IMPROVING DECISION SUPPORT PROCESS IN COOPERATIVE DESIGN FOR BUILDING PROJECT

Su-Kyung Cho[1], Chang-Hyun Shin[2], Jae-Youl Chun [3], Yoon-Ki Choi[4], and Dong-Woo Shin[5]

1 The master's course, Department of Architectural Engineering, Graduate school of Dankook University, Seoul, South Korea
2 The doctor's course, Department of Architectural Engineering, Graduate School of Dankook University, Seoul, South Korea
3 Prof. of Department of Architectural Engineering, Dankook University, Seoul, South Korea ; Ph.D
4 Prof. of Department of Architectural Engineering, Soongsil University, Seoul, South Korea ; Ph.D
5 Prof. of Department of Architectural Engineering, Ajou University, Suwon, South Korea ; Ph.D
Correspond to jojosk@hanmail.net

ABSTRACT: This paper presents how to establish the decision support model for the cooperative design in order to improve design coordination and optimize the building system. With this view, the paper presents the method that analyzes decision making participants of each building system on drawings. It also presents the combination evaluation method from the viewpoint of performance, cost and constructability to improve the decision making process in cooperative design.

Key word : Decision Support Model, Cooperative Design, BSI, Optimize the Building System

1. INTRODUCTION

A design team composed of architects, structural engineers, HVAC specialists, and electrical engineers has been having difficulty with communication while working on architectural projects.

The lack of communication has caused designs to be lack the ability to meet the performance requirements, cost, and constructability.

The reason why these problems occur is the result of design not responding to design changes. This is caused by various factors from the initial design through the construction phase. Therefore, the problems (such as low quality, etc.) happen because of disagreements between multi-disciplinary drawings.

This research proposes the establishment method of decision support model for optimization of a design plan through smooth communication among the multi-disciplinary design participants and a cooperative decision making process.

And the scope of research is limited to a Negotiation Phase of the Pre-final Design Step, in which design participants modify the basic design plan through negotiation.

2. DECISION MAKING IN DESIGN STEP

Architects play an important role in design and construction phase. Exceptionally in design and construction phase for the public building and plant construction, however, engineers and related experts play an important role.

In the past construction environment, architects played a role as a conductor of orchestra. But the decision-making in design step of the recent construction projects has been executed by the project manager, architects and engineers. And it is not recognized as architect's individual role any more.

In this section, the theories on the problem of decision making, cooperative design, and decision-making process in design step were considered, and then the method establishing cooperative decision making support model for improving decision-making process was presented.

2.1 The methods of decision making in Design Work Types

The major decision making process in design step have been related to work types of design companies.

Gray (2001) and Hughes (2001) classified design work into four work types. These work types are classified by how they are balanced between forms and functions.

At this time, the form is related to style and the function to engineering, and the decision making method in design progress is upon what is important in progress.

Table 1 compares decision-making methods by design work types.

These four types of design work are all for ordinary architectural design work. The "Cooperative design work type" is the most proper work type for construction project which is a large scale of complexity and variety.

This work was supported by grant No. (R01-2004-000-10258-0) from the Basic Research Program of the Korea Science & Engineering Foundation.

Table 1. Comparison on decision making methods by design work types

WORK TYPE	CONTENTS
Independent Type	- Architectural designers carry out the whole process of design step in person. - Suitable to small scale projects
Function separated Type	- Divide the design work into functions and forms, and organize the design team by charge of work, and integrate the designs between work areas before final design step - Suitable to simple projects
Dominated Type	- Architectural design team manages the whole design work, and engineering design team assists the former team's work. - Be possible to make troubles among multi-disciplinary design teams - Engineering design team is subordinate to architectural design team.
Cooperative Type	- Multi-disciplinary design teams carry out design work through teamwork and cooperative system. - The technical problem from design process is possible to be solved effectively.

2.2 The approaches on decision making with design participants

The method on examination for architectural plan and decision making are classified into 'Intuitive approach' and 'Systematic approach'. Each description of approach method is as following.

(1) Intuitive approach

In general, the intuitive approach is that the design team leader has a monopoly of the design information. Therefore it caused a lack of communication among design teams. And, it has a strong possibility to cause design errors to happen. On the other hand, it has merit; process of decision making is very quick. Most of the Design Companies except several large ones execute design work with intuitive approach. (Figure 1)

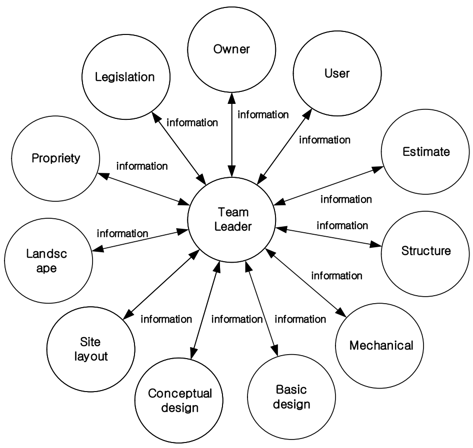

Figure 1. Intuitive approach

(2) Systematic approach

Systematic approach is that the design process could be operated systematically and decision making process be presented clearly in Design Step.

And systematic approach is that all design participants can sympathize with each other, and reduce design errors and changes which happened in design progress. (Figure 2)

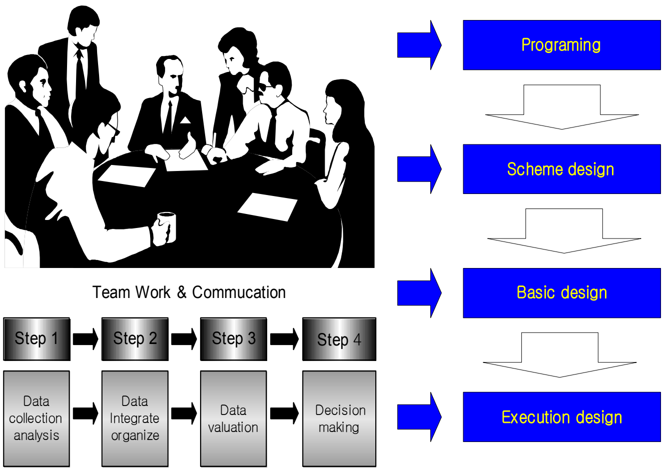

Figure 2. Systematic approach

2.3 Cooperative decision making problems

Generally, decision making process in design step should coincide with design process. But the responsibility and authority of participants and their scope of decision making are not clear because multi-disciplinary experts participate in construction project. As a result, the delay of work and evasion of responsibility could be generated.

And the authority of decision making is concentrated to the owner, so the rest of them don't just decide the important decision factors. As a result, the following steps can be delayed. In order to solve such problem, all participants should regard engineer as identical role with designer rather than assistant role in design progress. And they recognize the engineering to be related with the design identically from initial design step.

The result of interviews with field managers about the problems in design drawing found in construction step shows that many problems were caused by mistake of architects (design error, omission, discordance etc.) and the lack of communication among the participants on the constructability. And the investigation shows that these problems are rectified through redesign in construction step.

We investigated the drawings made by S Construction Company in Asia. Most of problems in drawings are as following: 1) Design error (32.7%), 2) omission (28%), 3) discordance (14%), and 4) the lack of constructability (11.2%).

Especially, in case of the design error, omission and discordance, we analyzed that such cases included various problems caused by the lack of communication among multi-disciplinary design teams.

Such problem happened in drawings can induce quality deterioration caused by design change and defective construction.

Therefore the design team should secure design quality through communication among multi-disciplinary design teams.

2.4 Improvement of cooperative decision making process

It is important that architectural designer communicate requirement of owner to collaborating teams in design step. The designer exactly reflects the requirement of owner, and systematically communicates with multi-disciplinary design teams. And the information support system which includes building performance, cost, and constructability is necessary for decision making in design process.

Especially, it is necessary to establish the definite standards reflecting the performance requirement, quality, budget, and constructability. Exactly detailed design guides should be supplied, which decide the property of space element of building, and the system of communication and decision making among multi-disciplinary design teams should be built. Design guides for cooperative design teams should be built based on the requirements of owner, and the cooperative decision support system (model) should be also as well.

3. ESTABLISHMENT METHOD OF COOPERATIVE DECISION SUPPORT MODEL

In this section, it describes the method of building a cooperative decision support system (model). The method of establishing the model is as following.

First, we analyze the geometrical information of drawing based on BSI theory [2], and then the multi-disciplinary participants of decision making in design step through analyzed interrelationship between UNIFORMAT II and CSI MASTERSPEC.

We propose the creation method of design plan for optimized building system satisfying with performance requirement, cost and constructability through creation and evaluation of design alternative plans according to cooperative decision making process. The concept of decision support model of this research is as following figure 3.

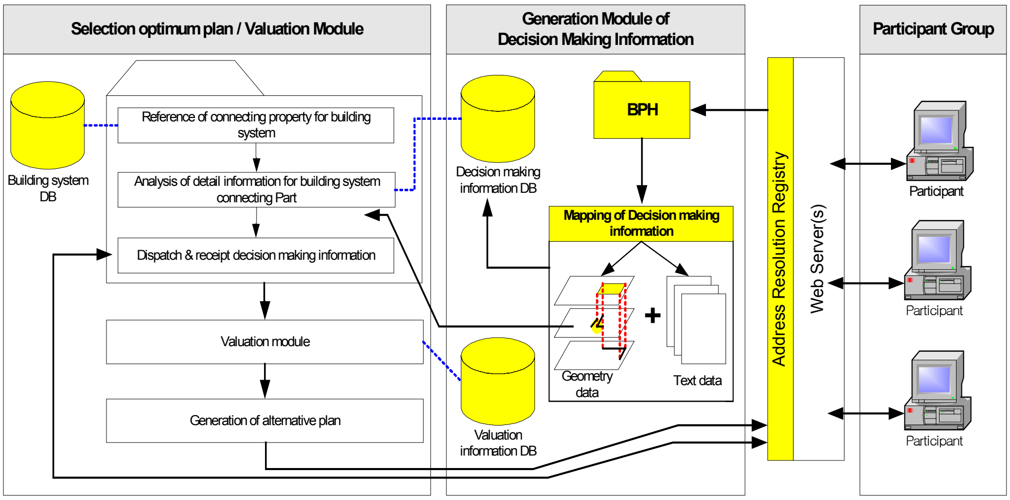

Figure 3. Concept of cooperative decision support model

3.1 Analysis method of Multi-disciplinary participants

In this research, we applied building code of UNIFORMAT II and classification of CSI MASTERSPEC. (figure 4)

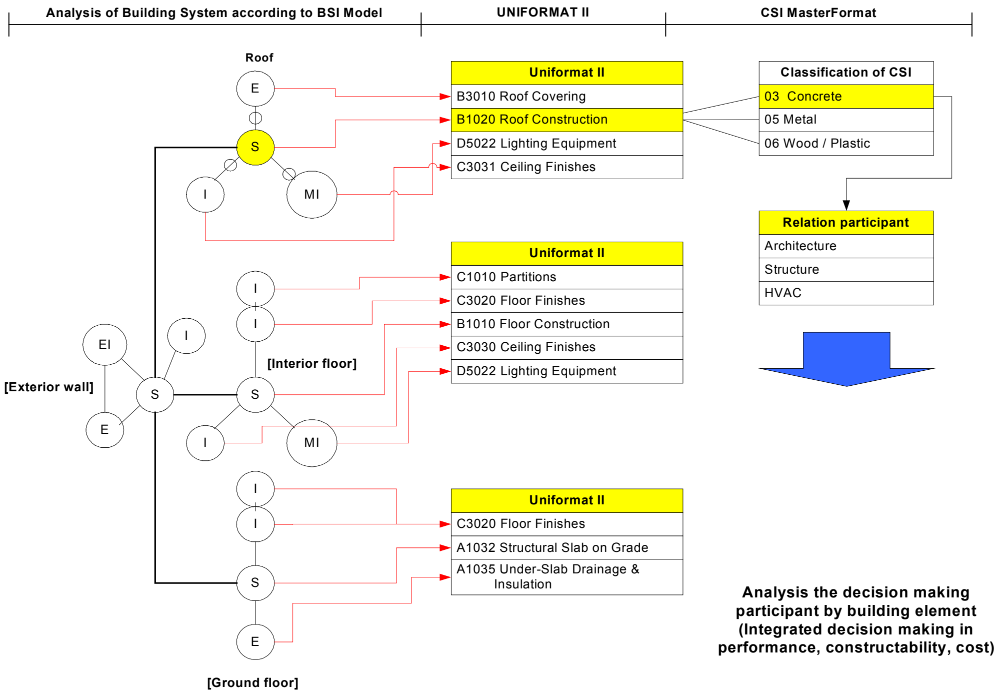

Figure 4. Concept of analysis the decision making participant by building element

The ball diagram in the center of figure 4 represents the elements of building for DBSIM (Design Building System Integration Model). And this represents the sections for roof, exterior wall, interior floor and ground floor, etc.

Such building system model classified by elements is possible to represent by building code.

The building codes of UNIFORMAT II have some interrelationship with CSI MASTERSPEC. For instance, ‘B1020 Roof Construction’ in figure 4 has interrelationship with ‘Concrete, Metal, Wood/Plastic’ in CSI MASTERSPEC.

A case of such interrelationship is as following figure 5. (Chapter B5, Design and Construction Management, “Architects Handbook of Professional Practice (Washington, DC: American Institute of Architects, 1984)”, p6) [4]

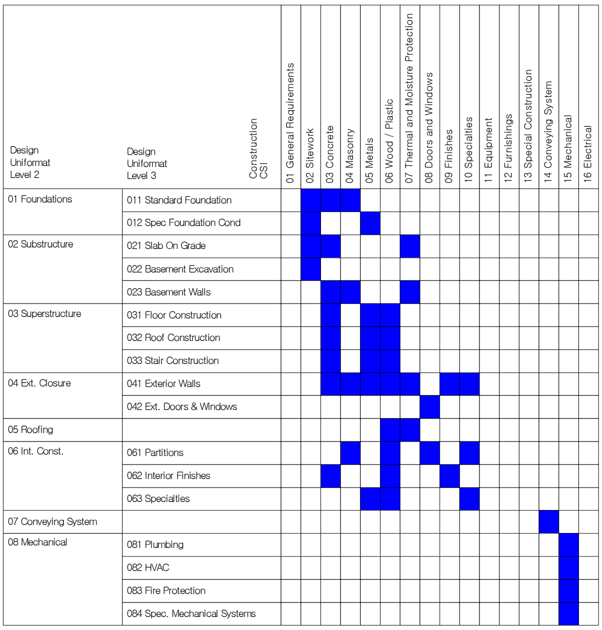

Figure 5. Example for relation between building system and work item

When analyzing the each paragraph of CSI MASTERSPEC, which is linked with building code (UNIFORMAT II), the confirmation of decision participants (Table 2) is necessary. (Lee, K.H., "Specifications for Bethel Center, Y.K. Architect Collaboration", Space Group Korea, 2000)

We can see that the multi-disciplinary design teams (architecture, structural and HVAC) have interrelation in ‘03520 section’ of CSI.

Ordinarily, each paragraph of specification represents performance requirement, material, physical quality, chemical ingredient, manufacture of component and stipulates the special form, and requires the quality of material or equipment, and represents the requirement on establishment. So, the requirement and construction criteria, etc., represented in each paragraphs, are related to the multi-disciplinary design teams who have reference to it.

“Primary responsibility” and “Secondary responsibility” represent such relation. The former represents described requirement and direct relation, and gets to be primary collaborator. The latter takes charge of technical support.

The analysis method in this research is possible to analyze the collaborators through analysis of building system which compose the building element and relation among building systems.

Therefore, we can analyze the participants of decision making process for detail of drawing which is drawn up at negotiations process of pre-final design step.

Table 2. Example of analysis of participant in CSI Masterformat

Specification Item		**Design Team Member**									
Section numbers and titles based upon MASTERFORMAT		C	L	A	S	P	FP	H	E	I	O
03500	**CEMENTITIOUS DECKS AND TOPPINGS**										
- 510	Gypsum Concrete			P						S	
- 520	Insulating Concrete Deck			P	S			S			S
- 530	Cementitious Wood Fiber Systems			P	S						S
- 550	Concrete Topping			S	P						
	Cementitious Floor Underlayment			P	S						S

Design Team Member Designations						
	C	Civil	P	Plumbing	I	Interiors
	L	Landscape	FP	Fire Protection	O	Other
	A	Architecture	H	HVAC	LP	Lead Professional
	S	Structural	E	Electrical		
	P	in column indicates primary responsibility			S	in column indicates secondary responsibility

3.2 Creation and evaluation of design plans according to building system

The building method of cooperative decision support model in design step is as following.

[Step 1] Classification of building system

Classify the composition types of building elements through analysis of building types and space. (Figure 6)

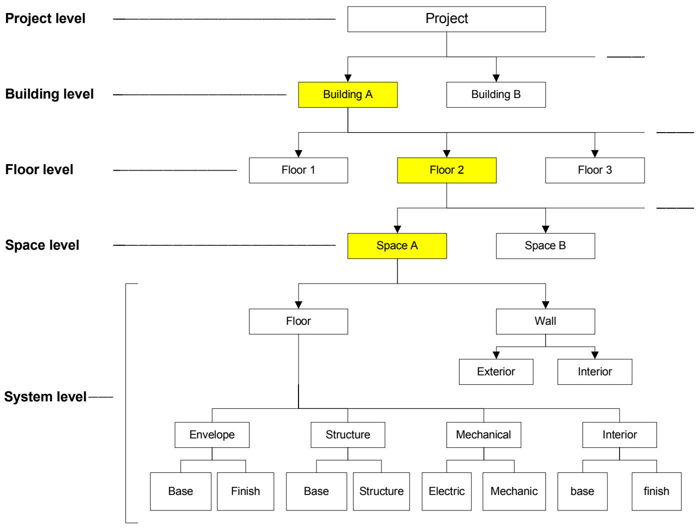

Figure 6. Classification system of project

[Step 2] Analysis of building system

Analyze the composition of building system through application of BSI theory [2], and make out building system model for unit element and whole building.

[Step 3] Selection of cooperative decision making subject

Select the design subject Space – Building Element for cooperative decision making, and analyze the system information by building element. Design subject Space – Building Element should be corresponded with following:

1) The Space – Building Element which needs multi-disciplinary decision making.

2) The Space – Building Element which has many problems in design before.

3) The Space – Building Element which is possible to improve performance and cut down cost.

[Step 4] Creation of design restriction

In this step, reflect the design condition of subject building and owner's requirement, and decide the grade of performance and cost for subject. And evaluate the building systems which compose building element through various restrictions depending on design condition and evaluation criteria of physical performance and cost.

[Step 5] Decision making by multi-disciplinary design teams

The multi-disciplinary decision making process, proposed in this research make the progress in decision making for building element belong to some space. The alternative plan which is made out through the decision making process is classified by following two types.

Alternative plans > 1: evaluation between alternative plans

Alternative plan ≤ 1: evaluation between original plan and alternative plan

Multi-disciplinary decision making process and creation of alternative plans are as following.

(1) Creation of performance restriction:

Create the minimum criterion of performance requirement for a pertinent building element.

(2) Classify the performance evaluation items by building elements:

The performance requirement is classified as following. The performance evaluation items are corresponding to KS F 1010. (Table 3)

Table 3. Example of building performance mandate for evaluation of building element

Performance mandate / building element		Load		Permanence		Safety of residence	
		L1	L2	E1	E2	R1	R2
Floor	living room	(F)	(F)		(F)	(F)	(P)
	bed room	(F)	(F)		(F)	(F)	(P)
	bathroom	(F)			(F)	(F)	(F)
	stair		(F)	(F)	(F)	(F)	(P)
	balcony				(F)		

Performance mandate:

L1- resist against impact, L2- resist of concentrated compressive strength,

E1- resistance of abrade, E2- resist against separation inflation of floor

R1- the slide of floor, R2- elasticity of floor

※ (F) : performance examination for finish material

(P) : performance examination for whole building element

(3) Weighting the performance evaluation items based on Importance evaluation.

Performance requirement should be reflected in evaluation process through considerate property of pertinent building element. Thus, it is crucial to decide the importance ranking of performance evaluation items. (Figure 7)

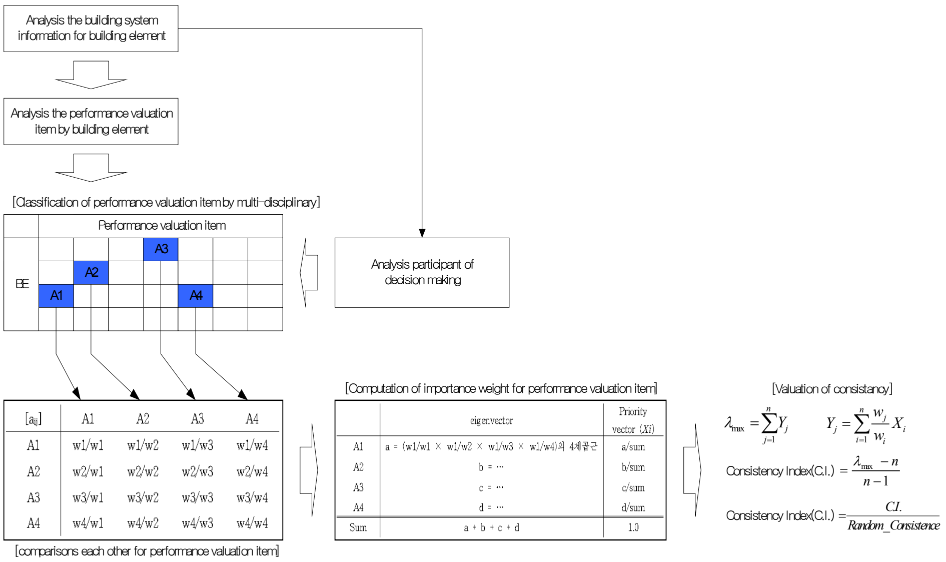

Figure 7. the method of computation of importance weight for performance valuation item

(4) Examination and Evaluation of performance about basic design plan:

Performance Criterion which is established by district conversion into performance index is applied to evaluate satisfaction grade for basic design plan. (Table 4).

Table 4. Example of performance index

Component of building element (thickness)	Heat flow ratio (K)	Heat flow resistance (R)	Moisture proof
Exterior water-paint		0.055	
mortar (24)	1.200	0.020	303.000
1B brick (200)	0.840	0.238	333.000
0.5B brick (100)	0.840	0.119	333.000
Urea Formaldehyde Form Insulation (40)	0.032	1.250	558.700

(5) Creation of alternative plan by multi-disciplinary:

In the case of performance evaluation result for basic design being deficient of criterion, and design subject space – building element not being enough to reflect the technical requirement of pertinent sphere, make out alternative plan.

[Step 6] Evaluation of alternative plan:

Evaluate the performance, cost and constructability about alternative plan made out by architects and structural, mechanical, and electrical engineers.

[Step 7] Selection of optimized plan:

The optimum design alternative plan which is generated by the progress of the above 6 steps is reevaluated with specified space and floor synthetically. Such re-evaluation progress is a process of interaction which balances between optimum design alternative plan and whole design. So to speak, establish the district of duration and cost by specified space and floor, and evaluate that each optimum plan for building element is satisfied by such district according to I.P modeling.

4. CONCLUSION

This paper presented the method to establish the decision support model for the cooperative design in order to provide improved design coordination and optimize the building system.

1) We analyze the geometrical information of drawing based on BSI theory, and then the multi-disciplinary participants of decision making in design step through analyzed interrelationship between UNIFORMAT II and CSI MASTERSPEC.
2) We propose the creation method of design plan for optimized building system satisfying the performance requirement, cost and constructability through creation and evaluation of design alternative plans.

This paper is a conceptual research for cooperative decision making in negotiation phase of pre-final design step. Furthermore, it needs a continuous data collection analysis and study of criterion and valuation method of performance for decision making and selecting the optimum plan from present. Moreover, the verification of presented model through case study is needed, as well as the practical proposal according to computerization.

REFERENCES

[1] D. Veeramani, "Computer-integrated Collaborative Design and Operation in the Construction industry", *Automation in Construction*, 1998.

[2] Richard D. Rush, "The Building Systems Integration Handbook", 1985.

[3] Traek Hegazy, "Improving Design Coordination for Building Projects", *Journal of Construction Engineering and Management*, 2001.

[4] The American Institute of Architects, "Chapter B5, Design and Construction Management", *Architects Handbook of Professional Practice* (Washington, DC: American Institute of Architects, 1984)