140.2
11	96.6	100.2	99.7	104.6	107.5	125.8	130.6	139.8
12	103.4	98.7	99.4	104.6	106.6	125.4	131.0	138.8

3.2 Examining appropriateness of this research

The calculated cost index of road construction is unreasonable to use for adjustment of contract cost because the number of the analyzed data is not sufficient. For examining this research, it is desirable to compare with cost index computed in the precedent study. However it is impossible to reconstruct through analysis of the preceding study. Therefore cost index calculated by proposed method was compared with cost index of road facility presented by Korea Institute of Construction Technology (KICT).

The method of making cost index is different and it is unreasonable what directly compares the value of index. It is appropriate that the comparison of cost index is focused on monthly rising rate of index. Figure 4 is the graph that compares with two cost index from August, 2003 to December, 2004. The maximum difference of monthly increasing rate is 1.1% and the rising rate of cost index between August, 2003 and December, 2004 is 0.5%. In aspect that cost index reflect the fluctuation of point of time, two cost indexes have the similar trend with change of time.

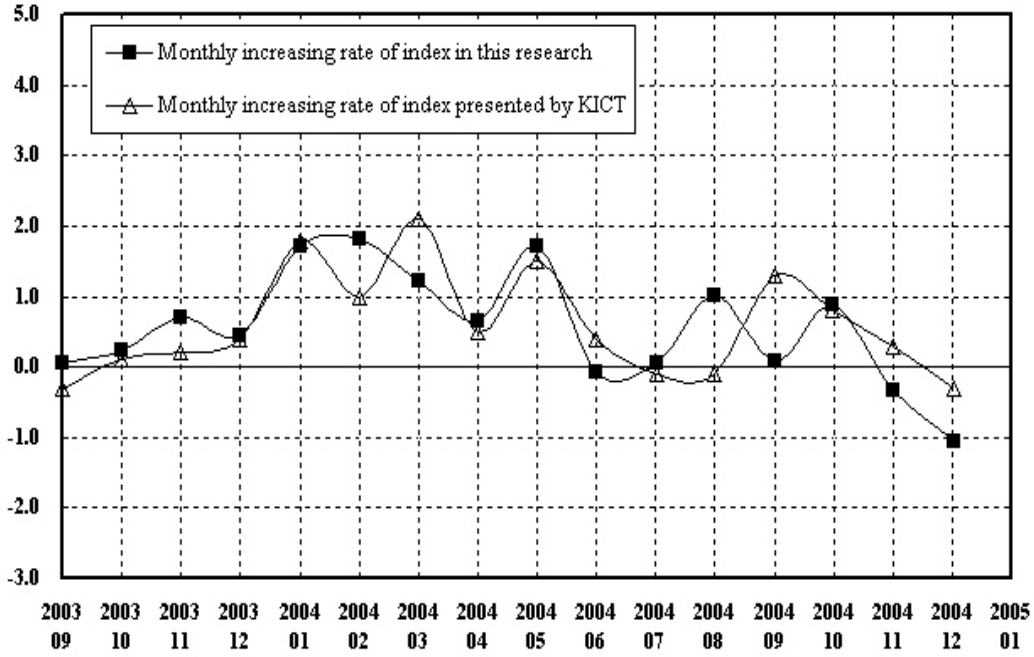

Figure 4. The comparison of monthly increasing rate of index

4. CONCLUSION

In this research, each cost index of labor, material and equipment is calculated by utilizing representative items and input ratio of each item of bill of quantity through analyzing bill of quantity. Cost index of road construction is calculated with using weight, actual results of earned value (2000) investigated by CAK.

Although it is impossible to compare with precedent studies that analyzed actual input cost of project, the propriety of the proposed method is verified through the comparison of cost index presented by KICT. With applying proposed method, it is expected to solve problem in index adjustment rate which applies the arithmetical mean of overall construction labor wages, the items of irrelative construction and the arithmetical mean of whole construction equipment cost.

Cost index of road construction calculated in this research has the limit of actual application because number of analyzed data of each road facility is not valid statistically. To apply the calculated cost index for adjustment of contract cost, it requires to analyze more data and to calculate input ratio of each representative item. If the limit of analyzed data is supplemented, proposed method would be enough to reflect the fluctuation of construction prices.

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