MATEC Web of Conferences **382**, 01031 (2023)
AMME 2023
https://doi.org/10.1051/matecconf/202338201031

Experimental study on bearing capacity of corroded angle steel members of in-service transmission towers

Binrong Zhu [1,*], Yao Huang [1], Zheng Li [1], Bin Chen [2] and Hailin Liao [2]

[1] China electric power research institute, Beijing 100055, China
[2] Zhejiang Electric Power Co., Ltd. Shaoxing Power Supply Company, Shaoxing 312099, China

Abstract. The tower is the load-bearing structure of the overhead transmission line. Due to the complex operating environment and other factors, the transmission tower is prone to corrosion, which weakens the bearing capacity of the tower and affects the safe operation of the power grid. Through the investigation of the corrosion situation of the transmission towers in service, the angle steel members were removed from the in-service transmission towers, and the axial compression bearing capacity test was carried out. As the corrosion rate increases, the bearing capacity of components shows a decreasing trend, and due to the existence of corrosion, and at the same corrosion rate, due to the location of corrosion , The corrosion depth and corrosion area are different, and the axial compression bearing capacity of the components fluctuates greatly.

1. Introduction

The tower is the load-bearing structure of the overhead transmission line, and its reliable operation is crucial to the safety of the power system. Under the influence of multiple factors such as the complex operating environment of the transmission tower in service, its components are prone to corrosion, and the corrosion of the components will lead to the weakening of the bearing capacity of the tower structural components [1, 2], which will further affect the force safety of the entire structure, thereby affect the safe operation of the power grid.

2. Corrosion of transmission towers

According to the corrosion status of transmission towers, it can be divided into local corrosion and uniform corrosion[3]. Local corroded iron towers have galvanized layers on the surface of most components, and some local areas or individual components are corroded, as shown in Figure 1. Local corrosion of transmission towers mostly occurs in areas with weak anti-corrosion capabilities such as tower feet, tower connections, and areas where the tower has galvanized leakage or scars. Uniform corrosion mainly occurs in coastal areas with high salt spray concentration or industrial areas with severe acid rain. The galvanized layer of the transmission tower with uniform corrosion of the entire tower is completely corroded, and the base steel has been corroded, as shown in Figure 2, where the line is Chongqing The 220kV Tiancha Line[4] has been in operation for 48 years.

Figure 1. Local corrosion

Figure 2. Uniform corrosion.

* Corresponding author: amzhubr@163.com

https://doi.org/10.1051/matecconf/202338201031

3. Axial compression bearing capacity test

3.1 Test plan

Select the corrod angle steel members of the in-service transmission tower, there are four specifications:L75×8, L63×6, L50×5, L40×4. Each specification is divided into four categories according to the degree of corrosion: A, B, C and D. Category A is almost no corrosion; Category B is mildly corroded; Category C is more severely corroded; Category D is severely corroded. Three specimens of each specification and each degree of corrosion were taken for the axial compression bearing capacity test. The size and quantity of the specimens are shown in Table 1.

Table 1. Dimensions of test members.

Component size	Length (mm)	Degree of corrosion
L75×8	1500	A、B、C、D
L63×6	1300	A、B、C、D
L50×5	1200	A、B、C、D
L40×4	900	A、B、C、D

Before carrying out the axial bearing capacity test, it is necessary to measure the corrosion degree of the section of the member. Since all the axial compression members have little corrosion on the limb width edge, the edge corrosion (corrosion in the limb width direction) is ignored, and only the limb thickness direction is measured with a metal ultrasonic thickness gauge [5,6].

The axial compression test uses a hydraulic press to apply pressure, as shown in Figure 3. A dial indicator is used to measure the bending degree of the measuring member, and a plumb bob and a ruler are used to measure the axial displacement. The experimental process adopts one-time loading, preloading the component before the test, and then increasing the load step by step (by 25%, 50%, 70%, 100%, and then by 5%) until the component fails to bend, and can no longer be loaded.

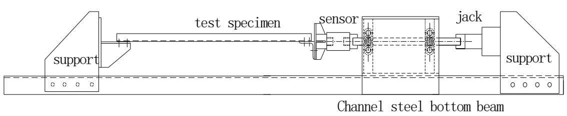


Figure 3. Test device

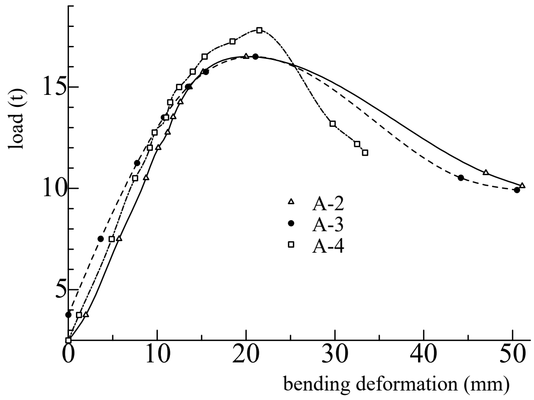
3.2 Test phenomenon

It can be seen from the test results that the corroded angle steel members basically suffer from bending failure, mainly bending in the direction of the middle minimum axis, as shown in Figure 4.

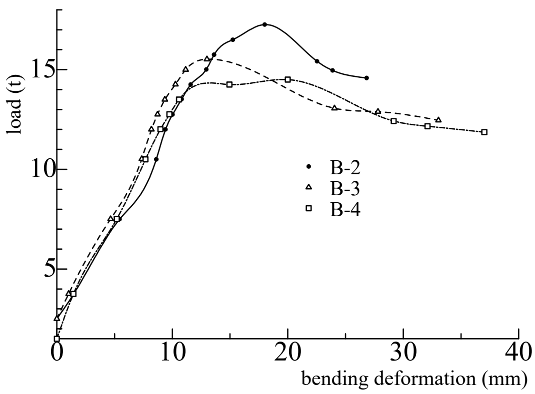
Figure 4. Axial compression member failure mode

3.3 Test data

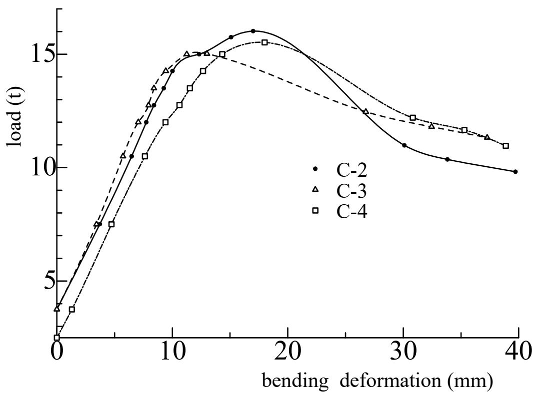
Through the axial compression bearing capacity test of angle steel with different degrees of corrosion, the load-deflection curve of the corroded angle steel specimen is obtained, as shown in Figure 5-Figure 7. It can be seen from the figure that the load-deflection curve of the component is basically similar to that of the uncorroded component, and it can be divided into an ascending section, a strengthening section and a descending section.



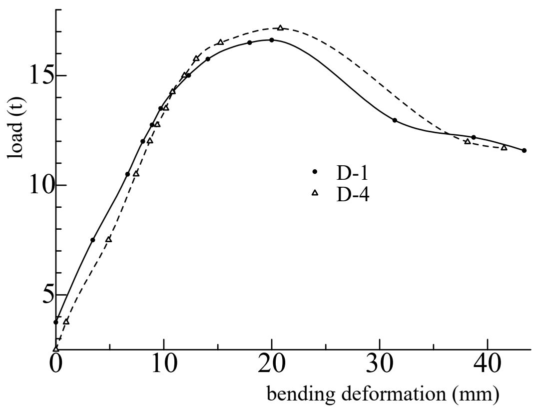
(a) Corrosion degree A



(b) Corrosion degree

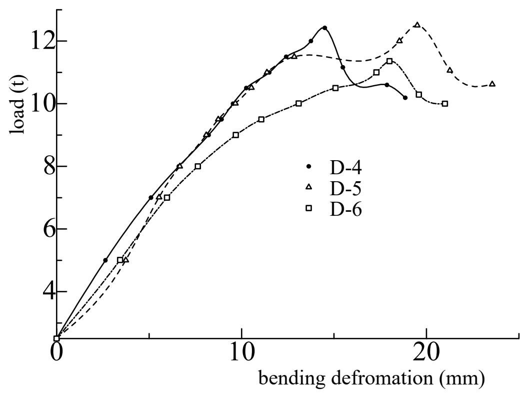


(c) Corrosion degree C



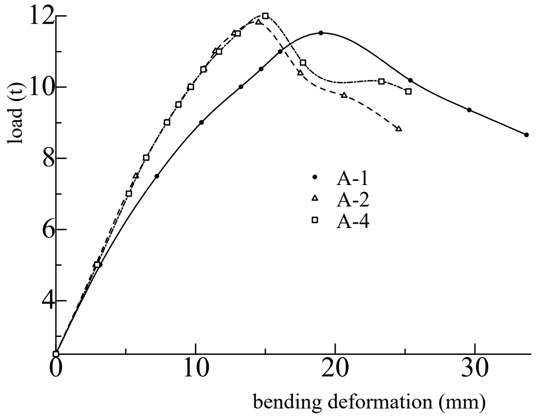
(d) Corrosion degree D

Fig.5 Load bending deformation diagram of L75×8 member

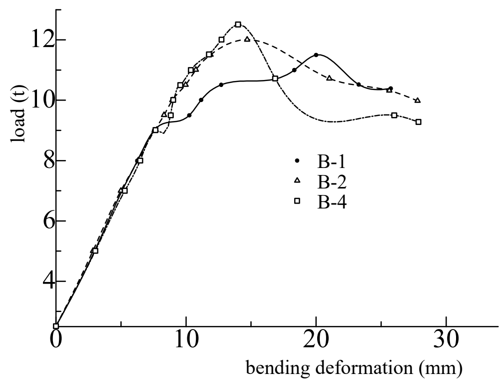


(d) Corrosion degree D

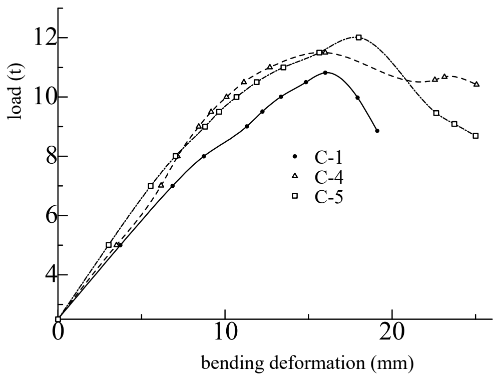
Fig.6 Load bending deformation diagram of L63×6 member



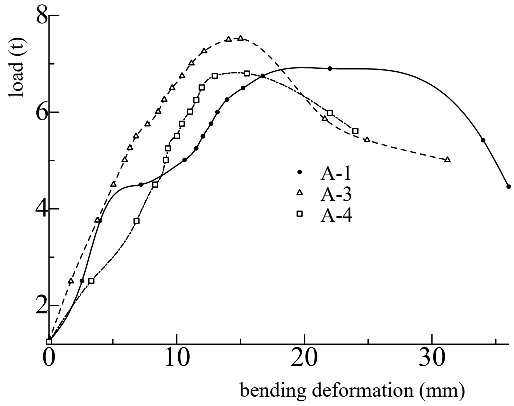
(a) Corrosion degree A



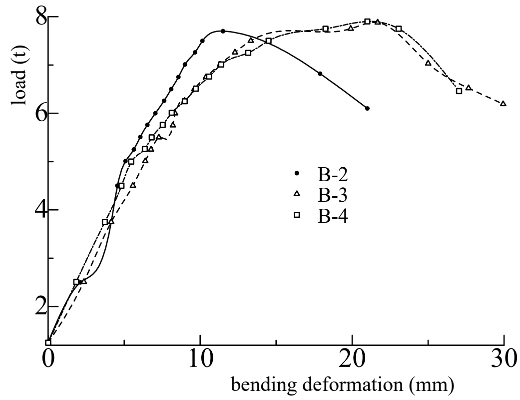
(b) Corrosion degree



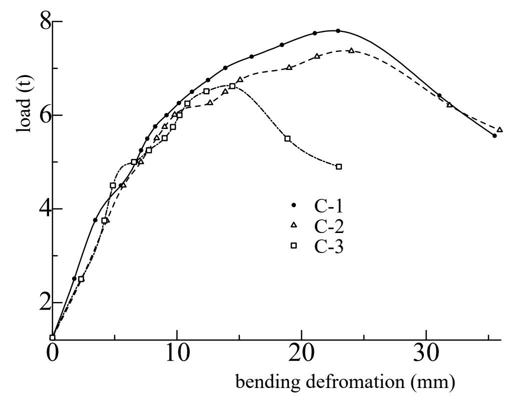
(c) Corrosion degree C



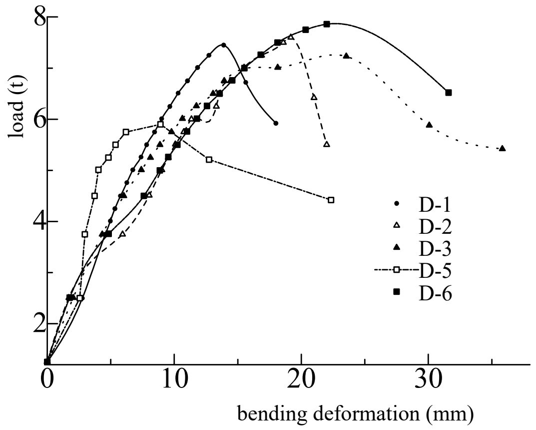
(a) Corrosion degree A



(b) Corrosion degree



(c) Corrosion degree C



(d) Corrosion degree D

Fig.7 Load bending deformation diagram of L50×5 member

The bearing capacity drop percentage is defined as the ratio of the bearing capacity of the corroded angle steel member in the axial compression test to the full-section bearing capacity, and the relationship with the corrosion rate is drawn as shown in Figure 8. It can be seen that with the increase of the corrosion rate, the bearing capacity of the components shows a decreasing trend, and under the same corrosion rate, due to the differences in the corrosion position, corrosion depth and corrosion area, the axial compression bearing capacity of the components fluctuates greatly.

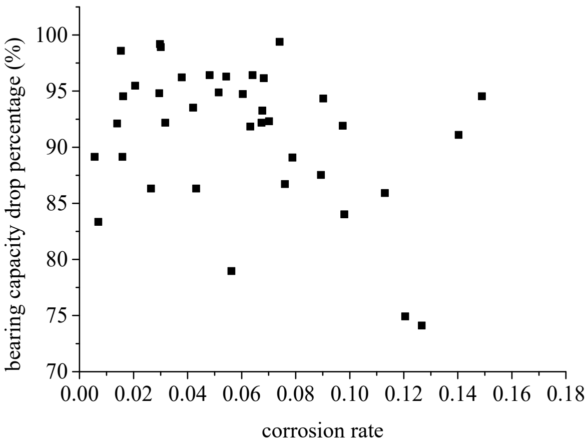


Fig.8 the ralationship between bearing capacity drop percentage and corrosion rate

4. Conclusion

The investigation of the current situation of corroded steel towers on transmission lines found that local corrosion of transmission towers mostly occurs in areas with weak anti-corrosion capabilities, such as the tower foot, the connection of tower parts, and the places where the tower has galvanized leakage or scars. The corroded components on the in-service transmission towers were sampled and the axial compression bearing capacity test was carried out. The results showed that with the increase of the corrosion rate, the bearing capacity of the components showed a decreasing trend. And under the same rust rate, due to the difference of rust position, rust depth and rust area, the fluctuation of the bearing capacity of the component's axial compression is large.

Acknowledgments

This work was financially supported by the State Grid Corporation of China. The project name is Research on edge intelligent perception and evaluation technology of health state of transmission tower structure. The project number is 5600-202019160A-0-0-00.

References

1. Shi Xianda, Chen Hao, Qiao Xin, etc. Analysis on corrosion of angle steel used for 500kV transmission tower[J]. Inner Mongolia petrochemical industry , 2021, 47(12): 38-41
2. Tan Jiancong, Long Zijun, Chen Jianping. etc. Analysis on corrosion of transmission tower and related factors in Guangdong coastal area. Mechanical & Electrical engineering technology, 2014, 43(11): 116-119.
3. Chen Yun, Yao Ningna, Xu Limin. etc. Discussion on rusting grade classification of transmission line steel tower. North China electric power, 2015, 4: 30-34.
4. Chang Hang. Corrosion and anti-corrosion research of transmission towers in Chongqing area[D]. Chongqing University, 2002.
5. Liu Ziyuan. Compressive bearing capacity of corroded single-angle connected with one leg[D]. China university of mining and technology, 2016.
6. Gao Chao, Liu Jianjun, Zheng Yichuan etc. Effects of corrosion on mechanical properties of transmission tower angle steel[J]. Corrosion & protection, 2020, 41(8): 32-38.