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A Study on Management Priority of Design Changes Through Technical Proposal Tendering Case of Office Buildings

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Abstract: Recently, the importance of design management for the effective and systematic management of architectural design has been emerged in the construction industry. Design management is an important part of the success and failure of the project from the planning stage to the construction stage. Failure of design management causes frequent design changes and leads to an increase in construction cost. This results in a monetary loss to the construction project. If systematic design management considering construction phase is performed, design change can be minimized. By analyzing and considering key proposals and design change factors for technical proposal tendering method in the design management phase, design for optimal construction and minimization of design changes can be possible. The purpose of this study is to present the priorities and the expected effects according to the major consideration of design change factors through analysis of design change factor and major proposal case of technical proposal tendering on office buildings.

Key words: Technical proposal tendering, design change, office building, improvement factor, management priority, cost

INTRODUCTION

Design change refers to the abbreviation of "Change specifications", namely, it is to change original design content during construction (Lee *et al*., 2005). Frequent design changes in construction projects lead to an increase in construction costs, resulting in significant losses to the project. In general, it is important to minimize design changes through efficient implementation of design project and systematic design management based on sharing of roles and responsibilities of the participants, so as to secure the appropriate quality in a limited budget within a fixed time (Choi *et al*., 2006).

If the design management does not perform the proper function in the architectural project, frequent design changes occur. If the design management considering the construction stage is carried out, the subsequent design change can be minimized.

Unlike contracts in other fields, construction contracts are subject to change due to different site conditions. In the event of a design change, most of the construction contracts will be handled through agreement between the contracting parties in the field. However, failure to reach an agreement can lead to disputes which will have an enormous impact on the overall business. Therefore, the type of design change needs to be analyzed closely (Park *et al*., 2000).

Technical proposal tendering is a tendering method that finds the best alternative in the state of design that is completed to improve the value of the building project through efficient proposal and the experts in each field find the best alternative (Lee and Soo-Young, 2014). The purpose of this study is to present the priorities and the expected effects according to the key considerations by design change factors for improvement of the design change of office buildings through analysis of the proposal cases during technical proposal tendering on office buildings.

Design change elements in previous research: Factors influencing the design changes of previous studies on design change factor and design change process are the use of new technologies and new methods, Discordance in field condition, basic plan change, design document and statement, owner's requirements, material change/quantity increase, requests for basic plan civil claim, safety and force majeure as common reasons of design change (Shin *et al*., 2010). In the related systems and regulations, owner's requirements, new technology new method, field conditions, basic plan change, design document and statement error are the reasons of design change. Analyzing the key considerations for each factor could lead to improvements that could reduce the factors affecting the design change in the design management phase.

MATERIALS AND METHODS

Selection of case study objects: Three projects were selected from public institutions from 2012-2014 in order

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Table 1: Factors of design changes from advance research, law and system

Design changes thesis and project	Factors of design changes										
	Owner's requirement	New construction and method changes	Material change/ quantity increase	Discordance in field condition	Lack of basic plan	Basic plan change	Design document	Statement	Civil claim	Safety	Force majeure
A study on development of change order management system for SOC project (2000)	-	o	-	o	-	o	o	o	o	-	-
A study on the factor of change order in the public construction project (2005)	o	o	o	o	o	o	o	o	-	o	-
A study on the analysis about causes of change based on case analysis construction project on the site (2007)	o	o	o	o	o	o	o	o	-	-	-
A study on process improvement of the building design change support by case studies (2009)	o	o	o	o	o	o	o	o	o	o	o
Study on the analysis about influence for change order factor in construction phase (2011)	o	o	o	o	o	o	o	o	o	o	o
Total	4	5	4	5	4	5	5	5	3	3	2

to derive proposals and major improvements in technical proposal tendering. Two office buildings and one computer center will be selected as a total of three business facility projects and key proposals will be analyzed. The main proposal of technical proposal tendering by design change factors and the change of construction cost are analyzed and it is aimed to derive the consideration for minimizing the design change of office building at the design stage (Table 2).

Suggestions and cases of technical proposal tendering on office buildings: In technical proposal tendering on office buildings there are total of 176 key proposals which are 84 basic plan change, 58 material changes/quantity increases, 14 lack of basic plans, 12 new construction and method changes and 8 safety securing. The number of proposals for the basic plan changes accounted for about 47% of the total number, making it the most important improvement. Material change/quantity increase accounted for approximately 33% of the total number. The number of proposals for basic plan change and material change/quantity increase accounted for about 80% of the total number which should be reviewed first at the design stage.

Construction cost changes of technical proposal tendering on office buildings: Construction cost changes of technical proposal tendering on office buildings is increased/decreased in the order of 389,846,686 won for securing safety 778,748,743 won for new construction and method change, 856,347,949 won for lack of basic plan, 2,029,082,584 won for basic plan change. Basic plan change showed the biggest increase. Material change/quantity increase is 4,908,946,835 won and it is the biggest decrease. Total construction cost change was also reduced by 854,920,873 won. Considering the use of appropriate materials and reviewing the quantity of materials, the cost of construction has been greatly reduced and the improvement of the function and performance of the building was considered by investing it in the change of basic plan and basic plan, proper method and securing safety (Table 3).

Table 2: Suggestions and cases of technical proposal tendering on office buildings

Reasons	Case A	Case B	Case C	Total
Material change/Quantity increase	27	24	7	58
Basic plan change	11	48	25	84
New construction method and construction method change	2	10		12
Lack of basic plan	7	7	-	14
Safety	3	5	-	8

Number of major improvements of the office building technical proposal tendering: Major improvements of the office building technical proposal tendering are total of 176 cases which are 46 of improvement of functions, 30 of improvement of performance, 24 of interior material change, 22 of exterior material change, 16 of equipment additional installation, 9 of method change, 7 of improvement of structure, 5 of design improvement and performance improvement, respectively, 4 of improvement of constructability, 2 of finishing materials change and

Table 3: Construction cost changes of technical proposal tendering on office buildings

Reasons	Case A	Case B	Case C	Total
Material change/Quantity increase	-1,787,826,832	-2,626,025,841	-495,094,162	-4,908,946,835
Basic plan change	76,746,500	1,882,030,148	70,305,936	2,029,082,584
New construction method and construction method change	-176,770,257	955,519,000		778,748,743
Lack of basic plan	-308,977,351	1,165,325,300		856,347,949
Safety	397,947,389	-8,100,703		389,846,686

improvement of facility system, security system, respectively and each of extension consideration and disabled consideration. Improvements of function and performance and the use of appropriate interior and exterior materials were the most important improvements and extension consideration and disabled considerations are each limited to one.

The main proposals of technical proposal tendering are proposals for areas where there is room for improvement or need improvement and a careful review of the basic plan and a review of major improvements are needed from the design stage, consideration on improvement of function and improvement of performance and consideration on the use of appropriate interior/exterior materials are considered to be necessary for priority review (Table 4).

Table 4: Number of major improvements of the office building technical proposal tendering

Reasons	Case A	Case B	Case C	Total
Improvement of function	13	17	16	46
Improvement of performance	-	26	4	30
Improvement of design	-	2	3	5
Exterior materials change	12	5	5	22
Interior materials change	7	16	1	24
Finishing materials change	-	1	1	2
Equipment system change	1	1	-	2
Equipment additional installation	6	10	-	16
Improvement of equipment performance	5	-	-	5
Improvement of structure	3	2	2	7
Construction method change	-	9	-	9
Improvement of constructability	-	4	-	4
Consider extension	-	1	-	1
Improvement of security system	2	-	-	2
Consider disabled	1	-	-	1

Change to construction cost for major improvements in the office building technical proposal tendering: For change to construction cost for major improvements in the office building, construction cost is increased/decreased in the order of improvement of constructability, consideration of disabled, equipment system change, improvement of security system, construction method change , interior materials change, equipment additional installation, improvement of structure. Construction cost is reduced in the order of extension consideration, finishing materials change, improvement of equipment performance, improvement of function, improvement of performance, improvement of design, exterior materials change. Exterior materials change is 5,311,467,944 won and it is the biggest reduction and construction cost of total major improvements is reduced 854,920,873 won.

The selection and use of proper exterior materials is a factor that can reduce the construction cost while improving the performance of the building. By choosing proper exterior and finishing materials and considering design and facilities, performance and functions, reduce the construction cost at the same time, it is possible to improve the function and performance of the building by investing constructability, consideration of disabled, security system, appropriate construction method, use of high efficiency interior materials, suitable equipment and structure and if a careful review is made at the design stage, it is considered that the design change can be minimized (Table 5).

Intermediate conclusion: Through the main proposal cases of technical proposal tendering the technical proposal suggestions for each case, the number of cases and the change of the construction cost were investigated and major improvements were obtained. Management priority according to number of case of major technology suggestions and management priority according to construction cost change is as follows (Table 6).

Management priority according to number of case is first, the basic plan change. Consideration should be given to ensuring usability according to the change of the basic plan, planning of traffic line and proper layout. Second, material change/quantity increase. It is necessary to consider proper material selection and use. In the third place, it is important to review the basic plan and to select the proper construction method due to lack of basic plan and new construction method and method change, lastly 4th is consideration on safety through ensuring safety is necessary. If these items are reviewed and managed at the design stage, it is considered that the design change can be minimized.

Management priority according to construction cost change can be divided into factors of reduction of construction cost and factors of increase of construction cost. The decrease factor of construction cost is material

Table 5: Change to construction cost for major improvements in the office building technical proposal tendering

Reasons	Case A	Case B	Case C	Total
Improvement of function	-208,331,776	832,467,947	-1,820,163,424	-1,196,027,253
Improvement of performance	-	-1,015,054,433	-834,261,661	-1,849,316,094
Improvement of design	-	35,700,000	-2,296,582,811	-2,260,882,811
Exterior materials change	-1,138,220,591	-3,562,613,723	-610,633,630	-5,311,467,944
Interior materials change	68,569,932	1,328,275,882	292,548,100	1,689,393,914
Finishing materials change		-3,200,000	-568,398,400	-571,598,400
Equipment system change	4,997,888	136,931,000	-	141,928,888
Equipment additional installation	96,963,456	2,307,463,300	-	2,404,426,756
Improvement of equipment performance	-849,013,704	-	-	-849,013,704
Improvement of structure	-176,770,257	25,846,931	5,412,703,600	5,261,780,274
Construction method change	-	1,277,372,000	-	1,277,372,000
Improvement of constructability	-	6,759,000	-	6,759,000
Consider extension	-	-1,200,000	-	-1,200,000
Improvement of security system	392,144,556	-	-	392,144,556
Consider disabled	10,779,945	-	-	10,779,945

Table 6: Management priority according to number of case and construction coast

Priorities			
1st	2nd	3rd	4th
Management priority according to number of case			
Basic plan change	Material change/Quantity increase	Lack of basic plan New construction method and construction method change	Safety
Management priority according to construction cost			
Cost decreasing factors			
Material change/Quantity increase			
Cost increasing factors			
Basic plan change	Lack of basic plan New construction method and construction method change	Safety	

Table 7: Management priority according to improvement and construction cost

Priorities			
1st	2nd	3rd	4th
Management priority according to improvement			
Improvement of function	Interior materials change	Construction method change	Finishing materials change
Improvement of performance	Exterior materials change	Improvement of structure	Improvement of security system
	Suitable equipment	Improvement of design	Consider extension
		Improvement of equipment performance	Consider disabled
Management priority according to construction cost			
Cost decreasing factors			
Exterior materials change	Improvement of design Improvement of performance Improvement of function	Finishing materials change	Consider extention
Cost increasing factors			
Improvement of structure	Suitable equipment Interior materials change Construction method change	Improvement of security system	Consider disabled Improvement of constructability

change/quantity increase. The choice of proper material is important to improve the function and performance of the building as well as to reduce the construction cost. Increase factor of construction cost is first, basic plan change, second, lack of basic plan, third, ensuring safety. From the design stage, it is necessary to review the basic plan, to use appropriate construction method and to consider safety. The increase factor in total construction cost is 4,054,025,962 won, material change/quantity increase which is a factor of cost reduction is -4,908,946,835 won and the selection and use of appropriate materials is a factor that can improve the performance, the function of the building and reduce the construction cost of the whole project. It is necessary to investigate factors of reduction of construction cost and factors of increase of construction cost (Table 7).

Management priority according to improvement factors is first, improvement of function and improvement of performance. Consideration should be given to improving usability, planning of traffic line and efficient layout. The 2nd priorities are interior material change, exterior material change and the use of suitable equipment. The use of appropriate interior and exterior materials and the consideration of suitable equipment are

necessary. The 3rd priorities are construction method change, improvement of structure, improvement of design and improvement of equipment performance, the 4th priorities are finishing material change, improvement of security system, extension consideration and consideration of disable. Consideration as a first review in the design phase is necessary (Table 7).

Management priority according to factors of improvement and construction cost can be divided into reduction factors and increase factors of construction. The reduction factors of construction cost are first, exterior material change which is the biggest reduction in construction cost, 2nd, improvement of design, improvement of performance and improvement of function. The 3rd is finishing material change and the 4th is extension consideration. The use of suitable exterior and finishing materials, design and performance and improvement of function are factors that can reduce construction cost. The increase factors of construction cost are first improvement of structure that is selection of appropriate structure is the biggest increase factor, the 2nd priorities are the use of suitable equipment, interior material change, construction method change. The 3rd priority is improvement of security system and the 4th priorities are consideration of disabled and improvement of constructability. Appropriate structure and construction methods, use of equipment and use of high-efficiency interior materials are factors of increase and decrease of construction cost but it is possible to improve the performance and function of buildings. It is possible to improve the value of the building by reviewing the basic plan to improve the performance and the function of the building by reinvesting it through saving the construction cost with a proper planning for cost reduction factors and considering the cost increase factors.

RESULTS AND DISCUSSION

Identify key considerations for improving design change factors: The main considerations for improving the design change factors of office building are as follows (Table 8).

Table 8: Key considerations for improving design change factors

Reason for design change/Considerations	Details	Expected effects
Basic plan change (1st priority)		
Improve space utilization	Improve work support environment	Secure views
	Adjust open space and remove beam	Improve openness
	Improve layout	Improve space utilization
		Use suitable structure
Design change	Adopt suitable design	Improve utilization
Optimize an underground parking lot	Efficient arrangement	Plan for an efficient parking lot
	Improve parking lot area	Minimize private space
	Improve natural ventilation capacity	Reduce construction costs through quantity reduction
		Integrate ancillary room
		Improve maintenance
		Reduce ventilation energy
		Improve economics
		Improve constructability
		Improve safety
Improve constructability	Choose proper column	Secure constructability
	Proper structure span intervals	Reduce construction costs
Improve energy capacity	Strengthen and improve insulation and air tightness by part	Reduce base load
	Plan for the prevention of solar radiation load	Minimize heat loss
	Passive technology	Improve work environment
	Minimize window area	Plan for energy saving
	Increase renewable energy	
	Shading device	
Material change/quantity increase (2nd priority)		
Improve insulation	Use phenolic foam	Satisfy the standard for energy saving
	Use rigid urethane insulator	Improve insulation and minimize thickness
	Minimize heat bridge of the part without insulation	Secure fire safety and improve constructability
Improve glass capacity	Use double low-E coating, triple glass	Reduce energy load
	Vacuum triple glass (air charging)	Reduce energy
	Use high-efficient low-E triple glass	Improve energy through improved thermal transmittance and shade factor
Lack of basic plan (3rd priority)		
Maintenance method	Secure maintenance methods	Improve maintenance
Plan of equipment delivery	Install the entrance for equipment delivery	Prevent flaws
		Improve maintenance
New construction methods and construction method change (3rd priority)		
Elevation reduction	Optimize structure construction methods	Plan for elevation reduction
	Optimize facilities	Reduce energy load through optimized elevation

Considerations related to the reasons for the change of the basic plan include improvement of space utilization, design change, optimization of underground parking lot, improvement of constructability and energy improvement. There should be reviewed on the improvement of the environment of the room, the adoption of appropriate design, the efficient arrangement of the underground parking lot, the proper column selection, the span interval and the energy saving plan and etc.

Considerations for material change/quantity increase include insulation performance improvement and glass capacity improvement. The use of high-efficiency insulation materials, minimization of thermal bridges and the use of high-efficiency glass materials should be considered to improve the insulation performance. It is necessary to review the selection and use of suitable materials considering the actual function at the design stage.

New construction method and construction method change is equivalent to the elevation reduction of floor height. Check whether the structural method is optimized and whether the equipment is optimized and review the plan of elevation reduction. The expected effect is that the energy load is reduced by the layer height optimization.

In the lack of basic plan, maintenance plan and equipment import plan are applicable. It is necessary to review maintenance plans and plans to install equipment entrance. Prevention of defects and improvement of maintenance can be expected.

Considering the above considerations according to the factors of design change and the expected effects according to the contents of the proposal systematically at the design stage, it is considered that the factors of design change can be minimized.

If we look at the suggestions for technical proposals tendering in buildings other than office buildings, the priority and expected effects will be different. And if common factors are derived, it will help to analyze the factors of design change (Hyun and Sooyoung, 2016; Jeong *et al*., 2016; Kyungsoo *et al*., 2016; Ogunkah and Yang, 2014).

CONCLUSION

In this study, we surveyed the proposals through proposal cases for technical proposal tendering on office buildings. By analyzing the main proposals and common proposals by case, major considerations and expected effects were suggested according to design change factors for improvement of design change of office building.

Most of the key proposals according to the design change factors of technical proposal tendering case was the proposal for basic plan change and the next were material change/quantity increase, lack of basic plan new construction method and construction method change and securing safety in order.

These items need to be reviewed first in the design phase. For the change of construction cost, material change/quantity increase appeared to be a factor of reduction of construction cost and the basic plan change, lack of basic plan, new construction method and the method change, securing safety appeared to be an increase factor of construction cost. Since, the reduction amount of factors of the material change/quantity increase is higher than the increase factors of total construction cost, selection and use of suitable materials is a factor that can improve the performance, function of the building and reduce the construction cost.

In key considerations for improving design change factors of office building, considerations related to the reasons for the basic plan change include improvement of space utilization, design change, optimization of underground parking lot, improvement of constructability and energy improvement. Considerations for material change/ quantity increase include insulation performance improvement and glass capacity improvement. New construction method and construction method change is equivalent to the elevation reduction of floor height. Check whether the structural method is optimized and whether the equipment is optimized and review the plan of elevation reduction. In the lack of basic plan, maintenance plan and equipment import plan are applicable. Each design change factor needs to be reviewed.

Considering the above considerations according to the factors of design change and the expected effects according to the contents of the proposal systematically at the design stage, it is considered that the factors of design change can be minimized.

RECOMMENDATIONS

On the basis of further examples afterwards, it would be necessary to continually study the main considerations and expectations for minimizing design changes for all types of buildings.

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