

Structure Performance Evaluation Method Research of Harbor Portal Crane

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Abstract. Harbor portal crane is composed of many pieces of metal structures, portal cranes various functional structures and cranes overall security evaluation system in accordance with the idea of the analytic hierarchy process and gives a quantified method, the application of expert investigation and the Analytic Hierarchy Process the calculation of index weights, the main structure of the portal crane security assessment, the final comprehensive evaluation of the overall security of the portal crane. The evaluation system is verified by an example, this method is feasible, the evaluation results are reliable.

Portal crane is the main equipment of port loading and unloading operation. Crane's skeleton is a metal structure, bearing and transmission load role. The reliability of the metal structure determines the safe use of the crane, on the safety evaluation is necessary. There have been no major through the safety evaluation system for temporary failure of door crane safety assessment, to assist users to maintenance decision[1].

Portal crane safety evaluation index system

Selection of evaluation index whether appropriate, directly affect the evaluation results is good or bad. Each indicator should be from one aspect reflect some information of the door crane safety, therefore selecting indicators should be paid attention to the following principles:

1) operability

Comprehensive evaluation in a certain sense is with some indicators can be directly observed and measured to infer an observation and measurement of performance. Although some indicators is very appropriate, but couldn't get, is not feasible, lack of operability.

2) representative

Selection of indicators as far as possible to reflect the evaluation content, though not all, but should be able to represent a certain side. Evaluation deviation will emerge if may have a lead.

3) sensitivity

Should be less as far as possible the main indicators used in the actual evaluation work. But generally there are some minor in the evaluation index, it doesn't matter even indicators, this needs according to certain principles of index screening, to distinguish between primary and secondary, scientific and reasonable to incorporate more excellent evaluation index set.

The construction of index system

Using analytic Hierarchy Process (AHP) basic train of thought for a variety of structure technical state evaluation is very effective, AHP (Analytical Hierarchy Process, the AHP) is home by the operations research T.L.S atty [2] in the mid - 1970 - s, it is the first systematic analysis of the evaluation objects, The portal crane safety affects the working status of many factors a methodical, hierarchical, and thus established evaluation model of class time.

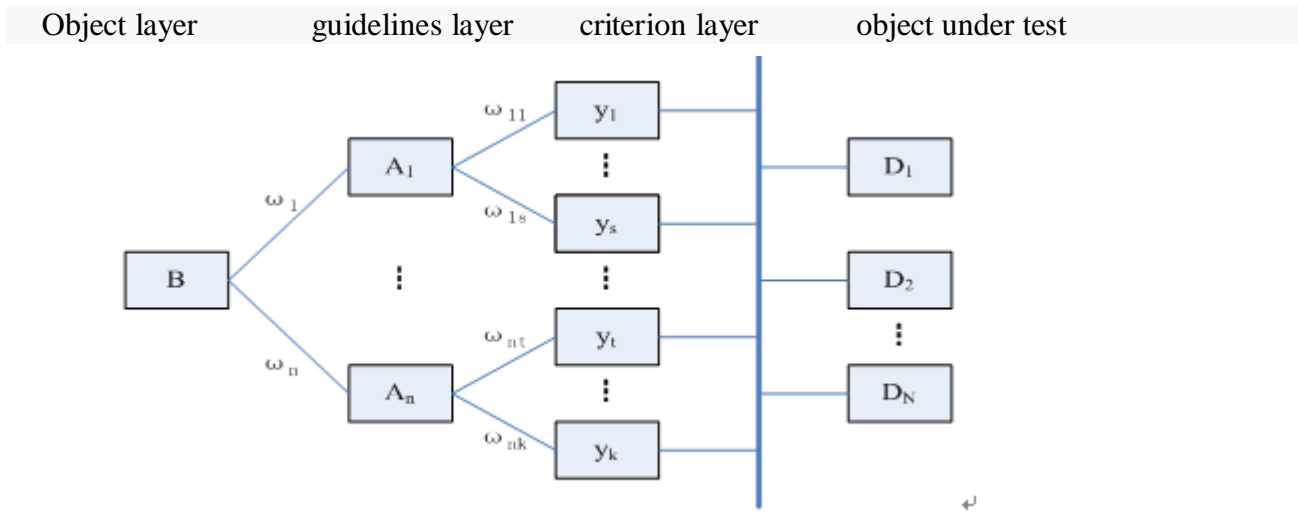


Figure 1 index system hierarchical structure

On the basis of the concept of hierarchical analysis, combined with the conditions of portal crane work state door crane safety evaluation index system of level classification result is shown in figure 2 [3]

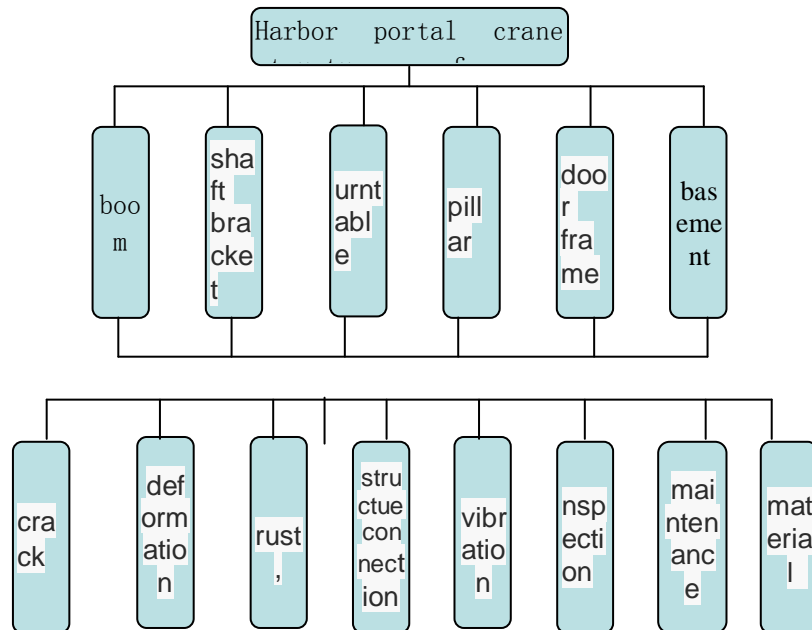


Figure 2 door crane evaluation index system of hierarchical structure

As P2 represents, the evaluation object of door-motor system is the whole metal system of it. The metal structure can be divided into the boom of the crane frame, shaft bracket, turntable, pillar, door frame, such as basic components. In the realistic use process, the possibility that all the metal structures is broken is little, usually with one or several components broken. Safety evaluation for the each part to crack, deformation, rust, structure connection, use of vibration, inspection, maintenance, and then the material performance of individual evaluation in the safety status of the structure to make comprehensive evaluation of the entire door machine system.

Index evaluation hierarchy

Valuation index score take out form, scope of [0100], and classification of each index for operation, which is divided into 5 levels, the most optimal for level 1, suboptimal for level 2, and so on, as shown in figure 3.

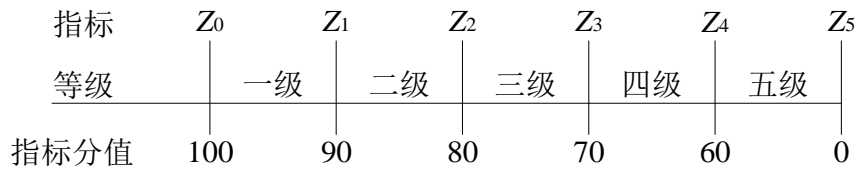


Figure 3 contrast figure index grades and scores

Specific indicators at all levels of hierarchy as shown in table 1.

Table 3.1 table of index system of hierarchy

Structure of the crane	The index type	等级划分				
		1	2	3	4	5
Project Frame Shaft bracket Turntable Volume Doorframe basement	cracks	Excellent	good	moderately	danger	danger
	deformation				Meet	does not meet
	rusting	No	slight corrosion	rust corrosion	Medium corrosion	serious corrosion
	The Structure connectivity		good	Poor	Very poor	
	vibration			Normal	abnormalities	severe abnormalities
	Testing	Intact	mild flaws	moderately	severe defect	extremely serious flaws
	The usage of maintenance	Good	Medium good	poor	Very poor	
	material property			Meet	Does not meet	

Comprehensive evaluation

The confirmation of index weight

The evaluation system of crane structure is a complicated system of multitarget, many indicators relative to the importance of target layer is different. There are many effective methods, to determine the weighing values of the comparative analytic hierarchy process as the weight calculation method in this paper.

Analytic hierarchy process(AHP) is a kind of multi-level weight analysis method of attribution weight for low index relative to a higher level index to determine the relative merits of order scheduling problems, and provides a set of methods used to determine the weights of attributes of objects.

Analytic hierarchy process is divided to several steps: 1 Establish hierarchical structure model 2 Construct judgment matrix 3 Hierarchical single sorting and consistency check

To construct judgment matrix is the basis of AHP, The value of the element reflects the relative importance of each factors .In order to form a judgement matrix, usually by comparing two elements, using 1-9 scaling method and its inverse. level 1,3,5,7,9 scale factor A_i and A_j are equally important ,somewhat important ,important, strongly important, extremely important; 2,4,6,8 represents the medial value of 1-3,3-5,5-7,7-9; A_i compares A_j is A_{ij} , the opposite is A_{ji} , $A_{ji}=1/A_{ij}$. A_{ij} is the element of judging matrix A ,the value is gotten by experts' investigation after evaluation. Matrix A is:

$$A = \begin{bmatrix} a_{11} & a_{12} & \dots & a_{1n} \\ a_{21} & a_{22} & \dots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{n1} & a_{n2} & \dots & a_{nn} \end{bmatrix} \quad (1)$$

According to the judgment matrix $A = (a_{ij})_{n \times n}$, we can make further calculation of the relative weight of each evaluation index. Calculation methods have volume method and the characteristic root method. when taking characteristic root method, the process of calculating the relative weight is:

(1) Calculate the matrix's each line's product m_i

$$m_i = \prod_{j=1}^n a_{ij}, \quad (i, j = 1, 2, \dots, n) \quad (2)$$

(2) Calculate m_i the N-root of \bar{w}_i

$$\bar{w}_i = \sqrt[n]{m_i}, \quad (i = 1, 2, \dots, n) \quad (3)$$

(3) for vector quantity $\bar{W} = (\bar{w}_1, \bar{w}_2, \dots, \bar{w}_n)^T$ Make the normalized processing:

$$w_i = \frac{\bar{w}_i}{\sum_{i=1}^n \bar{w}_i}, \quad (i = 1, 2, \dots, n) \quad (4)$$

$W = \langle w_1, w_2, w_3, \dots, w_n \rangle^T$ is the result of weight matrix.

According to the above method, the expert investigate ,construct judge matrix ,then calculate the weight of each expert ,then choose the annual value, get the weight value, Finally confirming at Excel 3.

Table 3 evaluation index weight

Evaluation index	structure connection	deformation	corrosion	structure connection	vibration	testing	maintenance usage	maintenance usage
weight	0.2444	0.1952	0.0755	0.1214	0.0899	0.1558	0.0545	0.0634

Table 4 door for safety evaluation of crane metal structure weight

project	frame	Shaft bracket	turntable	volume	doorframe	basement
weight	0.3190	0.2000	0.1693	0.0899	0.1482	0.0736

Comprehensive evaluation

Application value function method, by constructing the value or utility function U , calculation U of each single evaluation index value, a weighted sum, get a total value. Use the type calculating total value:

$$U = \sum \omega_i u_i \quad (5)$$

Type: ω_i — synthetic weight value of each single evaluation index;

u_i — each single index value.

Example for evaluation

Inevaluating team for a certain port door crane safety evaluation as an example.

(1) Get the value of the target

Evaluation process is to evaluate the team to evaluate the team to inspect the first detection of the actual condition of the crane, obtain evaluation index level value, and then set the parameter values'

(2) Comprehensive evaluation

Calculate the security level comprehensively by the index value and weight value

For example, We make evaluation and assessment for the metal structure system of the door crane's boom, Then we get the target value $u_i (i = 1, 2, \dots, 8)$, $u_i = (91, 76, 82, 96, 94, 82, 86, 96)^T$;

We get the evaluation target weight value : $\omega_i (i = 1, 2, \dots, 8)$, $\omega_i = (0.2444 \ 0.1952 \ 0.0755 \ 0.1214 \ 0.0899 \ 0.1558 \ 0.0545 \ 0.0634)$;

The total evaluation value $U = \sum \omega_i u_i = 86.92$

The security number of this system is 86.92, the security level is well, but we see from the evaluation condition of all targets, the value that influence the security of the body most is 76, which exists potential safety hazard.

We can obtain the other metal systems of the crane, Gradually, we can obtain the whole evaluation value of the door crane

Conclusion

According to the theory of analytic hierarchy process (ahp) to establish the door crane safety evaluation criteria and index system, and index quantitative method is given, the application of expert investigation and the analytic hierarchy process (ahp) to calculate index weight, the main structures of the crane safety evaluation, the comprehensive evaluation of the overall security of the portal crane. This evaluation system through the example, this method is feasible, and evaluation result is reliable.

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