Design of Hexcrete Towers

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Overview

1. Design Overview
   1. Materials
   2. Variables and Design Codes
   3. Design Process
   4. Connection details
2. 120-m 2.3 MW Design
3. 140-m 3.2 MW Design

Materials

All column and panel segments will be produced in a precast facility

- Columns – High Strength Concrete (HSC), 13 ksi compressive strength
- Panels – Ultra High Performance Concrete (UHPC), 26 ksi compressive strength
- Steel tendons – 0.6” diameter relaxed steel 270 ksi tensile strength

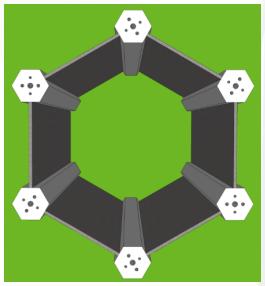
Variables and Design Codes

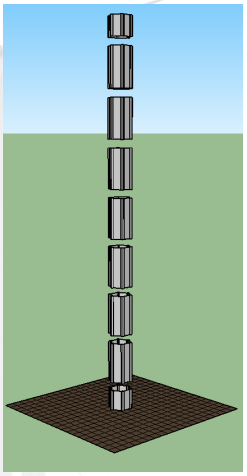
Variables

- Base diameter
- Diameter at blade tip for rotational clearance
- Top diameter (determined by nacelle)
- Frequency
- Deflection

Design Codes

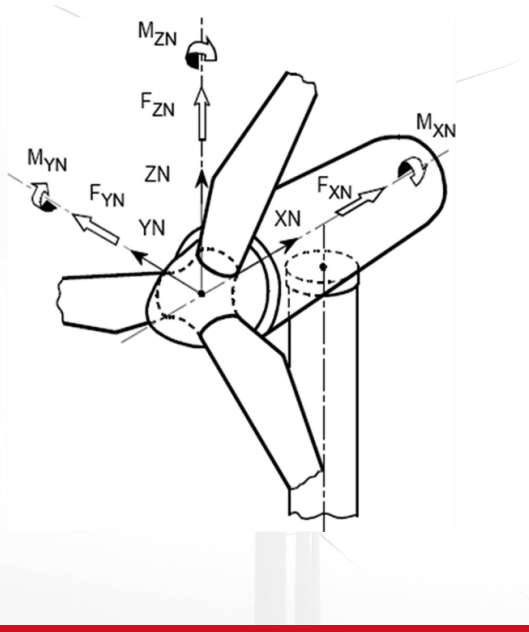
- IEC 61400-01
- GL Certification Guidelines
- EuroCode and ACI





Design Loads

- Provided by turbine manufacturer for specific turbines
- Wind load on tower as well as turbine load
- Geometry of Hexcrete tower provides difference in drag coefficient for wind loads

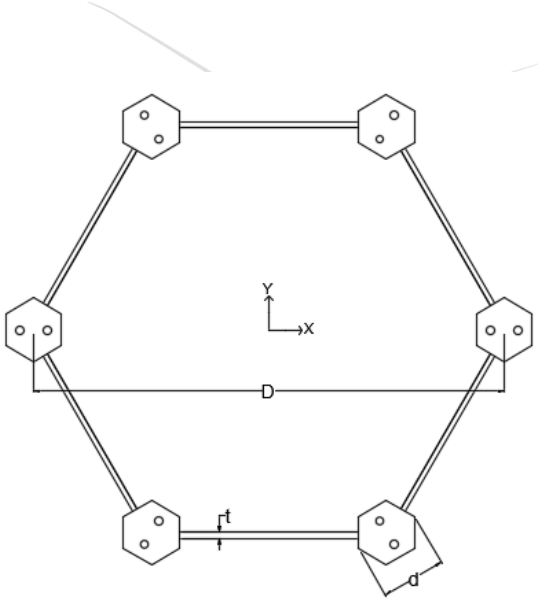


Dimension Design

D – Overall tower diameter
- Capacity analysis
- moment, shear, axial
  - Number of PT strands and total moment

d – Column diameter
- Stress analysis
- moment, shear, axial
  - Number of PT strands

t – Panel thickness
- Stress analysis
- torsion, shear, axial
  - Shear/torsion and concrete strength



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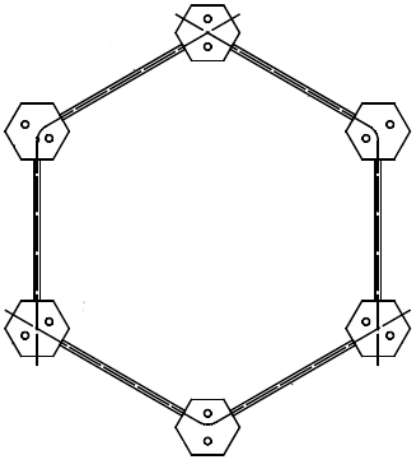
Connection Design

Shear friction design
- Capacity analysis
- Torsion, moment, shear, axial
  - Total forces along vertical column to panel interface

Current design incorporates epoxy between panels and columns
- Even bearing surface
- Increases friction



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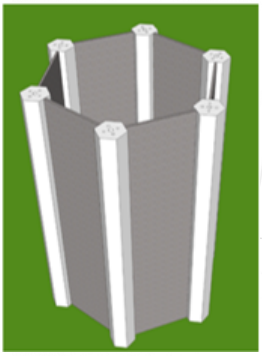
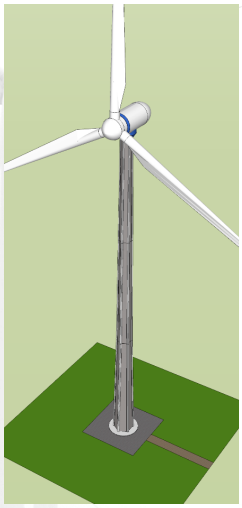
Design Checks

- Frequency check to ensure 1P and 3P criteria are met
- Tower top deflection
- Blade tip clearance
- GL Guidelines for stress limitations, PT decompression, and concrete cracking
- Fatigue loading of concrete members and post-tensioning tendons

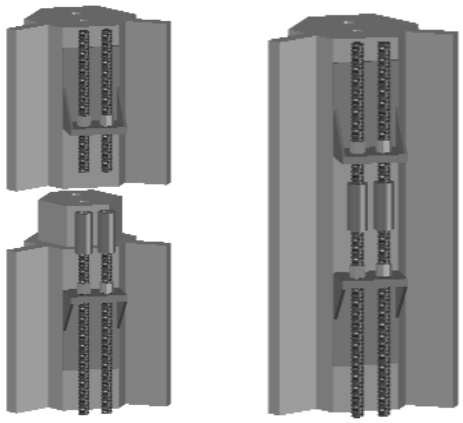




Section Connections

Columns connections

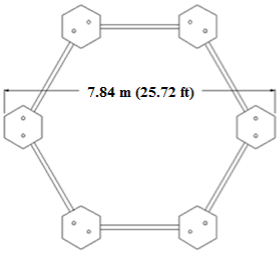
- Keyways to allow proper alignment and shear capacity
- 3” diameter 150 ksi steel threaded bars
- Threaded bars provide continuity and tensile capacity
- Grout seals connection after tower is erected



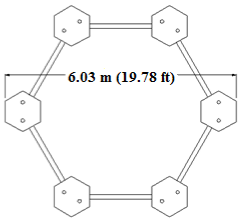
120 m – 2.3 MW Tower Design

- 120 m (393.6 ft) tower design
- Designed for 2.3 MW turbine
- Natural Frequency of 0.33 Hz
- Columns and tower diameter are tapered

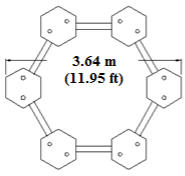
Tower base



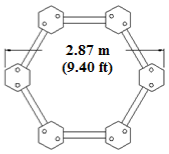
One third tower height



Two third tower height



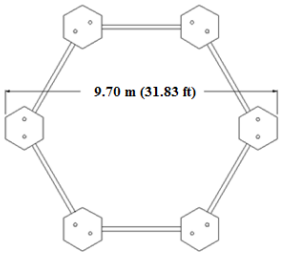
Tower top



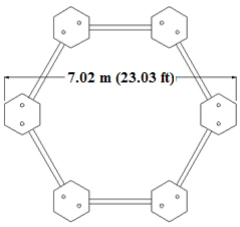
140 m – 3.2 MW Tower Design

- 140 m (459.2 ft) tower design
- Designed for 3.2 MW turbine
- Natural Frequency of 0.349 Hz
- Columns and tower diameter are tapered

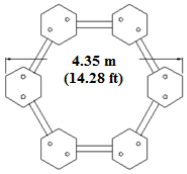
Tower base



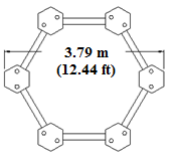
One third tower height



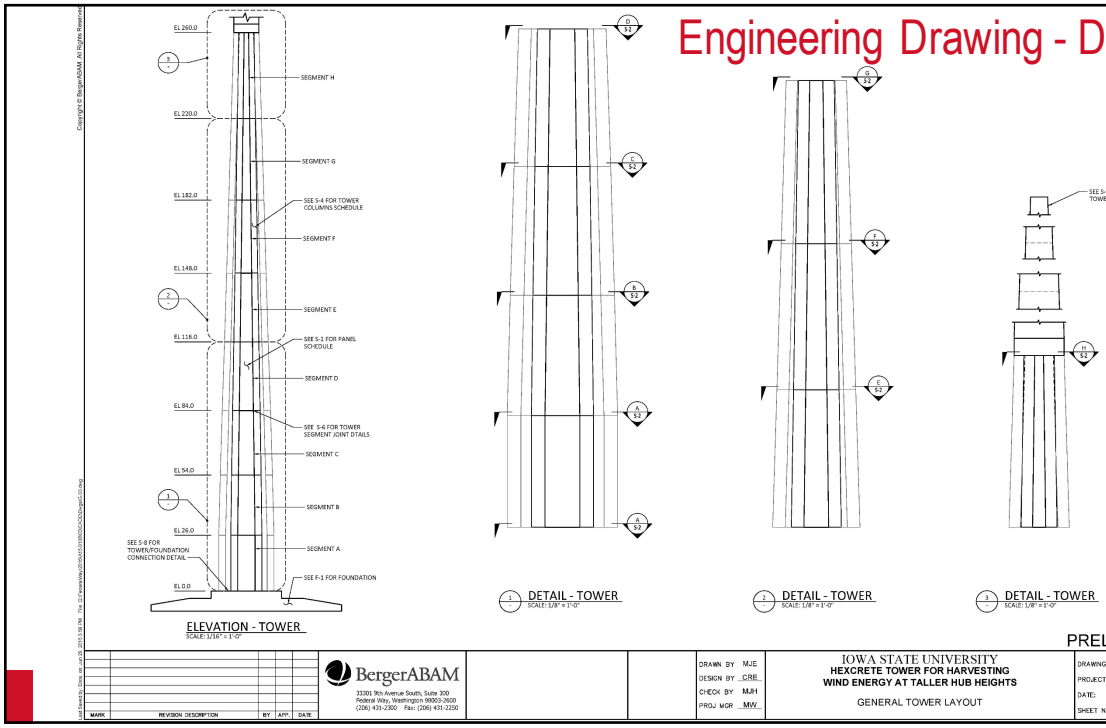
Two third tower height

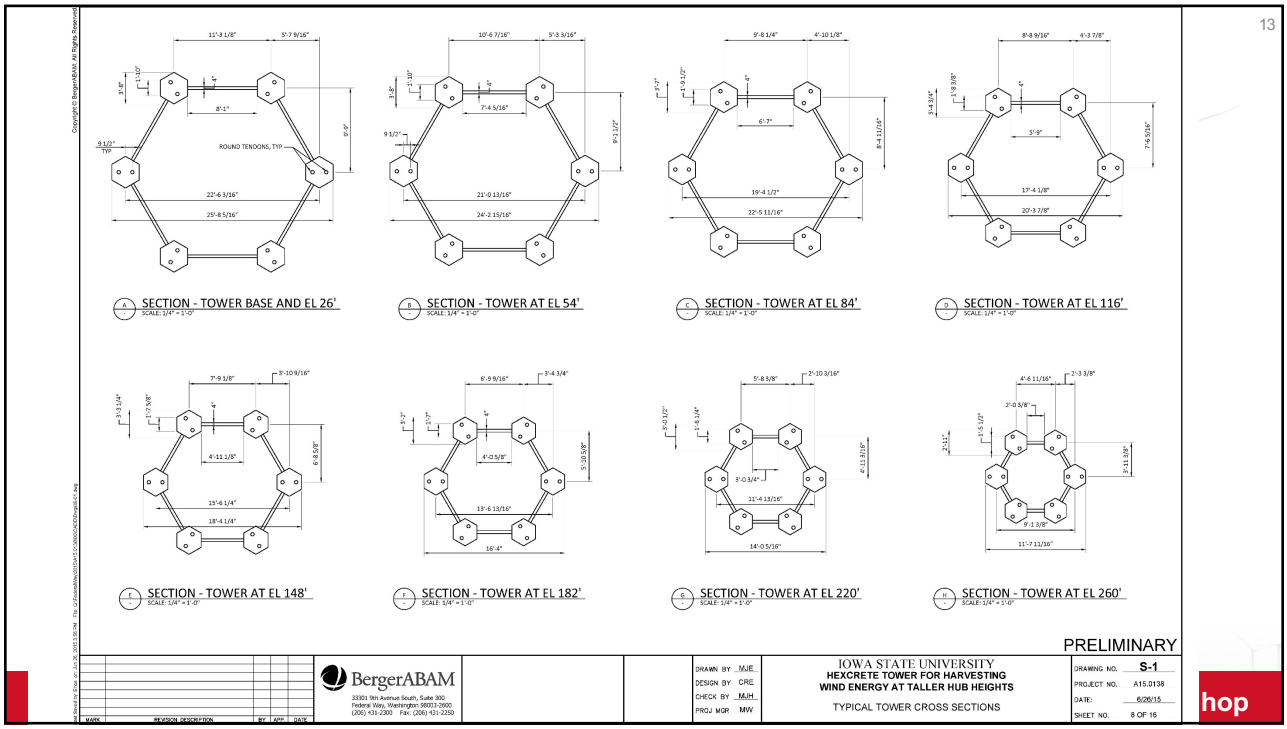


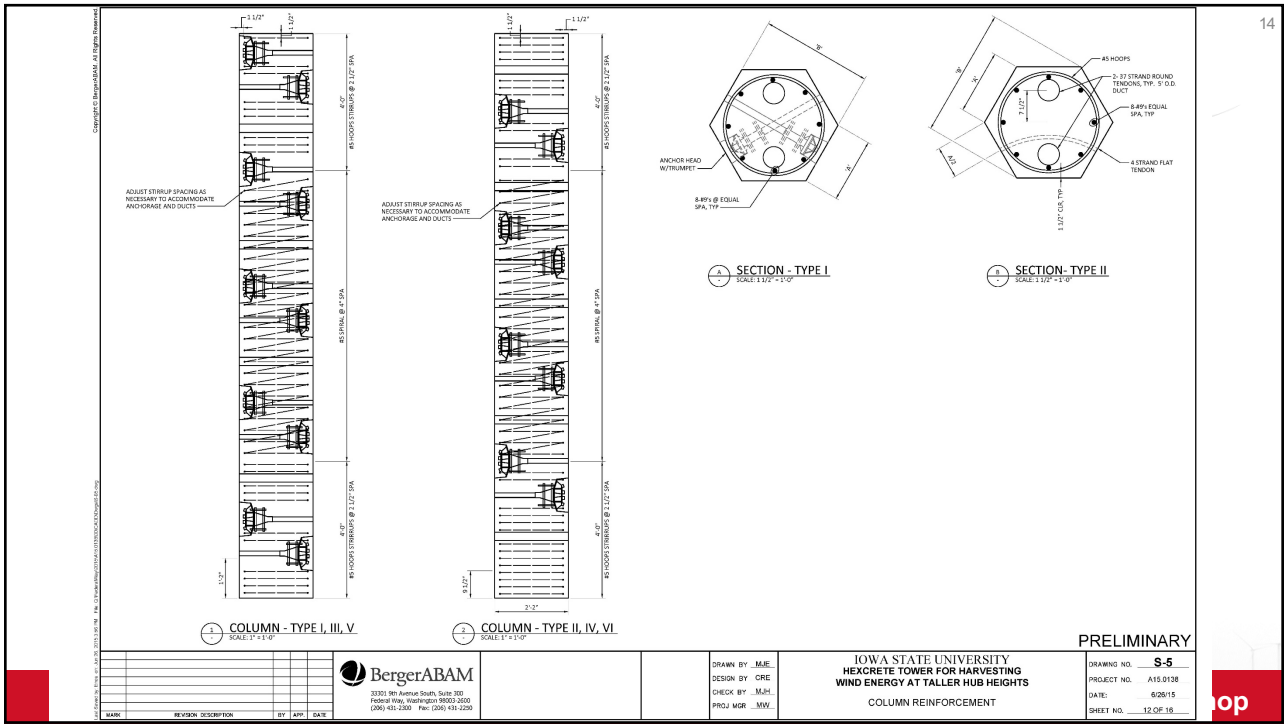
Tower top



Engineering Drawing - Draft




13
SECTION - TOWER BASE AND EL 26'
SCALE: 1/4" = 1'-0"
SECTION - TOWER AT EL 54'
SCALE: 1/4" = 1'-0"
SECTION - TOWER AT EL 84'
SCALE: 1/4" = 1'-0"
SECTION - TOWER AT EL 116'
SCALE: 1/4" = 1'-0"
SECTION - TOWER AT EL 148'
SCALE: 1/4" = 1'-0"
SECTION - TOWER AT EL 182'
SCALE: 1/4" = 1'-0"
SECTION - TOWER AT EL 220'
SCALE: 1/4" = 1'-0"
SECTION - TOWER AT EL 260'
SCALE: 1/4" = 1'-0"
PRELIMINARY
BergerABAM
33301 9th Avenue South, Suite 300
Federal Way, Washington 98003-2600
(206) 431-2300 Fax: (206) 431-2250
DRAWN BY MJE
DESIGN BY CRE
CHECK BY MJH
PROJ MGR MW
IOWA STATE UNIVERSITY
HEXCRETE TOWER FOR HARVESTING
WIND ENERGY AT TALLER HUB HEIGHTS
TYPICAL TOWER CROSS SECTIONS
DRAWING NO. S-1
PROJECT NO. A15.0138
DATE: 6/26/15
SHEET NO. 8 OF 16


14
ADJUST STIRRUP SPACING AS NECESSARY TO ACCOMMODATE ANCHORAGE AND DUCTS
#5 HOOPS STIRRUPS @ 1 1/2" SPA.
#5 SPIRAL @ 4" SPA.
COLUMN - TYPE I, III, V
SCALE: 1" = 1'-0"
COLUMN - TYPE II, IV, VI
SCALE: 1" = 1'-0"
ANCHOR HEAD W/TRUMPET
8-#9's @ EQUAL SPA, TYP
SECTION - TYPE I
SCALE: 1 1/2" = 1'-0"
#5 HOOPS
2- 37 STRAND ROUND TENDONS, TYP. 5' O.D. DUCT
8.49% EQUAL SPA, TYP
4 STRAND FLAT TENDON
SECTION- TYPE II
SCALE: 1 1/2" = 1'-0"
PRELIMINARY
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Federal Way, Washington 98003-2600
(206) 431-2300 Fax: (206) 431-2250
DRAWN BY MJE
DESIGN BY CRE
CHECK BY MJH
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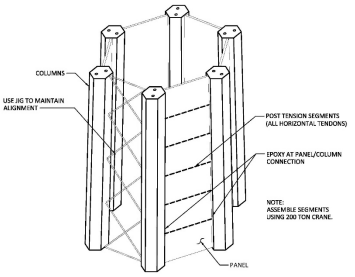
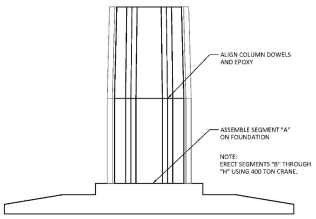
IOWA STATE UNIVERSITY
HEXCRETE TOWER FOR HARVESTING
WIND ENERGY AT TALLER HUB HEIGHTS
COLUMN REINFORCEMENT
DRAWING NO. S-5
PROJECT NO. A15.0138
DATE: 6/26/15
SHEET NO. 12 OF 16

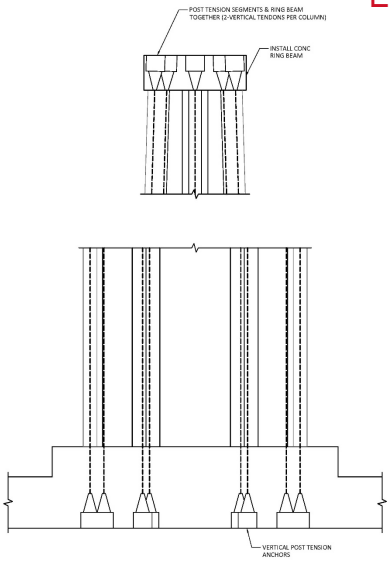
Erection Drawing Draft



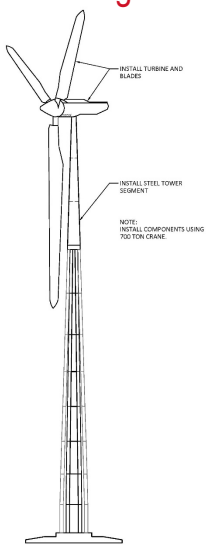
STEP 1 - ASSEMBLE SEGMENTS "A" THROUGH "H"



STEP 2 - ERECT CONC TOWER



STEP 3 - ERECT CONC TOWER



STEP 4 - INSTALL STEEL COMPONENTS

PRELIMINARY

MARK	REVISION DESCRIPTION	BY	APP.	DATE

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DESIGN BY CRE
CHECK BY MJH
PROJ MGR MW

IOWA STATE UNIVERSITY
HEXCRETE TOWER FOR HARVESTING WIND ENERGY AT TALLER HUB HEIGHTS
ERECTION PLAN

DRAWING NO. E-1
PROJECT NO. A15.0138
DATE: 6/26/15
SHEET NO. 5 OF 16

Questions