

FSI, Fabrication & Structural Testing

Ming-Chen Hsu, Todd Culp, Robert Peggar,
Bin Cai, Michael C. H. Wu, Sri Sritharan

Outline

- Fluid-Structure Interaction
 - CFD
 - FSI Analyses
- Precast Fabrication and Erection
- Structural Testing
 - System test
 - Fatigue test

Fluid–Structure Interaction (FSI) Simulation of HT2

Motivation:

To obtain quantities of interests using fully-coupled FSI simulation.

Typical simulation methods

- Standalone Computational Fluid Dynamics (CFD) simulation
 - Time-dependent wind forces on rigid tower
 - Tower base overturning moment of **rigid tower**
- Structural mechanics simulation
 - Natural frequency
 - **Static** tower deflection

Method we proposed

- FSI simulation (Fluids and structures are tightly-coupled)
 - Time-dependent wind forces on deformable tower
 - Tower base overturning moment of **deformable tower coupled with air flow**.
 - **Dynamic** tower deflection and vibration caused by the wind.

Hexcrete Tower Project



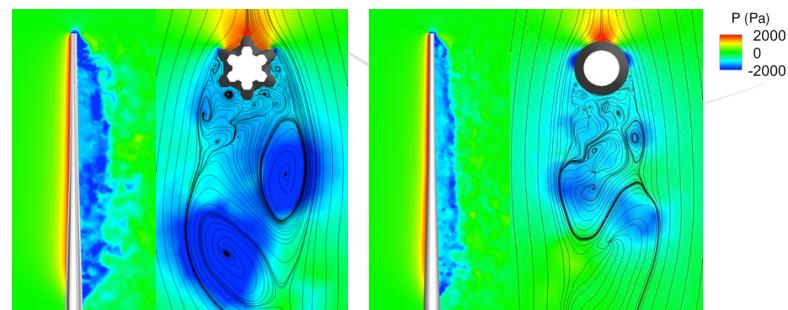
Commercialization Workshop

CFD Simulations

Design Load

50-year extreme wind case
 $M_{\text{base_total}}^* = 1.17 \times 10^8 \text{ N-m}$
 $M_{\text{base_rotor}}^* = 0.74 \times 10^8 \text{ N-m} (63\%)$
 $M_{\text{base_wind}}^* = 0.43 \times 10^8 \text{ N-m} (37\%)$

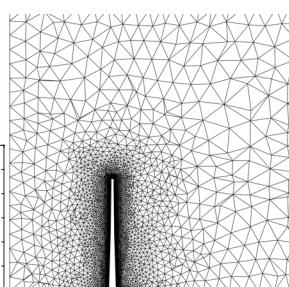
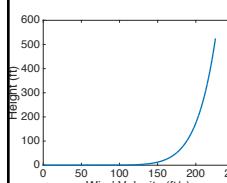
* Exact wind conditions and other details unknown



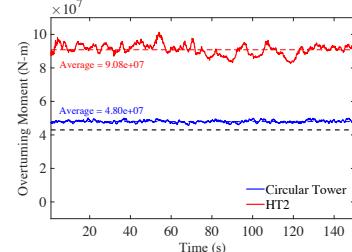
Comparison of pressure distribution and streamlines between HT2 and circular tower. The suction behind HT2 is clearly stronger than that behind circular tower. This difference results in higher overturning moment for HT2 than for circular tower.

Inflow:

50-year extreme wind profile



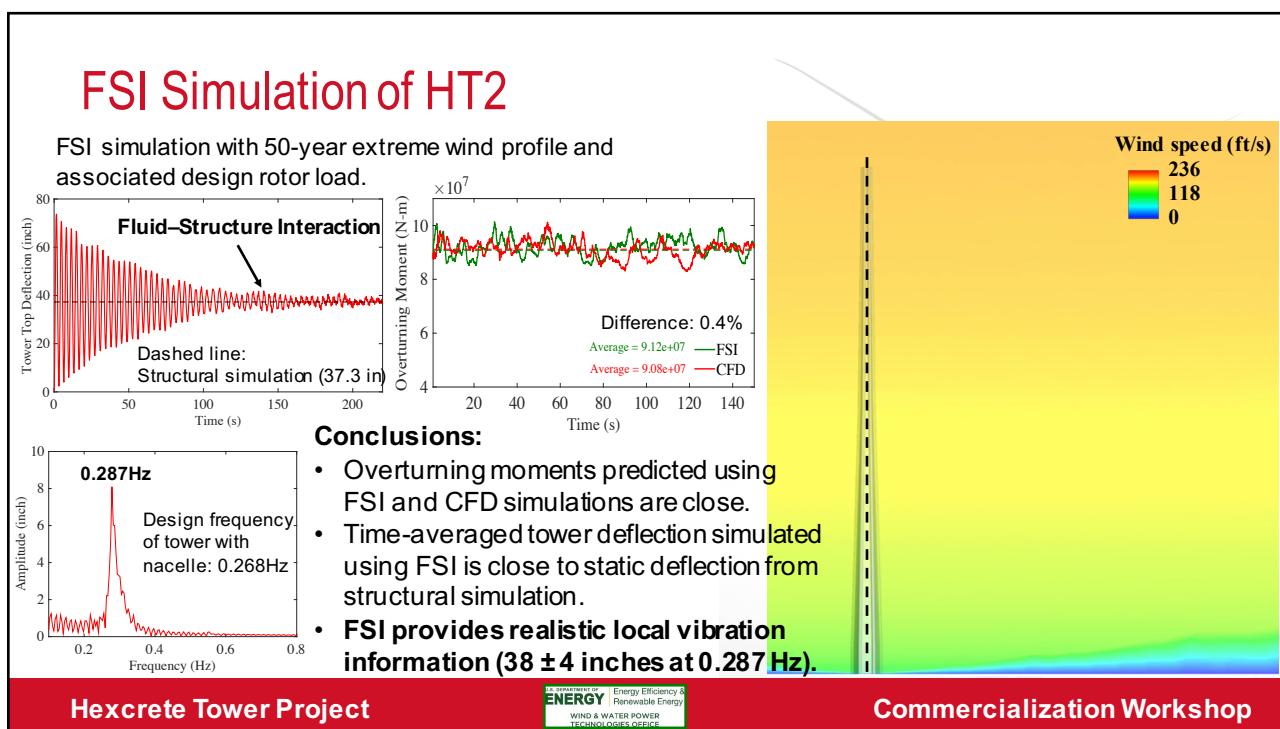
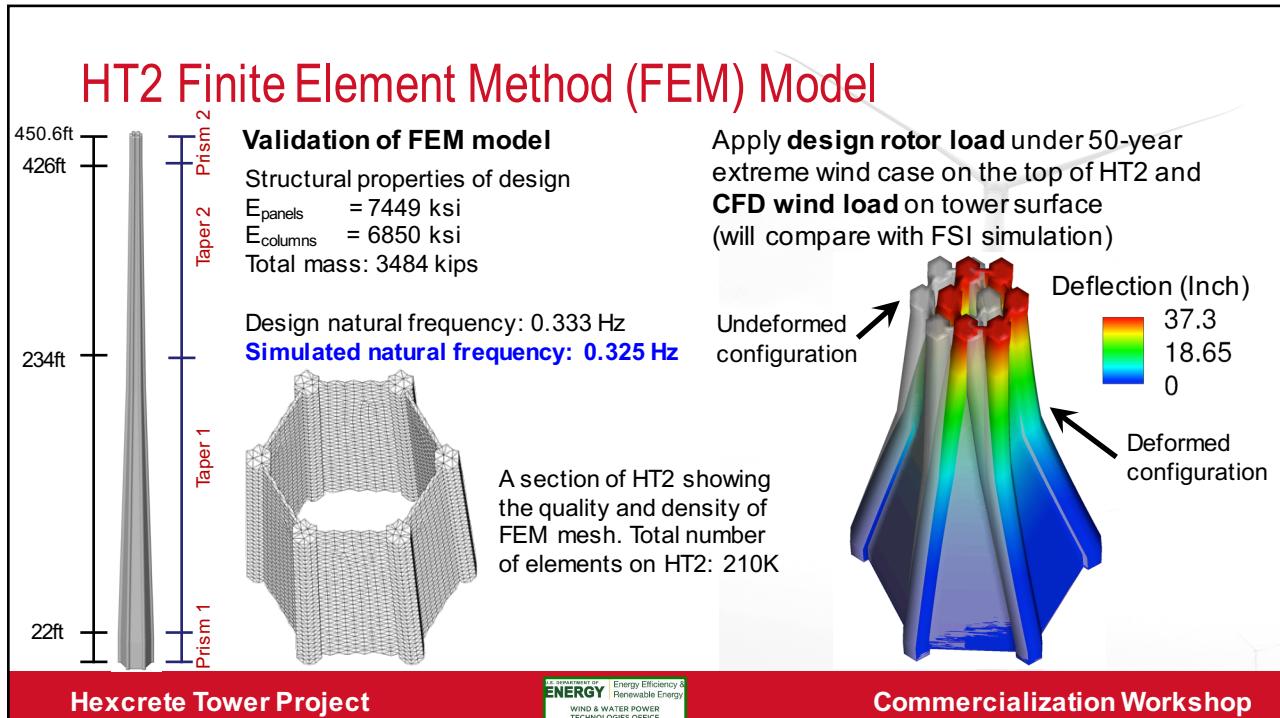
CFD Mesh: high density mesh around tower to resolve complex fluid activities. Total number of tetrahedral elements: 1.35M



Hexcrete Tower Project



Commercialization Workshop



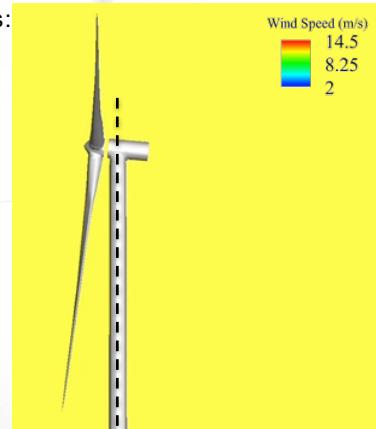
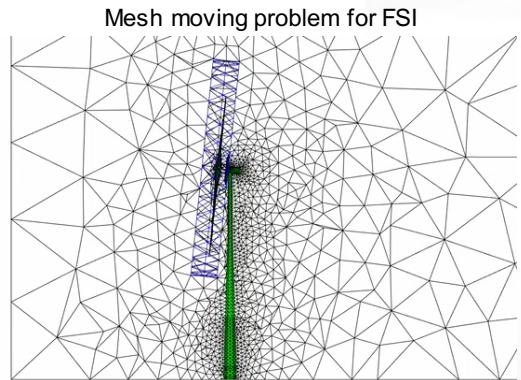
Future Work

- Current simulations use a static rotor load
- We plan to investigate coupled rotor-tower interaction (FSI rotor load)

Structural coupling between rotor and tower



Preliminarily FSI results:



Hexcrete Tower Project

U.S. DEPARTMENT OF
ENERGY Energy Efficiency &
WIND & WATER POWER
TECHNOLOGIES OFFICE

Commercialization Workshop

Fabrication and Testing



Hexcrete Tower Project

U.S. DEPARTMENT OF
ENERGY Energy Efficiency &
WIND & WATER POWER
TECHNOLOGIES OFFICE

This video was produced as part of the following project

Hexcrete Tower for Harvesting Wind Energy at Taller Hub Heights (DE-EE0006737)

Project Website:

<http://sri.cce.iastate.edu/hexcrete/>

Sponsors:



Collaborating Partners

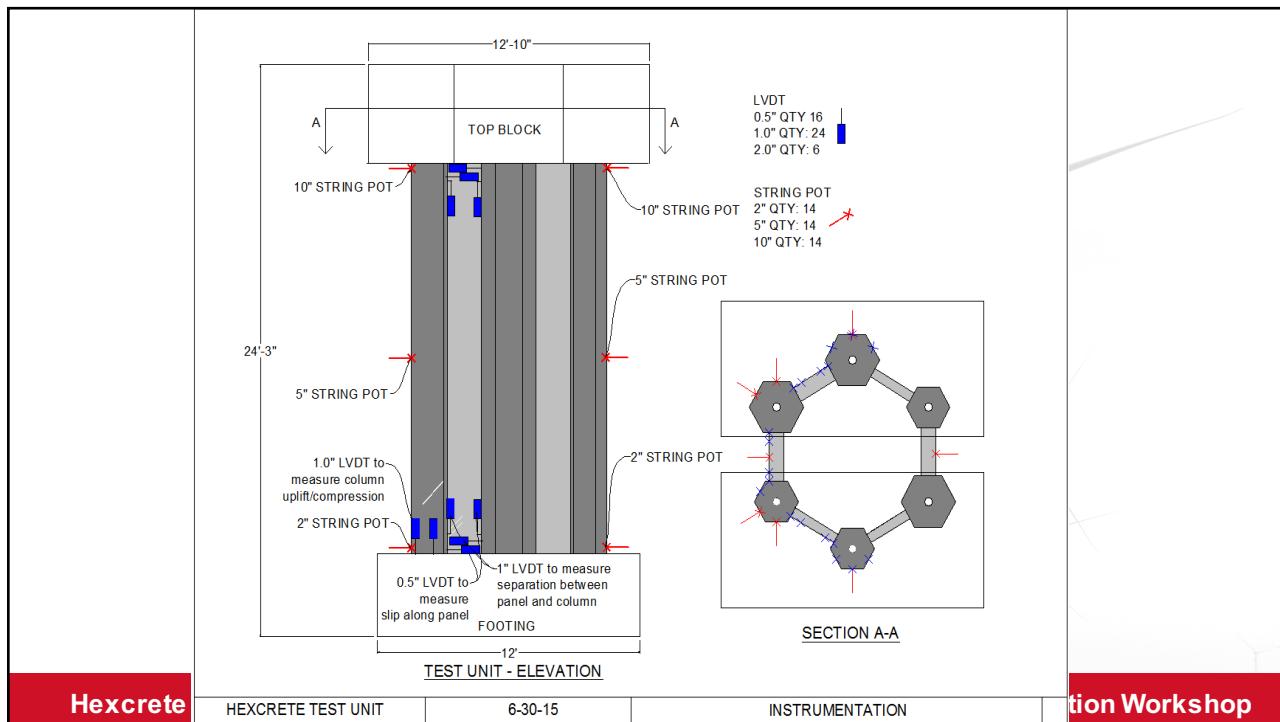
**IOWA STATE
UNIVERSITY**

SIEMENS

BergerABAM

**CORESLAB.
STRUCTURE**
(OMAHA)

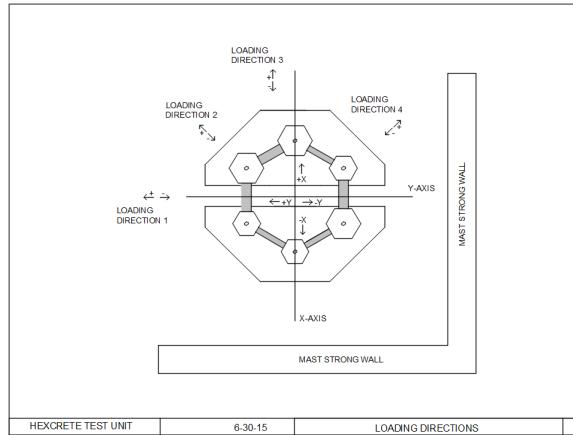
NRE
NATIONAL RENEWABLE ENERGY



Load Protocol

- Four loading directions were selected
- Three load cases were chosen based on largest overturning moment (1.1), shear (4.2), and torsion (2.2).
- Each of the three load cases were applied for operational and extreme loads
- Example of Operational Loading shown below

Operational Load Tests			
	Load Case	Load direction	Loading Percentages
Test 1	4.2	3	$\pm 25\%$, $\pm 50\%$ ($3x^*$), $\pm 75\%$, $\pm 100\%$ ($3x$)
Test 2	4.2	1	$\pm 25\%$, $\pm 50\%$ ($3x$), $\pm 75\%$, $\pm 100\%$ ($3x$)
Test 3	1.1	2	$\pm 25\%$, $\pm 50\%$ ($3x$), $\pm 75\%$, $\pm 100\%$ ($3x$)
Test 4	1.1	4	$\pm 25\%$, $\pm 50\%$ ($3x$), $\pm 75\%$, $\pm 100\%$ ($3x$)
Test 5	2.2	3	$\pm 25\%$, $\pm 50\%$ ($3x$), $\pm 75\%$, $\pm 100\%$ ($3x$)
Test 6	4.2	3	$\pm 50\%$ ($3x$), $\pm 100\%$ ($3x$)

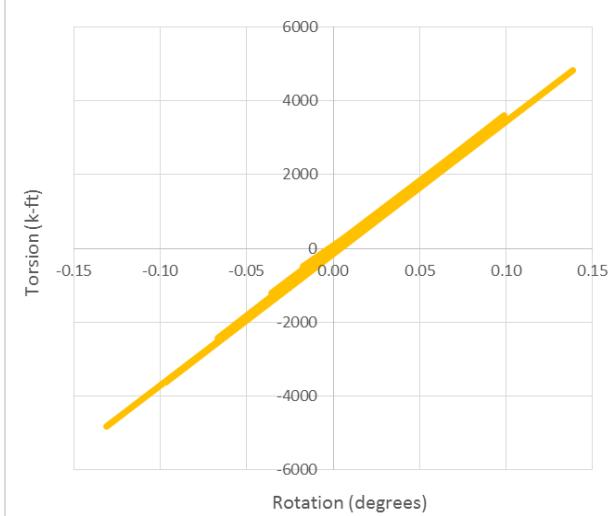
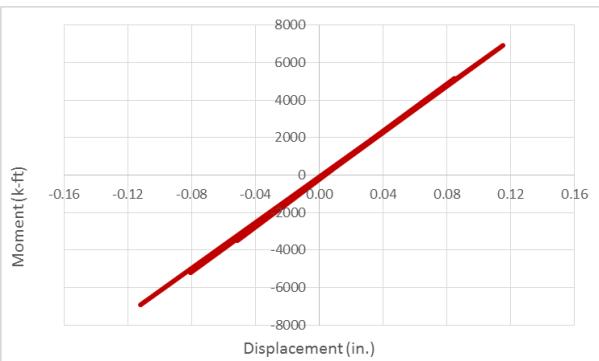


Hexcrete Tower Project



Commercialization Workshop

Operational Loads

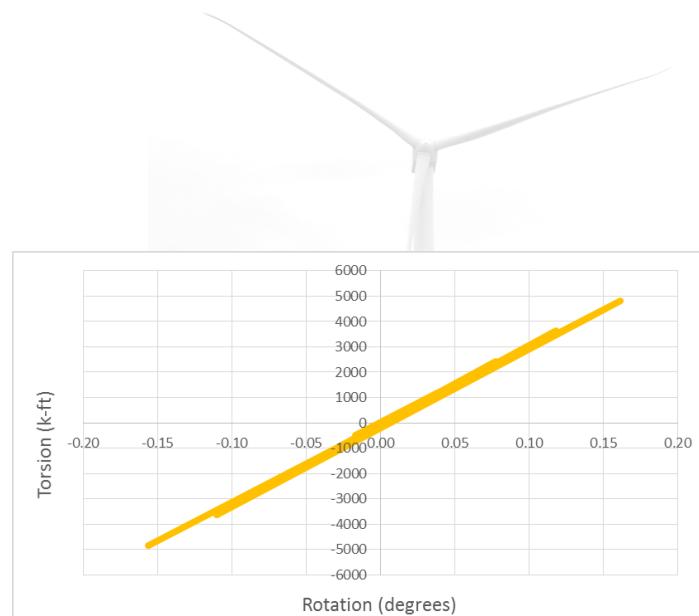
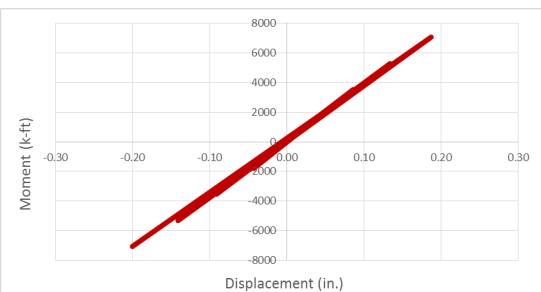


Hexcrete Tower Project



Commercialization Workshop

Extreme Loads

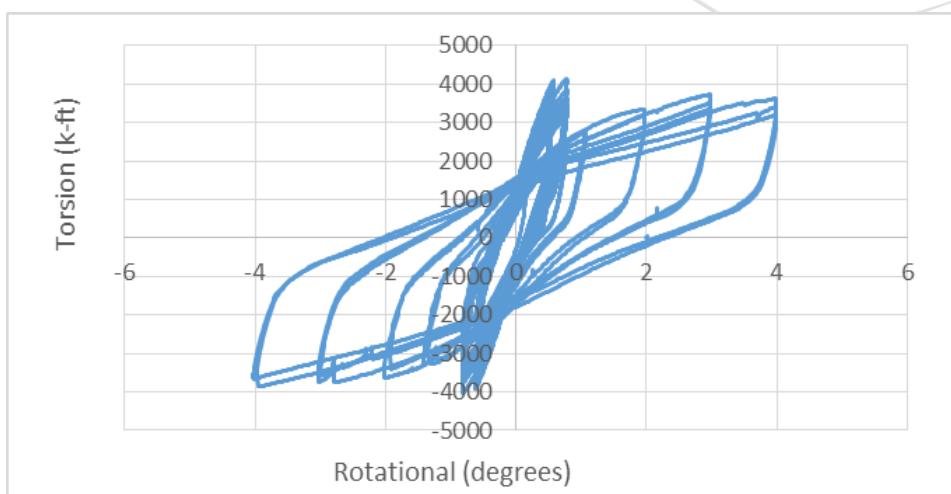


Hexcrete Tower Project



Commercialization Workshop

Ultimate torsion load test



Hexcrete Tower Project



Commercialization Workshop

This video was produced as part of the following project

Hexcrete Tower for Harvesting Wind Energy at Taller Hub Heights (DE-EE0006737)

Project Website:

<http://sri.cce.iastate.edu/hexcrete/>

Sponsors:



Fatigue Load Testing



Hexcrete Tower Project



Commercialization Workshop



Hexcrete Tower - Fatigue load evluation of members, connections, and prestressing steel and anchorage

Summary

- CFD vs FSI
- System test
- Fatigue test



Hexcrete Tower Project



Commercialization Workshop