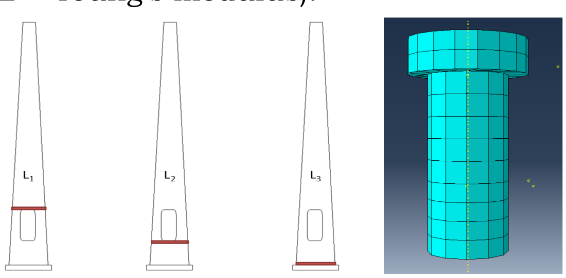
Finite Element Analysis for the Damage Detection of Light Pole Structures

Abstract: Light pole structures are commonly installed in everywhere of human society. Aging of light poles is unstoppable and inevitable, and eventually cause failures of light poles. Potential failures of light poles are detrimental to public safety since they bring risks to nearby residents and damage adjacent structures. Effective damage detection methods for light poles are hence required. In this study, a damage detection method is proposed by using damage sensitive modes to identify and locate three common damages in light pole models created by finite element methods (using ABAQUS).

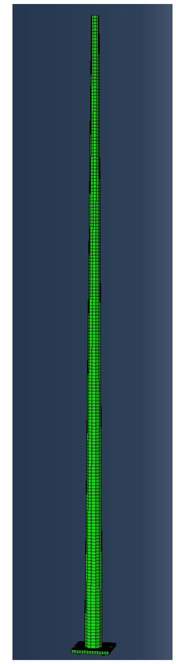
Fallen light pole in Massachusetts

Artificial damages: Damaged models are simulated by introducing artificial damages to intact light pole models. Any artificial damage can be described by following three attributes: i) damage location L_j ii) damage size $\alpha^j A$ (A = cross sectional area); and iii) damage level $\beta^j E$ (E = Young's modulus).



$$t_s = 1.25\frac{\sum_{i=1}^{10} f_i^j}{10} \qquad t_i = 0.25\frac{\sum_{i=1}^{10} f_i^j}{10}$$

- **Results:** Modal frequency difference (Δf_i^j) at the i^th mode:



$$\Delta f_i^j = \frac{(f_i^j|_{intact} - f_i^j|_{damaged})}{f_i^j|_{intact}}$$

Damage location:

Location	Sensitive modes	Insensitive modes
L_1	1, 7	6
L_2	1, 7	8, 10
L_3	9 or 10	7

Damage size and level:

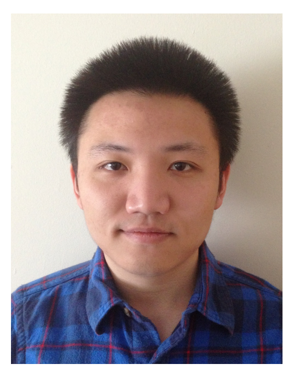
$$\alpha^j = a\Delta f_i^j + b$$

Location(j)	Best-fit mode(i)	a	b	R^2
1	10	0.0255	0.4614	0.9841
2	6	0.0526	0.1665	0.9966
3	4	0.6858	-0.1251	0.9750

$$\beta^j = c\ln(\Delta f_i^j) + d$$

Location(j)	Best-fit mode(i)	c	d	R^2
1	2	-0.195	0.3900	0.9911
2	2	-0.194	0.3879	0.9914
3	8	-0.199	0.3628	0.9914

Proposed method: 1) Extract the first ten modal frequencies from an intact light model and unknown light pole models; 2) Compute the modal frequency differences of the unknown light pole; 3) Compute thresholds t_s and t_i, and use them to determine sensitive/insensitive modes; 4) Locate the damage by checking combination of sensitive and insensitive modes of an unknown light pole in the table of *sensitive/ insensitive modes;* 5) Use obtained empirical equations to quantify the damage.



Qixiang Tang

[Research sponsor: National Science Foundation (CMS), Civil, Mechanical, Manufacturing Innovation (CMMI), 2014~2017] (Contact Prof. Yu at tzuyang_yu@UML.EDU)