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EXTENDED ABSTRACT

Stability analysis of Transmission Lines Under Simultaneous Ice-shedding and Wind loads

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Transmission line, Finite element analysis, Ice-shedding, Wind load, Stability analysis.

1. Introduction

In the present study, the effect of ice-shedding simultaneously at the transmission line's span and the wind was investigated using numerical modeling, and its results are presented. The transmission line has five transmission towers and six power transmission spans related to the 400 kV transmission line of the Khoy-Urmia power plant. The transmission tower's weaknesses have been identified using this study's results, which can be considered in strengthening existing towers and the design of new transmission lines.

2. Methodology

The numerical model using ABAQUS (Abaqus Manual) software and the wind load has been simulated using numerical methods, and in order to determine the critical wind speed for the transmission line, developmental analysis with stepwise increase of wind speed has been used.

3. Results and discussion

In this section, the results of the analysis are presented. The wind enters perpendicular to the transmission line, and the wind direction is not considered. The power transmission line failure has been investigated in the towers. According to the speed of 20 meters per second considered by the transmission line design regulations in the designed area, the transmission line analysis for this speed and speed less and more has been done. According to the speed of 20 meters per second considered by the transmission line design regulations in the designed area, the transmission line analysis for this speed and speed less and more has been done to determine the status of the transmission line in this speed range. According to the analysis performed of the power transmission line, failure in the upper area of the transmission towers and the upper members of the towers is started simultaneously. The Commencement of the transmission line failure is shown in Fig. 1. As can be seen from this figure, the transmission lines at the top section are weak. The transmission line failure is not limited to this local failure, and the failure is transmitted to the center of the transmission tower. And then, the failure is spread to most parts of the transmission tower. Fig. 2 shows how this failure is transmitted to the middle area of the power transmission tower.

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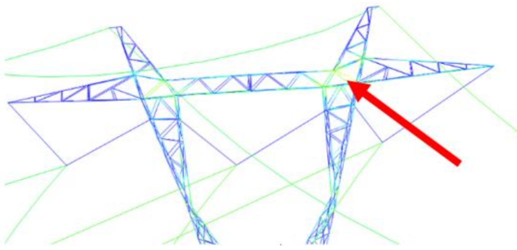

Fig. 1. Commencement of failure in the transmission tower

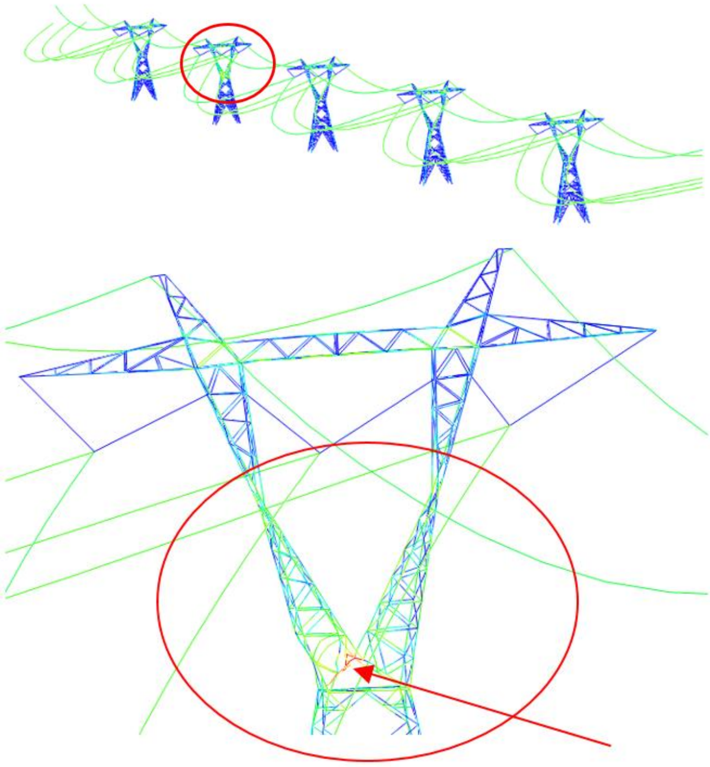

Fig. 2. Spread of failure to the middle of the power transmission tower

In the damaged tower, the power transmission tower's lateral displacement is shown in Fig. 3 for the speeds of 19, 20, and 21 meters per second. As shown in Fig. 2, the tower's top point's displacement increases abruptly, indicating instability. It seems that the towers used in the construction of this transmission line in its upper area are weak and need retrofitting.

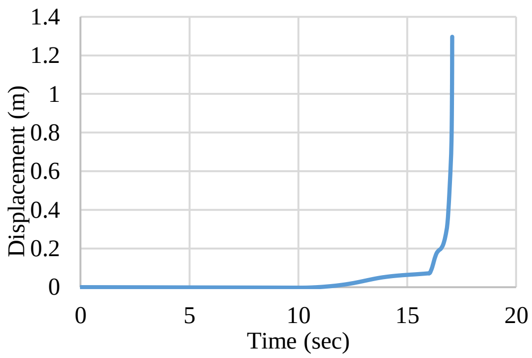

Fig. 3. Displacement variations of the top point of the last tower of the power transmission line

4. Conclusions

In this paper, the power transmission line's stability under wind force's simultaneous effect and sudden ice-shedding using the numerical modeling method and its design under wind and ice load effect by time history analysis in ABAQUS software were investigated. The wind force was modeled using numerical modeling, and the ice load was applied to the power transmission line model using volumetric force. The ice thickness on the cables fixedly and similar to the value suggested by the regulations was chosen, and the wind speed has been increased incrementally.

In the power transmission line under study, initially, failure from the type of yielding in the upper members of the transmission tower and then is occurred simultaneously in all transmission line towers. With increasing time and continuing dynamic analysis, this process is repeated, and the adjacent tower to the span will see ice-shedding in the middle area of the tower height. Then new failure from the type of members yielding occurs and spread to a large part of the tower. The interesting point is the difference between the tower's failure and the situation where only the wind load is applied to the structure, the results of which are given in the reference (Sarmasti et al, 2020). In the case where only wind force is applied, the failure is occurred only in the middle tower, while in the transmission line under wind and ice force, the failure is spread along the transmission line. However, the failure behavior and the members involved in the failure are in similar areas in both cases. It seems that the retrofitting of these members are essential for both types of loading.

Using the method presented in the present study, the stability of the transmission line under different wind speeds as well as different scenarios of ice-shedding (including ice-shedding on a cable from the span, falling at different times on the span cables and ice-shedding with different ratios, in such a way that part of the ice remains on the cable), and instability due to asymmetric ice-shedding can also be investigated. The proposed method can be used to analyze the existing transmission lines and design of new lines.

5. References

Abaqus Manual 2014, Finite Element Software, 2014.

Sarmasti H, Abedi K, Chenaghlou MR, “Stability behavior of the transmission line system under incremental dynamic wind load”, Wind and Structures, 2020, 31, 509-522.