Research on Security Evaluation System of Construction Machines and Tools of Transmission and Transformation Project based on AHP

PENG Fei; JIANG Ming; LIU Kai; Tang Guangrui

(China Electric Power Research Institute, Beijing 100055, China)

Key words: construction machines and tools; security evaluation system; analytic hierarchy

Abstract: Aiming at the categories of machines and tools of transmission and transformation project, the article established the security evaluation system of construction machines and tools of transmission and transformation project based on analytic hierarchy process from three categories, which respectively were machines and tools of iron tower assemblage scheme; machines and tools of transformation; machines and tools of transmission lines. The article determines the index weight vector based on analytic hierarchy process, which makes the quantitative analysis of safety of construction machines and tools, to classify and compare the safety, and find out the lowest security tools, then put forward the corresponding management measures, which will strengthen the safety management on construction machines and tools transmission and transformation project, raise the level of management on engineering safety.

Introductions

At present, State Grid Corporation of China is launching UHV project construction, in the process of construction, facing many problems: great workload and difficulty in construction, and too many special construction tools. State Grid Corporation of China puts forward a higher requirement on safety of project construction, the safety and reliability of construction tools play an important role in the quality of engineering and safety of construction, in case of serious safety accident, it will cause huge negative impact on the company. During the transmission line constructions, security risk mainly display in:

(1)Holding poles, pullers, tensioners, aluminium alloy grip clamps, stringing blocks, powered winch of overhead transmission lines are special equipment, but there are only a few professional testing institutions.

(2)Construction tools did not finish the type test, the factory inspection and the annual inspection according to the requirements of relevant regulations, construction organization's management is not in place, lead to a certain number of unqualified construction tools in engineering.

(3)There are dozens types of construction tools used in the transmission line engineering, each type of tool's number ranging from hundreds to several thousands, old and new tools are used at the same time. But the construction site does not have the condition to test each construction tool, a certain number of tools are put into use directly without test.

(4)For a large number of tools are used in the engineering , there are not any security evaluation methods of construction tools.

Therefore, we must research the security evaluation system of construction machines and tools of transmission and transformation project, carry out some works to ensure the safety and quality of construction.

The establishment of evaluation index system

The purpose of research about security evaluation system of construction machines and tools of transmission and transformation project is to reflect the level of safety management and the point of safety hazards, to reflect the key factors affect the safety, for the high risk factors, we will strengthen the management. Due to dozens types of construction tools, and the reliability of construction tools are also different, therefore, we need to classify the safety level of nearly hundred kinds of construction tools.

In order to accurately classify the safety level of construction tools, we ask for advice from electricity transmission and transformation facilities, each facility arranges 3~5 construction technical experts to fill out survey of construction machines and tools, We received 329 effective investigation tables. In this paper, we determine the index weight vector based on analytic hierarchy process, to analyze the category of construction machines and tools of transmission and transformation project: equipment of build tower, transportation equipment, and equipment of overhead transmission lines, to set up the evaluation system according to the score from experts

Table 1 Evaluation system of construction machines and tools

	The secondary indicators	The secondary weights	The third indicators	The third weights
Construction machines and tools of transmission and transformation project	Equipment of build tower	0.6370	Holding pole	0.4633
			Powered winch	0.0325
			Hoist	0.1424
			Hoist tackle	0.0783
			Hoist rope	0.2623
			Shackle	0.0213
	transportation equipment	0.1047	Ropeway	0.7997
			Crawler transporter	0.1417
			Electric forklift	0.0586
	equipment of overhead transmission lines	0.2583	Puller	0.0377
			Tensioner	0.0604
			Stringing block	0.0250
			Anti-bending swivel joint	0.1385
			Net connector	0.2602
			Grip clamp	0.4782

The analysis of evaluation index system

There are dozens types of construction tools used in the transmission line engineering, each type of tool's number ranging from hundreds to several thousands, according to the categories of construction machines, which can be divided into: Equipment of build tower, transportation equipment and equipment of overhead transmission lines, they are defined as the secondary

indicators. Equipment of build tower mainly include: Holding pole, Powered winch, Hoist, Hoist tackle, Hoist rope and Shackle; Transportation equipment mainly include: Ropeway, Crawler transporter and Electric forklift; Equipment of overhead transmission lines mainly include: Puller, Tensioner, Stringing block, Anti-bending swivel joint, Net connector and Grip clamp, they are defined as the third indicators, as shown in table 1.

(1)According to hierarchy evaluation system, construct two comparative judgment matrix.

There are 6 indexed of Security Evaluation System of Construction Machines and Tools of Transmission and Transformation for the most: A1, A2, ⋯,A6, according to the principle of AHP, we can construct judgment matrix A between the two factors using the ratio of scale 1 ~11.

$$A=\begin{bmatrix} a_{11} & a_{12} & \cdots & a_{16} \\ a_{21} & a_{22} & \cdots & a_{26} \\ \vdots & \vdots & \vdots & \vdots \\ a_{61} & a_{62} & \cdots & a_{66} \end{bmatrix}$$

The value principle in the judgment matrix A is : in the ratio of scale 1~ 11, we decide the value by comparing the importance of two machines, among them, $a_{ii}=1$， $a_{ji}=1/a_{ij}$, take the secondary indicators for example, Its importance from highest to lowest: Equipment of build tower, transportation equipment, equipment of overhead transmission lines, we can construct the judgment matrix A_1:

$$A_1=\begin{bmatrix} 1 & 5 & 3 \\ 1/5 & 1 & 1/3 \\ 1/3 & 3 & 1 \end{bmatrix}$$

Then, according to the same principle, the judgment matrix B_1 of Equipment of build tower is:

$$B_1=\begin{bmatrix} 1 & 9 & 5 & 7 & 3 & 11 \\ 1/9 & 1 & 1/7 & 1/5 & 1/9 & 3 \\ 1/5 & 7 & 1 & 3 & 1/3 & 7 \\ 1/7 & 5 & 1/3 & 1 & 1/5 & 5 \\ 1/3 & 9 & 3 & 5 & 1 & 9 \\ 1/11 & 1/3 & 1/7 & 1/5 & 1/9 & 1 \end{bmatrix}$$

The judgment matrix B_2 of Equipment of build tower is:

$$B_2=\begin{bmatrix} 1 & 7 & 11 \\ 1/7 & 1 & 3 \\ 1/11 & 1/3 & 1 \end{bmatrix}$$

The judgment matrix B_3 of Equipment of build tower is:

$$B_3=\begin{bmatrix} 1 & 1 & 2 & 1/3 & 1/5 & 1/9 \\ 1 & 1 & 2 & 1/3 & 1/5 & 1/9 \\ 1/2 & 1/2 & 1 & 1/3 & 1/5 & 1/7 \\ 3 & 3 & 3 & 1 & 1/3 & 1/5 \\ 5 & 5 & 5 & 3 & 1 & 1/3 \\ 9 & 9 & 7 & 5 & 3 & 1 \end{bmatrix}$$

(2)According to the judgment matrix, and then take the consistency test.

The result of various judgment matrix are solved with MATLAB, which is shown below.

A_1:r_{max}=3.0385，$W_0 = [0.9161 \quad 0.1506 \quad 0.3715]^T$，CI=0.0193，RI=0.58，CR=0.0332

The normalization processing for the characteristic vector of judgment matrix A was made:

$W_1 = [0.6370 \quad 0.1047 \quad 0.2583]^T$

B_1:r_{max}=6.5543，$W_0 = [0.8303 \quad 0.0582 \quad 0.2552 \quad 0.1403 \quad 0.4701 \quad 0.0381]^T$，

CI=0.1109，RI=1.24，CR=0.0894

B_2:r_{max}=3.0466，$W_0 = [0.9821 \quad 0.1740 \quad 0.0720]^T$，CI=0.0233，RI=0.58，CR=0.0402

The normalization processing for the characteristic vector of judgment matrix B was made:

$W_2 = [0.7997 \quad 0.1417 \quad 0.0586]^T$

B_3:r_{max}=6.2497，$W_0 = [0.066 \quad 0.1065 \quad 0.0441 \quad 0.2444 \quad 0.4591 \quad 0.8437]^T$，

CI=0.0499，RI=1.24，CR=0.0403

The normalization processing for the characteristic vector of judgment matrix B was made:

$W_3 = [0.0377 \quad 0.0604 \quad 0.0250 \quad 0.1385 \quad 0.2602 \quad 0.4782]^T$

RI is the random consistency of standard value, we determine the value according the dimensions of the judgment matrix, as shown in table.2.

Table 2 Parameter RI

n	1	2	3	4	5	6	7	8	9
RI	0	0	0.58	0.96	1.12	1.24	1.32	1.41	1.45

(3) Judgment consistency according to the value of CR.

According to the results of judgment matrix，the value of CR is 0.0332、0.0894、0.0402 and 0.0403 respectively, the extent of inconsistency of judgment matrix are allowable, because all CR's values are <0.1, Its eigenvector can be used as weight vector, as an evaluation criterion of Security Evaluation System of Construction Machines and Tools of Transmission and Transformation Project, the weight vector's value are shown in table 1.

Conclusions

We can sort the security of different indicators by the allocation of weight vector, and then find out the weakest factor, put forward the counter-measures to strengthen the safety management. According to the results in table 1, for the secondary indicators, transportation equipment > equipment of overhead transmission lines> equipment of build tower, the lowest safety of transportation equipment is ropeway, the lowest safety of equipment of overhead transmission lines is grip clamp, the lowest safety of equipment of build tower is holding pole, therefore, we should "distinguishing and then focused management", put forward management measures to strengthening the safety management in Construction Machines and Tools of Transmission and Transformation Project.

References

[1]LU Yuliang.Application of Analytic Hierarchy Process toTarget Computer Secure Quantitative Fusion [J]. Computer Engineering,2003,29(22):141-114

[2] Thomas S Ng, Kam Pong Cheng, Martin R Skitmoveb. A framework for evaluating the safety performance of construction contractors [J].Building and Environment,2005,40：1347-1355