Designing an Easily-Made Lattice Tower for a Small Wind Turbine

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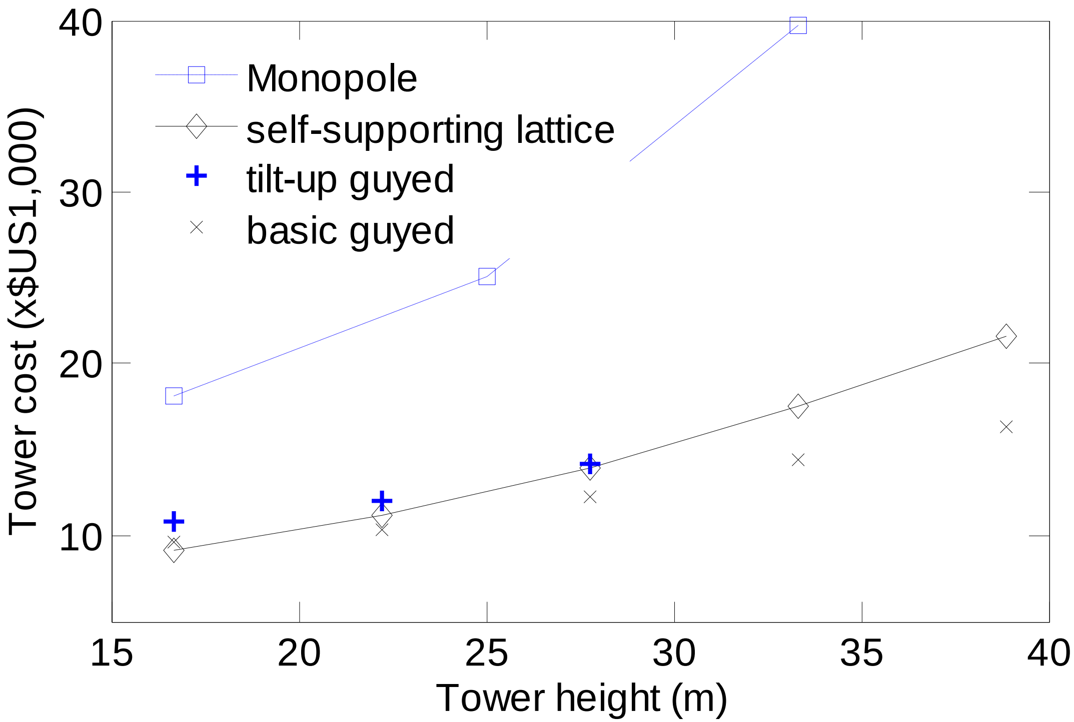
Monopole towers are becoming common but are expensive



USD price for towers for the Bergey 10 kW turbine

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Lattice towers are easily made as in this jig at Kijito Windpower Kenya

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Aim: to design an easily-made lattice tower for the Aerogenesis 5 kW wind turbine

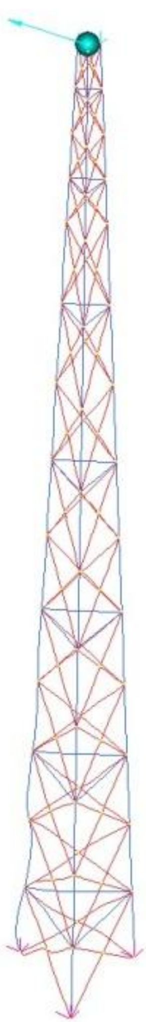
Design wind speed	52.5 m/s (IEC Class III)
General specifications for turbine	Height:18 m Turbine mass: 170 kg Maximum thrust: 2.2 kN. Two blades with maximum speed 320 rpm
General specifications for tower for compatibility with existing towers	Base distance between legs :1.975 m Length of tower sections: 2.98 m
Vertical and horizontal members	Low carbon steel: F_y = 255 MPa. 60.5mm diameter pipe. Wall thickness: 3.65mm
Cross Bracing	Low carbon steel: F_y = 255 MPa Solid round bar, 12.7 mm diameter

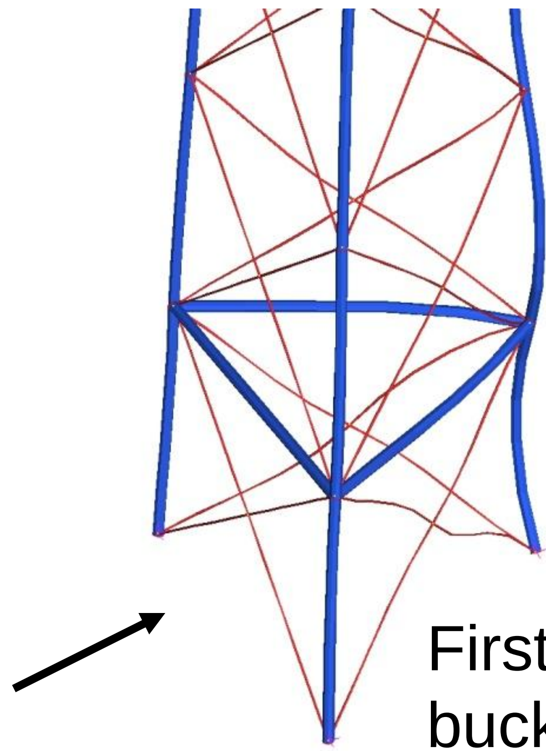
Same materials as for windmill towers

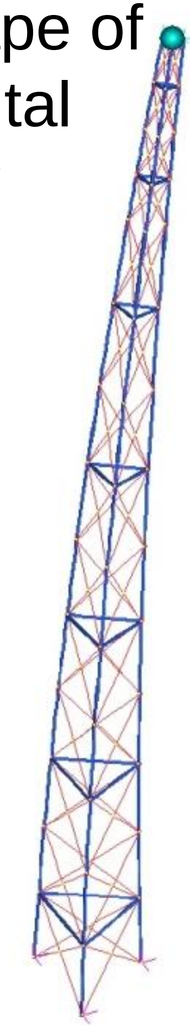
“*In the analysis of towers the largest uncertainty is an accurate knowledge of the wind loads. Highly sophisticated methods of analysis cannot improve this. A linear-static three-dimensional structural analysis is sufficient for almost all lattice tower structures*”, *Steel Designers Manual. Davison B, Owens GW (eds) The Steel Construction Institute, Blackwell Science, 2003.*

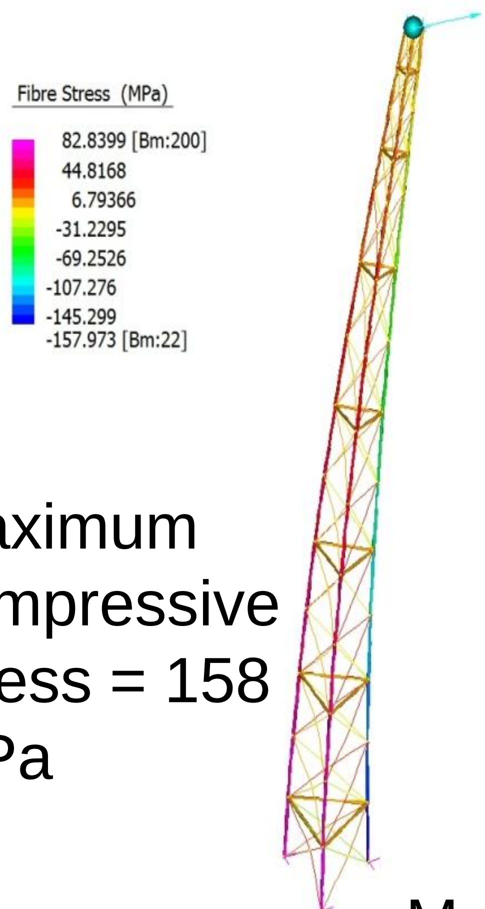
Need finite element linear static analysis (FEA) for a range of wind directions

Finite Element Analysis

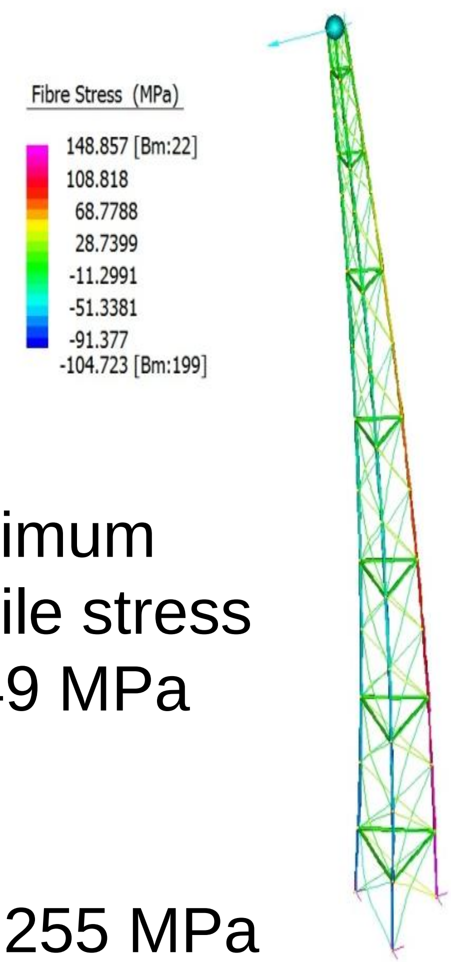








Maximum compressive stress = 158 MPa



Maximum tensile stress = 149 MPa

Material yield stress = 255 MPa

Buckling Calculations

Factor = load required for buckling/(maximum actual load)

1. Linear buckling factor from FEA = 4
2. ASCE (1990) guidelines factor ≈ 2
3. Eurocode 3 factor ≈ 2

The last two are empirical and so take some account of manufacturing defects

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Parameter	Monopole Tower	Lattice Tower
Mass (kg)	861	640
Natural Frequency (Hz)	0.84	2.53
Maximum blade passing frequency (1P) Hz	5.3	5.3
Turbine deflection at 52.5 m/s (m)	0.73	0.32

Conclusions

1. A lattice tower was designed to be built easily using existing facilities and materials for a two-bladed 5 kW wind turbine
2. Maximum tower stress =158 MPa. Material yield stress = 255 MPa. Tower is safe
3. Tower is safe from buckling
4. Tower is lighter and stiffer, and has higher natural frequency than monopole tower

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