

# Study on typical failure of concrete poles in large scale rural network reconstruction

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**Abstract.** Quality defects caused by raw materials, auxiliary electric power fittings and site weldings were revealed in technical supervision of rural network reconstruction. Corresponding countermeasures were proposed based on analysis of various factors, such as weight of prestressing tendon, strength, microstructure inclusion of holt hoop iron.

## 1. Introduction

With the implementation of the thirteenth five-year plan and rapid development of economy, the existing rural distribution network has already been overwhelmed. In order to constructing a strong rural network which keeping balanced development with backbone network, a huge amount of effort were put into the upgrading and reconstruction of rural network[1,4]. By reason of the strong demand and low entrance threshold of concrete pole, the production is also continuing to expand. However, imperfect process management and quality supervision led to uncertain service performance. Therefore, severe casual inspection aimed at electric power fittings including macroscopic and physical examination is indispensable[5,6].

In this paper, early failure cases and specific defects of construction supervision were studied and classified. Corresponding countermeasures were also proposed, hoping to provide experience and guidance to manufacturers and using units.

## 2. Experimental section

All the failed concrete pole samples were collected from rural network transmission lines in service. The weight of samples were weighed on a Mettler Toledo XS603-S laboratory balance. The tensile property test were conducted on a electronic universal testing machine (Suns). The morphologies and structures of the samples were analyzed by metallurgical microscopy (Zeiss microscope) and field emission scanning electron microscope (FE-SEM). FESEM characterization and inclusion composition characterization was performed on a JSM-7600F.

## 3. RESULTS AND DISCUSSION

### 3.1 Prestressing tendon

Two concrete poles of some rural distribution network once failed in 2010. According to design document, the type of cracked concrete pole was Y190×12000 which comprised of 18 twelve meters long prestressing tendons with 33.081 kilograms total weight. The weight test results of failed sample



revealed that sample No.1 weighed 143.5 grams for each meter, and sample No.2 weighed 142.4 grams for each meter. Subsequent calculations showed that the actual total weight of sample No.1 and sample No.2 were 30.996 kilograms and 30.7584 kilograms, respectively. Both of the total weight were less than 94 percents of design values.

Further tensile property experiment results were displayed in Table 1. The maximum tensile strength of prestressing tendons was 1277 MPa which is below the provided value (1370 MPa) provided by manufacturer. And the maximum yield strength and yield ratio of cracked sample was 555 MPa and 0.44, respectively, which is far below the requirements of standard GB/T 5223-2002 (1250 MPa, 0.80). In addition, the tensile strength of steel wire was divided into five grade including 1470 MPa, 1570 MPa, 1670 MPa, 1770 MPa and 1860 MPa. However, the provided value matches up none of the above five grades.

Table 1. Tensile properties of prestressing tendon.

Sample No.	Cross-sectional diameter/mm	Yield strength/MPa	Tensile strength/MPa	Elongation/%
A1	5	539	1277	5.9
A2	5	550	1266	5.1
A3	5	552	1274	4.8
B1	5	555	1269	6.3
B2	5	554	1252	4.8
B3	5	489	1257	5.5
Standard requirement	5	1250(The lowest level )	1370(Provided by supplier)	3.0

### 3.2 Auxiliary electric power fittings

Some non-standard auxiliary electric power fittings once failed during upgrading process of rural power grid, which is shown in Figure 1.



Figure 1. Scene photograph of cracked hoop.

The hoop was composed of Q235B steel. The cracked position was located on elbow near the bolt hole. The fracture morphology was displayed in Figure 2. As it is shown that the fracture exhibited a smooth flat with stratification existing in the core. Only center line and its vicinity were corroded which is easily visible.



Figure 2. Fracture appearance of hoop.

The metallographic observation result indicated that the matrix structure of hoop were composed of ferrite, pearlite and bulky ribbon inclusions. The metallograph was shown in Figure 3.

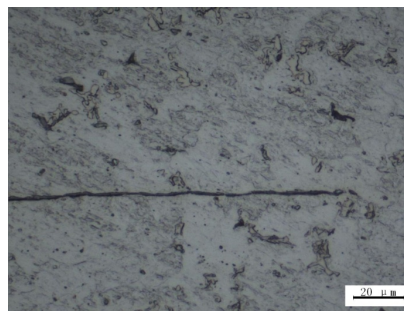


Figure 3. Metallographic structure of hoop.

The composition of inclusion was further analyzed by FE-SEM and energy dispersive spectrum (EDS) as was shown in Figure 4. It turned out the ribbon inclusions were mainly silicate compounds.

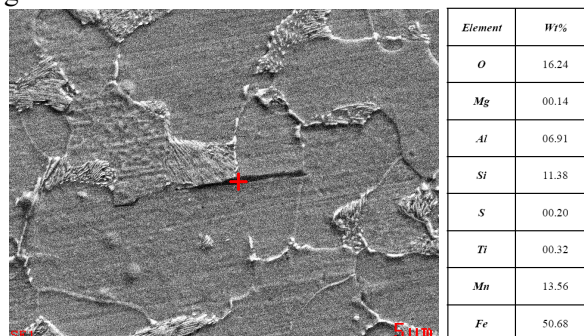


Figure 4. FE-SEM picture and EDS result of inclusion.

The ribbon silicate compounds not only destroyed the continuity of Q235B steel matrix, but also led to mechanical performance deterioration especially plasticity, tenacity and fatigue limit. During the manufacturing process of hoop, the microstructure of lateral corner were elongation deformed along the direction of cold bending after the cold bending treatment. Meantime, the microstructure of inside corner endured extrusion deformation resulting in the work hardening to some extent. On this condition, the steel plate were in the state of mechanical property deterioration of reverse bending. The hoop cracked during field bending test. Normally the hoop was tightened by bolts during installation process leading to the state of reverse bended. Hence, in the presence of inhomogeneous microstructures and silicate inclusions, the hoop would crack in the course of service.

### 3.3 Steel ring welding

Once cracks occurred on the steel ring of concrete poles for 35 kV transmission line in 2011. The steel weld of Concrete Pole No. 23 completely disconnected from each other. However, the cracks extended covering half of the steel weld of Concrete Pole No. 25. Further inspection indicated that the width of weld crack was 3 mm which coexisting with flaws on the weld surface, such as incompletely filled weld, overlap and undercut. As is displayed in Fig.5.

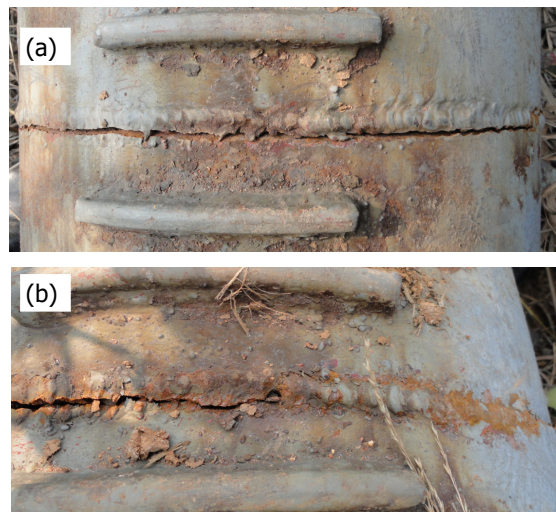


Figure 5. (a) Low magnification macrophotographie of weld crack, (b) High magnification macrophotograph e of weld crack.

In the view of weld fracture, root edge of V-groove which occupying one half of the whole welding possessed flat truncated edge. The upper weld was comparatively thin, as is shown in Figure 6. The obvious incomplete root penetration was directly caused by improper procedure during welding process.



Figure 6. (a) Side view of upper weld crack, (b) Top view of upper weld crack.

According to the GB50233-2005 standard, the width of concrete pole steel weld should be 13.1 to 15.1 mm regarding to dimensional requirement of weld bead. Further surface and dimension inspection indicated that both the two weld with of Concrete Pole No. 23 and Concrete Pole No. 25 were less than 12.75 mm which does not meet the standard requirements.

#### 4.CONCLUSIONS

In consideration of above discussions, the hidden dangers in the concrete pole of rural network including prestress tendon, auxiliary electric power fittings and site welding should be paid attention to. A series of measures are also imperative.

a) We should carry out regular sampling inspection for manufacturers during production process especially concerning in the quality and weight of prestress tendon and steel ring. In this way, illegal behaviour could be eliminated to some extent, such as cutting quality corners and shoddy product.

b) More attention should be paid to the quality supervision of auxiliary electric power fittings. Overall service stability are closely associated with hoop and bracing wire of concrete pole.

c) Quality supervision of infrastructure construction is also of great importance. Installation quality problem could be avoid by strengthening the management of site welding.

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