S17-1

A CASE STUDY OF CONSTRUCTION ENGINEERING FOR CABLE SUPPORTED BRIDGE BY COLLABORATIVE SYSTEM

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ABSTRACT: This paper presents the case study of the CE by collaborative system and proposes a model of the CM group for the cable supported bridge. The cable supported bridges have a large project scale and need a high level of construction method. Therefore an advanced construction management system is required for successful completion of project. The construction management (CM) group which control design management, construction plan, subcontract, technical support and R&D is organized for the cable supported bridge project. The CM group established a collaborative system with construction site and drew an effective management of cost, process, quality, safety for each project. Furthermore, the CM group established the procedure of construction management based on the construction engineering (CE) items and performed the project management on the construction phase. Efficiency of cost reduction and site control is maximized by using a collaborative system.

Keywords: Construction Engineering ; Construction Management System ; Collaborative System

1. INTRODUCTION

1.1 Background of Study

South Korea has a territory with 4 big rivers and many islands shown in Figure 1. Cable-supported bridges such as suspension bridges and cable-stayed bridges have been built for linking an island to main land or to another island as shown in Figure 1.

Figure 1. Topography of South Korea

Especially, many cable-supported bridges are recently under construction in South Korea and the ten bridges of them (5 cable-stayed bridges, 4 suspension bridges, 1 cable arch bridge) are being constructed by Daelim Industrial Company. Daelim was founded in 1939 and is one of the best construction and engineering companies in Korea.

In case of the early days of construction of cable-supported bridge, project has been implemented by the site entity who performed the project as a main managing entity with technical help of overseas construction engineering entity.

However, this type of practice has problems such as delay in work schedule and quality problems due to indistinct scope of work and responsibility and deteriorated usefulness of overseas manpower. Therefore a separate organization which is capable of managing entire process of bridge project is required.

1.2 Purpose of Study

This study presents a CM group which manages entire process of work plan, design, ordering and construction of cable-supported bridge project and studies the method of establishing a collaborative system to minimize conflict between participating entities.

Through such method, this study would like to present a managing model which can maximize cost reduction and efficiency of site management.

1.3 Scope and Method of Study

An expansive review been made through analysis of existing management method of cable-supported bridge project and matters to be improved have been derived.

Based on the review, this study presents a new management method suggesting establishment of a collaborative system between CM group and participating entity and applicable process.

Also effects of reduction of construction period and cost reduction through application of suggested collaborative system and process to practical bridge are mentioned.

2. EXISTING MANAGEMENT METHOD

There is no entity which integrally manages work plan, design, ordering and construction of cable-supported bride project and instead, there are entities which manage project by each stage of work.

Consequently, the leading group which participate in each stage of work is not present so the procedure of work purpose, work scope, division of role and applicable process is not settled.

Because of indistinctness of work, various problems are rising and delay in work schedule, cost raising and deterioration of quality etc. are undermined success of project.

For example, in case of construction engineering(CE) of cable supported bridge, since CE item is not included in the breakdown of bills of material, sometimes that work is given as burden of sub-contractor of cable part. In this case, work scope and responsibility with sub-contractor become indistinctive and as the result, it is difficult to ask responsibility when problem is happened related with CE work.

In addition to above, there are many cases that local cable installing entity utilizes overseas manpower due to insufficient capability of own construction engineering, and there are problems such as lack of quick decision making due to long distance support and difficulty of intermediate review etc. When local cable installing entity assumes exclusive charge of construction engineering, problems of delay in work schedule and quality rise.

In order to solve such problems, it is necessary to prevent delay in work schedule and improve quality of service through inclusion of service fee of construction engineering in project cost and implementation of construction engineering work by CM group itself. Also, it is considered necessary to verify technical capability of entity at the time of selecting installing entity through appraisal of technology and site explanation and decide adequate implementation method

Consequently, for successful implementation of cable-supported bridge, there should be a main entity which can integrally manage entire process, and accordingly, collaborative system and applicable process should be established.

3. NEW MANAGEMENT METHOD

3.1 Organization of CM Group

Cable-supported bridges presently under construction by Daelim are shown in table 1 and figure 2. It is hard to find any entity who is constructing so many numbers of cable-supported bridges simultaneously in the world.

Table 1. Long Span bridges in Korea(under construction)

Type	Name	Construction Period	Span (m)	Contract Sum (KRW)
Suspe-nsion Bridge	Jeokgeum	2004.11~2012.4	850	205.5 billion
	Lee Sun-Shin	2007.10~2012.4	358+1545+358	417.4 billion
	Dandeung	2009.12~2013.11	400	111.0 billion
	Saecheonnyeon	2010.7~2018.7	225+2@650+225	308.8 billion
Cable-Stayed Bridge	Cheongpung	2004.12~2011.3	28+327+58	38.0 billion
	2nd Dolsan	2005.8~2012.6	82+230+82	36.5 billion
	Sepoong	2006.10~2014.6	85+2@220+85	26.6 billion
	Geumgang-2	2008.12~2012.2	200+140	39.8 billion
	Simgok-5	2009.9~2011.3	80+50	97.2 billion
Cable Arch Bridge	Gusuro	2005.11~2011.8	140	20.0 billion

Figure 2. Long span bridge in Korea(under construction)

CM group is organized for improvement of process work and effective management of many bridges being constructed. Organization of CM group is shown in Figure 3.

CM group performs business activity for progress of project, establishes task force(TF) team for design work and performs construction engineering through dispatching members to the site and technical support at the site.

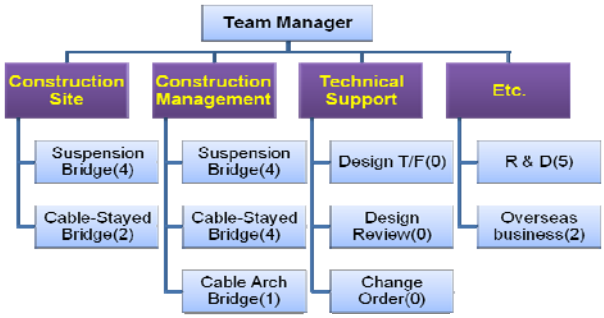

Figure 3. Organization of CM group

3.2 Establishment of Collaborative System and Applicable Process

Cable supported bridge project can be successfully implemented through leading role of CM group, supporting role of entity who participates in each stage of work and clear process applied. Figure 4 shows the collaborative system and process applied.

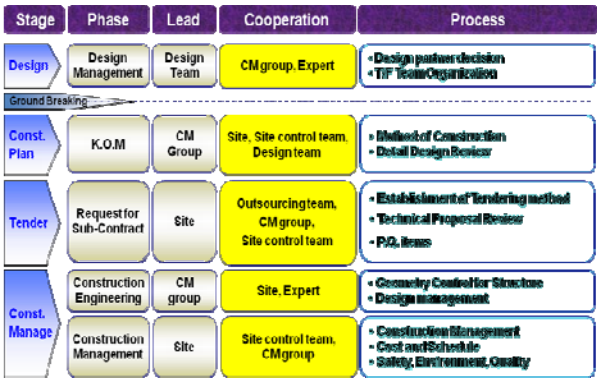

Figure 4. Collaborative system and process applied

First, main pending problems and improvement method from business to construction phase are shown in Table 2. In the stage of participating in project, the role and responsibility(R&R) of business team and CM group is established for selection of design and cooperative teams necessary for the project and active supporting system is established at the time of organizing design management TF team. In addition to this, for the project newly received, at the stage of preparation of site, CM group promotes connective efficiency between design and construction through positive participation.

At the stage of applying construction engineering after starting work, preparatory matters are adjusted through kick off meeting between CM group and site entity, both parties jointly possess implementation plan, and establish and agree selection criteria of cooperative entities of main works for upgrading of quality of construction.

For decision of main technical and construction methods raised during the process of installation of cable-supported bridge, discussion procedure between CM group and specialists is newly established to reduce waste of work time and construction cost. Also, data base of technical data/materials derived from construction engineering is established to utilize it for future similar projects.

Table 2. Major issues and Improvements

Stage	Major Issues	Improvement
1. Sales Management		
- Project Survey	Technical Business	R&R establishment between business team and CM group
2. Design Management		
- Task Force Team	Organize a group	Participation of CM group Technical Meeting with specialist
- Detail Design	Connectivity between design and construction	Dispatch a member of CM group to the site
3. Construction Management		
- Const. Planning	Method of construction Value engineering	Kick Off Meeting between site and CM group
- Sub-Contract	Tender management	Technical reviews for Super structure and Cable work
- Const. management	C/E performance	Discussion with CM group for main construction
- Technical application	Database and Systemize	Technical DB Establishment

In the stage of design and implementation of cable-supported bridge, design team, site control team, outsourcing team, site and bridge engineering team (CM group) are involved. Division of role of each team is shown in table 3.

Table 3. R & R between cooperative teams

O :Manage / Run
△ :Support / Participate

Task	Cooperative team R&R						Note
	Design Team	Site Control Team	Outsour-cing Team	Expert	Const-ruction Site	CM Group	
1. Design Management							
- Project Participation	O					O	
- Basic Design	O					O	T/F Team
- Detail Design		O			O	O	
2. Construction Management							
- Construction Plan		△			O	△	K.O.M
- Instruction to Sub-cont.			O		O	△	P.Q.
- Technical Support				△	△	O	
- Construction Engineering					△	O	Database

Project team implements project and when participation in project is decided, design team implement basic design work establishing the TF team.

When selected as a successful bidder of the project, site preparation team is organized by help of site control team, and outsourcing team is involved at the time of ordering sub-contract work.

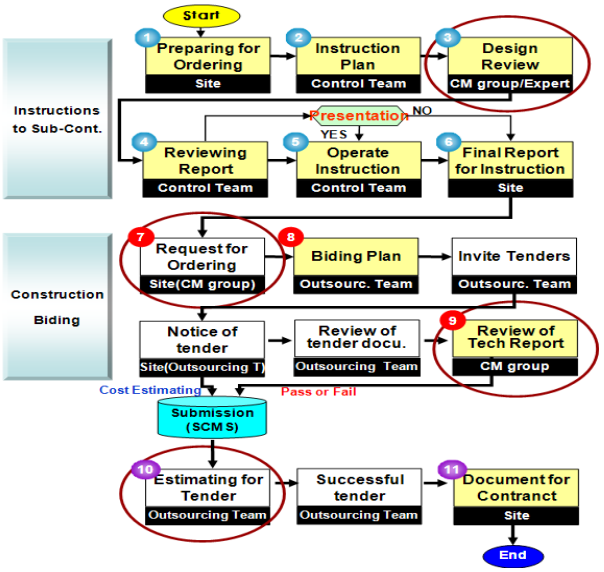

Figure 5. Tender Process and Relevant team

CM group organizes R&R so as to participate in most of process of project. Process of project ordering is shown in figure 5. CM group participates as main management body in the stages of review of design drawings, decision of type of ordering, selection of entity, review of technical proposal and tender appraisal/review.

Figure 6 shows work procedures of construction management work. CM group prepares technical road map of each site under close cooperation with site, performs technical review of each main work schedule, jointly possesses technically related work during construction and performs discussion on technical parts in case design change and method change are required.

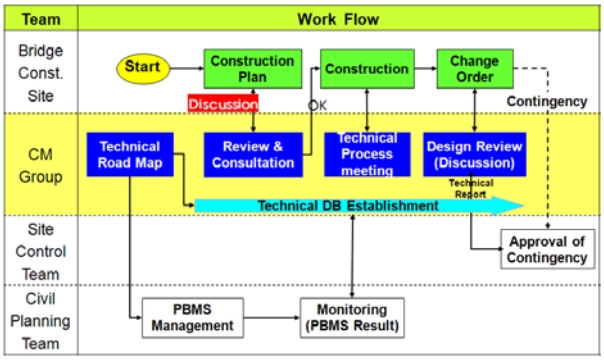

Figure 6. Construction Management Work Flow

3.3 Expected Effect

As mentioned before, success of cable-supported bridge project is depending upon establishment of CM group, degree of cooperation between participating entities and relative importance of mutual communications.

Connective efficiency in the stages of design and construction can be secured through leading role of CM group. Improvement method taking advantage of this is indicated on table 4.

Table 4. Improvement by collaborative system

Phases	Process	Improvement method
1. Design Management		
Budget Development	Design partner decision Project manager decision	CEO Design Team Manager ↔ CM Group T-FTeam Constant
Task Force Team	Join with design expert	Organization → Design work → Deliberation
2. Construction Management		
Construction Plan	Kick Off Meeting	Minimization of Risk Value Engineering
Ordering System	Presentation for order Check about low price (Technical Review)	Establishment of Tender process Capacity Check of Subcontract
CM &Technical App.	Construction Method Technical Meeting DB Establishment (Management of CM Group)	Lower the Cost Accumulation of technology Site CM Group Data Base Webhard Filtering PW/ID sharing

In case of participating in the project, work efficiency can be promoted by establishing R&R for design work, selection of sub-contractor and business activity on sub-contractor, and in the design stage, efficiency can be promoted through adjustment of opinions with design team by project manager, and review of important pending problems is possible when active support system is established through organization of task force team. Pending matters can be adjusted before start of construction and implementation plan can be jointly possessed through kick off meeting between CM group an site, and in case CM group participates in ordering sub-contract work and construction management with leading role, it is judged that reduction of construction cost can be attained through improvement of construction methods.

Efficiency of management of cable-supported bridge project can be maximized through securing key technology by establishment of specialized strategy of project and action plan and advancement of process management.

4. EXAMPLE OF APPLICATION PROJECT

4.1 Project Overview (CM Group Organization)

The national detour road construction project of Gwangyang city including 1 cable-stayed bridge and 3 tunnels is ordered as a design-build system and the total cost of project is 23.5 million US dollar(Figure 7).

Sepoong bridge is a multi-span curved cable-stayed bridge with 610m (85+2@220+85m) long. It will be opened to traffic in 2014.

To accomplish the successful completion of the project, collaborative system was set up and managed from the design phase to the construction phase at the instigation of CM group.

Especially, Sepoong Bridge is the first Curved cable-stayed bridge and it has many state-of-art technique, for example steel strut, compact type cable and transversal cables. So, high level of construction management is required.

Project name	National Detour Road Construction of Gwangyang City		
Owner	Iksan R.C.M.A.	Construction period	Oct. 2006~Jun. 2014
Contract amount	26.6 billion KRW (≈ $23.5 million)		
Details	Bridge	Cable-Stayed Bridge 875m/1EA PSC Girder Bridge 105m/1EA Precast Con'c Arch Bridge 3EA	
	Tunnel	3 Tunnels (739m, 1075m, 1645m)	

Figure 7. Project layout

4.2 Collaborative System and Applied Process

At the design phase, TF team was organized together with CM group and specialists. After successful awarding of the project, during site preparation stage, removed foreseen safety jeopardizing elements through cooperation among construction team, design team and

SEQ team and prepared the most effective and economical construction method and plan.

Engineer from CM group which leads design process stays at the site and performs construction engineering together with site organization.

The other engineer in CM group which belongs to the head office, from the time of ordering works, establishes cooperative system with related management team, sub-contract team and SEQ team etc. participating in budget discussion of construction engineering, appraising construction capability of entity of above ground work for selection of sub-contractor and providing additional technical support to site.

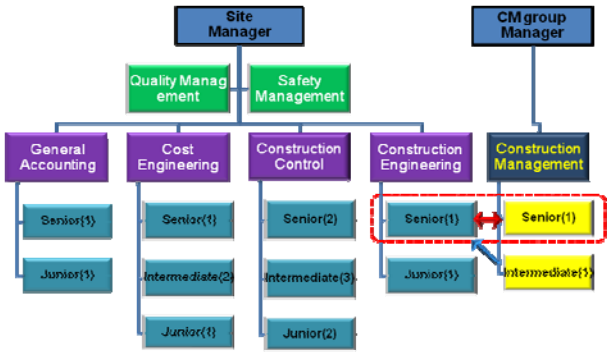

Figure 8. Organization of Construction Site

4.3 Result of application and matters improved

Table 5 shows result derived from design management stage. CM group adjusts opinions with design team based on accumulated experiences and technical know-how and as the result of this, succeeds to receive the project by proposing the design which is distinctive from that of competitors and also, it is possible to bring out items which can reduce cost.

Table 6 shows result and improved matters attained through collaborative system at construction stage. Through adjustment of opinion between site construction part and CM group, unnecessary work of site is reduced and discussion is made on change of construction methods to promote productivity.

Table 5. Improvement at the design phase

Items	Result
Bridge Design	Extradosed Bridge → Cable-Stayed Bridge : Maximize the aesthetic and a landmark
Detail Design	Transversal Cable : Enhance Transversal stiffness
	Steel strut : Minimize the weight of girder(20%)
	Compact cable : Reduce aerodynamic effect
Construction Method	ACS Form : Reduce the construction cycle
	Temporary Bridge : Minimize environmental damage
	Form Traveller : Application for F.C.M.
Value Engineering	Minimize the weight of girder
	Optimization of Geometry Control

Table 6. Improvement at the construction phase

Items	Details	Result
Constructability / Cycle Time	Setting of jig for anchorage	-2day2/lot
	Change of cable installation sequence	-3days/segment
	Con-Ten Method	-2days/cable
Cost	Temporary structure sequence	Steel bar -20%
	Perform C/E by CM group	-250,000$
	Aero dynamic analysis	-45,000$
Safety Environmental Quality	Concrete crack check	-
	Quality of concrete	-

Especially, change of installation sequence etc. is a rare example case of cost reduction. This can be called a representative example which is suggested by the construction part and cooperative synergy is created through technical support of CM group and design part.

Through such cooperative system, jeopardizing elements and cost reduction elements which can arise before and during construction are brought out, construction mistake is minimized and efficiency of work is maximized through quick decision making.

5. CONCLUSION

This study observes structural problem of management organization existing during construction stage of cable-supported bridge project and presents example of the improvement attained through application of cooperative system which can maximize efficiency of cost reduction and site management of bridge construction presently implemented by Daelim.

Participating entities are CM group, site, related teams of head office. Efficiency of cost reduction and site management is maximized through establishment of collaborative system in entire process of work such as planning, design, ordering and construction stages.

It is judged that participation in international cable-supported bridge projects can be realized by specializing construction engineering part of cable-supported bridge based on such collaborative system.

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