ANTENNA MAST COLLAPSE ANALYSIS

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A b s t r a c t: In long-term usage of the steel antenna, masts corrosive processes occur that are especially manifested at the welded joins and joins with bolts. Combined with the irregular renewal of the anticorrosive protection these processes may become a dominant cause for disaster, especially at the sections where critical tensions stresses occur. These constructions are exposed to wind forces that are by their nature variable in intensity and frequency. In this paper is given an analysis of the causes for disaster of an antenna mast.

Key words: antenna mast; corrosion; welded joints; tension stress.

1. INTRODUCTION

Antenna masts and towers are often manufactured in the form of steel constructions in various shapes. One of the most common form of antenna mast is tubular. Tubes with different or same diameters are joined together via welding and combination of joint flanges with bolts in the form of segments. At certain heights of the mast, antennae are mounted for receiving and transmitting of signals. Antenna masts are found at various locations and terrains on altitudes often higher than 800 meters. At such locations dominant are significant loads by wind. Occasionally, because of longer period of usage, irregular maintenance of anticorrosive protection, defects happen that are combination of the corrosion of the welded joints and material fatigue. These defects in some cases can cause minor or severe disaster of the supporting structure of the mast.

2. TECHNICAL DESCRIPTION OF THE MAST

In this paper was done an analysis of the causes of a disaster of antenna mast, manufactured with construction tubes using welding and bolts. The outline of the antenna mast is on Figure 1.

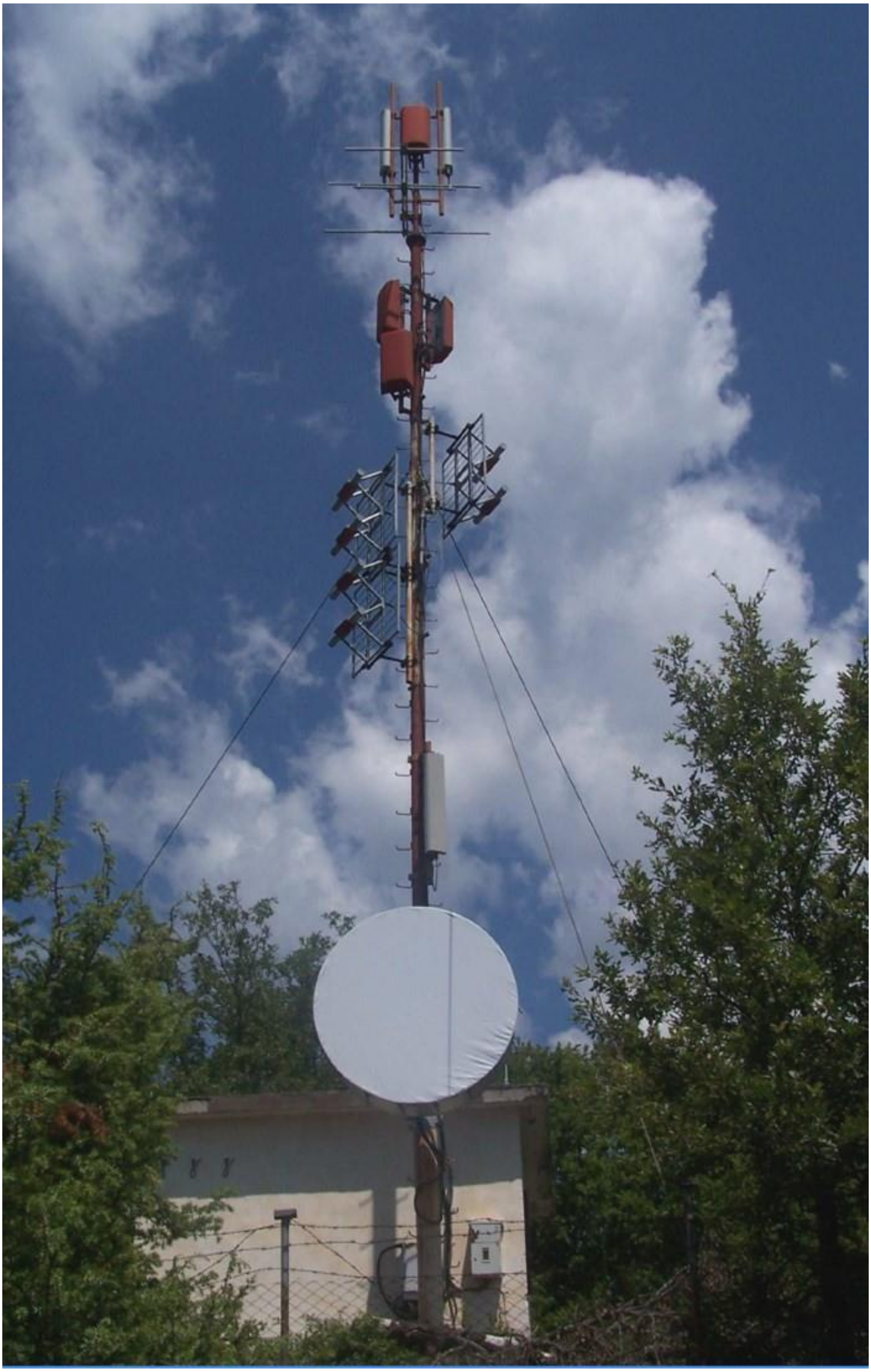

Fig. 1. Outline of the antenna mast before the disaster

The total height of the mast is 19.5 m. The mast is composed of four segments with diameters: Ø273, Ø168, Ø168, Ø88.9 mm, and heights of 4.5, 6.0, 6.0 and 3.0 meters respectively. The mast is additionally fastened with three guys. The point of fastening of the guys is at height of 12.5 meters.

On Figure 2 is shown the joint between the first and the second segment of the mast. The first segment of the mast is a tube with diameter of Ø273 mm and wall thickness of 5.0 mm. The second segment is a tube with diameter of Ø168.3 mm and thickness of the wall of 4.0 mm. The first and second segments of the mast are connected with flanges having diameter of Ø403 mm and wall thickness of 10 mm. The joint between the first and second segment is of dismantling type using 6 M16 bolts (Figure 2).

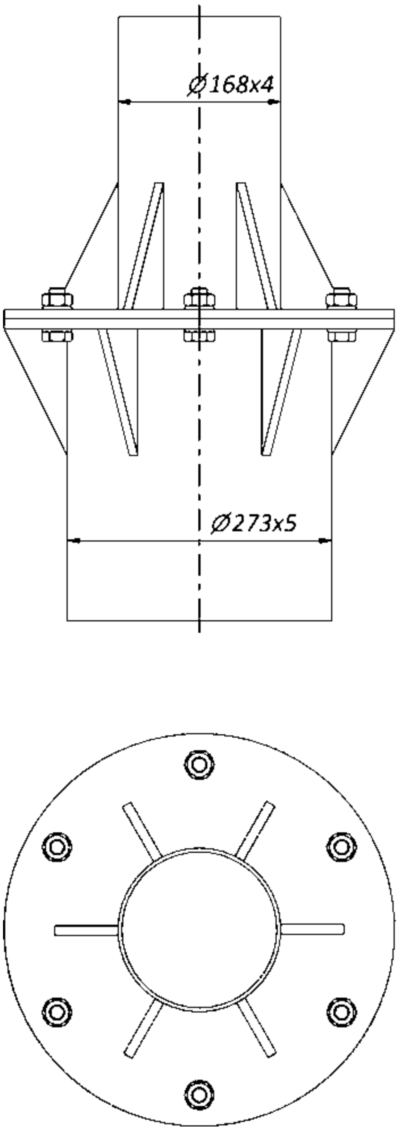

Fig. 2. The joint between the first and second segment

3. ANALYSIS OF THE LOADS

The loads on the mast are from the mounted antennae at different heights. For this mast a project was prepared for the real condition where structural analysis at various cases of loads was given [1]. In the structural analysis is shown that the dominant loads occur by the forces of wind over the antennas and the mast. In the analyzed combinations of loads at different sections stresses occur that are exceeding the permitted.

Fig. 3. Photo of the fallen mast segments

Figure 3 shows the state of the mast after the fall of the second, third and the fourth segment. The calculated bending moment at the cross-section where the break occurred in the worst case of load is M = 6.5 kNm [1].

Also, the wind loads have to be taken into consideration, that are with variable magnitude and dynamic knock effect. These conditions can easily lead to local tension overloads in the critical sections of the mast [3] and [4].

4. ANALYSIS OF THE CRITICAL SECTION

The critical section of the mast where the breaking happened, the welded joint was long time exposed to corrosion (Figure 4). The mast is in use since 1987, which is a time frame of 30 years.

The processes of corrosion in this case are the dominant causes of weakening of the cross section of the welded joint. On Figure 4 torn welded connections can be seen. That could not withstand the loads acting on the mast in the moment of the disaster. Likewise, at the breaking section evident are insufficient weld connections.

Fig. 4. The critical section at the welded joint

The transition of the mast between the segment number 1 to segment number 2 is made with big difference between the sections of the steel tubes (Figure 2). Namely, the first segment has diameter of Ø273 mm and wall thickness of 5.0 mm, while the second segment is a tube with diameter of Ø168.3 mm and wall thickness of 4.0 mm.

Usualy, the maintenance of these objects is irregular and often is avoided because of the difficult access to the location of the antenna mast. Anticorrosive protection is done relatively rare. Often practice is that the anticorrosive protection is only done with a simple application of the protecttion paint without thorough cleaning. Thus, the checks of the weld connections and bolt joints are missed.

To support these comments in the following text are given few examples of corrosion at other antenna masts (Figures 5 to 7).

On Figure 5 evident is mature phase of corrosion due to many years of not maintaining the anticorrosive protection. Corrosion in this case is especially dangerous at the welded joints.

Fig. 5. Corrosion of the connecting flange

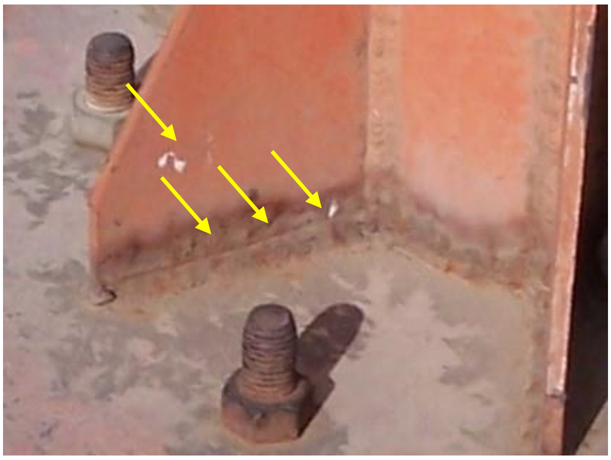

Fig. 6. Tensile stress crack caused by corrosion

Fig. 7. Tensile crack caused by corrosion

This condition in combination with the tension state shown on Figure 8 clearly points that development of the cracks in the welded joints started at the locations with the highest concentration of tensions stresses.

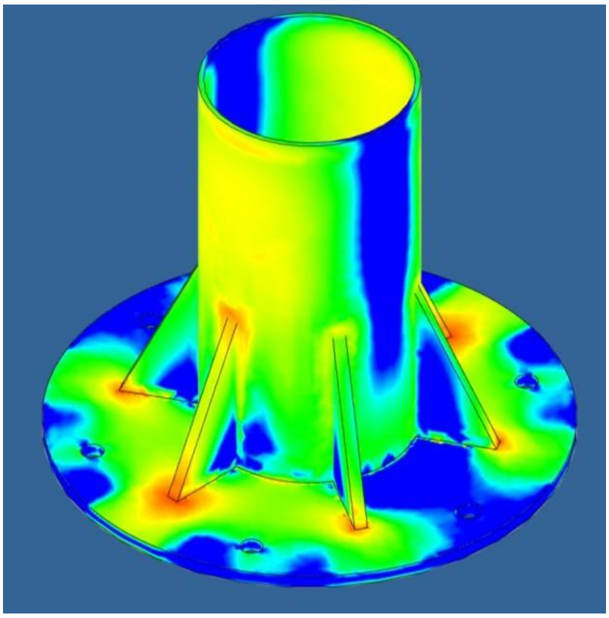

Fig. 8. Computer simulation of the tension stress state at the critical section of the mast

With these types of welded joints, it is clear to expect the development of welded fatigue cracks to occur in the zones of higher local concentration of tensions stresses [2] to [6].

5. CONCLUSIONS

Over the many years of usage of the steel structures for antenna masts, occasionally happen disasters of minor or severe type. In this case the analysis of the causes of the disaster of one antenna mast shows a mutual effect of more factors that in a given time period superposed and lead to the breaking of the mast in the critical section. One of the basic causes in this case is the corrosion effect in the welded connections of the joint between the steel tube, reinforcing ribs and the connection flange. The effect of corrosive weakening at the sections with the greatest concentration of tensions stresses lead to the critical decreasing of the loadable area of the section between the first and second segment of the mast.

As a basic conclusion from the above mentioned analysis the following can be summed up:

– The antenna masts are specific objects that often act in complex environments.

– Renewal and maintenance of the anticorrosive protection is often neglected or procrastinate to longer time intervals.

– The negative effects of the corrosion at the welded joints can cause disasters of the masts.

– In mountainous and rural environments the damage is often manifested in the material damage of the antenna systems and the antenna mast as a whole.

– In the urban environments these disasters, besides property damage can cause human losses.

To avoid these events, regular checks and maintenance of the antenna masts are mandatory by qualified teams.

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