

Macro Quality Chain Management and Coordination Optimization Research

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Abstract—The quality of large complex projects is more difficult to manage, because there are more quality interfaces and quality conflicts. This paper aims to explore the quality coordination approaches of large complex projects from the quality chain perspective, so as to reduce the quality conflicts. We firstly give the definition and operation mechanism of the macro quality chain with comparing the supply chain quality management and the quality chain management. The analysis results indicate the feasibility and necessity to introduce the quality chain management into projects construction management. The large complex project is divided into five importance levels that have critical control points respectively. Finally, based on the optimization concept model, the optimization measures of quality capability are concluded to designate the quality improvement directions. The research results may provide a new theoretical perspective and management support.

Index Terms—Large Complex Projects, Quality Chain, Quality Capability, Coordination

I. INTRODUCTION

The quality is not only the prerequisite for construction enterprises' survival in the fierce competition, but also the basic requirement for the normal use of engineering projects. The quality of engineering projects, however, is always a difficult problem that plagues the government and project proprietors. Many research institutions and government supervision departments have made extensive researches on improving product quality level. Besides, the construction enterprises themselves also try to adopt the advanced quality management techniques and methods and regard construction quality as their core competence. But, some engineering projects, even some large complex projects which are vitally important to people's livelihood, still have quality defects to different degree. Some research results manifest that the large complex projects have more quality interfaces which may cause to quality risk transfer. And it is easy to produce the chain reaction [1-2]. In other words, some quality defects remained by one contractor may induce defects in subsequent process causing great loss in people's health and property. This kind of quality problem which tends to involve complex benefit-games between project

participants is hard to deal with by the simple liability investigation [3].

This paper summarizes three respects of reasons for quality defects. First of all, the occurrence probability of quality defects will increase when participation's quality capability cannot meet the appropriate quality requirements, for the contractors' quality capability directly determines the local quality level according to the contracts. Secondly, there are more interfaces of contract and quality in large complex projects, which may cause quality conflicts between contractors easily. The project quality not only depends on the capability of a single participation, but also has close relationship with other related contractors. Moreover, the whole project quality is not decided by the contractors who have the best quality capability, but decided by the contractors who have the worst quality capability. In that way, the investment on the good contractors is liable to be wasted when the capability doesn't match each other. However, the past research results which were obtained through the traditional viewpoints and methods of quality management and doesn't focus on the quality coordination are difficult to explain the quality relationships between contractors. Therefore, it is necessary to attempt to study the construction project quality management in the coordination perspective. The research results may provide the project owners or the construction enterprises a new theoretical perspective to improve project quality management.

II. LITERATURE REVIEW

(1) The Literature Review of Supply Chain Quality Management

With the gradual expansion of the research scope of the quality management and the acceptance of the supply chain management, the supply chain quality management is becoming a research hotspot of related research areas. And the authorized definition of the supply chain quality management is universally approved by academic circles. Kuei and Madu [4] state the concept of supply chain management (SCM) which includes following aspects: the production and distribution networks, satisfactory of product and service quality and the trusted basement. They also claim that the quality management subjects had

shifted from particular corporate to all enterprises in the supply chain. Carol and Manoj [5] define the supply chain quality management (SCQM) as series of processes that members of the supply chain use the integration and coordinative methods to perform the quality measurement, analysis and continuous improvement of the product and service in order to meet the middle and final customer satisfactions [6].

The above statements about SCQM from different angles both contain the following contents and connotations.

1) All the members of the supply chain should have the common goals which are to make the customers satisfactory including the final and the middle customers.

2) The members of the supply chain should achieve the above goals through some coordination approaches.

Under the traditional management paradigm, enterprises just concern about their own price, product quality and delivery time. However, under the SCQM paradigm, the communication of quality requirement between members of SCQM and the customers become the core issues.

(2) The Literature Review of Quality Chain Management

The concept of quality chain is first introduced by Troczynski [7], a scholar in University of Colombia in 1996. Juran and Godfrey [8] puts forward the Quality Loop and thinks that the quality is formed during the production process with spiral improvement.

Quality chain theory has been continuously enriched and extended since 1999 in China. Ding Wenqin and Zhao Junhua [9] believe that the quality awareness, the human resources quality, quality culture, work environment, products quality together form a linked quality chain. Tang Xiaoqing [10] who is inspired by the supply chain quality management method presents the cooperative quality chain management theory (CQCM) that emphasizes to break the boundaries of quality black box and is used on globalization manufacture. The three-dimensional quality mode is proposed by them to integrate the internal quality management, products quality and the quality processes of different enterprises which can build up the open, cooperative and collaborative macro quality chain road and the implementation framework among the suppliers, manufacturers, distributors and final customers. Xie Qiang [11] deeply analyzes the key techniques of quality chain management including the rapid information reconfiguration system, the coordination service technique and the supplier evaluation and selection technique. Tang Xiaofen [12] further proposes some basic concepts such as quality flows, quality chain, chain link, chain link graph and coupling effect through the analysis of the quality formed in the process between the members of quality chain. Cai Zhengying [13] analyzes the closed-loop structure and quality-control processes and proposes the process controlling technology. Jin Guoqiang [14] summaries and analyzes the applications values in industries from the quality chain concept, the characteristics, the theoretical framework and the

coupling method. He also concludes the theory's development and connotation.

Zhang Renlong [15] provides an improved DEA model to measure the coordination validity. Xiao Renbin [16] and Cai Zhengying [13] research the cost control problem of closed-loop quality chain to balance the quality and cost level under the indeterminate quality condition using the fuzzy control method. Zhang Zhi [17] studies the micro quality chain that focus on the procedure quality. He considers that one procedure can form integrated quality chain through two kinds of quality parameters. Some scholars also research the software of quality management [18-19].

As mentioned above, the study of supply chain management is one of the most popular research topics in recent years. With the improvement of quality requirements and the intensification of competition, the quality management research of supply chain gradually becomes an attention hotspot of manufacture industry. However its research results are still not enough comparing with the some mature theories. Inspired by the model of supply chain quality management, some scholars begin to study the quality chain management. But they only have limited research methods and research perspectives, especially very little in engineering construction field and just focus on quality thought and consciousness. The effective case study of quality chain in engineering construction projects has not been reported. Therefore, the view of quality chain to solve the large complex projects is an important research method worthy of study.

III. INTRODUCTION OF MACRO QUALITY CHAIN IN ENGINEERING CONSTRUCTION PROJECTS

A. The Concept of Macro Quality Chain Management

Engineering construction quality chain emerges from the background of intensive production. It is an important reason to propose the quality chain that the one single construction corporation is unable to meet the requirement for the construction capability and quality capability of large complex projects. The coupled multi-corporation and multi-element construction environment is needed to construct the large complex project. The literatures [5, 20-21] define Quality Chain (QC) as the quality aggregate process that is the carrier of quality, information and the value and is implemented by a group of organizations. Quality chain management (QCM) is a management method that researches the QC operational rules of multi-organization and multi-element in the specific time. It can achieve the effective coupling management through the core node controlling [22-23].

Macro quality chain of large complex project chain is formed by many participators which together affect the quality of engineering construction projects. The weaker links in macro quality chain have a larger influence on the projects quality and the participators' coordination degree also affects the quality investment effectiveness.

B. The Differences and Similarities of Supply Chain Quality Management and Quality Chain Management

Supply chain quality management and macro quality chain have close similarities and connections. They both advocate breaking the close boundaries of enterprises' internal quality system with the quality systematic, holistic and synergistic viewpoints. Engineering project macro quality chain is composed of contractors and supply chain is composed of upstream and downstream corporations. The quality of products is gradually transmitted, accumulated and transformed by participators which the engineering projects are no exception.

However, the macro quality chain and supply chain quality management also has some essential differences.

(1) Different applicable objects

Currently, most researches about the transformative characteristics of quality mainly focus on the supply chain of manufacture industry [24]. The black box should be eliminated by effective and coordinative management to form a pass-through and controlled quality chain [25-26].

Different from the manufacture industry, the construction project is a kind of customized product which has more unsteady effect factors. The statistical methods of quality defects in supply quality chain could not be fully applicable to it.

(2) Different Quality Attitudes

Supply chain quality manufacture enterprises which generally have batch production are often easy to form stable and long-term supply contracts relationship. Therefore, the managers can control the quality by statistics or sample checks under the long-term corporation relationship that are cherished by the participators. It is easy to independently control the products quality.

The quality chain of engineering construction management is formed by projects bid in China so that the different bidders don't have the stable cooperative relationships. They more value their own obligation within contracts. Therefore the quality coordination and communications become unimportant for them.

In that way, the cooperation relationships of supply chain quality management and quality chain management decide the different quality attitudes and the participators in supply chain quality management will be more stable. So the quality conflicts may be more in engineering construction management because of the different attitudes and relationships between the participators.

(3) Different Quality Rectification Costs

The products that are assembled by upstream and downstream suppliers are easier to repair or partially replace with relatively lower cost when the quality defects are found out. But the materials and equipments of engineering construction projects are often expensive and disposable. The quality problems make the cost of rework or replacement higher.

This paper introduces the supply chain quality management thoughts to the engineering construction

project quality chain which is different from supply chain and more suitable for construction projects.

IV. MACRO QUALITY CHAIN OF ENGINEERING CONSTRUCTION PROJECT

A. Quality Viewpoints and Optimization Principles

The quality capability of contractors having multi-dimensional indexes includes the basic quality capability and quality coordination capability. The traditional choice of subcontractors is usually based on project breakdown structure. Then the quality capability of sub-contractors will be respectively evaluated and selected in the bidding process.

The broken parts still have the certain connections although the projects quality can be broken down. We not only consider the independent quality capability of one single contractor, but also the quality coordination capability. For example, the subject structure is sub-contracted by the general contractor or the owner to one contractor who has good quality capability at a high cost. However, in order to save the cost they subcontract the foundation to a weak quality subcontractor. If the foundation has the quality defects that are not found out, the subject structure will be affected and the quality investment for good quality contractors will be wasted even through the subject structure itself has good quality level. In other words the project quality still has short board.

Therefore the quality is a whole concept that although the quality can be broken down, the every part of quality has some relationship that we often ignore in the traditional quality senses. As shown in figure 1, to achieve the overall project quality coordination, we firstly need to identify the importance degree of every part of project quality chain including structure security, reliability & durability, decoration & aesthetic, environment protection, materials & equipment. The different quality levels have the different key chain which has high quality defects risk. The qualities of structure security and reliability & durability depend on the weakest links. However, the significance of structure security level and reliability & durability level are also not the same because the quality assurance of structure should be guaranteed throughout the project lifetime but the reliability & durability level just needs to work well in a given period. The decoration & aesthetic level which is distinguished from the security and durability levels is mainly considered from the consumer's perspective to meet the requirement of comfortable sensation. It depends not only on the worst quality chain, but also on the good quality or humanized design which can make up the worse decoration imperfections of quality. The environment protection level mainly incarnates the development between people and the environment harmoniously. The key quality chain of environment protection is decided by the construction methods and the materials that have the most serious threat to the environment and human health. Materials & equipment

used in different parts of project influences the quality in the whole process.

From what has been mentioned above, the engineering quality that composes of sub-segment projects is a complete and systemic concept. The every part of whole engineering quality mutually influences each other in a non-linear way. These new views on quality change the traditional evaluation perspectives which more emphasize quality highlights. So the projects owner or the general contractor should evaluate and choose the sub-contractors' quality capability based on the importance degree of the quality chain.

The viewpoints of quality chain include the assumptions below.

- The quality capability of sub-contractors directly affects the engineering construction parts which are in the charge of the sub-contractors.
- The engineering quality is not only decided by the quality of each part, but also affected by the quality coordination in every different importance degree.
- The parts having good quality cannot make up the quality shortcomings in the other parts for structure security level and reliability & durability level.

As shown in Figure 2, in order to improve the quality capability of combined contractors, we need to concern about the weakest macro quality chain to balance and coordinate the quality capability.

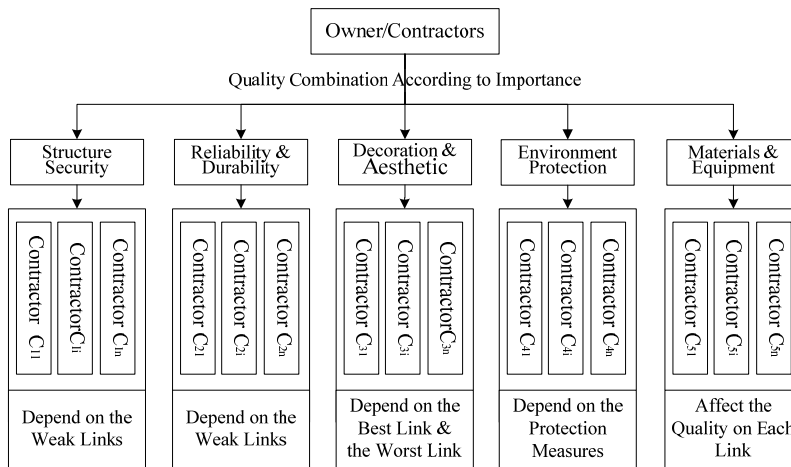


Figure 1 Importance Level of Project Quality Chain and the Control Scheme

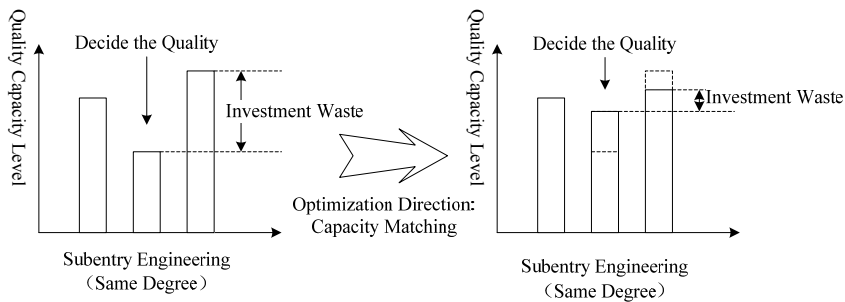


Figure 2 the Improving Direction of Quality Capability

B. The Operation Mechanism of Macro Quality Chain

The viewpoints of the traditional quality concept on quality management procedures consider the every participator as a black quality system which has some problems such as delayed information and lack of quality coordination ability. In comparison, the quality chain of engineering construction project regards every participator which has a significant relationship with each other as a ring on the quality chain to form the whole organic unity. If the rings or the links have some quality problems, the whole quality of quality chain will be affected.

(1) Traditional Closed Quality Controlling Mode

The quality transferences among suppliers, manufacturers, distributors and final customers are cut off

by the black quality box that may cause the information asymmetry problems in traditional product quality management model [17] (as shown in Figure 3). It will induce the lack of basic motivations to assure quality during the manufacturing process.

(2) The Operation Mechanism of Bulk Productions Quality Chain

In order to keep quality black-box transparent in the production chain circumstances, quality chain theory of supply chain needs to give a systematic and comprehensive analysis about the participators' quality capability. This operation mode emphasizes quality relationships between enterprises and pays attention to the quality requirement of final customers. It is good for gradual products quality increase to base on the traditional quality management adding the feedback of

manufacturing processes which form the cycle quality chain shown as figure 4 [27-28].

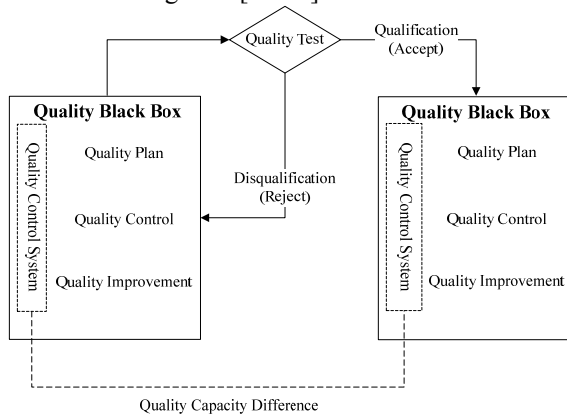


Figure 3 Closed Quality Mode of Traditional Management

(3) The Operation Mechanism of Engineering Project Quality Chain

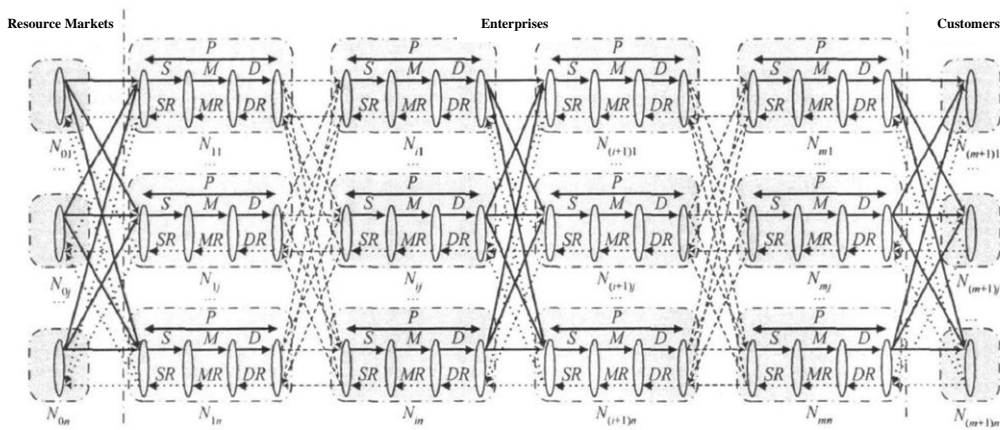


Figure 4 Quality Chain Model of Manufacture [15]

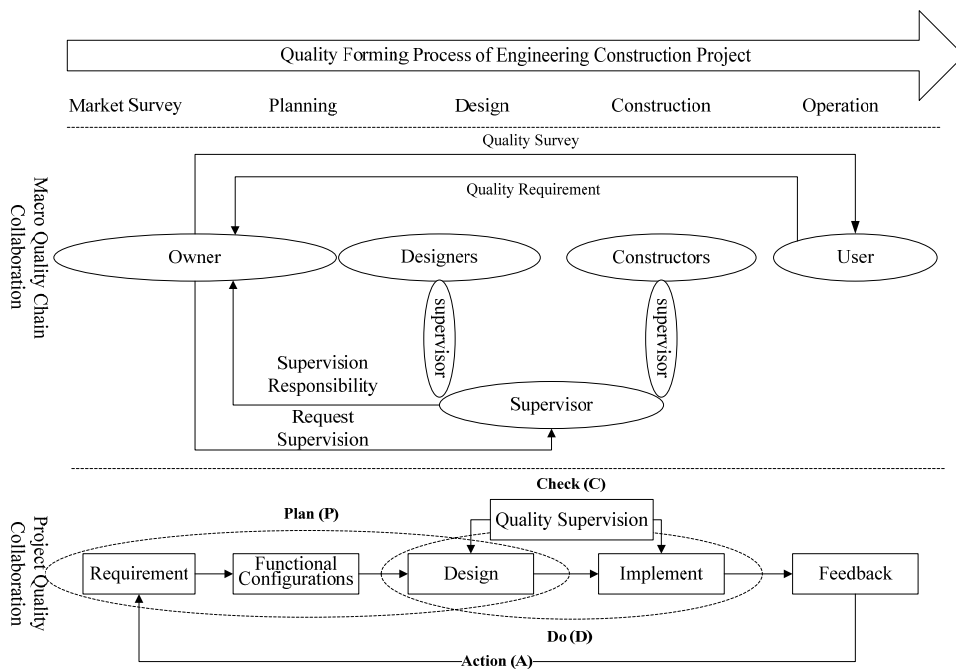


Figure 5 Project Macro Quality Chain Coordination

Distinguished from the bulk production mode in the manufacturing industry, an owner or construction enterprise cannot form mass production, for they usually have the limited quantities of engineering projects which has the unique characteristic. Therefore the supply chain quality management with feedback and correction functions cannot fully apply to engineering construction project.

Project quality relates to numerous factors, such as materials and equipment quality, the contractors and subcontractors' quality. These influence factors can be summed as the quality capacities and quality attitudes [3]. So this paper focuses on the couple and optimization of related projects participators that the relationships between them are shown in figure 5. The optimized portfolio of participators may be more effective to guarantee the project construction according to the quality requirements.

V. QUALITY CHAIN OPTIMIZATION OF MACRO ENGINEERING PROJECT

A. Quality Chain Optimization Concept Model

(1) Quality Chain Elements of Engineering Construction Project

The coordination quality chain includes three elements: vision, contribution, trust & punishment. The vision of the coordination quality chain is to improve the economy conditions, to meet the quality satisfaction and to work in harmony environment. At the same time, the incentive mechanisms for contributors and trust basement of every participator with credit punishment should be built up. The figure 6 shows the relationship between coordination factors. The contribution and trust are the support for conditions of vision and the vision is the guide for contribution and trust goals.

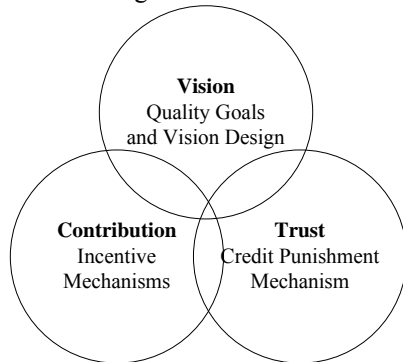


Figure 6 Critical Factors of Quality Coordination

(2) Coordination Optimization Concept Model

The purpose of proposing the optimization concept model is to improve the economy, to pay more attention to quality demand of investors or customers and to keep enhancing the harmony in construction process.

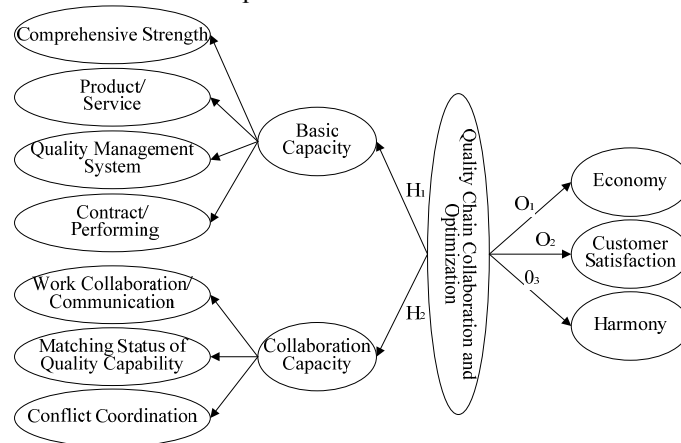


Figure 7 Coordination Optimization Concept Model

Large complex projects have lots of quality interfaces, which initiate quality conflicts. Quality conflict coordination capacities are also different by reason of the different coordination methods and conflict resolution mechanism. Quality conflict coordination condition reflects the effectiveness of resolving conflicts in an orderly and rational way.

Literature [15] points out that the quality capability can be reflected by the quality activities and quality results of these independent constructors. The specifications degree of quality behavior and the quality results are decided by the quality guarantee capability which comprehensively reflects the operational condition of human resources, material resources, financial resources and the management effectiveness. It is the basis and precondition of quality formation. However the contractor' quality capability is independently evaluated without considering the coordination capability in the traditional perspective. For large complex projects, the concerted and coordination work capability needs to be introduced into the quality chain evaluation.

The quality capability is divided into basic capability and coordination capability forming the concept model, which is shown in figure 7. The basic capability reflects the quality capability to complete the work defined in the contracts and the coordination capability reflects the economy and synergy between contractors. Quality coordination capability refers to the coordination capacities and communication attitudes, matched quality capability, quality conflicts negotiation mechanism, etc. The quality interfaces are often the weak rings of quality chain which can be reinforced by coordination work and communication [16].

The quality chain mentioned above is divided by importance degree into structure security, reliability & durability, decoration & aesthetic, environment protection, materials & equipment. When the quality capability of contractors in one same importance quality chain doesn't mutually match, the quality investment for high quality contractors may be wasted. Therefore, the matched quality capability can improve the engineering economy and the customer satisfaction.

In order to form the macro quality chain, the rational driving factors are the spurs for the participators to become a group who has common interests and win-win targets. The rational driving factors forming effective quality chain includes economic interests, work environment and superiority of coordination. At the same time, what is also important is the effective rule system namely the support factors including the quality

contribution reward mechanism, quality defect punishment mechanism and the credit punishment mechanism. The basic quality capability and the quality coordination capability compose macro quality chain listed on the table 1. The quality chain operation elements shown in figure 8 will be checked and the quality expectations and authentic status are compared regularly to form more effective and stable macro quality chain. After determining the coordination quality targets and methods, this paper proposes the optimization index system to provide optimization directions.

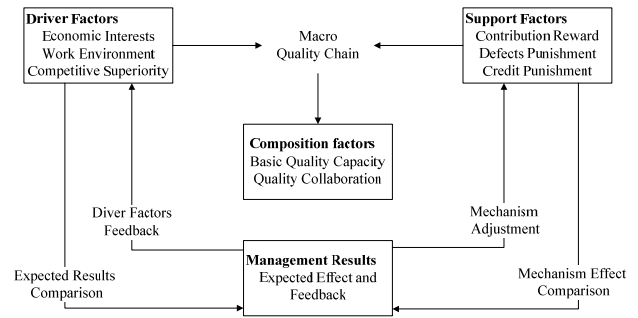


Figure 8 Quality Coordination Mechanisms and the Critical Factors

TABLE 1
QUALITY CAPABILITY OPTIMIZATION INDEX AND DIRECTION

First-class	Second-class	Third-class	EML	PML	TL	CL
Basic Quality Capability	Comprehensive Strength	Qualification	▲	△	△	△
		Technical Equipment	▲	▲	△	△
		Human Resource	▲	▲	▲	▲
		project performances	▲	▲	▲	▲
	Product/ Service	Mandatory Standard	△	△	▲	▲
		Construction Method	☆	▲	▲	△
		project qualification rate	△	▲	△	▲
		project Repair rate	☆	△	▲	▲
		material quality	△	▲	▲	△
		Quality System	implementations of ISO9001	▲	▲	▲
		implementations of ISO14001	▲	▲	▲	☆
	Contract/ Performance	Manager' success records	△	▲	▲	△
		Contracts performance rate	△	▲	▲	▲
		On time completion rate	△	▲	△	▲
Coordination Capability	Work Coordination/ Communication	Experience	△	▲	▲	▲
		coordination capability	▲	▲	▲	▲
		Communication Capability	▲	▲	▲	▲
	Capability Matching	Interface Quality	△	▲	▲	▲
		work coordination attitude	△	△	▲	▲
	Conflict Coordination	Quality conflicts frequency	△	▲	▲	▲
		Conflict coordination capability	▲	▲	▲	▲

▲ Direct Correction △ Indirect Correlation ☆ No Correlation

B. Coordination Optimization Measures

Quality coordination optimization has different implementation levels that have different methods and effects. Enterprise management layer, project management layer, technology layer and construction layer need different quality capabilities and communication capabilities with different optimization index systems and management measures.

(1) Enterprise Management Layer (EML)

Quality chain management coordination methods mainly include enterprise quality culture, human resources management and quality training, contract coordination measures. Quality chain optimization of enterprise management layer focuses on the strategies and directions of enterprise development. The quality culture is one endogenous factor affecting quality especially some large enterprises that emphasize cultivating the quality culture for improving enterprise image and quality

capability. Human resources management and quality training is to form the quality culture and attitudes for every employee to active their quality capability. Contract coordination requires the enterprise management layer to rationally allocate resources and guarantee the supply of personnel, financial, and material resources. And it can reduce the quality conflict events when the clear contracts terms have clearly defined the right and responsibility of each other.

(2) Project Management Layer (PML)

The quality management behaviors of project management layer are the core of quality management. The quality standards and specifications, the division of rights and responsibilities, penalties and incentives and conflict resolution mechanisms are all the significant contents of project quality management. The quality conflicts come from two aspects that are the inconsistency in quality specifications and the disputes of responsibility after the quality conflicts happening.

Therefore, the clear definitions of quality standards and responsibility can obviously reduce the quality conflict events. The quality penalty and incentive are the effective mechanisms that can spontaneously promote quality level of the participators who are on the quality chain. It not only emphasizes the local quality, but also the coordination quality. The conflict resolution mechanisms have different methods to harmoniously and effectively solve the quality conflicts.

(3) Technical Layer (TL)

The quality coordination methods of technical layer mainly include drawing review and design disclosure, construction plan disclosure, quality assurance measures and the quality supervision for the critical parts. They are responsible by technical departments which can guarantee the constructors to understand the design ideas and the key technique. The quality assurance measures are organized to ensure the construction quality and design requirements. Quality supervision for the critical parts is the process controlling and comprehensive evaluation that is conducive to the timely adjustment and correction.

(4) Construction Layer (CL)

The quality coordination methods of construction layer mainly include regular quality meeting, competition and ranking of quality. The regular quality meeting is to inform the quality statistical data to take countermeasure to demolish the quality defects. The competition results should be linked with wages to drive the motivations of the constructors based on the competition and ranking of quality.

VI. CONCLUSIONS

This paper studies the macro quality management and optimization of large complex project in the quality chain perspective. Firstly, the feasibility of quality chain concept on construction projects is demonstrated comparing with the supply chain quality management. We states core ideas of macro quality chain management and quality capability optimization. The quality chains in one project have different significant levels divided into five levels which are structure security level, reliability and durability level, decoration and aesthetic level, environment protection level, materials and equipments level. Then, this paper proposes the concept model of quality capability coordination optimization on the quality chain which can improve the economy of quality management, customer satisfaction and the harmonious construction process. Finally, we illustrate the optimization methods of different constructors in various significant levels according to the built index system of quality capability optimization.

The research results provide new theoretical perspectives and quality decision support methods for the project owners and construction enterprises to further enhance quality level in project quality management.

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REFERENCES

- [1] Wang Y.M., Zhao D.Z. (2008). The Transmission Model of Controlled Quality Risks in Construction Projects. *Journal of Business Economics*, (6): 15-20.
- [2] Xiao Yiyong, Chang Wenbing, Zhang Renqian. (2009) A research on the quality risk transfer model based on the quality supply chain. *Project Management Technology*, (8):13-18.
- [3] Wu Y.N., Yang Y.S., Feng T.T., et al. (2011). Government Investment Projects Collusion Regulatory Based on the Prospect Theory. *ICIC Express Letters, Part B: Applications*, 2(6): 1357-1363.
- [4] Kuei, C., Madu, C.N. (2001). Identifying critical success factors for supply chain quality management. *Asia Pacific Management Review*, 6(4):409-423.
- [5] Carol J. R., Manoj K. M. (2005). Defining the concept of supply chain quality management and its relevance to academic and industrial practice. *Int. J. Production Economics*, (96):315-337.
- [6] Qian Y. (2007). Study on the Coordination of Supply Chain Quality Management Based on SCOR. He Hai University.
- [7] Troczynski T. (2008). The quality chain. *Quality Progress*, 29(9):208.
- [8] Juran Joseph M., Godfrey A. (1999). *Blanford. Juran's Quality Handbook 5th edition. Hardbound. 1-183p.*
- [9] Ding W.Q., Zhao J.H. (1999). Quality Chian—A Domino—the Consideration of Production Quality Improvement. *Quality for Chemical Industry*, (6):28-31.
- [10] Tang, Xiaofen, et al. (2005). Research on the Theory and Realization Mode of Quality Chain. the 10th International Conference on ISO9000 and TQM. 158p.
- [11] Xie Qiang. Research on Quality Chain Management and Some Key Technologies. Nanjing University of Aeronautics and Astronautics, 2002.
- [12] Tang X.Q. Duan G.J. (2002). Cooperative Quality Chain Management in Glibbal Manufacturing Environment. *China Quality*, (9):13.
- [13] Cai Z.Y., Zheng L.X. (2006). Closed-loop Quality Chain and its Control Method. *China Quality*, (9):91-93.
- [14] Jin G.Q. (2006). Research on the Quality Chain Management Theory. *Standardization & Quality Management*, 16(3):21-24.
- [15] Zhang R.L. (2008). Research on Cooperation Validity of Mass Customization Quality Chain. Hunan University.
- [16] Xiao Renbin, Cai Zhengying. (2009) Fuzzy cost control of closed-loop quality chain under uncertain quality level. *Computer Integrated Manufacturing*, 15(6):1207-1214.
- [17] Zhang Z. (2007). Research of Construction Project Quality Management Based on Quality Chain. Tianjin University.
- [18] Heeseok C., Youhee C., Keunhyuk Y. (2006). An integrated approach to quality achievement with architectural design decisions. *Journal of Software*, 1(3):10.
- [19] Weiliang Z., Yaping L. (2012). Research on Quality Measuring of CMMI Cyclic Implementation in Software Process. *Journal of Software*, 7(8): 11-18.
- [20] Xu G.D. (2007). Project Management Method Research Based on Value Chain. Liaoning Project Technology University.
- [21] Yuan F.L. (2010). A Study on Synergic Quality Management in Agile Supply Chain. Wuhan University of Technology.

- [22] Zhang D.L. Gao Q.S. Li Z.L. (2008). Critical Quality Chain Analysis and Evaluation Based on Quality Loss in Service Industry. 2008 CHINESE CONTROL AND DECISION CONFERENCE. 1588-1592.
- [23] Stefanovic N., Mistic M. (2013) QUALITY MODEL FOR SUPPLY CHAIN EXCELLENCE. METALURGIA INTERNATIONAL, 18(4): 330-338.
- [24] Xiong Z.K., Cao J., Li K.J. (2007). Study On the Quality Control Policy in the Closed-loop Supply Chain Based on the Dynamic Game Theory. Chinese Journal of Management Science, 15(4): 42-50.
- [25] Hu L. (2008). Research on Agri-product's Supply Chain Management for Quality Safety and Its Information Platform. Tongji University.
- [26] Zheng J.T. (2011). Study on EPC Project Quality Chain Management. Chongqing University.
- [27] Liu W.H., Xie D., Xu X.C. (2013) Quality supervision and coordination of logistic service supply chain under multi-period conditions. INTERNATIONAL JOURNAL OF PRODUCTION ECONOMICS, 142(2): 353-361.
- [28] Cai Z.Y. (2008). Operational Optimization of Cycle Quality Chain Based on SCOR Model. Huazhong University of Science and Technology.
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