Field monitoring the wind-induced response of a large-area fabric membrane structure


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ABSTRACT: (10 pt)
This paper provides preliminary observations on the structural wind-induced response of an in-service fabric structure located in a coastal environment near Panama City, FL. The structure was instrumented in July 2020 with 66 individual sensors. Between August 2020 and November 2020, the instrumented structure was affected by ten windstorm events with peak 3-second gust wind speeds of at least 15 m/s. The captured data provides insights on the lateral and vertical load paths through the structure, the dynamic response of the building to high winds, and the role of wind-induced internal pressurization.

Keywords: field-monitoring, fabric, wind loads, structural response

1. INTRODUCTION
Tensile fabric structures have historically served many purposes, including use in stadiums, airports, and outdoor pavilions where their light weight and varied form factors are ideally suited. However, these same factors make them dynamically sensitive to high winds, and several notable failures have occurred (e.g., the collapse of a professional football team’s practice facility in 2009). This sensitivity is particularly a risk in temporary fabric structures, which are often employed in mining and military operations, as the necessary cost-efficiency prioritizes design based on simplified static loads that ignore dynamic and aeroelastic effects. The objective of this study is to explore the wind-induced response of a temporary fabric membrane structure through in-situ monitoring of an in-service structure located near the coast in Panama City, FL.

2. METHODS
The LAMS is a temporary, enclosed building consisting of T6160 aluminium frames and a stretched fabric membrane envelope as shown in Figure 1. It is located in flat, rough terrain per the Davenport terrain classes but with large open patches from 0°-180°. A weather station is located approximately eight roof heights from the LAMS, measuring wind velocity at 10 m above ground at 1 Hz. A suite of 66 sensors were installed in the LAMS to measure strain, displacement of the frames and fabric membrane, internal forces, and acceleration in key locations within the longitudinal and transverse load path, and internal pressure within the enclosed interior volume. Between 1 August 2020 and 31 January 2021, 451 10-minute segments were measured at the
LAMS site with peak 3-second wind gusts of 11.5 m/s (25 mph) or higher, representing 27 different storm events. The storms included two hurricane events—Hurricane Sally (2020) and Hurricane Zeta (2020)—both of which tracked north of the LAMS site but were close enough to subject the LAMS to wind speeds as high as 22 m/s (50 mph) over a wide swath of wind directions. A sample segment with illustrative structural response is shown in Figure 2.

2. PRELIMINARY RESULTS
Preliminary data show stresses in the frames and bracing cables that, when scaled to represent design conditions (assuming linear elastic response), are higher than those being designed for as provided by the manufacturer. The data also suggests that wind loads acting in the longitudinal axis of the building are disproportionally being carried by the purlins/struts in the first bay, with the tension cables in the roof not being engaged as much as expected. Further, secondary loading effects are noted, including loose fabric transferring wind loads into (what are designed to be) two-force elements as bending stresses. This paper will present these amongst other findings and highlight some of the challenges encountered in monitoring the structural response of structures to wind in a remote environment using a self-contained monitoring system.

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