

Research on Intrinsic Management: Practices in the Hong Kong-Zhuhai-Macao Bridge Island & Tunnel Project

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Abstract: The new era has prompted engineers to consider both current issues and future development trends in the engineering industry. Based on the practices in the Hong Kong-Zhuhai-Macao Bridge Island & Tunnel Project, this article developed a new theory of intrinsic management and defined it from the viewpoints of etymology and practice. It also proposed three factors and four key points of intrinsic management, established a logical model, and elaborated its process and methodology using the Hong Kong-Zhuhai-Macao Bridge Island & Tunnel Project as an example. Intrinsic management is derived from engineering management practices in China, and it integrates Chinese management philosophies with other advanced management ideas from all over the world. Intrinsic management regards people as the most crucial factor, emphasizes conversational and positive views, and fully develops the subjective initiative. It is an innovative methodology for solving complicated engineering challenges and is forward-looking and dynamically applicable to engineering practices. It presents a simple philosophy of “Ben Li Dao Sheng,” meaning, with the essence, or intrinsic element established, the way (of doing things) will emerge, and has a pervasive significance in large-scale project construction and engineering management in China.

Keywords: intrinsic management; Chinese engineering practice; Hong Kong-Zhuhai-Macao Bridge Island & Tunnel Project; logical model; management innovation

1 Introduction

The Hong Kong-Zhuhai-Macao Bridge Island & Tunnel Project (Island & Tunnel Project), which was praised as one of the “Seven Wonders of the Modern World” by *The Guardian*, is a world-class traffic cluster project integrating bridges, islands, and tunnels. The undersea tunnel contained in this mega project is a central node, which is recognized as one of the most challenging projects in the modern world. This deep-buried highway tunnel, which is the only one of its kind, not only relies on engineers’ wisdom and tenacity but also depends on the support of the country’s comprehensive national strength. Furthermore, effective management perspectives have played an irreplaceable guiding role.

The Island & Tunnel Project has the characteristics of being exploratory, pioneering, and high-risk, which have become more prominent with the advancement of the project. The project management team has gradually deepened the understanding of these characteristics through repeated “acquaint–practice” processes and introduced the guiding ideology of intrinsic quality and intrinsic safety. Positive results have been achieved from all aspects of response and implementation in terms of quality, safety, time, cost, environmental protection, and occupational health. Over seven years of engineering practices, the intrinsic quality and intrinsic safety have gradually evolved into the prototype of intrinsic management.

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Intrinsic management is an innovative engineering management methodology based on the concise experience of modern engineering practices in China. It upholds the idea of the integration of Chinese and Western advanced management ideas, has distinct characteristics, and will herald a new era of engineering management. The primary purpose of this paper is to propose the theoretical concept of intrinsic management, define its concepts and build a logical model, and elaborate the thinking, methods, and innovative points of intrinsic management.

2 The definition of intrinsic management

2.1 The practical explanation of intrinsic management

Intrinsic management is the summary and promotion of intrinsic quality and intrinsic safety in the construction management of the Island & Tunnel Project. The purpose of intrinsic quality is to ensure good quality from the most fundamental point, with people, materials, machinery, equipment, methods, and working environment as the basic control objects. The purpose of intrinsic safety is to achieve overall safety by keeping people, the most fundamental and crucial factor of the project, safe. It seeks to develop strengths and avoid weaknesses through the analysis of human capabilities and needs and utilize people's initiatives and creativity while using sophisticated equipment to assist or replace operations conducted by people who work together to complete the safety requirements. These two guiding principles are derived from the understanding of the project's characteristics and main contradictions and benefit from the advancement of science and technology.

The core of intrinsic management in practice lies in recognizing the attributes and rules of the most fundamental, crucial, and basic elements between the practice subject and the practice object, and realizing the controllability from the source, the process, and the result by combining management thought and technical means.

2.2 Etymology of intrinsic

2.2.1 The Eastern and Western context of intrinsic

The word intrinsic has different meanings in Eastern and Western contexts. In the Western context, intrinsic is a philosophical term that translates as "essence." Aristotle believed "the essence of things is its 'genus' and its 'form,'" while Hegel thought that a process that the "object of self" of a knower is recognized and manifested in consciousness is the process of self-understanding and self-manifestation of the essence of the object or thing. The Marxist philosophy defines essence as "the internal connection and fundamental nature of things." Mao Zedong states that in the Marxist philosophy, "any form of movement contains its own special contradictions," which constitutes the unique nature, or essence, of one thing that differentiates itself from other things. Essence in these notions is regard to be subordinate to other object and used for revealing what the object really is. In Chinese, essence has an independent meaning as a word (which will be explained further below) besides the meanings mentioned above. It can be used with other objects, but it is by no means affiliated.

2.2.2 Intrinsic in a philosophical sense

There are four kinds of intrinsic concepts in academic research [1], among which, the intrinsic theories of Hegel and Marxist philosophy are relatively scientific and complete. This paper differentiates and analyzes the discussion of essence domestically and internationally, especially in Hegel's and Marxist essence theory, and summarizes them into two aspects: the definition and the explanation of the concept of essence.

The concept of essence is defined in two ways: (1) the central or most important quality of a thing, i.e., its fundamental nature; (2) that which makes a thing what it is, i.e., the reason or basis for a thing to be itself. The former is defined in terms of nature, quality, and quantity while the latter is defined in terms of essence and phenomenon.

The explanation of essence: (1) (internal) basis refers to the essence of things as the unity of their common essence, or identity, and special essence, or difference; (2) essential characteristics refer to profound, internal, and relative stability; (3) essential functions relate to deciding the nature, appearance, and development of things and distinction from other things.

2.2.3 Intrinsic as an independent word

In Xu Shen's *Shuo Wen Jie Zi*, the first Chinese etymology dictionary, it states that "'Ben' means the lower part of a tree," which refers to the root of trees and extends to "the source and basis of things." "'Zhi' means exchange of goods," which is related to wealth and shellfish (used as money in ancient China). "Zhi" has another meaning similar to "Ben" as is defined above. The definition of their combination, "Benzhi," means essence, which is more closely related to the definition of "Ben". Therefore, in Chinese, essence has three meanings: (1) root or base, such

as in the saying “a strong root is the premises of a giant tree;” (2) key or core, such as in the sayings “shoot the horse to neutralize the cavalryman, capture their leader to defeat the enemy,” “kill a snake by beating its heart;” and (3) origin, such as in the saying “a gentleman focuses on the essence of things, and with the essence, or intrinsic element established, the way (of doing things) will emerge.”

2.3 Definition of intrinsic management

Intrinsic management requires not only understanding the intrinsic attributes, but also grasping the intrinsic methods of engineering. The former elaborates the attributes, the basis, or reason, and the significance of the object involved in the project. Its opposite is an intuitive and superficial “surface.” Intrinsic attributes refer to the foundations and basic strategy of the project management method, including the principles of upholding the original concept, tracing the source, being pragmatic, and grasping the critical links in practice, while the opposite is non-essential and trivial details, as shown in Fig. 1.

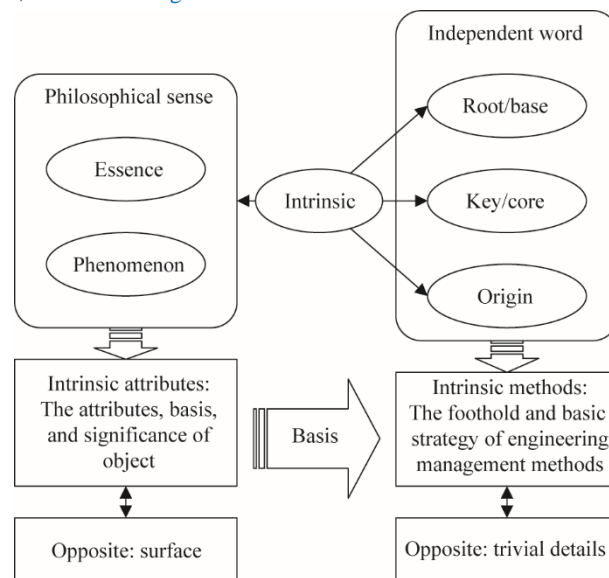


Fig. 1. Interpretation of intrinsic and two aspects of intrinsic management.

Based on this interpretation, intrinsic management thought can be defined as an engineering management philosophy. The core of intrinsic management thought is sticking to the crucial factor and being practical. It is constructed by recognizing the essence of the objects involved in the project and the foundation and basic strategy of the management method. Appropriate scientific and rational management methods and techniques are used to effectively realize the control of the whole management chain from the source, to the process, to the result, or the goal. The critical points of intrinsic management include the following aspects.

2.3.1 The most crucial element in engineering

People are the essence of all engineering elements and drive other engineering elements. Kant once stated that “human beings should be treated as an end (purpose) in themselves.” That means realizing human value is the starting point of engineering. It includes not only providing people a place for future activities but also satisfying their basic requirements for cultivation and development. Additionally, people are a resource. Engineering includes elements of personnel, resources, technology, and funds. Construction of a project depends on people, the subject that drives other elements [2]. Sound management of people’s minds and behaviors leads to effective source control. In the environment of dynamic change, people’s initiative and creativity are the only way to overcome predicaments in practice.

2.3.2 The ultimate target of engineering

Quality and safety are the intrinsic requirements of target management. Project targets include quality, safety, cost, and the schedule. Safety includes people’s occupational health and safety, project safety, and ecological environment safety. Quality and safety are the top priorities of engineering construction and the core of all work, which is the fundamental requirement of the Scientific Outlook on Development, a development view proposed by China’s former General Secretary Hu Jintao in 2007. Time limits and investments constitute the boundary conditions of

project construction. The schedule and cost determined by these not only constitute the project constraints but also direction and scheduling for engineering construction through planning, which primarily plays the role of a management tool. Typically, multi-objective management should be carried out jointly and comprehensively. In special cases, the cost and schedule should not take precedent but provide support for quality and safety. The project can be controlled through reliable quality and safety feedback and adjusting cost and schedule plans.

2.3.3 Selection of engineering methods

The Chinese background is the essence and premise of practicing engineering methods. Incorporating different ideas and methods is the fundamental approach to engineering practices. Modern engineering practices are based on multiple successful engineering experiences. When choosing or innovating engineering methods, one should fully understand and grasp the social environment in which the project is located, including cultural traditions, the era, and characteristics of the system [3]. In the selection of technical methods, one should consider the problems of intergenerational construction technology and equipment matching. In the selection of management methods, one should attach importance to the practicability and creativity of traditional Chinese thinking and draw lessons from Western management thinking and its scientific methods. This integrated thinking approach can be used to deal with problems and adjust procedures to local conditions.

2.3.4 Organizing management

Efficiency is the essential principle of organization design, and the application of information technology is the key to improve work efficiency. Organization is the foundation of engineering management, which realizes the advantages of the division of labor and scale benefits through the aggregation of groups and resources. In engineering construction, much information requires prompt feedback and communication. Time efficiency requires reducing the management hierarchy and adopting a flat organizational structure, but the scale of the project creates a significant workload. The quality of the work requires the scope of management to be reduced and requires an efficient and reasonable organizational structure. The use of information technology to optimize management and information processing capabilities is conducive to increasing the scope of management and improving work efficiency.

3 The conceptual model of intrinsic management

The conceptual model of intrinsic management aims to analyze the black box in the process of management and transform and model the thinking path of intrinsic management. Based on the definition, elements, and critical points of intrinsic management, it uses essential cognition as the starting point, the highest goal as the endpoint, and the logic of solving problems as the bridge. The conceptual model of intrinsic management is shown in Fig. 2.

The model consists of three closely related parts:

(1) Part One: Understanding the subject and the object

The first part focuses on recognizing strengths and weaknesses. It sets up the basic understanding of both the subject and the object and revises and improves it in practice. For the project, or object, it gradually reduces uncertainty and improves controllability. For the implementer, or subject, it recognizes advantages, compensates for disadvantages, and develops its ability by drawing on strengths and weaknesses. After recognition, the key points of the nature of the project are determined, which, together with the contractor's capability, constitute the basis of scientific problems.

(2) Part Two: Framing the problems to be solved

The second part involves proposing problems, which is a bridge connecting Part One and Part Three. According to the needs of Part One, a series of problems to be solved are framed, such as basic scheme, internal efficiency, resource supply, technology upgrading, and incentive measures. Through the analysis of the problems, five questions of intrinsic management are suggested to guide for solving problems.

(3) Part Three: Constructing a structured methodological system to achieve the targets

The task of the third part is to construct a structured methodology system. First, respective roles and missions are built based on five items [4] and corresponding engineering methods are designed around them so that each method can perform its duties and match each other, to achieve the most important goal.

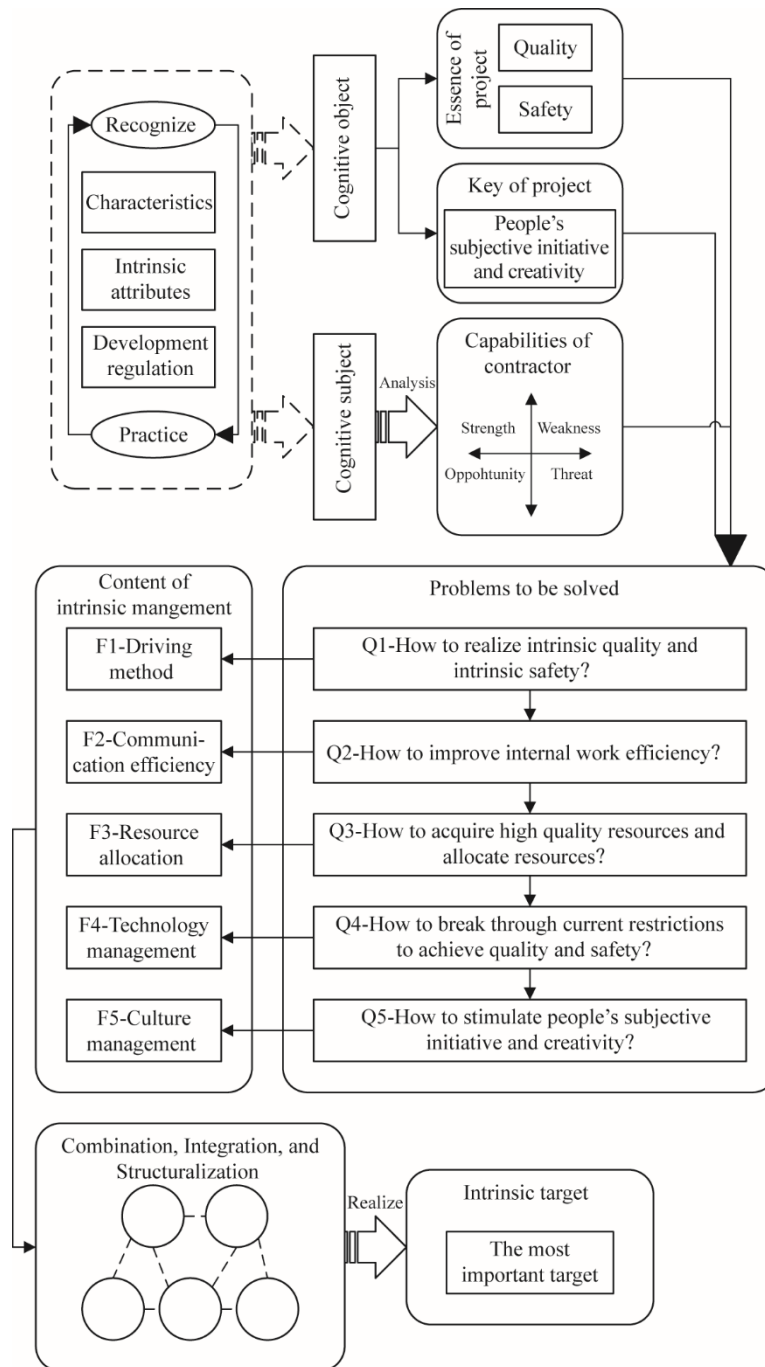


Fig. 2 Conceptual model of intrinsic management thought.

4 The practice of intrinsic management in the Hong Kong-Zhuhai-Macao Bridge Island & Tunnel Project

4.1 Recognize the intrinsic nature of the project and the capability of contractors

4.1.1 The characteristics of the project

The Pearl River Delta region where the Island & Tunnel Project is located is an essential gateway for China's internationalization. The undersea tunnel utilized the deep-buried immersed pipeline method. Most of the parameters of the project scale and technical scheme are world-class records, and the governments of Guangdong, Hong Kong, and Macao initiated a co-construction and co-management mode. The Island & Tunnel Project adopts the engineering procurement construction (EPC) mode. The construction area is offshore, the waterway transportation had already been developed, the navigation environment is complex, and the project passed through the core and buffer zones of the China White Dolphin Reserve. The insufficient depth of preliminary design led to multiple design

changes, which increased the difficulty and uncertainty of the project.

The Island & Tunnel Project is high-risk, pioneering, exploratory, systematic, and uncertain. Therefore, there is significant uncertainty regarding the progress and cost of the project. Quality and safety must be taken as a priority, and these also face significant challenges.

4.1.2 The capability of the contractor

As the general contractor for the design and construction of the Island & Tunnel Project, the Joint Venture of China Communications Construction Co., Ltd., which contains seven companies, has a robust system of integration capability, relying on the advantages of its industrial chain. Additionally, as a Fortune 500 enterprise, China Communications Construction can seek a global perspective to effectively remedy its shortcomings. Finally, China Communications Construction has the innovative ability of self-reliance and grasps the core technology to break through difficulties. This contractor has the ability of integration, open-source, and innovation, thus supplying a sufficient guarantee for the realization of intrinsic management targets.

4.2 Frame scientific issues and plans

For Q1, according to the high-risk characteristics of the Island & Tunnel Project, the project team sees risk management as the priority in carrying out project planning and sees eliminating or reducing risks as the basis to realize intrinsic quality and safety.

For Q2, the project team recognizes the advantages of design–construction integration under the EPC mode and proposes the method of whole-process linkage to improve work efficiency and quality.

For Q3, to achieve the goal of obtaining high-quality resources, the project team uses dynamic alliances to gather high-quality enterprises to form a consortium while seeking international cooperation. The effective allocation of resources can then be achieved through the organizational structure.

For Q4, the project team recognizes the importance of necessary technology and the necessity of wide-ranging innovation. The team suggests five principles, including standardization, industrialization, large-scale, assemblage, and intellectualization, and introduces the mode of industrial production to ensure the quality and safety of engineering production from the start.

For Q5, the project team proposes the concept of a people-oriented culture, carries out the “people project,” and implements the concept of respecting, cultivating, and developing people.

4.3 Combine and integrate the methods

In the intrinsic management method system of the Island & Tunnel Project, risk management is a goal-setting and driving method that determines the direction and goal of management by identifying problems and requirements to select suitable methods and provides the driving force. The methods make management more orderly and controllable, thus reducing risks. Dynamic alliance is a method of realizing resource acquisition through organizational relationships as a driving force for engineering. Providing a stable supply of resources is the basis for the implementation of the whole-process linkage and industrial production. Whole-process linkage is a method to optimize the process efficiency based on the internal structure of the organization, to promote organizational integration and technological innovation, and to strengthen the alliance. Industrial production centers on the specific implementation method of technology management. It aims to liberate people’s productive forces by guaranteeing the production capacity of mechanical equipment and technology. Productivity further stimulates people’s initiative and creativity, thus strengthening the whole-process linkage and dynamic alliance methods. The people-oriented culture realizes the deep integration of organizational members in ideology, consciousness, and behavior by stimulating and uniting people. This method condenses all aspects of the organization process and is infiltrated in all five methods. Each of the five methods has its functions that interrelate and interact with each other, and together constitute the system of intrinsic management of the Island & Tunnel Project, as shown in Fig. 3.

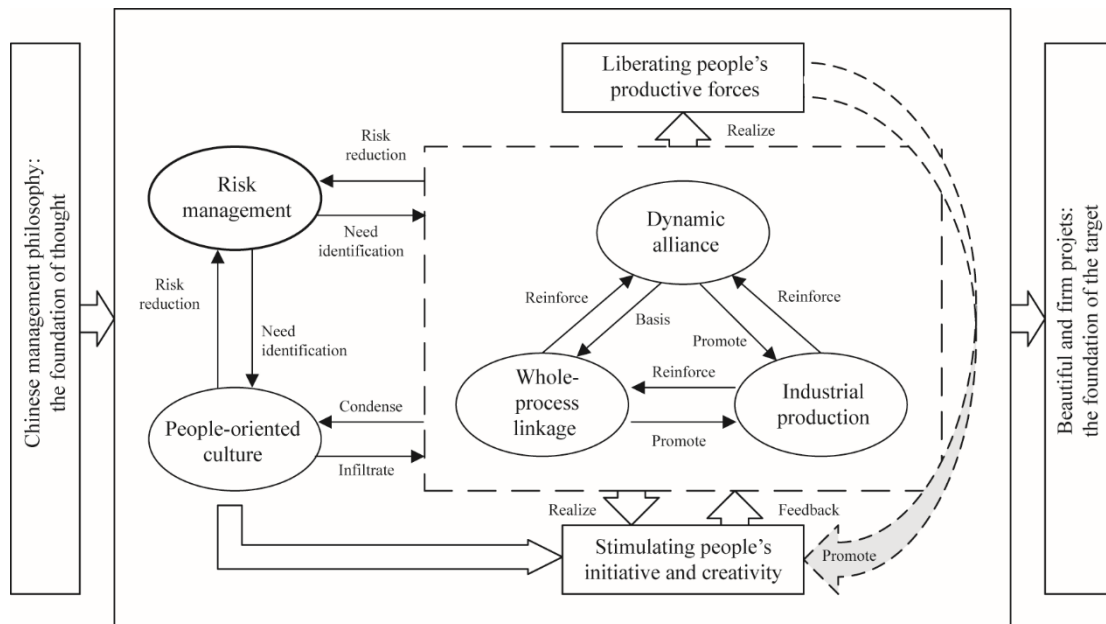


Fig. 3. Intrinsic management method system for the Hong Kong-Zhuhai-Macao Bridge Island & Tunnel Project.

5 The significance of the intrinsic management philosophy

5.1 The epochal character of the thought

Intrinsic management concentrates on three points. First, it creates an effective engineering management method system with adaptability to the unknown. Second, it upgrades engineering management from relatively underdeveloped to a high-tech process. Third, it provides suggestions for the construction of quality engineering.

(1) On the one hand, with the development and progress of society, more large-scale and complex projects will appear. The development and progress are the need of the era, as well as the trend of engineering. On the other hand, after 40 years of reform and opening, the gap between China and developed countries has narrowed, and China is now a significant member with frontier researches in the world. In this case, China will not only meet an increasingly serious technical blockade but also encounter a “no one to learn from” situation. Facing such large, complex, and exploratory tasks, China could only rely on itself and advance cautiously. To improve the adaptability of engineering management, the intrinsic management method is suggested, which can be used when facing the unknown.

(2) Intrinsic management is also a future-oriented management model [5]. With the development of information technology and the improvement of management transparency, the dividend source for engineering will change from monopoly to management. The emphasis on management efficiency and the development of productivity will be simplified, and the middle management will be reduced. The popularization of education will enhance the knowledge accomplishments of the engineers and stimulate their minds, and mechanical management will rapidly change to organic management. All these factors encourage project managers to consider changing and upgrading project management. Intrinsic management fundamentally requires solving low-level management needs, such as replacing manual work with systems, software, and machinery. It also requires concentrating people’s energy on management problems that cannot be solved by external forces, such as developing integrated man–operated machine systems and integrating the advantages of man and computer. Intrinsic management also requires developing individual initiative and creativity, thus achieving the fundamental goal of developing people and upgrading the project management to high-tech.

(3) Entering a new era, Chinese engineers need to establish the sense of mission, construct more quality projects, adhere to the concept of sustainable development, and promote the transformation of the original extensive engineering. Intrinsic quality and safety advocated by intrinsic management are the core of quality engineering.

5.2 The origin and development of intrinsic management philosophy

The practicality and methodology of engineering determine that engineering activities need the guidance of engineering philosophy and system science. Engineering philosophy [6] is the guiding ideology at the practical level and distinguishes the nature, process, and consequences of engineering practice from the philosophical level. Its

fundamental aim is to integrate theory with practice and guide engineers to establish the engineering concept of how people should carry out creative activities. Its goal is also to answer the organizational and management questions regarding engineering activities from the guiding principles and basic directions, including the establishment of engineering values, dialectical understanding, and identification of key issues. System science [7] is the guiding ideology at the practical methodology level. It advocates a holistic, open, and multi-level style of thinking, rethinks the basis of rationality, the method of action, the angle of understanding the world, the goal of reforming the world, and looks at problems from the perspective of connection and development. System science fully recognizes that a major project is a complex system, not only a multi-and-cross-disciplinary integration of science and technology but also a multi-level and cross-organizational portfolio. As it is also affected by the dynamic changes in the internal and external environment, it is necessary to establish an engineering system view, develop systematic thinking, and master system engineering methods. Thoughts and theories provide methodological guidance for engineering implementation while perceptual knowledge provides practical entry points. Based on many engineering practices, engineers analyze, summarize, and reflect on the successful experiences and failures of past engineering management, and extract the intrinsic drivers of engineering activities and the intrinsic objectives of engineering management. This experience-dependent cognition consciously or intuitively uses engineering philosophy and system science ideas and overcomes problems through reasonable logic and methods. Though simple in principle, it is the fundamental principle of intrinsic management philosophy, as shown in Fig. 4.

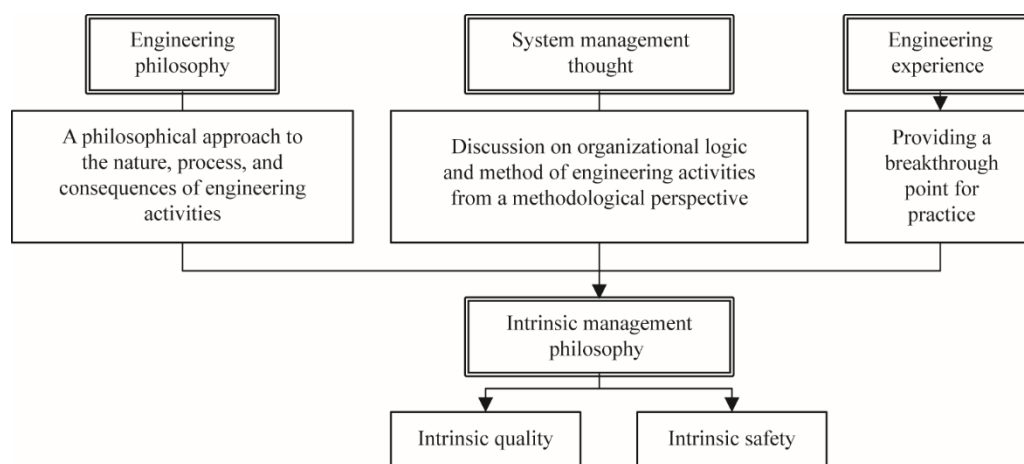


Fig. 4. The theoretical and practical basis of intrinsic management philosophy.

5.3 The applicability of intrinsic management

Applicability is a critical element of intrinsic management. From the viewpoint of the practice of intrinsic management, as seen in the Island & Tunnel Project, the essential characteristics of this project are large-scale, highly complicated, and systematic, and its outstanding features are highly risky, pioneering, exploratory, and uncertain. For the Island & Tunnel Project, social responsibility is the primary goal, followed by economic benefits. It not only undertakes the design function of the project but also bears the vision of the country and the nation. It is an arduous, duty-bound, and exploratory historical mission. From this analysis, large and complex projects need to use the idea of intrinsic management to discover the key points and key lines of management. Pioneering and exploratory projects need to use the idea of intrinsic management to guide the project, and high-risk projects need to use the idea of intrinsic management to overcome difficulties in prioritizing the objectives.

However, intrinsic management includes simple philosophical ideas, or minimalist thinking, such as “deal with the difficult problem from its easiest part,” “the key minority,” and “simplifying complexity,” which are also applicable to small and medium-sized projects. The use of a structured thinking model can effectively improve the logic and ability to deal with affairs and achieve twice the results with half the effort. It is not only applicable to the local industry but can also be extended to projects such as irrigation, metallurgy, and aerospace. Additionally, intrinsic management has simple, philosophical ideas and can be applied to all aspects of life and work.

6 Conclusion

With the development of the times and the rise of the comprehensive strength of the country, the engineering industry in China will face a more severe test, and change and exploration will become the central theme. Under this

background, the proposal of intrinsic management will enable engineering management to realize more significant projects. According to the practice of a series of subprojects in the Island & Tunnel Project, intrinsic management is a practical methodology for engineering management. It contains the essence of both Chinese and Western ideas, focusing on Chinese thoughts, which is a combination of cultural confidence and open-mindedness. This paper systematically discussed the origin, definition, connotation, elements, and conceptual model of intrinsic management, aiming at providing a valuable reference for the development of intrinsic management theory.

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