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The Origin and System Analysis of Harmonious Management for Engineering

Abstract Engineering is a production activity aimed at increasing people's utility; however, serious crises are frequently reported to be caused by engineering constructions, both for nature and human beings. Based on engineering theories of philosophy, systems and ecology, this paper analyzed the prevailing defects of traditional project management approaches, explored the importance of harmony in engineering and engineering management, and discussed the developmental inevitability, concept connotation and system structure of harmonious management for engineering.

Keywords: engineering, harmony, management

1 Introduction

With the development of human society, engineering has created numerous civilization miracles such as the Egyptian Pyramids and the Chinese Great Wall. As civilization developed, major civil and military engineering feats such as the Three Gorges Project, the South to North Water Transfer Project, Manned Space Flight, and the Aircraft Carrier Base are all being implemented on a large scale. Emerging market countries represented by China are in a period of "unprecedented" large-scale construction.

Within the whole life cycle, the construction projects consume around 47% of the earth's energy, 42% of the water resources and 50% of the materials on the earth; moreover, the emissions in the life cycle of the construction projects have caused 24% of the air pollution, 50% of the greenhouse effect, 40% of the water pollution, 20% of the solid waste and 50% of HCFCs.

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To a certain extent, engineering has brought a serious crisis to the natural environment and humans. What is the essence of engineering? How should construction occur? What is the relationship between engineering and project management? Over a period of more than 20 years, the Guangzhou Military Air Force Engineering Construction Bureau has engaged in numerous "urgent, difficult, dangerous and important" major military engineering projects, expediting the discussion about harmonious management for engineering.

2 Engineering, project management and their harmony analysis

2.1 Engineering, engineering construction and engineering construction systems

2.1.1 Engineering concept

General engineering is the process in which a group of people engages in collaborative activities over a period of time in order to achieve a certain goal. In a narrow sense, engineering is "the process that a group of organized people turn an (or some) existing entities (natural or artificial) into artificial products with intended utility value, based on a certain set of targets, relative scientific knowledge and technology.

Academician He Jishan wrote "engineering is an integrated activity to create or change traits to achieve a specific purpose for human survival and development by applying science and technology and using resources organizationally". In terms of engineering property, engineering can be divided into five categories: construction engineering, manufacturing engineering, mining engineering, exploration engineering and other engineering (He, Chen, & Hong, 2005).

2.1.2 Engineering construction

Engineering, in essence, is a creative activity for peoples'

utility. The purpose of engineering construction is to build an object with certain attributes by taking advantage of natural resources and relevant technologies to satisfy certain human needs. Engineering construction is a creative practice using resources and technology, and what is colloquially called “engineering” usually refers to engineering construction. According to Yin (2008), member of the Chinese Academy of Engineering, engineering construction has gone through a development history of people fearing nature, people conquering nature and finally people living harmoniously with nature.

2.1.3 Engineering construction system

From the perspective of system engineering, engineering subject and object and their production relations constitute the engineering systems. Yin et al. said that engineering system is an organic entity formed by people, materials, facilities, energy, information, technology, capital, land, management and other elements based on specific targets and technical requirements in order to achieve functions like the fundamental innovation and construction (Yin, Wang, & Li, 2007). It is extensively and deeply affected by environmental factors such as nature, the economy and society. To sum up, the formula of engineering systems can be represented as follows: “humankind + natural environment + object + function”. Engineering construction systems emphasize the constructive relationship between people and substance; in other words, people utilize the technological element of tools. So construction systems can be understood as a basic system with the elements “humankind + natural environment + object + function + technology”.

2.2 Management, engineering management and engineering management method

2.2.1 Essence of management

The concepts of management are diverse. Through the summary of the relevant references, the essence of management can be illustrated as follows: people administer process and control objects to achieve some functional goals.

2.2.2 Definition of engineering management

There are many engineering management definitions. The American Society for Engineering Management (*n.d.*) defines it as “the art and science of planning, organizing, allocating resources, and directing and controlling activities which have a technological or systems component”. In China, engineering management science defines it as “the activity that related to the decision-making, planning, organization, guiding, coordination, and the control of

engineering project in order to achieve the expected goal and to use the resources effectively”. Engineering management originated from engineering practice. Engineering management, a kind of engineering-oriented management science, is a combination of engineering science and management science.

2.2.3 Engineering management method

In modern society, it is well known that there are various kinds of engineering management methods. The decision-making, planning, organization, direction, coordination and control related to engineering all can be classified as engineering management methods. The intrinsic methods of engineering management are closely associated with the development of management science as engineering management is a branch of management science and engineering in disciplinary nature. Engineering management methods were derived from the guidance of management theory and application of management technology. The development of engineering management method was also derived from the guidance of the management theory. As a result, corresponding to the development of management theory, engineering management methods have gone through four development stages. They are experiential management stage, scientific management stage, system management stage and the innovation management stage.

2.3 Harmony, harmony management and engineering harmony theory

2.3.1 Harmony analysis

The English word “harmony” comes from ancient Greek, in which means an awareness of beauty involving different music scales. There is no “hexie” as one word in ancient China. The word “he” means the mixture of five flavors, and “xie” is related to music, referring to the coordination of eight musical instruments. As time passed, the words “he” and “xie” were combined into one word “hexie”, meaning harmony, referring to “harmonious coordination” and “suitable symmetry”. The word “harmony” in China became a kind of philosophy and social ideology later, the so-called “harmony without uniformity, nature and humanity”. The word “harmony” also evolved in Western philosophy; Pythagoras thought, “The whole sky would be a harmony”. Heraclitus thought “harmony produced in opposite things”. The Marxists combined “harmony” with political ideas, advocating social harmony.

It should be mentioned that harmony refers to humanity’s understanding of transformation and law of development about nature and human society, as well as humanity’s pursuit of beautiful things and the values and methodology of doing things.

2.3.2 Harmonious management

Above all, harmony is a specific, dynamic, relative, and dialectical unity between the opposites under certain conditions. It also means the relationship of different things that unify each other, complement each other, reverse each other, cooperate with each other, benefit each other, and promote each other. So, guiding management activity with harmonious idea should be classified as harmony management method. As defined by Xi et al. (2003), “harmonious management is a practical activity to provide solutions by optimization and uncertainty reduction around the theme of harmony in the changing environment to achieve its goals”.

Harmonious thought is a philosophy, a concept, a culture, and a method. It contains both strictness and tolerance, both separation and combination. Therefore, harmony could be a feeling and could also be expressed in formulas. Namely, harmony comes when formula is balanced. This is the necessary and sufficient condition for existence; besides, the activity to satisfy the equation formula is exactly the harmonious management.

2.3.3 Engineering harmony theory

Engineering is artificial. Observations (He, 2013; He, Chen, & Hong, 2005; He & Wang, 2008; He, Wang, & Wang, 2009) show that, the essence of engineering is to serve people, especially when new balance and new harmony were badly in need, as major engineering construction destroyed original balance; engineering construction must be people-oriented, harmonious and unified.

The essence of engineering is creating purposeful activities for people’s utility. The basic elements of engineering construction system include humankind, natural environment, object, usage function, and technology. The concept of engineering harmony requires that engineering must coordinate with people and be friendly to the natural environment. The concept of engineering harmony management is that in order to achieve the goal of certain human functions, people should take advantage of natural resources and technical invention to decide, plan, organize, direct, coordinate and manage engineering projects.

Engineering harmony is one of the key connotations of engineering harmony management, namely, people live in harmony with engineering, natural environment and natural resources on basis of the idea of harmony. Another key connotation of engineering harmony management is that engineering management should conform to the lead of engineering science and management science theories. Engineering harmony management should be attributed to the development of engineering technology, especially the guidance of the harmony thought and management theory. Thus engineering harmony management is the product guided by the idea of harmony.

All artificial systems are man-thing-content systems in which people make use of material resources to achieve the specific goal. There were efforts taken to establish the basic framework of harmony management for military engineering construction (Lin, Wang, & Peng, 2011) and there should be further discussions of the theory of engineering harmony management.

3 The development, problems and harmony needs of engineering management

3.1 Development stage and analysis of engineering management

Where there is engineering, there is engineering management. He (2013) observed that, “engineering management can be divided into five phases: engineering management bud, experience management, scientific management, engineering management and innovation management”. In the opinion of the authors of this paper, engineering management is largely constrained by management theories and methods. Since management science has substantially experienced traditional empiricist theory, scientific management theory, system management theory, the development of engineering management can be divided into three stages.

3.1.1 Experience management stage

Ancient times held the seeds of engineering management and created many splendid ancient civilizations even without the help of the systematic theories. Not until the 20th century did the engineering management theory develop, including the principles and methods of management, such as the division of labor specialization, standardization, and project profiles. These were widely recognized and used, accelerating the development of traditional construction and other engineering.

3.1.2 Science management phase

Corresponding to the application and development of scientific management theory, 14 scientific management principles and 5 major functions of scientific management have been widely applied in the 20th century. Natural science and social science continue to integrate with each other and organizational behavior methods and construction technologies continue to develop. Under this condition, engineering management kept turning into an independent professional discipline. It means that engineering management came into the scientific management phase and initially formed basic theory systems of engineering management.

3.1.3 Project management stage

Since the mid-20th century, with the emergence of information theory, cybernetics, systems theory, management contingency theory and later decision theory, engineering management has developed into project management stage. Project management and network planning techniques are used in U.S. defense projects. These major projects succeeded. The idea of overall planning method greatly benefits key engineering; and engineering systems theory, contributed to the success of major engineering practice, also caused significant results in engineering management theory. Currently, “Chinese project management body of knowledge” has been widely used in engineering management practice.

It should be recalled that there are connections and differences between engineering management and project management. Engineering management is for specific technology integration in the particular form of objects in a particular environment. Project management is a temporary endeavor undertaken to create a unique product, service, or result. When engineering management is mainly designed for a specific project, people use engineering management to do project management which is, in fact, engineering project management. Engineering project management refers to management activities that ensure project quality, shorten construction periods and improve investment returns. This is done through certain forms of organization using the ideas, theories, and methods of system engineering to plan, organize, coordinate and control the work within the project life cycle.

3.2 The essence and deficiencies of engineering project management

Recently engineering philosophy, ethics, engineering systems and engineering ecology, particularly advances in computer science and network information technology, are booming. Engineering management theory continues to innovate and integrate. Engineering management shortcomings appear continuously, making it essential for engineering management theory to reach a new stage and call for theoretical innovation. Engineering project management had features and defects in common with methods of management.

3.2.1 Features of engineering projects

First, it is the nature of the project. “Project” is a one-time effort made to complete particular product and service goals and has resource and time constraints. Engineering project management has the basic features of “project” management and it is a “one-trial process with the unique temporary operation, the certain target, the temporary organization and the irreversible results”.

Second, it has system characteristics. Constructions are

activities in which a subject organization acts on the object of the project using appropriate techniques to achieve the project function. Engineering project management is an overall system consisting of various participants, resources, related technologies to achieve project goals in an environment that restricts organization, project and technology.

Third, it has stage properties. A project can last for a long time. Generally, it can be divided into three stages: the pre-planning and decision-making phase, the design and construction phase, and the operation and maintenance phase. Participants vary at each stage of the project life cycle, and tasks at different stages are undertaken by different participants.

3.2.2 Deficiencies of engineering management

It is not difficult to see from the perspective of the project life cycle that engineering management activities in different stages are discontinuous. There are many problems when main implementers work on sub-management such as “separate organization”, “flow separation”, “technology shield” and “information island”. All these problems increase project costs, resulting in construction waste and management deficiency.

From the perspective of engineering systems, it is not difficult to find that there are numbers of participants in the project, especially complex stakeholders. Motivated by profit, their behavior inevitably affects results; moreover, different stakeholders have different expectations and needs from the project, and their concerns are often far from the goal of the project. Objective differences occur on target and connotation between the life cycle system of the project and the life cycle of systems engineering.

Do the decision-makers consider the harmony between man and nature when scientifically demonstrating the function and the target of the project? Do contractors consider people-oriented, environmentally-friendly and sustainable development of raw materials and construction? Do users continue the scientific mission of decision-makers and contractors to promote the harmony among projects, human and ecological environment? These problems have become important deficiencies of engineering project management, and must be considered at philosophical and ecological levels. Thus harmonious project management, based on works of philosophy, ethics, ecological view of engineering, has inevitably emerged.

3.3 Contradictions and harmony demand of engineering management

3.3.1 Contradictions of engineering management system

A construction system is an organic entity consisting of “people”, “objects” and “usage functions”. The “construc-

tion technology” and “natural environment”, the engineering management system make up the system with appropriate individual organization, program of function material, construction techniques, the external environment and other components. It is not difficult to analyze from an engineering system and project management perspective. In this system there are contradictions among organizational management, project function, construction technology and external environment at the macro-level. At the micro-level, there are contradictions between the internal organization of the participant elements such as leadership, teamwork and culture, among material resources elements which impact the function of “investment, efficacy, quality” of the project.

This would include elements such as “feasibility, advance, applicability” of the project implementation technology, and among elements “the social, political and ecological” in constrained environment. At a micro level, there are much greater contradictions among elements in every subsystem, and the system total factors have to truly realize the harmony in engineering, people and nature in the whole life cycle. There are questions, contradictions and conflicts that exist everywhere.

3.3.2 Harmony demand of engineering management

Concepts of engineering harmony management require a friendly coordination among engineering, personnel, and the natural environment. First, it requires a harmonious engineering organization system which must reach the point that the project decisions are made scientifically and that project organizations are integrated. Engineering management must be standardized. Also needed is an integrated and highly-qualified project team, a leadership concept for project organization. Harmonious construction culture plays an indispensable role. Second, the engineering is friendly and in harmony with people and the natural environment. This requires the harmony of functions of the engineering project object with “investment, efficacy, and quality”. It requires harmony both in the project “materials, equipment, funds” and other material resources, as well as in the social and ecological environment. Similarly, project implementation technology requires that “the knowledge, tools and methods” of construction project not only share technology to complete the project and be applicable to a project, but also coordinate ecologically and socially. Therefore, harmony needs to exist everywhere in the engineering management system. In a certain sense, the process of engineering management is the process of harmoniously solving the contradictions among project system elements, systems and the environment.

3.3.3 Features of project harmonious management

In engineering management systems analysis, the harmo-

nious project management emphasizes coordination. It emphasizes the coordination between engineering organization and “human” elements, the coordination between engineering projects and “material” elements, the coordination between engineering methods and “thing” elements, and the coordination among “human” elements, “material” elements and “thing” elements.

Harmonious project management features a management process that organizes the project system, uses resources rationally, and uses appropriate technology to achieve the goal of the project. It is a new development of project life cycle management under the concept of ecological project. It has a new requirement that the project return to the nature of “people-oriented, heaven and people are the same one”.

4 The foundation and system framework of engineering harmonious management

4.1 The developmental foundation of engineering harmonious management

4.1.1 Based on the theory of engineering project and system integration

Engineering project management is the main method of engineering management. It is a system management method used by project managers by integrating theories, knowledge, instruments, and skills for the project to achieve the objectives set by project stakeholders within time and resource constraints. It is characterized by the full exploitation of limited resources within a specific time range through special planning mechanisms, leadership, organization, and control to achieve the given goal. Engineering is the construction activity conducted by specific persons to achieve specific goals of value and to create specific objects. Engineering management in a specific project organization has the basic characteristics of engineering project management, so that the theories, methods, and means of project management are equally applicable to harmonious engineering management. Engineering project harmony requires coordinating management elements and the environment. Engineering harmonious management is management that lasts through the entire life of project cycle from decision-making, to plan implementation, and to practical operation. It is a new management style, emphasizing the accordance of management activities with the project’s target value.

Engineering systems are artificial systems. Harmonious engineering management is a complex system that must be managed by the organization in the entire function of the optimal system. It can adapt to changes in the environment to achieve the goal of the system, namely system management. According to system engineering, there is a complex

relationship among system structure, function, and the environment. In general, function is not only determined by structure but also determined by the system and the environment. Engineering integrates construction activity, and the system effectiveness is guaranteed by a integration management system guided by system theory.

Integration is the process that creatively integrates two, or more elements, or systems, to form an organized whole. The essence of integrated management lies in the use of integrated thought to ensure internal connection integrity between the management object and the management system to improve the overall system coordination degree so that a greater range of organic whole can be formed. Integration management is the process of system optimizing and harmonizing, so the engineering harmonious management must be based on project integration management.

4.1.2 Based on the concept and philosophy of engineering and sustainable ecology

All theories must have a philosophical basis. Harmonious engineering management must be from a philosophy of engineering perspective in order to discuss the issues in engineering ontology, epistemology and methodology. Engineering ontology tries to reveal the innate character of construction engineering. To answer the basic questions about the components of harmonious entity and how human beings could as the main body of the project implementation harmonize with the project as the object of project implementation. How connections between components and tasks could harmonize with each is another question. Engineering epistemology focuses on discussing issues on human recognition of the essence and structure of engineering harmony. The objective of harmonious project management is to focus on the contradictions among engineering organizations, engineering objectives and the environments involved and then determine solutions to what is called the "Engineering Question Resolution". Engineering methodology is a basic method to explore the issues of engineering harmony. Engineering harmonious management needs to systematically summarize engineering practice from the perspective of practice methodology as well in order to promote the innovative integration of engineering organization, implementation objects, technical innovation and system innovation.

If engineering philosophy needs to answer "what, what to do, how to do?" as part of engineering harmonious management, then engineering ecology and notions of sustainable development answer the question "what is the goal value of engineering harmonious management?" There is an ecological system in engineering harmony. The resources used are limited and they should be recycled.

Technology should be applied without irreversible destruction and man-made engineering projects should aim at serving the people so that their safety and comfort can be guaranteed. The life-cycle-operation of the project should realize that nature requires sustainability. In short, engineering management harmony should accept the rationality of natural existence. Engineering management should regard the engineering object as a part of the natural ecological cycle, whose goal is to have engineering benefit the ecology without deteriorating the quality of life for descendants. The ecological notion of sustainable development is required.

4.1.3 Based on engineering ethics and harmony between man and nature.

Engineering means creation, transforming things from one state into another, creating items that never existed before, and creating the world humans live in today. It must be subjected to rigorous ethical evaluation. Engineering embodies human creation. Objects are made to meet certain needs for certain people, such as buildings for accommodation,, machines for easy production, and vehicles for the convenience of travel. The process of using resources, inventing technologies and creating the objects is the process of engineering. The ethical value of engineering harmonious management requires people to realize that engineering should create the world without despising, damaging, and destroying people. Engineering harmonious management must respect people, serve people and develop people. It does this by emphasizing engineering ethics with a people-oriented viewpoint.

Similarly, as the human civilization progresses, the resources required by engineering are not infinite, and the natural environment destruction continues to be a threat to human survival and development. People can use resources, consume resources, but cannot, safely, exhaust resources and destroy the environment. We cannot ignore nature when we meet our needs with the invention of technology. With the globalization of the world economy, the global village and the engineering era, engineering harmonious management must make the "project" people-oriented to achieve harmonious development between man and nature.

4.2 The three-dimensional structure of engineering harmonious management

4.2.1 The three dimensional model

Based on a three-dimensional structure and system integration management method, three-dimensional system frameworks, shown in *Figure 1*, can be established using the organization integration dimension, technology inte-

gration dimension, and project integration dimension which is the constraint-integration environment of three dimension systems.

4.2.2 Dimension characteristics

As has been mentioned above, project management system is a management system including the organization of humans, project of tasks, technology of construction and the external environment. As the engineering harmonious management integrating system, it must emphasize the project life-cycle, system factors, the realization of target function, engineering, and the coordination between human and environment.

First, the organizational dimension emphasizes harmonious integration within the engineering organization system, that is to say the project investors, designers, construction contractors, project operation and maintenance personnel form an integrated system. They keep their own factor in harmony and in the whole process of project. They need to coordinate the relationship among construction technology, project resources and environment at the same time.

Second, the project dimension emphasizes the integrated harmony within the project object system, namely the project in each stage of the life cycle should focus on the functions like investment, efficiency, ability to handle its own resources elements and serve the people, the choice of technology, and coordination of external environmental factors at the same time.

Third, the technology dimension emphasizes the integrated harmony in the implementation of the project technology system. While engineering organization system

is achieving the goal of the project value, if its technical condition permits, the coordination of organization system, resource system and the external environment should be taken into account.

The three-dimension framework is the external integration environment system which forms the engineering harmonious management integrating system.

4.2.3 System logic

In the engineering harmonious management integration system, organization integration system is the integration of the people who participate in the organizational units, and they are the implementation subject of the system. The object of project integration system is the integration of the function of “substance” and its resources which is the object of system implementation. Technology integration systems integrate the “tools” used by “people” to deal with “substance”. This reflects the relationship between subject and object system. The three-dimensional system is subjected to the integrated environment system such as “society, politics, ecology”, and the three-dimensional system’s coupling evolution and the catalytic cycle can realize the harmonious state of engineering system.

5 Conclusions

As a creative activity, engineering has played an important role in the “knowledge chain” of “science»technology»engineering»industry»economy»society” and “activities network”, which has profoundly influenced the history and development of mankind.

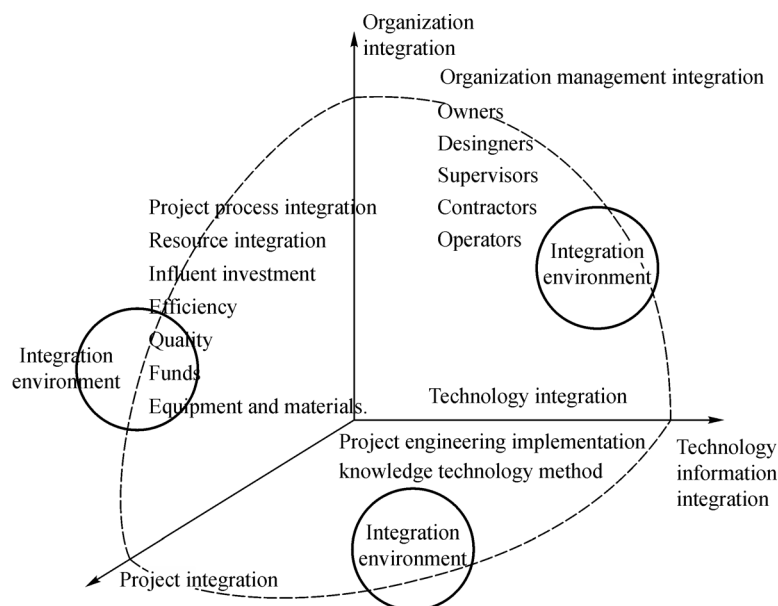


Figure 1. Three-dimensional system of harmonious management for engineering.

The essential requirement of engineering development is that the whole life cycle, whole system elements and the whole goals and functions of an engineering project should coordinate with the development of nature and human beings. As a result, engineering harmonious management based on philosophy, engineering ethics and engineering concept of ecological has emerged and progressed. As a giant and complex system, engineering harmonious management should follow the integration, project-based management pattern, which imposes higher requirements on the methods of engineering information management. The development of engineering information technology provided important support for engineering harmonious management. Based on the information integration platform, the plan and scheme, the integration of the whole life cycle from design to construction, dynamic decision-making, and coordination among resources and the technology and method selection of engineering can find useful and reliable platforms and tools. In addition, the 3D digital visualization spatial expression can directly illustrate the harmonious degree of the engineering construction. The robust database and web-based real time modification function provide guarantee for the all-lifespan, all-element, all-function and multi-dimensional engineering harmonious management.

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