Resilience Metric Determination for the Electric Distribution Poles

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Abstract: This study presents a methodology for evaluating resilience of electric power distribution poles, aims to increase the accuracy and rapidity of the assessment of conditions and evaluation of resilience. Since the electrical distribution systems are extremely vulnerable to hurricanes, researchers are constantly focused on designing and operating structures linking the resilience philosophy. A pound-foot(lb-ft) resilience metric is defined for the electrical poles in this study. To predict the pole failures before and after a hurricane, a 3-dimentional finite element model is illustrated for stress and deflection analysis of wooden electrical distribution poles.

1. Introduction

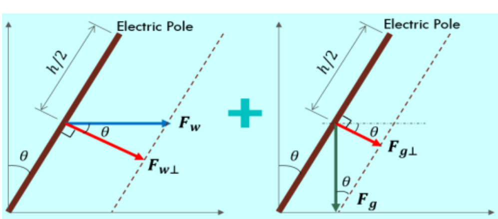
A resilience approach constantly investigates the capability of a system to anticipate and absorb threats, take precautionary activities to reduce their adverse consequences, and develop response and recovery actions for the system to resume its normal operations quickly [1]. Resilience metric can help decision makers more effectively in prioritizing preventive maintenance work as well as corrective maintenance work. This will allow them to allocate and utilize limited resources. Influence of soil condition is not considered in this study.

2. Objective

The main contribution of this study is developing a resilience metric for accurate assessment of the health conditions of electric poles, and evaluation of their resilience under pre-disaster and post-disaster conditions caused by wind-related events.

3. Materials and Methods

The total force on a particular electric pole has been defined as a resilience metric to determine the health of a wooden pole for pre-disaster and post-disaster events. Poles may experience two types of forces; the gravitational force due to the weights of the pole and the lateral force caused by winds as shown in Figure-1. Total forces were calculated for 90 mph as well as the maximum speeds of Category 1 and Category 2 hurricanes, which are 95 mph and 110 mph, respectively. The anchor depth of pole is defined by ANSI standard number ANSI 05.1-2002 and ASCE standard-7 was used for minimum design load. Present angles of wooden poles were determined by three-dimensional (3D) imaging technology (photogrammetry) to calculate these forces on them which is shown in Figure 2.



(a) (b)

Figure-1: Wind force (a) and Gravitational force (b).

Figure-2: Manual registration of a pole at Lamar University, Beaumont, TX.

Ranges of angles were defined to assess the present conditions of poles. If θ is the angle of a pole defined as shown in Figure-1, the angle ranges, $0 \leq \theta < 15$, $15 \leq \theta < 25$ and $\theta \geq 25$, correspond to healthy, critical and unhealthy conditions of a pole, respectively. The developed resilience framework is shown in Figure-3. The directional deflection and principle stress model are shown in Figure-4 and Figure-5.

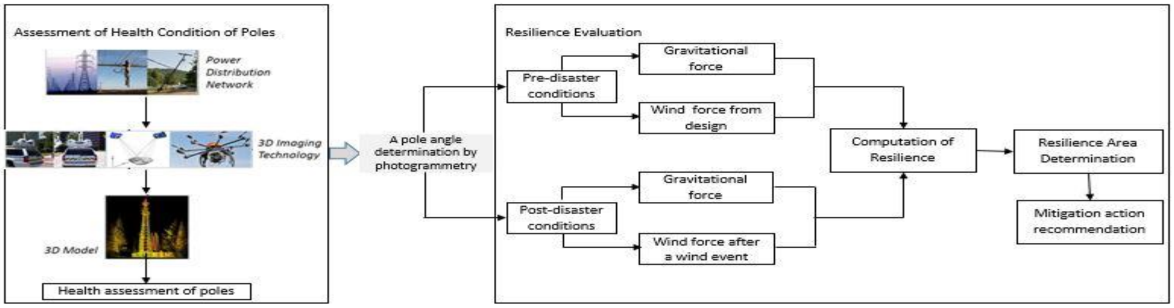


Figure-3: Resilience Framework

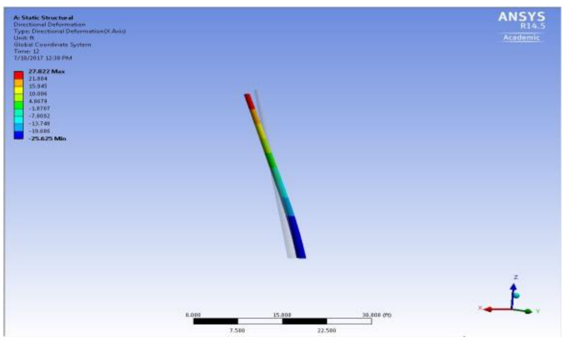


Figure-4: Directional Deflection

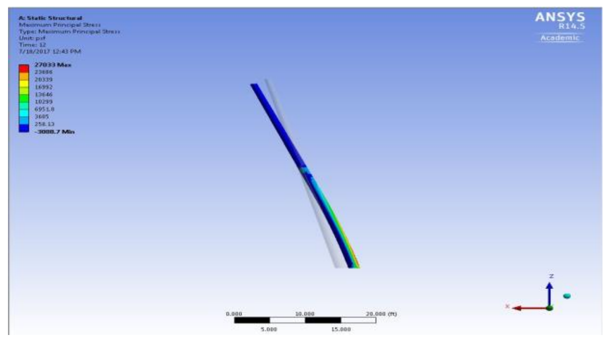


Figure-5: Principle Stress

4. Result and Discussion

Green, yellow and red zones corresponding to the healthy, critical and unhealthy conditions were defined to visualize the resilience of a particular pole. If a pole is in the red zone, it requires an immediate corrective maintenance action. If it is in the yellow zone, it raises a question on whether a corrective action needs to be taken immediately or not. Intuitively, if it is in the green zone, an immediate mitigation action is not needed. Such a visual representation is helpful for decision makers in prioritizing their resources before and after experiencing a wind-related disaster.

5. Conclusions

In this proposed study, a resilience framework for electric distribution poles are proposed as a preliminary study. The proposed approach can be used for determining the conditions of poles after a major wind event. It also can prioritize corrective maintenance and mitigation actions, based on the conditions of poles.

6. Acknowledgment

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7. References

[1] B. Eren Tokgoz, and A. Gheorghe, "Probabilistic resilience for building systems exposed to natural disasters", *International Journal of Critical Infrastructures*, vol.10, no. 3(4), 2014.