Dependability analysis of inventory management in construction project based on joint inventory management model

ZHAO Huifang

Abstract: **The joint inventory management is an advanced inventory management mode, and it is applied more and more widely in construction engineering.In order to give full play to the advantages of joint inventory management in the construction industry, Dependability evaluation indexes system is established according to the joint inventory management mode, which provides a new method for inventory management.**

Key words: **Construction project; joint inventory management ; Dependability evaluation indexes**

Introduction

Joint inventory management （JMI） is a kind of inventory management mode that the upstream enterprises and downstream enterprises balance the rights and share risks,which is developed on the basis of the supplier inventory management mode(VMI).JMI reflects the new cooperation between enterprises which forms strategic alliance ,and it emphasizes the mutually beneficial cooperation between the supply chain enterprises,solves the problem of the demand amplification caused by the independent stock operation mode of each enterprise in the supply chain system[1].In the construction project, it is the premise and key to reduce the cost of production that ensure the continuous production and reduce product consumption.Joint inventory management mode makes the inventory management integration a reality between suppliers and construction enterprises,so as to the joint procurement. And It also reduces inventory quantity thus reducing procurement costs.So, it is the effective way to reduce production costs, improve the economic benefit that implements the joint inventory management in construction enterprises.The dependability study about joint inventory in the inventory management of construction project.

1.Joint inventory management model of construction project inventory

The main participants in the construction supply chain include: owners, contractors, designers, manufacturers, suppliers, lenders and insurance companies and other financial institutions and government agencies.Joint inventory management model of construction project is established[2], combined with the characteristics of each participant.As shown in Figure 1.

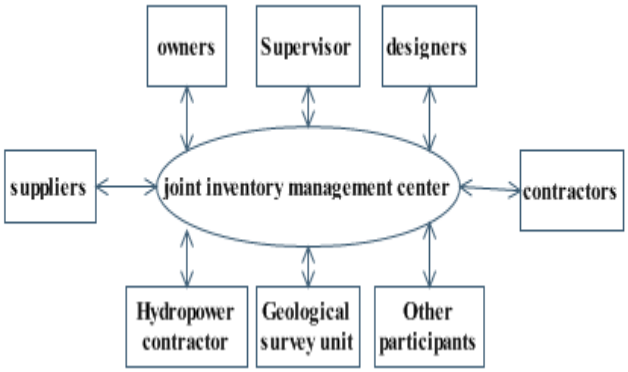

Fig. 1 Joint inventory management model of construction project

2.Basic theory of dependability

2.1The definition of dependability[3]

The concept of "credibility" is mentioned in the ISO9000 standard value.It is one of the important characteristics of products quality. The product is the result of the process,including hardware, process based materials, software, services, or a combination of them. The construction project inventory been mentioned in this paper is the service to complete the project.The narrow dependability refers to the ability of a product to perform specified functions in a specified task .Generalized credibility is a comprehensive term describing the availability and its influencing factors,including reliability, maintainability, security, sometimes with safety and economical efficiency.The qualitative and quantitative requirements of dependability can be expressed through availability, reliability, maintainability and security.

2.2The general measure of dependability

2.2.1Definition and measurement index of reliability

Reliability is the ability of a system to perform its specified tasks at a given time and condition.Reliability index can be used to design, analyze, evaluate and manage the reliability of products.We can choose different reliability indicators for different products.Common indicators includes:

(1)Reliability and unreliability

Reliability is the probability that a product performs a specified function within specified conditions and specified period of time.

Reliability: $R(t) = P(T > t)$

Unreliability: $F(t) = P(T \le t)$

In which, T is the product life; t is the specified working hours.

ZHAO Huifang, College Management， Xi'an University of Architecture and Technology, Xi'an, China, 18710878235

For a finite sample,we assume that the total number of samples examined is N_0, and the number of failures $r(t)$ is after t, so the the estimated value of the product reliability and reliability in [0, t],is:

$$R(t)=\frac{N_0-r(t)}{N_0}$$

$$F(t)=\frac{r(t)}{N_0}$$

(2)Mean time between failures (MTBF)

Mean time between failures (MTBF) refers to the average working time between two adjacent failures of repairable products.

$$MTBF=\frac{1}{N_0}\sum_{i=1}^{N_0}t_i$$

In which, N_0 is the number of faults that can be repaired; t_i refers to the i st working hours.

(3)Mean time to failure (MTTF)

MTTF means the life expectancy of non repairable products.

$$MTTF=\frac{1}{N_0}\sum_{i=1}^{N_0}t_i$$

In which, N_0 is the number of non repairable products; t_i is the working time before failure of the i st product.

2.2.2Definition and measurement index of maintainability

Maintainability refers to the ability to maintain or restore state provisions of the Repairable Products in specified conditions and within the stipulated time, maintenance according to the rules of procedure and method.Maintainability includes two aspects.On the one hand, it is maintenance ,also called preventive maintenance,it is a daily reliability control process.On the other hand it is repair which refer to the product restore to complete the specified function after a failure.Maintainability reflects the acceptable maintenance ability of repairable products in the demonstration phase of the product, the development stage, the life cycle of the use phase and the processing stage.Common indicators includes:

(1)Mean time to repair (MTTR)

MTTR is the average value of the total time required for the repair of the product at any specified service level in the specified conditions and within the specified time.

$$MTTR=\frac{1}{n}\sum_{i=1}^{n}t_i$$

In which, t_i is the i st ($i=1,2,\cdots,n$)repair time; n is the times of repair.

(2)Mean time to maintenance(MTTM)

MTTM is the average value of the total time required for maintenance at any specified maintenance level.

$$MTTM=\frac{1}{n}\sum_{i=1}^{n}t_i$$

In which, t_i is the i st ($i=1,2,\cdots,n$)maintenance time;is the times of maintenance.

2.2.3Definition and measurement index of maintenance support performance

Maintenance support performance refers to the design characteristics of the product and the planned protection of the resources to complete the required function.Common indicators includes:

(1)Maintainability index(MI)

MIMI refers to the average maintenance hours per hour , also known as maintenance ratio.

$$MI=\frac{MMH}{OH}$$

In which,MMH is the total number of hours of repair in the specified service life of the product,OH is the number of working hours during the specified period .

(2)The average hours of maintenance activities

The average working hours of maintenance activities is the ratio of the total number of hours of maintenance and the total number of hours of preventive and restorative activities under specified conditions and within the specified time.That is MMH/MA.

2.2.4Definition and measurement index of availability

Availability refers to the ability of the product to be in an executable state under specified conditions and at the specified time or time interval in the requirements of the external resources under the premise of being guaranteed.It is the comprehensive reflection of the product reliability, maintainability and maintenance support.Common indicators includes:

(1)Instantaneous availability

The repairable product is in a random process from a specified state to a fault condition and from a fault state to a specified state, so that the probability that the product is in a prescribed state at t can be used to indicate its availability index,that is instantaneous availability $A(t)$ .In the steady-state condition, the mean of the instantaneous availability in the specified time interval is called steady-state availability.

(2)Operational availability

Operational availability A_0 the ratio of working hours to not working hours:

$$A_0=\frac{MUT}{MUT+MDT}$$

In which, MUT is the mean working hours, MDT is the mean nonworking hours.

(3)Inherent availability

Inherent availability A_i is an availability parameter related only to working time and repair time.

$$A_i=\frac{MTBF}{MTBF+MTTR}$$

In which, $MTBF$ is mean time between failures, $MTTR$ is mean time to repair.

2.2.5 Definition and measurement index of economical efficiency

(1)Life cycle cost(LCC)

The cost of the product is the resource Human, (financial, material and time)consumed by the product.It is usually measured in terms of money.The life cycle cost of a product is the sum of all the costs paid for the demonstration, development, production, use and protection of the product during the expected life cycle of the product.Life cycle costs are usually calculated using the principles of Engineering Economics.

(2)Effectiveness and cost-effectiveness

System effectiveness means that the system satisfies the given quantitative characteristics and service requirements under defined conditions,that is to say,the system achieves the ability to specify the use of the target.Cost-effectiveness is usually expressed by the ratio of the effectiveness of product and the equivalent annuity of life cycle costs.

$$V = \frac{E}{A_c}$$

3Dependability analysis of inventory management in construction projects

3.1The definition of dependability of inventory management in construction projects

According to the definition of dependability,in this paper, the dependability of the inventory management of construction project is the ability to complete the inventory management and related logistics and information exchange of service flow within the specified time, according to the required quantity and quality,and to ensure delivery smoothly and use finally.

3.2Research on dependability measurement of inventory management in construction projects

3.2.1The principle of establishing the dependability index of inventory management in construction projects

(1)Covering the whole process of project construction

The characteristics of complexity and long-term of construction project determines the intricacies of its inventory management, So if we want to evaluate dependable level of the inventory management objectively,the attributes and the index system of dependability should be established covering all aspects of project construction,design,construction, maintenance,and so on.so as to reflect the credibility level of inventory management.

(2)Integrity of evaluation index system

We should take into account the structure and requirements of inventory management dependability evaluation model when establishing the dependability attributes and evaluation index system of inventory management in construction projects.The number of dependability attributes and evaluation items should not be too much,and it must be easy to establish and implement the inventory management dependability measurement model.

(3)Easy to collect and estimate index data

The date of inventory management of the construction project, especially the past project data,is difficult to collect, so when designing the dependability attributes and evaluation index system we need to consider the difficulty to the measurement and collection of inventory management date and choose the date which is easy to collect and estimate.

3.2.2Reliability index and its measurement of inventory management in construction projects

3.2.2.1Reliability of node

(1)The reliability indexes of supplier[3]

1)Credit degree of supplier.The credit degree of supplier reflects the reliability of the supplier's credit, including credit rating and credit rating within the industry.

2)The reliability of supply.

The reliability of supply is the degree of reliability to provide products, including production capacity reliability, the rate of delivery on time, response speed reliability.The index of production capacity reliability is the ability to provide a sufficient number of products to the customer if the customer order is driven; the rate of delivery on time refers to the supplier delivering on time or not.Rate of delivery on time=Order quantity of on time delivery/Total order;Response speed reliability is the degree of reliability that the supplier responds to the order change and the market change.It is a qualitative index.

3)The reliability of supplier service.

The reliability of supplier service is the degree of reliability of the provider's service,including pre-sale service reliability, sales service reliability, after-sales service reliability.These three indicators are qualitative indicators,and reflects the supplier in the pre-sale, sale, after-sales service reliability level ,respectively.

4)The reliability of quality .

The reliability of quality is not only the product qualification rate, but also the overall quality and management level, quality assurance system and quality improvement mechanism that adapt to market changes.Quality reliability indicators include Rate of qualified products, rate of return and rework, labor quality and reliability.Rate of qualified products=The number of qualified products / the total number of products;Rate of return and rework= the number of products returned / total sales of products; Labor quality reliability is a qualitative indicator.

(2)The reliability indexes of construction contractor

1)Credit degree of construction contractor.The credit degree of the construction contractor reflects the reliability of the construction contractor's credit, including the reliability of the completion and the credit rating within the industry.The reliability of the completion is mainly evaluated from projects that construction contractors have been involved in the past.Credit rating within the industry mainly refers to the reputation,the credit of financial,and the evaluation from its partners.

2)The reliability of contractor's technology.The reliability of contractor's technology is mainly measured from the qualification and relevant construction experience and performance of construction contractor.Whether the contractor has undertaken projects similar to the nature and scale of this project is also the measurement standard, as well as construction experience similar to climate and geological conditions and the manager experience, technical capability, reliability of the advanced machinery and equipment.

3)The reliability of contractor's inventory management.The inventory management of the construction project is relatively backward compared with the manufacturing industry. It is usually based on the temporary storage of the site and lack of norm.It may be affected by other department such as the Ministry of Finance, the Ministry of Finance, the Department of Budget which is lack of coordination and cooperation and only take into account inventory management issues from self-interest. They have different views on the inventory, which will make the construction enterprises to develop inconsistent inventory management program, and lead to the final development of the inventory program may not be the best inventory management program.The reliability of contractor's inventory management is mainly measured from the performance of past construction projects and the

organization of project inventory management , technical staff experience and knowledge and other aspects of measurement.

(3)The reliability indexes of joint inventory management center

1)The reliability of storage.The functions of the joint inventory management system are inseparable from the support of physical resources such as storehouse, freight yard, loading and unloading equipment and means of delivery.So the reliability of storage of the joint inventory management center is mainly measured from the reliability of its infrastructure and equipment.

2)The reliability of management.There are three kinds of joint inventory management mode, including storage of goods on the supply side,storage of goods on the demand side,storage of goods on the third party.The reliability of management is measured from the the reliability of managers and field staff, the reliability of information and instructions.It can effectively improve the reliability of its management if managers control the inventory and the time and quantity of goods out of storage.

3)The reliability of service.The reliability of service of the inventory management center,which mainly reflects the inventory system's time performance and service capabilities,is generally reflected in the security of the storage process, the convenience of the goods access, and the quality and attitude of the on-site staff.

3.2.2.2Reliability of relationship

(1)The reliability of information communication channel

The construction inventory management system is a complex supply chain system.The efficiency of joint inventory management depends on the cooperative behavior of the node enterprise, and the information and its effective delivery are the basis of the joint inventory management operation.It is beneficial to achieve the information communication channels fast and accurate sharing and improve the stability and consistency of the whole inventory management information if we integrate barcode technology, scanning technology, POS, GPS and electronic data interchange (EDI) to take advantage of Internet benefits.

(2)The reliability of system coordination capability.The joint inventory management of construction engineering is based on the coordination and the win-win cooperation of the participating parties.The coordination is mainly from the cooperation and communication of the parties involved.Participants of joint inventory management system should establish a mechanism based on supply chain coordination management, clear the objectives and responsibilities of the parties, and provide an effective mechanism for joint inventory management.Participants should clear the common objectives of cooperation, understand the contradictions and conflicts in the construction market and common ground,establish a fair system of benefits distribution to improve the reliability of coordination.

3.2.3Maintainabilityindex and its measurement of inventory management in construction projects

The joint inventory management of construction engineering can be seen as a repairable system that are in the normal working state and in the maintenance state.System failures and maintenance are random.The repairable system commonly used in the construction engineering system is the system that the time of failure and the time of maintenance are subject to the exponential distribution[4].When the system system failure, the inventory manager repair the system.In this paper,the maintenance is measured by the Mean time to repair and the Mean time to maintenance.

3.2.4Availability index and its measurement of inventory management in construction projects

In the construction engineering inventory management system, commonly used repairable system is a system that the time of failure and the completion of the maintenance time are subject to the exponential distribution.so availability is measured by instantaneous availability and inherent availability.

$$A=\frac{MTBF}{MTBF+MTTR}=\frac{\mu}{\lambda+\mu}$$

$$\overline{A}=1-A=\frac{MTTR}{MTBF+MTTR}=\frac{\lambda}{\lambda+\mu}$$

In which, λ is failure rate; μ is repair rate;MTBF is mean time between failures;MTTR is mean time to repair; A is stead-state availability;is stead-state unavailability.

3.2.5economical efficiency index and its measurement of inventory management in construction projects

(1)Joint inventory management fees.

Joint inventory management costs, that is, the total cost of joint inventory management, the measure is mainly currency.

(2)Rate of cost deviation.

The cost deviation rate is the ratio of the actual cost to the planned cost ,which reflects the level of credibility and the accuracy of the plan.It is calculated as:

$$c=\left|\frac{C_s-C_j}{C_j}\right|$$

In which, C_s is the actual cost, C_j is the planned cost.

Conclusion

Based on the analysis of the joint inventory management mode of construction project, this paper further analyzes its dependability. Combined with the general measure of dependability,this paper establishes the measures such as reliability, maintainability, availability and economical efficiency of construction project joint management, which is based on the principle of selection of indicators whole process, completeness and collection and evaluation easily. These indicators provide a depend guarantee for the joint inventory management of construction projects, and provide a new idea and method for the inventory managers of construction projects.

Reference

[1]WANG Wei-hua .The Application Research of Jointly Managed Inventory (JMI) Based on the Supply Chain[J].Logistics Engineering and Management,2013, 35: 83-84

[2]CHEN Xiang-lan.The Research of Management of Material Inventory of Projects Based on the Supply Chain Management[J]. Value Engineering, 2013, 23:21-22.

[3] He Guowei.Reliability engineering [M]. Beijing: Standards Press of China, 2008 ·

[4]LUO Jun .An Analysis of the Reliability of Suppliers [J].Journal of Wuyi University(Natural Science Edition), 2009, 2: 69-74.

[5]CAI Jian-ming.Reliability Analysis of the Supply Chain Based on the GO Methodology[J]. Journal of Highway and Transportation Research and Development, 2007,24: 145-148.