NUMERICAL SIMULATION OF ANCHORAGE TO CONCRETE UNDER EXTREME WIND LOADS

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Purpose and Research Questions

A great number of HVAC anchorage failures was reported during recent hurricanes.

We hypothesize that environmental exposure and the dynamic nature of wind loads may be the reason.

The response of an HVAC anchored to a concrete slab under dynamic wind loads was numerically investigated.

Fig. 1: HVAC anchorage failure.

Study Plan and Methodology

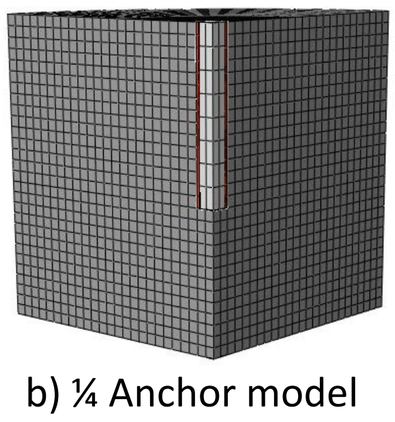
3D nonlinear finite element models of single anchors were created and validated with experimental data in order to assess the environmental exposure influence.

A complete model of the HVAC-anchor system was subsequently analyzed under static and hurricane loads.

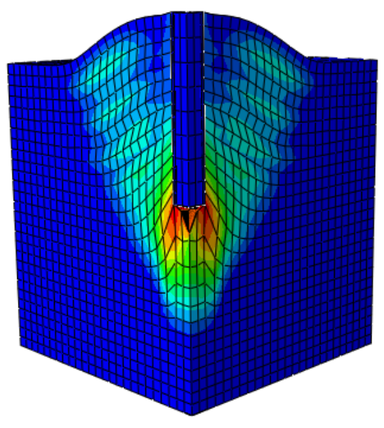
Single Anchor Validation

Models of single anchors were created using ABAQUS/CAE to simulate the main modes of failure of adhesive anchors: Steel rupture, concrete breakout, and bond failure.

a) Real anchor

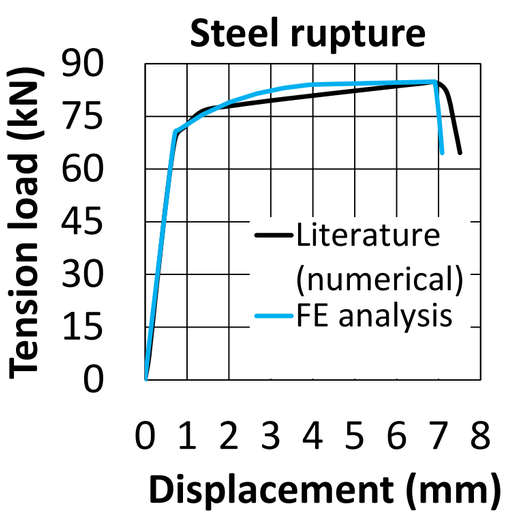


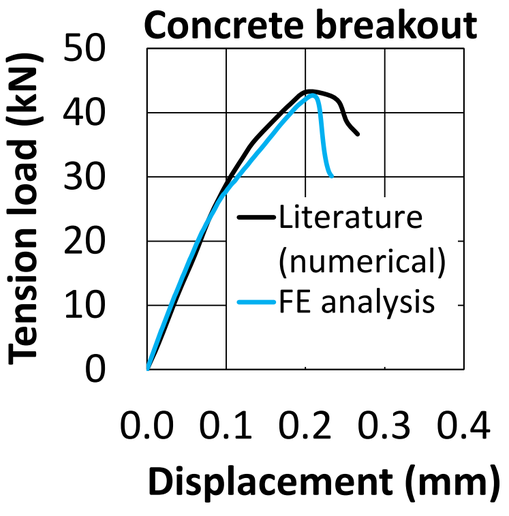
b) ¼ Anchor model



c) Concrete cracking

Fig. 2: Single anchor modeling.





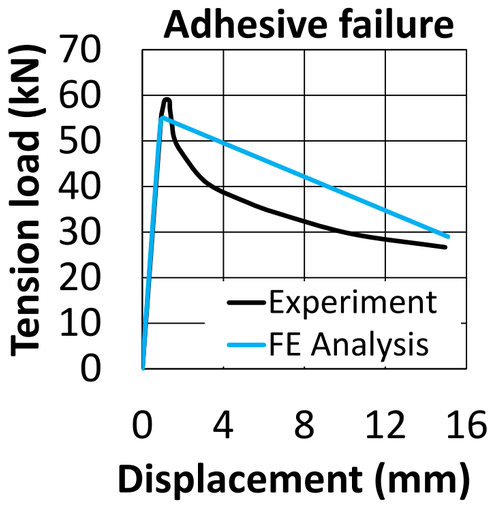


Fig. 3: Load-displacement curves.

Environmental Exposure Effects

Elevated temperatures and existing service cracks, common at rooftop level, can significantly reduce the anchorage load capacity.

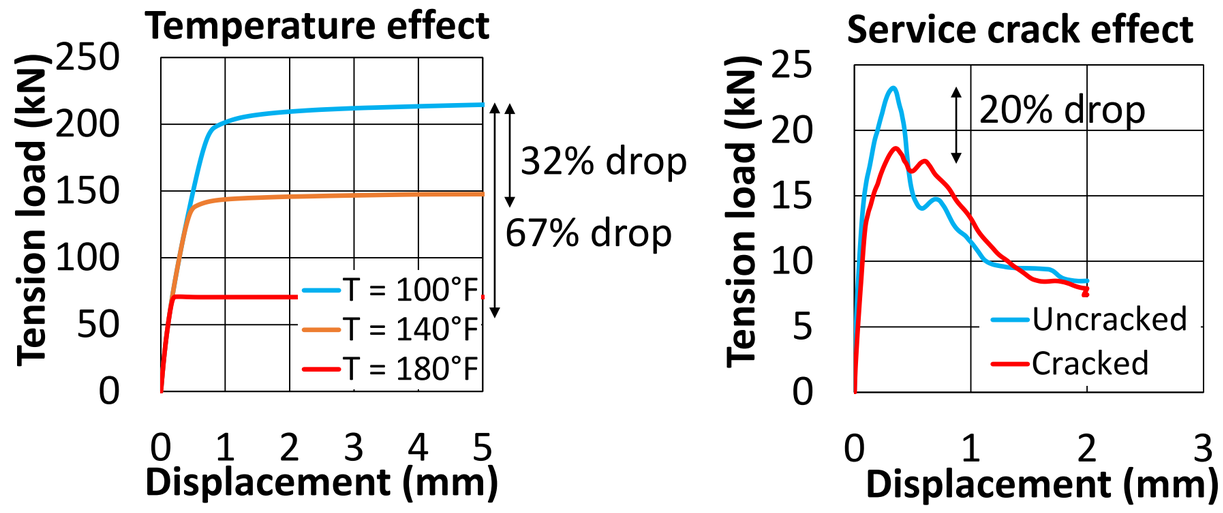


Fig. 4: Environmental exposure effects.

Complete HVAC System Modeling

The response of the entire system under pure tension and shear was studied before their simultaneous application. The equivalent static load from the wind (according to ASCE 7-16) was applied. The same model was subjected to dynamic loads, representing realistic hurricane conditions.

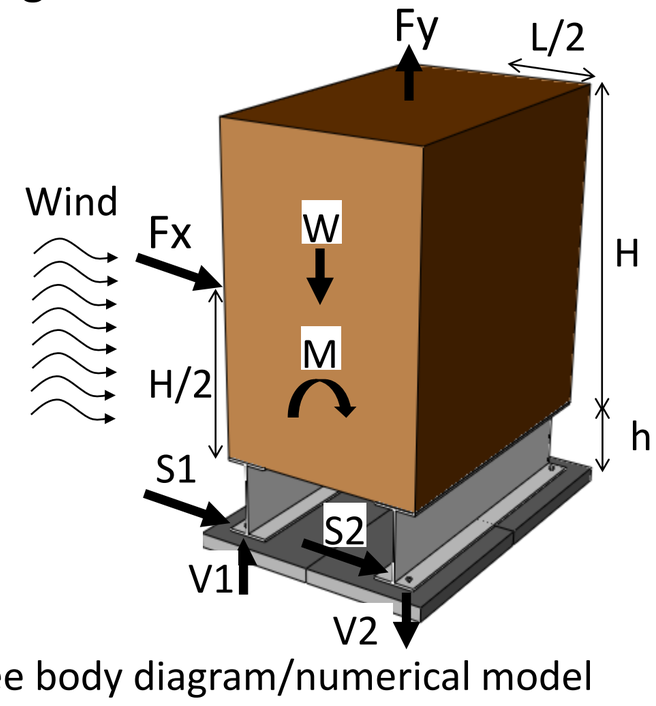


Figure 5: Real HVAC and free body diagram/numerical model

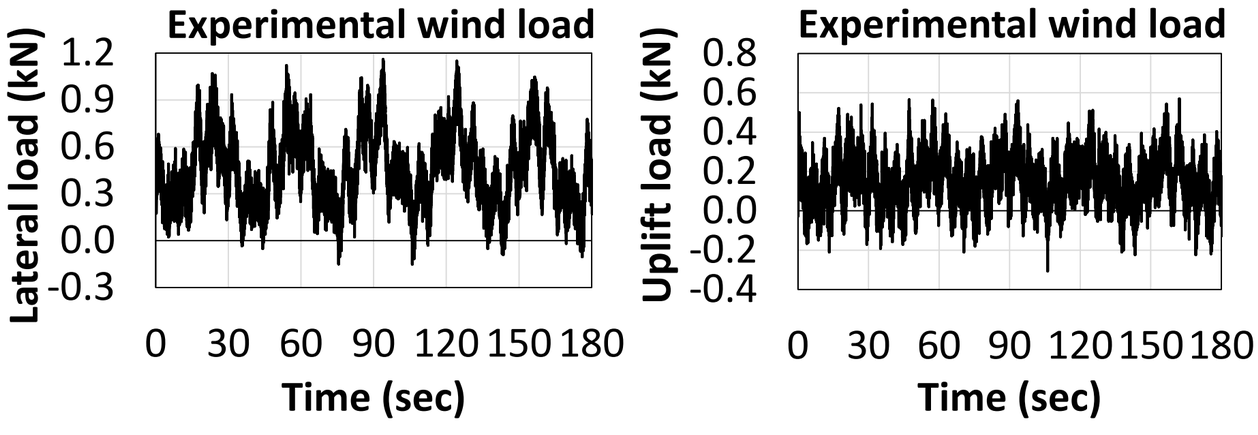


Figure 6: Wind load profile (adapted from Erwin et al. 2011).

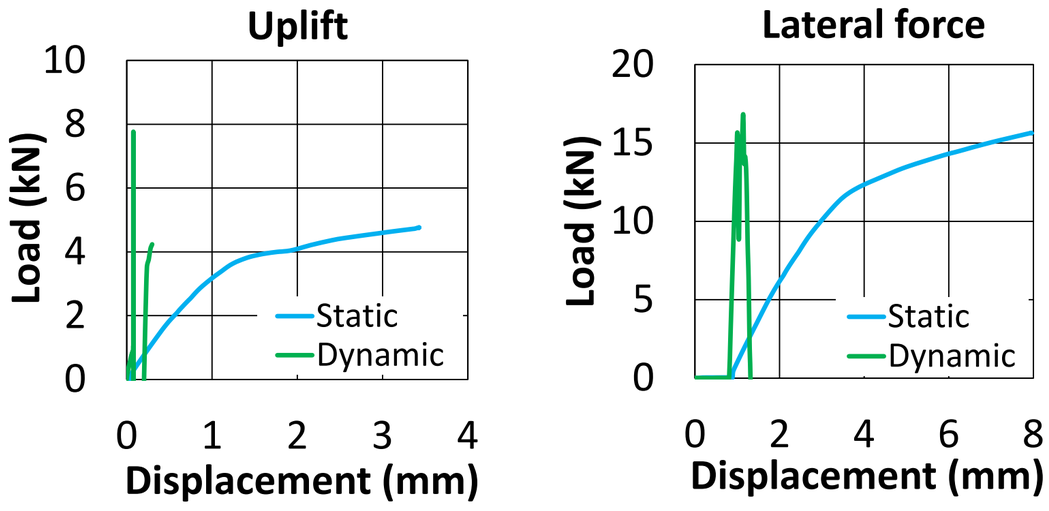


Figure 7: System response under static and dynamic loading.

Conclusions and Practical Implications

- High wind dynamic effects subject the anchors to higher loads than statically designed
- The displacement capacity is significantly reduced under extreme dynamic loading conditions
- Service temperatures can reduce the strength of adhesive anchors up to 70% and should be considered in the design
- Service cracks can reduce the concrete breakout strength by 20%