S11-1
Suggestion and Verification of Assessment model on Construction-Cost of Steel Bridge in Project Performance Phases

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ABSTRACT: Estimating the reasonable construction-cost according to the construction phase in public construction is an important element for securing and executing a national budget efficiently. As a general rule, the predetermined cost of construction is estimated at the end of the design of the target structure. Therefore, it seems to be a considerably difficult problem to estimate the approximate cost of construction, only with its basic information of the bridge in the design planning phase and the early design stage where we can not have specific detailed-section of the target structure. In this paper, we present the calculation of construction-cost in the planning phase based on the analysis of factors affecting the cost of construction conducted in the previous study. Beside, to estimate the cost of construction in early design phase, we would like to present the calculation of construction-cost in the early design phase by executing the analysis of data collected from 61 steel box bridges. It was found from the result of study that the estimated cost of construction gained by the calculation of construction-cost in this paper reduces the error between the real cost of construction and that by the existing method of using.

Keywords: Steel bridge; Construction-Cost; Planning Phase; Design Phase; Approximate Construction-Cost

1. INTRODUCTION

It is very important to estimate the reasonable construction-cost for each process in a construction for public facilities and works when securing and executing the national budget effectively. However, compare to the advanced countries, the construction-cost prediction methods are relatively insignificant and the performance of systematic construction-cost management is still not sufficient enough. Generally the predetermined construction-cost is estimated at the time when the design of targeted structures is finished. Namely, after completing the design drawing of target structure, the quantity- and the unit cost-estimation for the construction are made and finally the generated data are put together and the predetermined construction-cost can be calculated. Thus, the calculation of the predetermined construction-cost in the general design stage requires a lot of time and cost. Therefore, it is considered that predicting the approximate construction-cost by having only simple information on the bridge structures in the planning stage or the early design stage without any detailed sectional drawings is a very difficult problem. However, from the point of view of the national budget securing, the estimation of the approximate construction-cost with basic information on the targeted structure can be still considered to be very important in aspect of budget estimation. The previous studies on the predetermined cost estimation for steel bridges have only dealt with a series of researches for the enactment or amendment of the standard quantity per unit method that were related to the steel bridge construction and any study that analyze the characteristics of variation of total predetermined cost has not been carried out yet. Therefore, in this study, more efficient and proper the approximate construction-cost model in the planning stage or the early design stage was presented and verified for reliability by analyzing the existing steel bridge construction-cost data in the previous studies and the relative importance of items as well as the quantity.

2. METHODS & SCOPES OF STUDY

Generally the project conducting stages for steel bridge construction can be fallen into the survey stage of preliminary propriety, propriety survey stage in the planning stage and basic- and practical- design stages in the design stage. In the survey stage of preliminary propriety, the propriety of the project is generally verified in advance to compile a budget for a large-scale project and the propriety survey stage is the stage for the full project commencement after passing the survey stage of preliminary propriety. The assessment objectives of construction-cost for each stage, the available information to be used for the construction-cost estimation at each stage, and the existing assessment standards of construction-cost were presented in Table 1 and Table 2. In this study, the assessment standards of construction-cost in the planning stage were suggested on the basis of the construction-cost effect factors that were analyzed in the previous study and an assessment model was also presented after analyzing the collected data for 61 steel bridges to estimate the construction-cost in the early design stage. The 61 bridges, which were used for the reasonable construction-cost estimation in the early design stage, are steel box girder bridges with the most actual results. The representative items that has high ratio of construction-cost or are highly influential to construction-cost were selected by analyzing the constitution ratio of construction-cost and the effect factors, then the unit quantity for the representative item of the collected data were estimated and finally the construction-cost was predicted.

Table 1. Assessment System of Construction-cost

Business performance Step	Planning stage and survey stage of preliminary propriety	Basic and practical design stage	
Objective	• Selection of target project • Understanding of budget plan • Propriety analysis	• Assessment of approximate construction-cost • Assessment of predetermined construction-cost	
Available information	Length/ Width/ Number of lane/ Regional factors/ Construction condition (Ground, River bed)	Span composition/ Crossing composition/ Structure type/Main section information	Detailed information of structure

Table 2. Existing Assessment Standards of Construction-cost

Existing assessment standards for construction-cost	Standard guide for preliminary propriety (KDI)	Guide for highway work	Guide for investment and evaluation
	Average construction-cost for unit length/ area	Average construction-cost for unit area	Average construction-cost for unit length

3. ASSESSMENT OF APPROXIMATE CONSTRUCTION-COST IN THE PLANNING STAGE

3.1 Survey of effect factors on the approximate construction-cost in the planning stage

By optioning the application data at the level for the construction-cost estimation process and the decision making that is related to the construction-cost from the related references, the effect factors for construction-cost were analyzed, the construction-cost for each item of the bridge was calculated, and the average unit cost of predetermined construction-cost at the planning stage was estimated on the basis of the data acquired. To estimate the construction-cost in the planning stage, as shown in Table 3, the construction-cost effect factors in the standard guide for preliminary propriety (Korea Development Institute, 2004, 4th edi.) and the guide for investment and valuation (the Minister of Construction and Transportation, 2004) were analyzed and the cost effect factors for construction in the planning stage were presented. When estimating the predetermined construction-cost based on the effect factors, the unit costs in Table 4 and Table 6 and the unit costs surveyed in this study were used. The standard construction-cost of the Korea Expressway Corporation (the Korea Expressway Corporation's internal data, 2003 Expressway Construction Average Unit Cost) and the average unit cost of the Minister of Construction and Transportation (2004, the average unit cost of more than two constructions with same or similar classes road execution design that were completed within two years were listed in Table 4 and Table 6.

Table 5 and Table 7 show the standard construction-cost and the standard unit costs that were generated by using the construction-cost data in Table 4 and Table 6 for the targeted 61 bridges in this study.

Table 3. Analysis of Construction-cost Effect Factors in Planning Stage

Classification			Effect factors of Construction-cost	Reference
Planning Stage	Existing model	Standard guide for preliminary propriety (Calculation from Table4)	Bridge Form	Standard unit cost/m Standard unit cost/m^2
			New/ Widen	
			Number of Lane	
			Length/ Width	
			Highway/ Road	
		Guide for investment and evaluation (Calculation from Table5)	Bridge Form	Standard unit cost/m
			Length	
			Highway/ Road	
	Suggested Model		Bridge type	Standard unit cost/m Standard unit cost/m^2
			New/ Widen	
			Construction condition (Ground, River bed)	
			Number of lane	
			Length/ Width	
			Highway	

Table 4. Standard Construction-cost of the Korea Expressway Corporation (unit cost/m, unit cost/ m^2, unit: 1,000won)

Type	2 Lanes (Both way)		4 Lanes (Both way)		6 Lanes (Both way)		8 Lanes (Both way)	
Steel Box Bridge	20,421	1,723	41,271	1,681	54,456	1,729	61,196	1,533

Table 5. Standard Construction-cost Presented in This Study (unit cost/m, unit cost/ m^2, unit: 1,000won)

Type	2 Lanes (Both way)		4 Lanes (Both way)		6 Lanes (Both way)		8 Lanes (Both way)	
Steel Box Bridge	24,172	1,756	35,804	1,711	52,755	1,867	50,735	1,423

Table 6. Standard Unit Costs of the Minister of Construction and Transportation

Classification	Bridge type	Standard Unit Cost (1000won/m)
Highway	Steel Box Bridge	54,000

Table 7. Standard Unit Costs Presented in This Study

Section	Bridge Type	Standard Unit Cost (1,000won/m)
Highway(4 Lane)	Steel Box Bridge	34,876

Table 8. Target Bridge for the Estimation of Approximate Construction-cost

No.	New/ Widen (High-way)	Ground/ River Bed	Length (m)	Width (m)	Area (m^2)	Practical Construction -cost (1,000won)	No.	New/ Widen (High-way)	Ground/ River Bed	Length (m)	Width (m)	Area (m^2)	Practical Construction -cost (1,000won)
1	New	Ground	50	21.0	1050	1,501,079	18	New	River Bed	160	21.9	3504	6,318,551
2	New	Ground	55	20.9	1150	4,624,856	19	New	River Bed	160	24.6	3936	5,798,046
3	New	Ground	80	20.9	1672	2,388,035	20	New	River Bed	210	20.9	1389	6,477,888
4	New	Ground	230	20.9	4807	7,555,464	21	New	River Bed	320	20.9	6688	8,419,746
5	New	Ground	248	24.9	6463	4,775,500	22	New	River Bed	330	20.9	6897	8,901,695
6	New	Ground	495	20.9	10346	13,199,748	23	New	River Bed	335	23.3	7819	11,371,135
7	New	Ground	47	24.4	1147	3,040,006	24	New	River Bed	386	20.9	8074	12,938,456
8	New	Ground	50	20.9	1045	1,801,538	25	Widen	Ground	55	20.9	1150	1,122,704
9	New	River Bed	60	20.9	1254	2,870,636	26	Widen	Ground	170	21.1	3587	5,229,411
10	New	River Bed	90	20.9	1885	2,311,729	27	Widen	Ground	185	24.9	4358	6,200,759
11	New	River Bed	105	20.9	2195	3,866,774	28	Widen	River Bed	300	21.1	6321	10,974,193
12	New	River Bed	115	20.9	2404	3,242,265	29	Widen	River Bed	50	21.1	1054	2,055,807
13	New	River Bed	135	20.9	2822	4,107,768	30	Widen	River Bed	180	20.9	3762	10,974,193
14	New	River Bed	144	20.9	3010	6,251,655	31	Widen	River Bed	200	21.0	4200	7,172,366
15	New	River Bed	145	21.2	3080	3,021,562	32	Widen	River Bed	340	21.0	6510	11,270,761
16	New	River Bed	150	20.9	3135	4,540,222	33	Widen	River Bed	329	20.9	6876	10,614,520
17	New	River Bed	160	21.6	3451	6,563,447	34	Widen	River Bed	565	20.9	11809	19,478,399
Highway with 4 Lanes → New Construction : 24 Bridges, Widen Construction : 10 Bridges													

3.2 Assessment of Approximate Construction-cost in the Planning Stage

To estimate the construction-cost in the planning stage that reflects on the data variables and the analysis results above from the targeted 61 bridges in this study, 34 four-lane highways were classified in Table 8 in accordance with the effect factors of the suggested model in Table 3, considering that four-lane highways has the most application achievement out of the whole steel box bridges in Korea. The approximate construction-cost estimation results in the planning stage and the functional formula with bridge length and deck area as variables after applying the suggest model to the construction–cost in Table 3 for four-lane targeted bridges in Table 8 were presented in Figure 1 and Figure 2. As shown in Figure 1 and Figure 2, as the bridge length and the deck area increased the approximate construction-cost per unit length decreased.

Figure 3 and Table 9 demonstrated the results of the assessment of approximate construction-cost according to the suggested model in Table 3. The coefficient of correlation between the estimated approximate construction-cost by the suggested model in Table 9 and the conventional model and the design construction-cost was withdrawn from Figure 3. The estimated approximate construction-cost for the case 4 with the suggested Model-1 in Table 9 was calculated by using the average unit cost for construction per length. Also the estimated approximate construction-cost for the case 5 with the suggested Model-2 and the case 6 with the suggested Model-3 were calculated by using the estimated functional equations for the bridge length and the bridge deck area in Figure 1 and Figure 2 respectively.

In Figure 4, the average values and their variances calculated from the absolute value of the error of the estimated approximate construction-cost and the design construction-cost, and the maximum and minimum values of the absolute values were listed. From the Figure 4, it was found that the estimated approximate construction-cost used the suggested model-2 and -3 are relatively exact than the other models.

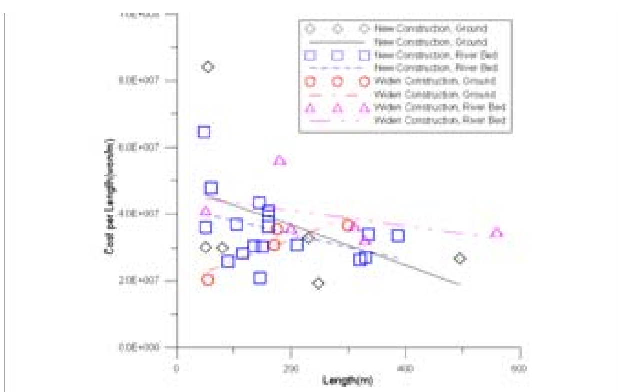

Figure 1. Assessment of Approximate Construction-cost in the Planning Stage of Bridge with Length as Variable

(New • Ground)
$Y=-60428.22868X+48786155.88$ (1)
(New • River Bed)
$Y=-39426.16472X+41934062.26$ (2)
(Widen • Ground)
$Y=65532.0565X+19328788.39$ (3)
(Widen • River Bed)
$Y=-23512.36844X+45843450.65$ (4)

X=Bridge Length (m), Y=Construction-cost (won/m)

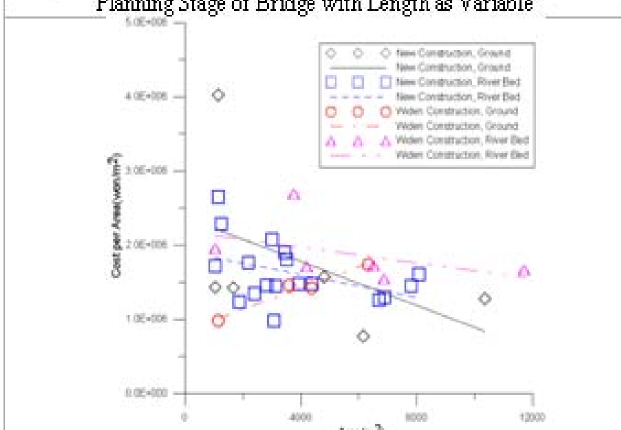

Figure 2. Assessment of Approximate Construction-cost in the Planning Stage of Bridge with Deck Area as Variable

(New • Ground)
$Y=-148.6231818X+2374516.828$ (5)
(New • River Bed)
$Y=-76.94478173X+1908874.098$ (6)
(Widen • Ground)
$Y=143.5498572X+845225.8192$ (7)
(Widen • River Bed)
$Y=-52.81200586X+2182840.395$ (8)

X=Deck Area (m^2), Y=Construction-cost (won/m^2)

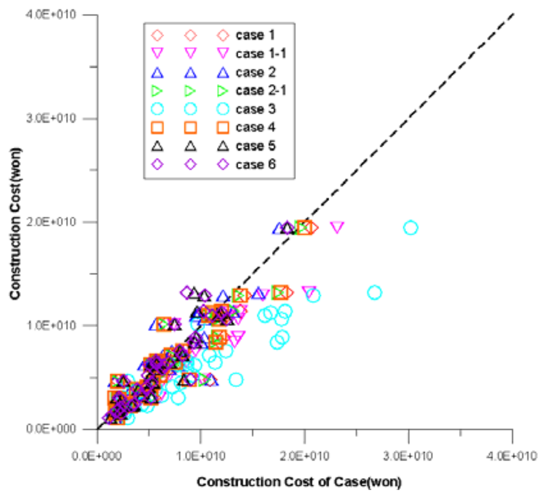

Figure 3. Relationship between Estimated Approximate Construction-cost and Design Construction-cost in the Planning Stage

Table 9. Correlation Analysis of Construction-Cost in the Planning Stage

Section			Coefficient of Correlation
Standard guide for preliminary propriety	Considering Width	Won/m (case 1)	0.8634
		Won/m2 (case 2)	0.8265
	Non-Considering Width	Won/m (case1-1)	0.8804
		Won/m2 (case2-1)	0.8636
Guide for investment and evaluation	Won/m (case 3)		0.8804
Suggested Model-1	Won/m (case 4)		0.8804
Suggested Model-2	Won/m (case 5): using Fig. 1		0.8701
Suggested Model-3	Won/m2(case 6): using Fig.2		0.8596

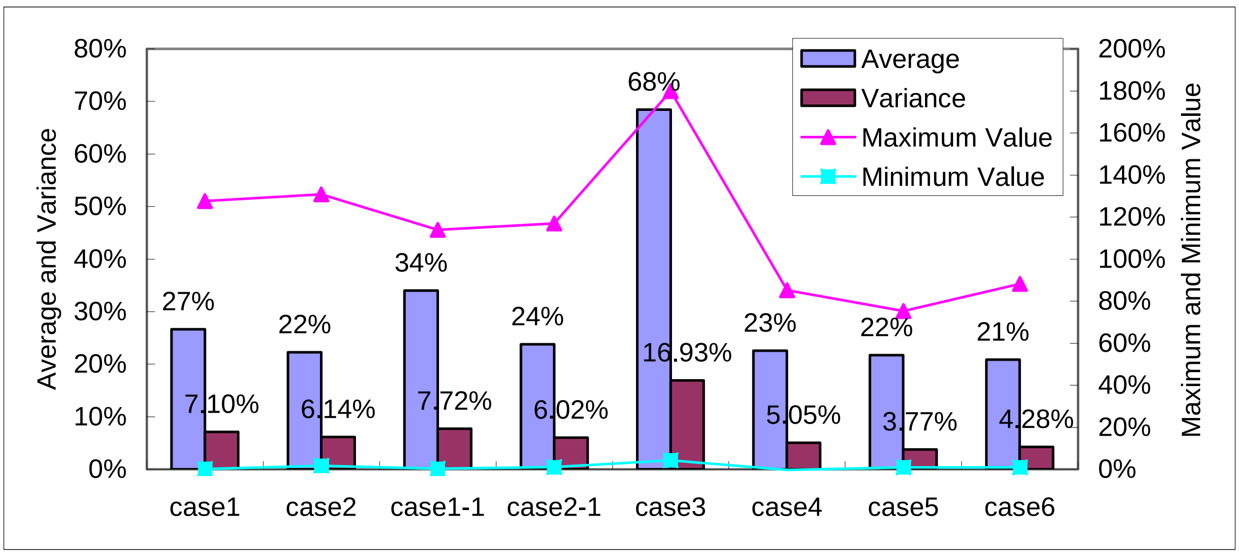

Figure 4. Average Values and Variances Calculated from the Absolute Value of the Error of the Estimated Approximate Construction-cost and the Design Construction-cost according to Table 8

4. ASSESSMENT CONSTRUCTION-COST IN THE DESIGN STAGE

4.1 The selection of representative item and the calculation of unit quantity

By analyzing the level of the available information in the early stage of the design and the construction-cost constitution ratios in practical design documents of the 61 steel box bridges, total seven representative items centered on higher construction-cost ratio and more important items out of the targeted items were chosen.

The ratio of the construction-costs for the steel box bridge superstructure work to each item was shown in Table 10. Based on Table 10, the chosen seven representative items were steel bridge (fabrication, erection, transportation and coating), construction materials, bridge floor water proofing, reinforcing-bar process/structure, timbering, mold form and concrete placing, these seven representative items took up 99.85% of the construction-cost of the total superstructure work and the rest portion of the items was 0.15%. For the chosen items, the unit quantities for each item were calculated; the construction-cost was predicted by using the unit quantity and the unit cost for each item; and the total construction-costs for the steel box bridge superstructure work were estimated by multiplying a constant rate about the rest portion of the items.

Table 10. The ratio of the construction-costs for the steel box bridge superstructure work to each item

Item	Ratio(%)	Accumulated Ratio(%)
1. Steel Bridge		
1.1 Fabrication	59.35	59.35
1.2 Erection	14.23	73.58
1.3 Transportation	2.00	75.58
1.4 Coating	11.20	86.78
1.5 Non-destructive Inspection	1.05	87.83
2. Construction Materials	3.40	91.23
3. Bridge Floor Water Proofing	2.32	93.55
4. Reinforcing-Bar Process/Structure	2.43	95.98
5. Timbering		
5.1 General Timber	1.77	97.75
5.2 Deck Finisher	0.29	98.04
6. Mold Form	1.45	99.49
7. Concrete Placing	0.36	99.85
8. Surface Treatment	0.086	99.936
9. Shrinkage Compensating Concrete	0.031	99.967
10. Installation Spacer	0.021	99.988
11. Construction Joint	0.001	99.989

According to the previous studies, it was found that the fabrication, erection and transportation were highly related to the bridge length and the bridge deck area; and they had closer relationship with the bridge deck area than with the bridge length. Therefore, the estimated construction-cost was estimated by using the unit weight as a unit item that the values for the fabrication, erection and transportation were divided by the bridge deck area.

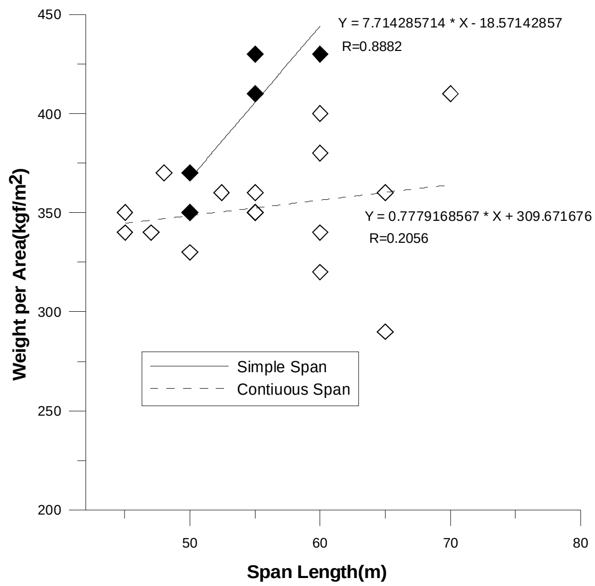

Figure 5. Relationship between the Span Length and Unit Weight of Steel

Figure 4 demonstrated the relationship between the span length and unit weight of steel for the simple span bridge and the continuous span bridge. The average steel weight increased in proportion to the span length. In the case of the simple span bridge, the average steel weight per unit area was increased proportionally by 0.32~0.44tonf/m^2 by changing the span length while in the case of the continuous span bridge the average steel weight increased by 0.27~0.37tonf/m^2 as the span length changed but its variation range tended to be smaller.

The estimated unit quantities for the representative items were listed in Table 11. As shown in Table 12 the unit quantities for the fabrication, erection transportation and coating were calculated by each regression equation using the span length and the maximum span length as variables, and for the rest of the representative items, the construction-costs were estimated by multiplying the unit value for the items by the unit quantity that was calculated by the average value that the quantity was divided by the span length for the bridges with standard cross-section.

Table 11. List of Estimated Unit Quantities for the Representative Items

Item	Unit	Unit Quantity	Item	Unit	Unit Quantity
1. Steel Bridge			3. Bridge Floor Water Proofing	m^2/Length	19.493
1.1 Fabrication	ton/Area	• Short Span Steel Bridge (X=Length) f(x)=(7.714X-18.571)/1000 • Continuous Span Steel Bridge (X=Maximum Length) f(x)=(0.778X+309.672)/1000	4. Reinforcing-Bar Process/Structure	ton/Length	1.448
1.2 Erection	ton/Area		5. Timbering		
1.3 Transportation	ton/Area		5.1 General Timber	bon/m^3/Length	16.583
1.4 Coating	m^2/Area	• Short Span Steel Bridge (X=Length) f(x)=0.091X+4.29 • Continuous Span Steel Bridge (X=Maximum Length) f(x)=0.101X+3.59	5.2 Deck Finisher	bon/m^3/Length	5.535
2. Construction Materials			6. Mold Form	m^2/Length	15.062
2.1Ready-Mixed Conc.	m^3/Length	6.836	7. Concrete Placing	m^3/Length	7.181
2.2 Reinforcing-Bar	ton/Length	0.236			

Table 12. Calculation Method of Construction-cost by Representative Item

Item	Unit	Calculation Method Construction-cost	Item	Unit	Calculation Method Construction-cost
1. Steel Bridge			3. Bridge Floor Water Proofing	m^2	Unit Quantity×Length=Total Quantity Construction-cost=Total Quantity×Unit Cost
1.1 Fabrication	ton	Calculating Total Quantity After Calculating Unit Quantity by Regression Equation, Construction-cost=Total Quantity×Unit Cost	4. Reinforcing-Bar Process/Structure	ton	Unit Quantity×Length=Total Quantity Construction-cost=Total Quantity×Unit Cost
1.2 Erection	ton		5. Timbering		
1.3 Transportation	ton		5.1 General Timber	bon/m^3	Unit Quantity×Length=Total Quantity Construction-cost=Total Quantity×Unit Cost
1.4 Coating	m^2		5.2 Deck Finisher	bon/m^3	Unit Quantity×Length=Total Quantity Construction-cost=Total Quantity×Unit Cost
2. Construction Materials			6. Mold Form	m^2	Unit Quantity×Length=Total Quantity Construction-cost=Total Quantity×Unit Cost
2.1 Ready-Mixed	m^3	Unit Quantity×Length=Total Quantity Construction-cost=Total Quantity×Unit Cost	7. Concrete Placing	m^3	Unit Quantity×Length=Total Quantity Construction-cost=Total Quantity×Unit Cost
2.2 Reinforcing-Bar	ton	Unit Quantity×Concrete Quantity =Total Quantity Construction-cost=Total Quantity×Unit Cost	8. The Other Item	Eq.	Representative Item×0.015

4.2 Verification of the estimated construction-cost for the steel bridge superstructure work in design stage.

The propriety of the suggested estimation model for steel bridge construction-cost was verified by applying the provided unit quantities and the regression equations to the research targeted bridge in this study. To have the construction-cost of the targeted bridge, the total quantities for each representative item were calculated, and then each cost was estimated by multiplying the calculated quantities by unit design cost. When estimating the unit quantities, the standard width of 20.9m was used and the unit quantities were corrected based on the ratio of the standard width to the targeted bridge width.

For the total 15 bridges with different widths in Table 13, the propriety of the suggested estimation model was verified, and the design construction-cost and the estimated construction-cost for the targeted bridges were presented. The error range of the estimated construction-cost calculated by using the suggested model and the design construction-cost of superstructure work for 15 bridges was between -3.89 and +5.86%. These errors were generally from the unit quantities for the fabrication, erection and transportation that take up high percentage of the superstructure work construction-cost of the steel bridge, and it was suspected that only a small error value could affect a lot to the total construction-cost.

Table 13. Comparison between the Design Construction-cost and the Estimated Construction-cost

(Construction-Cost Unit : 1,000won)

Number	Construction Condition	Alignment	Type	Design Construction-cost	Estimated Construction-cost	Error (%)
1	Ground	Curve	Continuous Span	5,581,310	5,423,522	-2.83
2	Ground	Straight	Continuous Span	11,027,263	10,623,278	-3.66
3	Ground	Straight	Simple Span	583,632	575,208	-1.44
4	River Bed	Curve	Continuous Span	4,362,723	4,278,181	-1.94
5	River Bed	Curve	Continuous Span	5,174,180	4,972,711	-3.89
6	River Bed	Straight	Continuous Span	10,436,747	10,967,460	5.09
7	River Bed	Curve	Simple Span	919,623	920,535	0.10
8	River Bed	Curve	Continuous Span	2,956,802	2,845,305	-2.41
9	River Bed	Curve	Simple Span	1,644,062	1,706,355	3.79
10	River Bed	Curve	Continuous Span	4,913,074	4,976,038	1.28
11	Ground	Curve	Simple Span	814,856	785,509	-3.60
12	Ground	Curve	Continuous Span	1,389,052	1,470,390	5.86
13	River Bed	Curve	Continuous Span	4,577,232	4,507,213	-1.53
14	River Bed	Straight	Continuous Span	7,071,157	6,956,827	-1.62
15	River Bed	Curve	Continuous Span	14,536,597	14,436,406	-0.50

The error ranges of the design construction-cost and the estimated construction-cost were presented in Figure 6. The estimated construction-cost by length and area as shown in the figure are generally calculated by using only construction-cost for unit area and unit length without taking into consideration of the unit quantity of the targeted bridge in the preliminary propriety study.

As indicated from Figure 6, the deviation for the case that the superstructure work construction-cost was calculated with the span length as a variable was from -5.14% to 252.49% and the deviation was from -28.04% to 79.89% for the case with the area as a variable. This indicated that the results are very inaccurate by giving a huge error range compared to the design construction-cost.

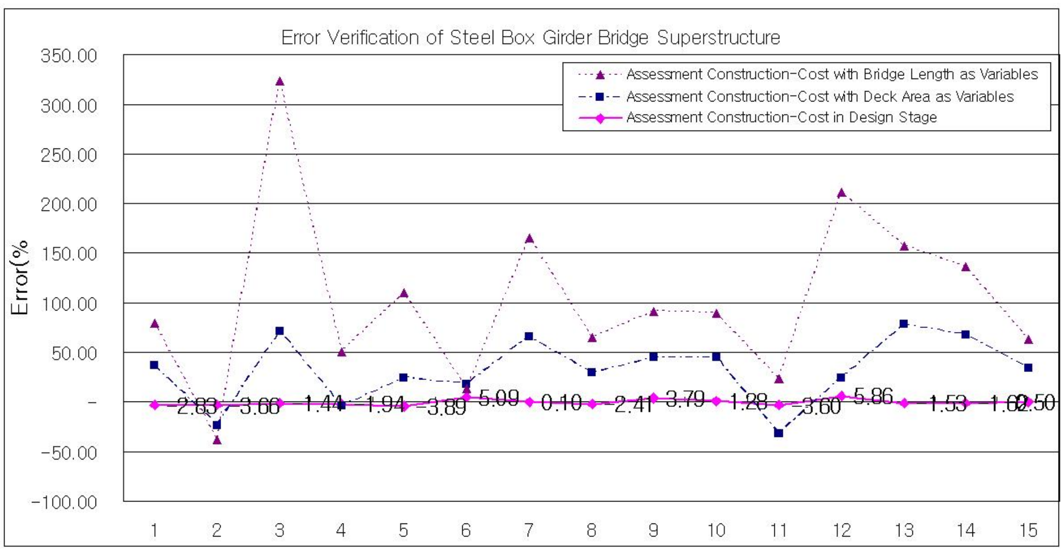

Figure 6. Errors between Design Construction-cost and Estimated Construction-cost

However, in this study, when the superstructure work construction-cost was calculated with the suggest model that uses only a simple information of the structure, the deviation was from -3.89% to 5.86% and therefore the accuracy was quite high compared to the conventional construction-cost estimation guide. As a result, it was concluded that the construction-cost estimating model suggested in this study had sufficient propriety.

5. VERIFICATION OF THE SUGGESTED MODEL FOR ASSESSMENT CONSTRUCTION-COST

The assessment construction-cost models for steel bridge in the planning stage and the early design stage that were suggested in this research were applied to a research purposed target bridge for verification of propriety. The construction-cost of steel bridge in the planning stage was estimated by using the regression analysis equation given in Figure 1 and Figure 2, and the cost in the early design stage were achieved by calculating the total quantity for each representative item of the bridges and then the total construction-cost was estimated by multiplying the calculated quantity by the unit design cost. The unit quantity was calculated based on the standard width, 20.9m and the unit quantity was corrected by the ratio of the standard width and the width of the targeted bridge. The propriety of the construction-cost assessment model for 6 bridges with different widths and lengths in Table 14 was verified.

Table 14. Basic Information of Targeted Bridge Using In Verification

No.	Length (m)	Width (m)	New/ Widen	Ground/ River Bed	Span Type
A	45	9.9	New	Ground	Short
B	295	12.4	New	River Bed	Continuous
C	330	12.4	New	River Bed	Continuous
D	200	21	Widen	River Bed	Continuous
E	310	21	Widen	River Bed	Continuous
F	580	23	Widen	River Bed	Continuous

Table 15. Comparison between Actual Construction-Cost and Estimated Construction-Cost

(Unit : 1000won, Ration of Error)

Section	Actual Construction -Cost (1000won)	Preliminary Propriety Standard Guide	Guide for Investment and Valuation	Planning Stage		Design Stage Estimated Model
				Length	Area	
A	1,179,283	35%	64%	-74%	15%	-7%
B	6,902,719	9%	38%	-30%	12%	7%
C	8,261,973	15%	42%	-16%	20%	8%
D	7,789,316	19%	-7%	-6%	-6%	6%
E	13,334,244	26%	3%	10%	10%	11%
F	25,261,572	22%	4%	34%	30%	18%

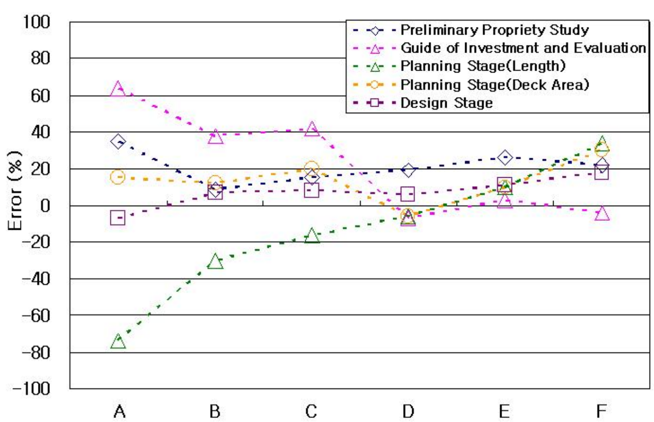

Figure 7. Verification of Error between Design Construction-cost and Estimated Construction-cost

The error range between the assessment construction-cost results by using the estimating model suggested in this study and the design construction-cost and the error range between the preliminary propriety study standards which is the conventional construction-cost estimation standards and the design construction-cost were presented respectively in Figure 6. As a result of the assessment construction-cost in the planning stage with the suggested model in this study, if the length was used as a variable, the error was large because the width of bridge did not take into consideration but if the area was used, the error was between -6% and 30%. This indicated that the confidence level was high compared to the case using the conventional guides. When the construction-cost was estimated by applying the suggested model in the design stage, the error range was -7% ~ 18%, which gave a high accuracy level.

6. CONCLUSTION

The estimating model, that gave a reasonable construction-cost estimation by having only a few information on the structure in the planning and early design stages before completing the sectional detail drawing, was suggested and verified, then the conclusions were made as follows,

1. The construction-cost estimating model in the planning stage was more close to the design construction-cost when the construction-cost was estimated using the area.
2. When the construction-cost predicted by the construction-cost estimating model at the design stage was compared with the cost from the conventional standards, the suggested model in this study gave the results with very high confidence level.

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