Applying Reliability Theory to Appraise Quality of Irrigation System in Vietnam

Pham Hong Cuong, Quang Hung Nguyen

***Abstract*: This article is about the approach to propose an appropriate method to appraise the quality of the irrigation system based on the reliability theory - a theory which has been applied to a lot of fields of human life all over the world. In this method, the reliability of the element of the structure is determined by the durability, the reliability of the whole system or a group of structures in the system is determined based on the linking chart of the structure elements on the reliability theory. This approach has been applied to appraise the quality of the construction and the structures on Troi canal in Cau River irrigation system in order to evaluate the applicability of the systematic reliability appraisal and analysis based on the proposed method**

***Keyword*: Systematic quality appraisal, Reliability; Irrigation system, Element, A set of elements.**

I. INTRODUCTION

The quality of Vietnam's irrigation system is shown by the following criteria: a) serving the design tasks; b) Convenient operation and management; c) There is a reasonable investment cost. The irrigation system is called a problem when the system no longer ensures the function to meet the water supply and drainage tasks. According to the statistics report of the management agency, the current irrigation works only reach 60 ÷ 70% of the design capacity, the main reason is the serious deterioration of the project and the management and operation of the system. many shortcomings. Repair and upgrade the system asynchronously leading to the service efficiency of the project as well as the system is not as effective as expected.

Currently, in our country, the technical quality of irrigation works in general and irrigation in particular is assessed through analyzing the limited state of overall stability, stabilizing the structure and rationality of each work. Process in the system. Some detailed structures have been evaluated by reliability indicators. The quality of the system is assessed through hydraulic problems, in which the technical quality of the buildings is simulated through the ability to remove, and the load capacity of the structures affects the working of the system. How is the system not considered as a whole. Previous studies have just stopped at the study of quality assessment for a specific, single project, but there has not been a study to assess the technical quality of the structure of a group of works as well as The whole system of irrigation works. Therefore, it is necessary to study a structural quality evaluation method of irrigation systems.[1-4]

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II. BASIS OF SCIENCE AND METHODOLOGY

The system is conceived to include many elements that are joined together according to a diagram. The system is also referred to as the system. The structure yv 1e of an independent building is considered a system of many structural elements. Gathering many works of continuous operation is also seen as a system, as the irrigation system consists of many works with different functions, in which each "unit works" is considered a "super element". join together according to a diagram. Therefore, the term "system" used can be interpreted as an independent building or a collection of multiple works according to common goals. Based on the coupling between the elements, the reliability of the whole system can be determined according to the reliability of the elements. There are diagrams connecting elements in the system: System with serial structure; System with parallel coupling structure; The system has a composite structure; Any system with any compound structure.

A. General model for irrigation systems

By definition of irrigation system (irrigation system in particular) is a collection of irrigation works distributed on a large area to work together to solve irrigation tasks so the works closely related to each other, the damage of this work leads to obstacles or inactivity for the other project and vice versa. The level of influence of this project depends on the location and importance of itself to the other building. To compare the role of the building to the system using the concept of "rank". Level 0 corresponds to trunk, level 1, level 2, level 3 are branches, with the operation of the water flow from the "root" to the "branches" according to the steps. Each construction in the system (such as intake structures, regulating structures, etc.) is called an "element-building" and each Canal section is called a "Canal-element". The "tree" model is an important basis for assessing the reliability of irrigation systems.

B. Uncertainty factors affecting the quality of irrigation systems

Uncertainty factors for irrigation works in Vietnam conditions are generalized into the following three groups:

- Group I: Uncertain factors of natural and social conditions: Meteorology and hydrology; Hydraulic power; Rock ground; Structural and structural construction materials; Economy.

- Group II: Uncertainty factors of technological equipment and operation management: Technological

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machines and equipment; Automatic operation management system (SCADA) and semi-automatic.

- Group III: Uncertainty factors caused by human beings such as: Errors due to improper implementation of rules, processes, or negligence in the stages of project implementation and implementation: Collection and treatment the "input data" of the problem of determining reliability; Process of design calculation; Manufacturing process; The process of exploitation and use; The process of periodic inspection, maintenance and repair of the system.

C. Assumptions to assess the reliability of irrigation systems.

The evaluation of the reliability of element-building groups and the whole system will be done based on the following assumptions:

- The relationship between the elements-works together is considered independent (not correlated, according to the theory of reliability);

- Relationship of super-elements with the same level but different branches are considered independent;

- Relationship between element-building clusters (in which each cluster is called "super element" or "ladder" of the system) follows the principle of water distribution diagram from upstream to lower source, in the direction of the flow, the one-way dependency relationship, ie the safety state of the lower order (downstream) depends on the safety state of the order on it.

D. The general problem assesses the reliability of irrigation systems.

The general problem assesses the reliability of irrigation systems with 2 steps:[5-8]

Step 1: Determine the reliability of each element, based on the limit states considered for that element, assuming each element is independent of each other.

Expressions to determine the reliability of each independent building (element-building) are of the form:

$$P\ (\text{element}) = \text{Prob}\ \{Z\ (X) \geq 0\} \quad (8)$$

Step 2: Building the model of the system; Based on the coupling scheme of the system's elements, it is possible to determine the reliability of the system according to the principle of reliability theory, which takes into account the correlation between the elements based on the principle ensure the hydraulic continuity of the irrigation system.

The expression of determining the reliability of the system is a function of the reliability of elements-buildings, elements-Pi Canal, with symbolic form:

$$P\ (\text{system}) = F\ (P1, P2,., Pi, .., PN) \quad (9)$$

E. Prepare a configuration diagram of the system of irrigation works to assess reliability

A system of irrigation works consists of many canal routes arranged in order of "tree type." Each project in the system (such as water intake, regulation works, etc.) is called. is a "work-element" and each Canal segment is called a "Canal-element." Each step consists of many "super-order-elements" (SPT-levels), (Figure 2), each containing SPT-levels Some super elements, each SPT contains some elements (PT), each PT will be PT-CT or PT-K.

A system of irrigation works consists of many branches-systems, starting from SPT-level I to SPT-level II, connecting to the lowest level, to transfer water to the Water user. The number of branch-systems equals the final SPT-level of the system of irrigation works.

The operation of the system of irrigation works at a certain position of SPT-level, depends on the quality of the SPT itself - that level and at the same time all the SPT-levels on it until the first step (headwaters)), means not dependent on the SPT-lower order. With this property, we say "The system of irrigation works has the configuration of one-way serialized branched SPT branch system".

Figure 1 provides a general description of the structure of a shallow irrigation system, in which the sections of Canals a, b, and c are separated by regulating works, the focal work with the first symbol is ĐM; Regulated-works element is IĐT.2 = 2nd regulating project of Canal I; Element-Canal is IIK.b.2.1 = [Canal branch level II, part b is in Canal I, Canal branch is water intake project (culvert) No. 2 in part b, Canal number 1 of Canal section]; The water-intake element is IIC.a.1.2 = [Canal II, water intake C belongs to part a of level I Canal, the beginning of the canal is the water intake work (sewer) No. 1 of part a of Canal I, second water intake].

Similarly, we can describe all groups of works in the system's SPTs, allowing full identification of the relationship between them to study the reliability of each "super-element - ladder "and the whole building system.

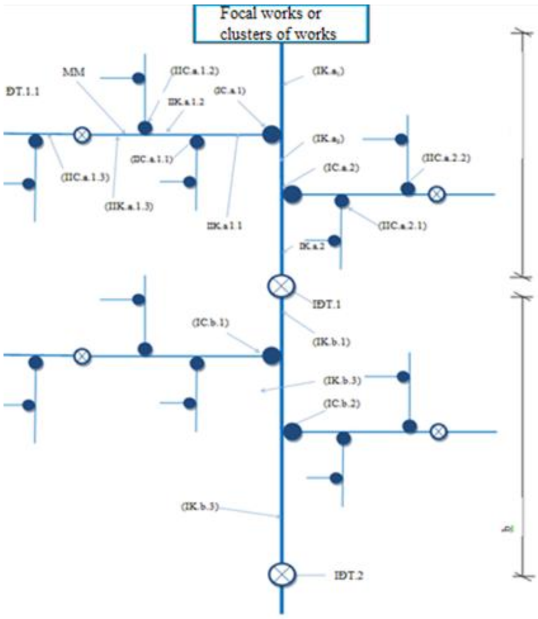

Figure 1. Schematic diagram of works in the irrigation system.

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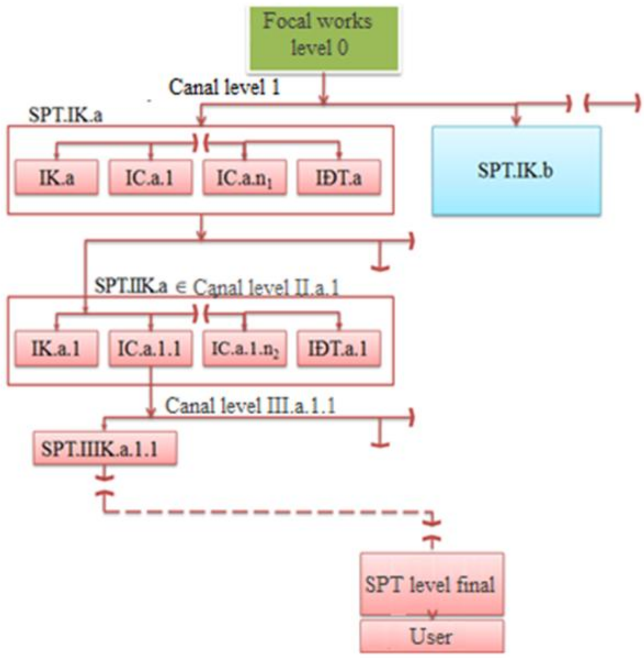

Figure 2: Schematic symbol of a branch of super-connected "super-elements" of the irrigation system.

F. Evaluate the reliability of the irrigation system.

The reliability of the system of irrigation works at position 1 super-element (SPT) at any level is determined based on the coupling diagram between that SPT itself and all SPTs at the top level, until the first step First, on the same branch of the system, according to the 1-way SPT-ladder configuration.

From Figure 1, we consider the first Canal segment (paragraph a) of the first-order Canal, called **SPT-I.a**. SPT. (I.a) is a subsystem that is serialized by PT-CTs of vectors {IK.a} and {ICT.a}, with diagrams:

Figure 3. Serial element super diagram (IK.a)

G. Software to assess the reliability of the system of irrigation works (DTC07)

The tool used to build DTC07 is Delphi2006 object-oriented programming language based on Windows operating system.

Program system DTC07 operates according to the main diagram as shown in figure 5. After the calculation, the software can give results of the reliability of each project, the reliability of the system, the reliability of any system group, compilation of analytical and analytical reports. Results of analytical calculations.

H. Review

With the methodology presented above, we can determine the reliability of the whole system, by determining the reliability of all branches according to the specific configuration of the system, respectively from upstream to downstream, with the order from the upper steps to the lower steps. The condition that the entire operating system is safe is that all the last branches of the system must be safely operated.

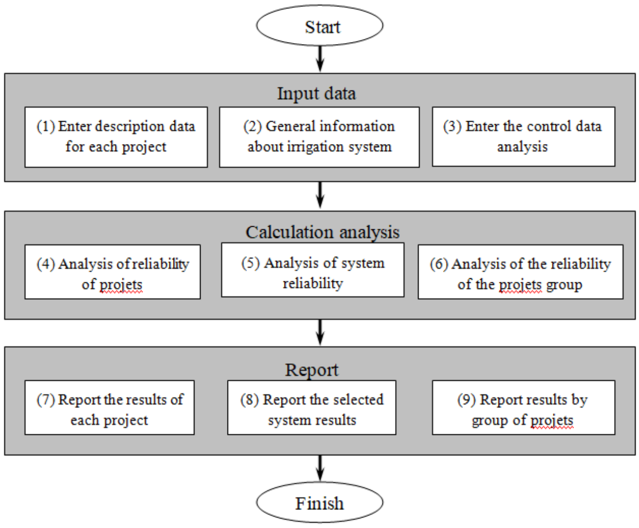

Figure 4: Block diagram of the main modules of the program DTC07

$$P_{(sys)} = \operatorname{Prob}\left\{R_{DM} \bigcap R_{(I.a)} \bigcap R_{(II.a.1)} \bigcap R_{(II.a.2)}\right\} \quad (10)$$

$$= \mathbf{P}_{\mathbf{DM}} \cdot \mathbf{P}_{\mathbf{(I.a)}} \cdot \mathbf{P}_{\mathbf{(II.a.1)}} \cdot \mathbf{P}_{\mathbf{(II.a.2)}}$$

In which:

+ $P_{(I.a)}$ = reliability of super elements (I.a);
+ $P_{(II.a.1)}$ = super-element reliability (II.a.1);
+ $P_{(II.a.2)}$ = reliability of the super-element (II.a.2).

The reliability of the system is determined according to (10) to assess the ability of safety exploitation simultaneously in terms of the structure of the whole system. However, due to the unidirectional "ladder" nature of the "tree-shaped" diagram system, it is possible that some branches are destroyed, but other branches still work normally, depending on the quality of each separate branch as stated in formula (10).

III. RESULTS AND DISCUSSIONS

A. Research location

Drifting Canal and works on Troi canal belong to Cau river irrigation system, Bac Giang province of Vietnam.

B. Diagram of the system

The system diagram is included in the evaluation and symbols of PT-CTs as shown in table 1. In order to assess the reliability of the system, it is necessary to assess the reliability of the elements-buildings and Canal-elements as shown in table 1. Due to the lack of data, in this study, some figures were calculated. [9]

Table 1: The PT-CT and PT-K take into calculate.

No	The name of construction	Location	Aperture	Element symbols
I	**Clue culvert**	K0	8	ĐM
II	**Drain for water :**			
1	Drain irrigated left	K_{1+901}	2 Φ 100	IC.a.1.1
2	Irrigation culvert must	K_{5+350}	Φ 60	IC.a.1.2

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III	**Canal segment :**			
1	K_0÷K1+901L	Paragraph a		IK.a.1.1
2	K1+901÷K_{7+996L}	Paragraph a		IK.a.1.2+3
3	K0÷K5+350R	Paragraph a		IK.a.1.1+2
4	K5+350÷K7+996R	Paragraph a		IK.a.1.3
IV	**Regulatory:**			
1	Regulate	K_{7+996}	3 Φ 100	IĐT1

The reliability of the calculation and selection system with the following diagram is as

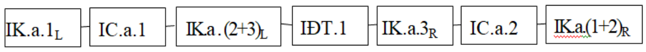

Figure 4 . Serial diagram of SPT-Ia

C. Determine the reliability of SPT-ladder

Reliability of Lang Trinh sewer (**PT-CT ĐM**) : $P = P_{imin} = 0,8413$

Reliability of vector elements-Canal (**IK.a**): (table 2)

$$\mathbf{P_{(IK.a)}} = \min_{(k)} \mathbf{P_{(IK.a)k}} = 0,61202$$

Table 2. Reliability of each type of destruction of PT-K

Element / DestructionForm	*IK.a.1 left*	*IK.a.(2+3) left*	*IK.a.(1+2) right*	*IK.a.3 right*	Reliability $P_{(IK.a)k}$
1	0.91664	0.91801	0.81377	0.89376	0,61202
2	0.91664	0.91801	0.81377	1	0,68477
3	1	0.91801	0.81377	0.89376	0,66768
4	1	0.91801	0.81377	1	0,74705
5	0.91664	0.91801	1	0.89376	0,75209
6	0.91664	0.91801	1	1	0,84148
7	1	1	0.81377	0.89376	0,72732
8	1	1	1	1	1,00000
9	0.91664	1	0.81377	1	0,74593
10	0.91664	1	1	1	0,91664
11	1	1	1	0.89376	0,89376
12	1	1	0.81377	1	0,81377
13	0.91664	1	0.81377	0.89376	0,66669
14	0.91664	1	1	0.89376	0,81926
15	1	0.91801	1	1	0,91801
16	1	0.91801	1	0.89376	0,82048

Reliability of vector the PT-CT (**ICT.a**) : (table 3)

$$\mathbf{P_{ICT.a}} = \min_{(k)} \mathbf{P_{CT.k}} = 0,67389$$

The reliability of the super-element (Ia):

$$P_{(I.a)} = \text{Prob}\{\mathbf{R}_{IK.a} \bigcap \mathbf{R}_{ICT.a}\} = P_{IK.a}\, .\mathbf{P}_{ICT.a} = 0,67389 \text{x } 0,61202 = 0,41243$$

The reliability of the system at a SPT-ladder (in this case is also the reliability of the whole system):

$$\mathbf{P_{HT(IK.a)}} = \text{Prob}\{\mathbf{R}_{MĐ} \bigcap \mathbf{R}_{IK.a} \bigcap \mathbf{R}_{ICT.a}\}$$

$$\mathbf{P_{HT(IK.a)}} = P_{ĐM} . P_{IK.a} . \mathbf{P}_{ICT.a} = P_{ĐM} . P_{(IK.a)} = 0,8413 \mathbf{\ x\ } 0,41243 = 0,34698$$

Table 3: Reliability of each type of destruction of PT-CT

Element / Destruction form	*ICT.a.1.1*	*ICT.a.1.1*	*IĐT.1*	Reliability of destructive form $P_{CT.k}$
1	0,9995	0,9940	0,9875	0,98108
2	0,9995	0,9940	0,8461	0,84060
3	0,9995	0,8906	0,9875	0,87903
4	0,9995	0,8906	0,8461	0,75316
5	0,8943	0,9940	0,9875	0,87782
6	0,8943	0,9940	0,8461	0,75213
7	0,8943	0,8906	0,9875	0,78651
8	0,8943	0,8906	0,8461	0,67389

D. Calculation results.

According to the chosen system calculation, there is vector reliability of the element-building on the Canal (PICT.a), vector-Canal reliability (PIK.a), public-element reliability. The focal point (MSM) and the reliability of the system (PHT (IK.a)) give the following results:

$P_{ICT.a} = 0,67389$; $P_{IK.a} = 0,61202$; $P_{ĐM} = 0,8413$; $P_{HT(IK.a)} = 0,34698$

Calculation results show that the reliability of the system chosen to calculate is very low. It is necessary to have a solution to improve the reliability for the system to operate effectively.

E. Reasonably adjust the reliability of the elements to improve the reliability of the system.

Assuming an incremental increase in the reliability of each vector of elements and focal building elements adds 0.02 while maintaining the reliability value of another element, we obtain the corresponding reliability. Calculation results are shown in the graph in Figure 5.

See Figure 5, the reliability of the system in this case increases the most when the vector reliability of the Canal $\mathbf{P_{IK.a}}$ is increased, then the vector reliability of the

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parts $\mathbf{P}_{\mathbf{ICT.a}}$ e-works. Therefore, in order to increase the reliability of P_{HT} system, it is necessary to invest in upgrading and selecting the system of selected Canals.

Continue, return to the reliability of each type of destructive assemblies of Canal-elements in Table 3, showing that the reliability of $P_{IK.a}$ is determined by the first type of destruction N = 1 .T should first increase the values in this destructive form to achieve the next reliability value (in this case, the 13th destructive form. N = 13, $P_{(IK.a)\ k}$ = 0.66669) , It is also possible to increase the roof slip reliability values P_K in the roof stability stability calculation table of Canal part a table 2 .Continuing to investigate the variation of reliability of roof stability of a P_K Canal section as the reliability of the above-mentioned system, will result in the need to increase the reliability of roof stability of the element. Which Canal has the most stable stability of the roof of the Canal A section? From there, it will choose the best repair plan for the system.

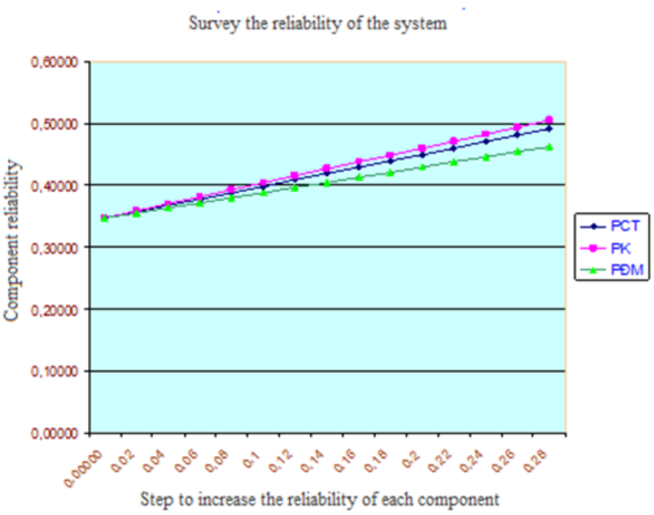

Figure 5 . Reliability of the system corresponds to increasing steps

IV. CONCLUCTION

The irrigation system in the natural and socio-economic conditions of our country now suffers from many uncertainties. Use your S probabilistic models of reliability theory, allows quantifying performance of the structural safety of the system. The research given is appropriately configured for The irrigation system follows the basic diagrams of the theory of reliability, the "tree shape" plays a decisive role to correctly determine the safe or destructive state of the department and the whole system. In determining the reliability of structural elements under durable conditions, determine the reliability of the whole system or a group of works in the system based on the coupling diagram of the project elements according to the degree theory.

A. Assessment of the reliability of the system of irrigation works also allows the selection of the optimal scheme of the system with the goal of minimizing chemical cost of the initial investment and the mining process while ensuring the trust is within safe range;

Through examining the variability of the composition works affect the reliability of the system outcome study launched by the rational plan for the system to operate effectively. From there, help managers choose the way and order of repairing and upgrading the works in the system. However, the assessment only stops with the purely problem of giving a reasonable plan for the system to work most effectively when there is sufficient capital to invest. But in fact, the limited funds so the question is how this source of capital to upgrade and repair works in the system to be the reliability of the system is highest The problem needs further research.

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