Success with ModelSmart3D

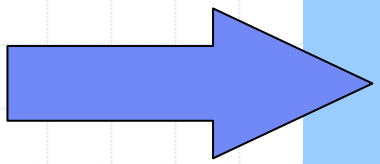
Pre-Engineering Software Corporation

Written by:

Robert A. Wolf III, P.E.

Tower - Show 1

Series Outline



Show # 1

I. Possible benefits

II. Introduction to towers

Show # 2

III. Model towers

IV. Using ModelSmart3D

V. Extra for Experts

Show # 3

VI. Optimization

VII. Printing

Show # 4

VIII. Building Your Model

I. Possible Benefits

1. Practical application for math and science.
2. Create a “feel” for engineering.
3. Foster innovation.
4. Re-label mislabeled students
5. Efficient method for experimenting

Motivation and Enhancement

II. Introduction to Towers

Why build a tower?

To support something or someone above ground level.

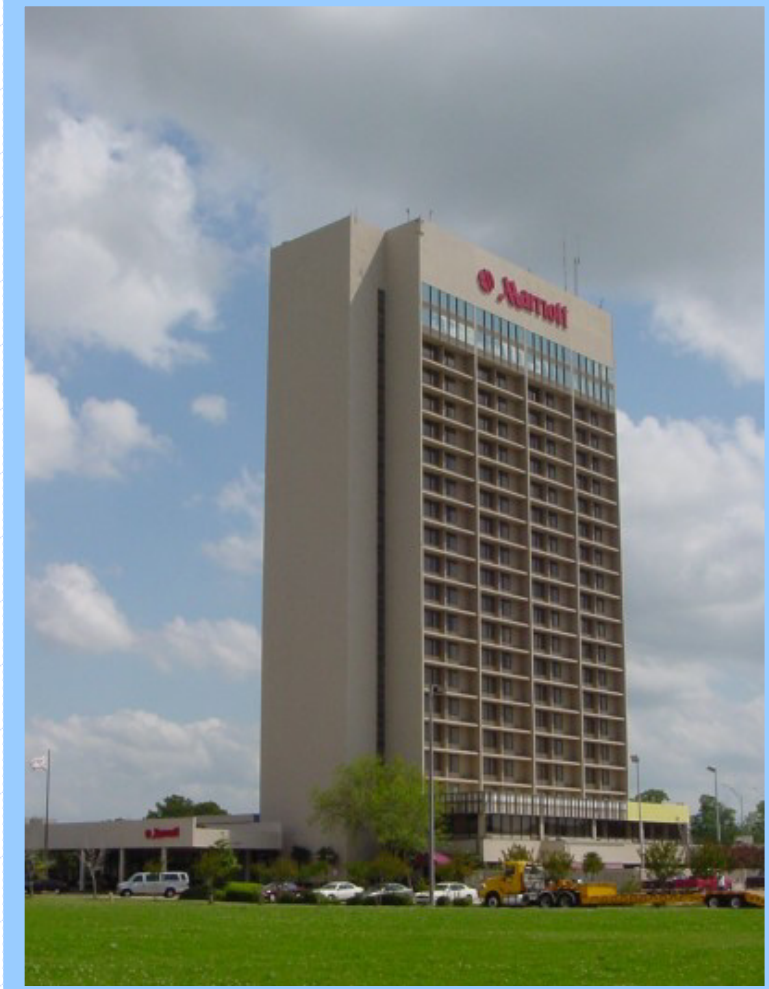
Example Towers

Observation

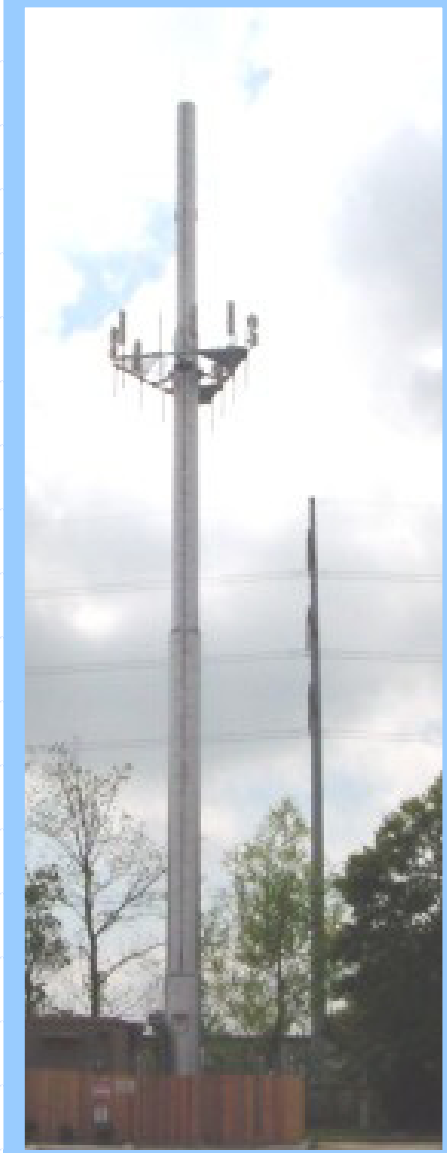
Radar

More Examples

Communications

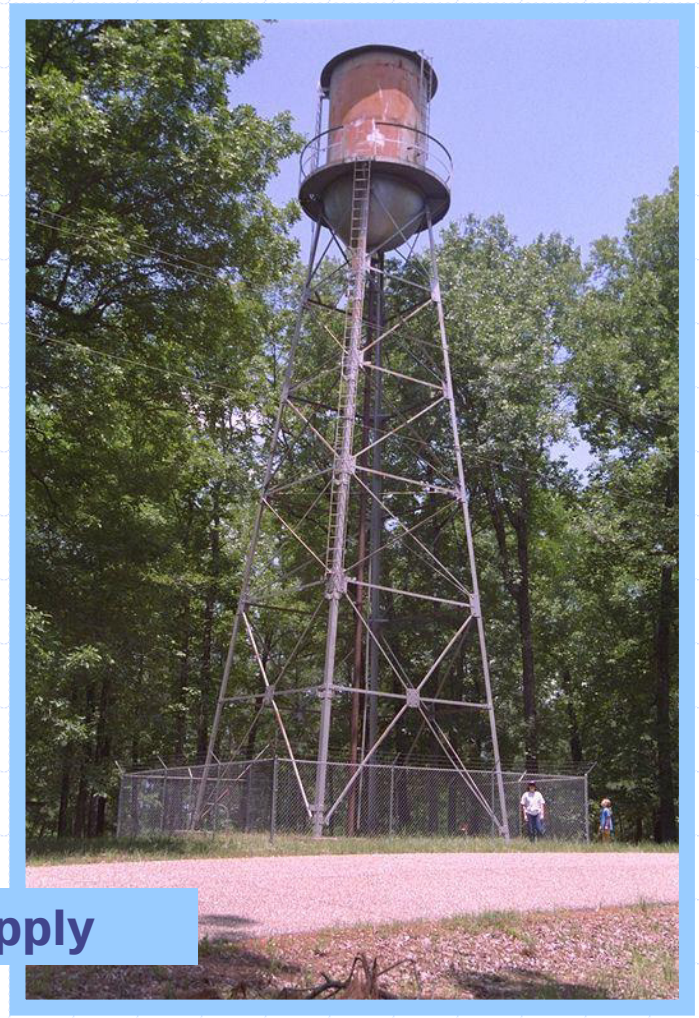


Hotel



Communications

More Examples



Water Supply

Definition

What is a tower?

It's a tower if $H \geq 3 \times W$

The Job of a Tower

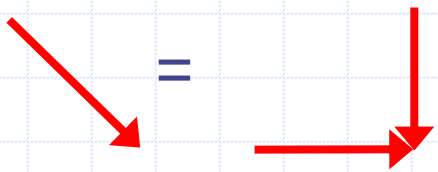
To safely support people, materials, and equipment at the design height.

Types of Loads on a Tower

Classified by Direction

- Vertical – Acting up or down 
- Horizontal – Acting left or right (also forward of back ward) 

(Diagonal forces can be resolved into vertical and horizontal components.)

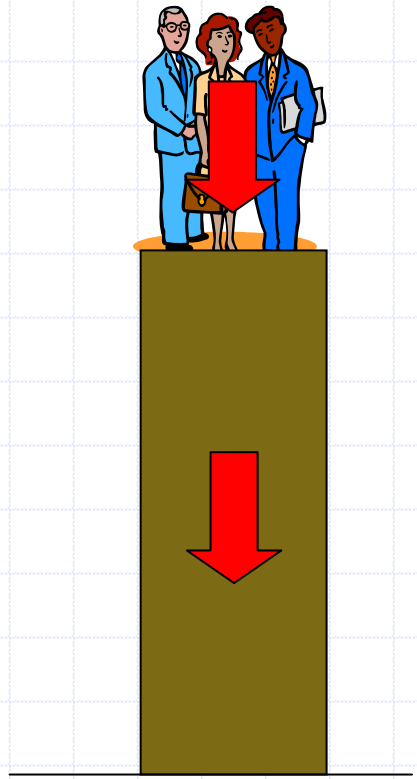


Vertical Load

Vertical (Gravity) Loads

- Dead Load – Immovable Materials (the structure's self-weight)

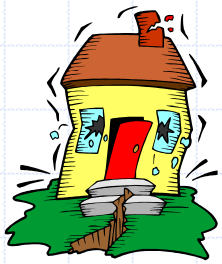
- Live Load – People and moveable things



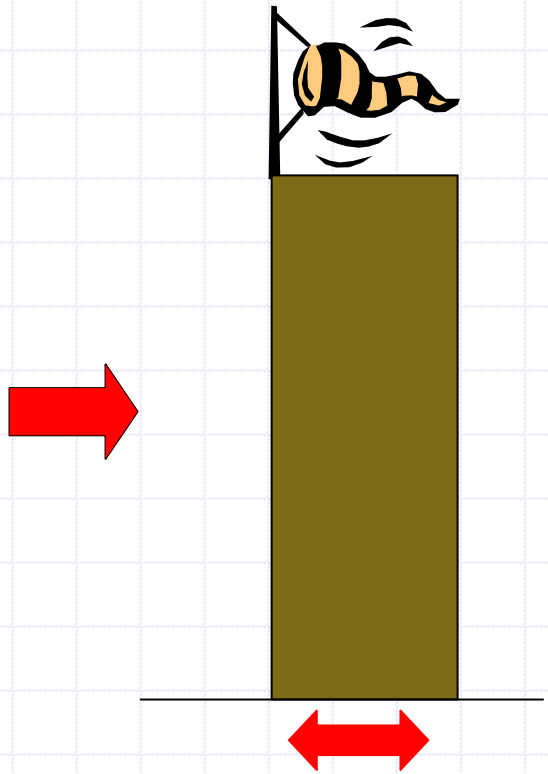
Horizontal Load

Horizontal (Lateral) Loads:

- Wind
- Earthquake



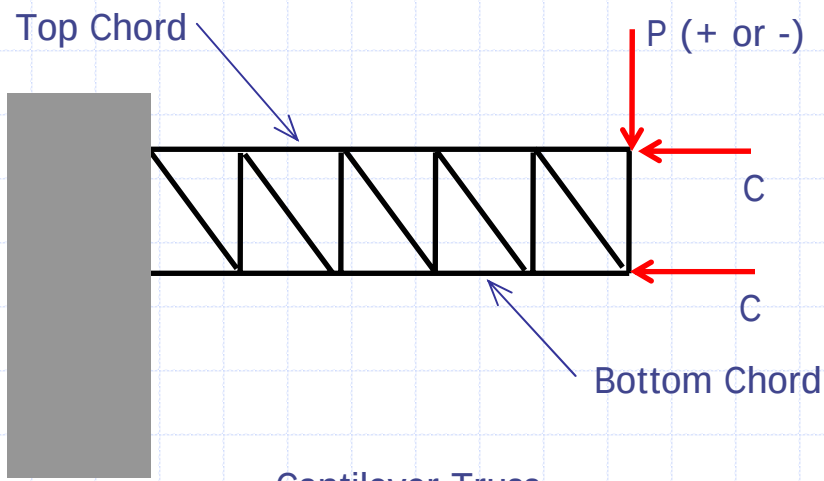
- Flowing water



Design Concept

The Cantilever Analogy

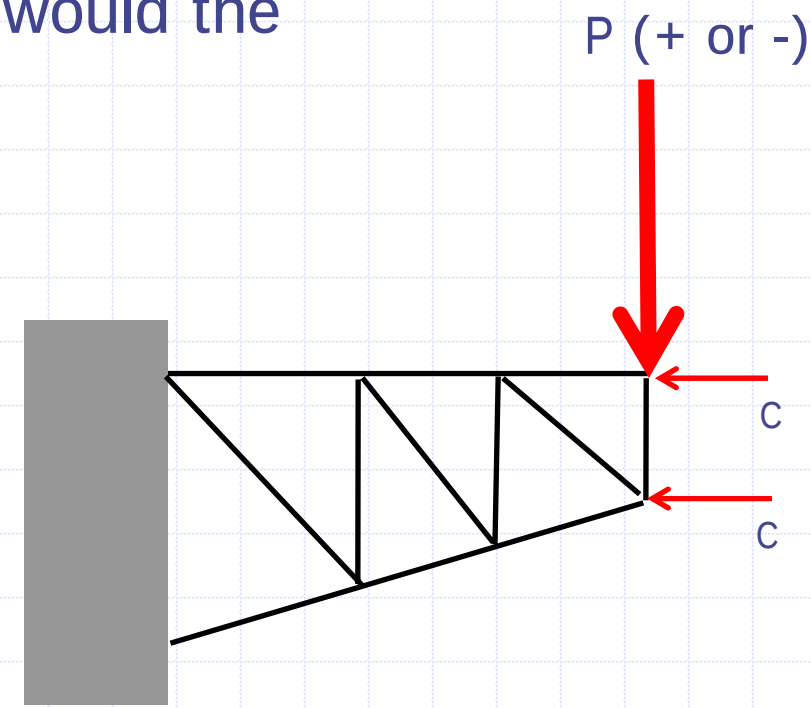
One way to think about a tower is by considering a cantilever truss with a vertical load (P) that acts up and down and horizontal loads (C) that cause compression in both the top and bottom chords.



Cantilever Truss

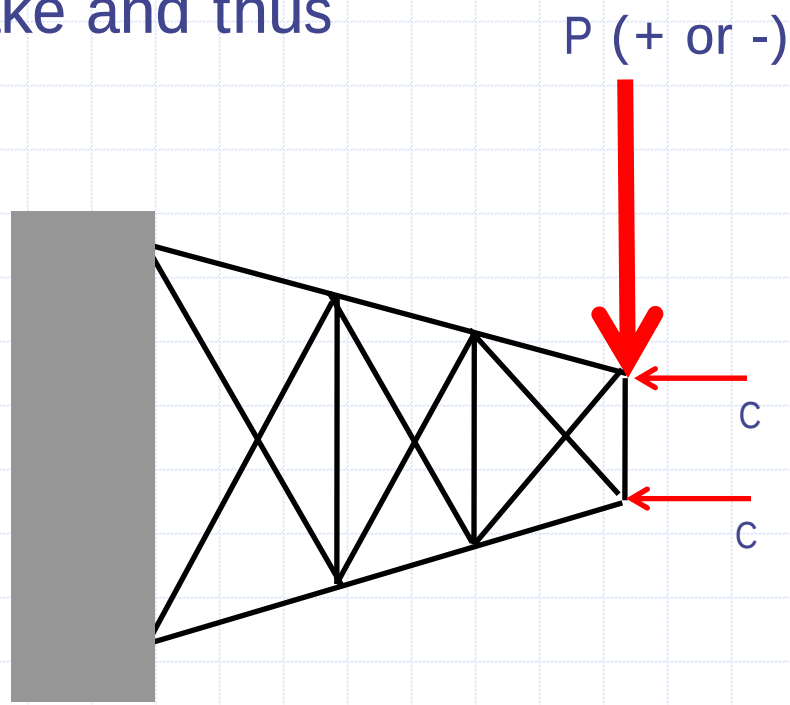
Which load is greater?

What if the vertical (lateral load if the tower was standing up) load was the greater load? What shape would the tower take?



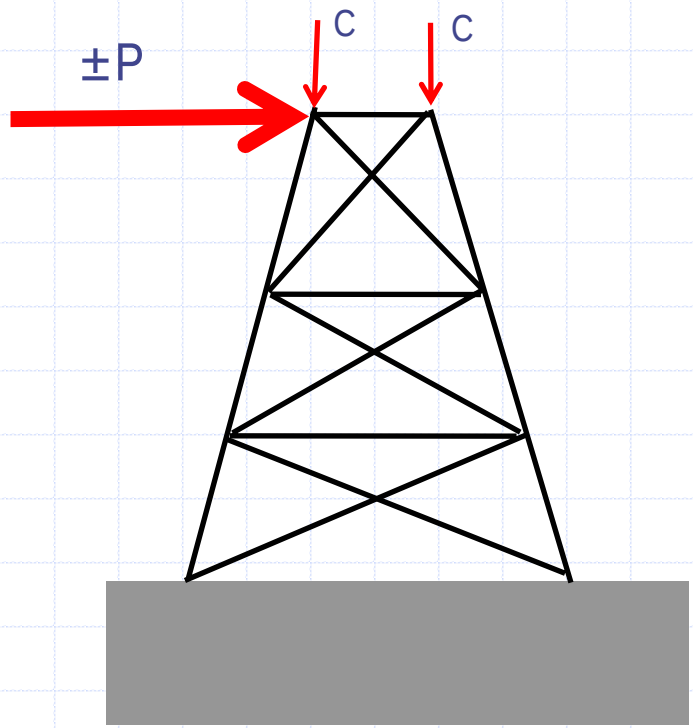
Wind Direction Varies?

Remember, we are really designing a tower and the “P” load might be a load caused by wind or earthquake and thus could act in either direction.



A Tower is Born?

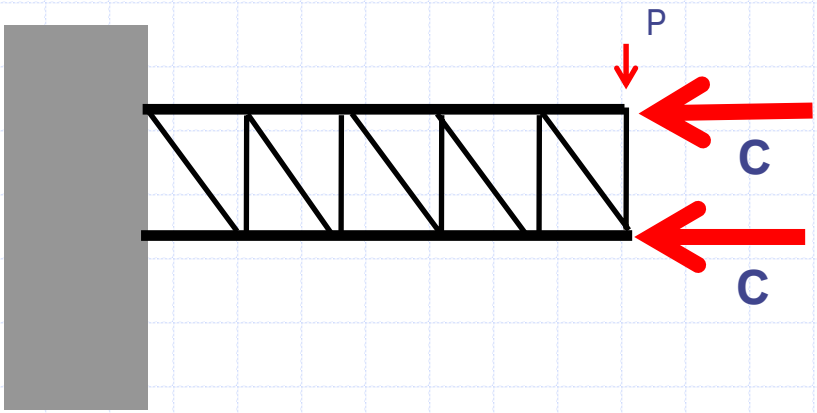
That looks like a tower!



Which load is greater?

What if the horizontal load was the greater load? What shape would the tower take?

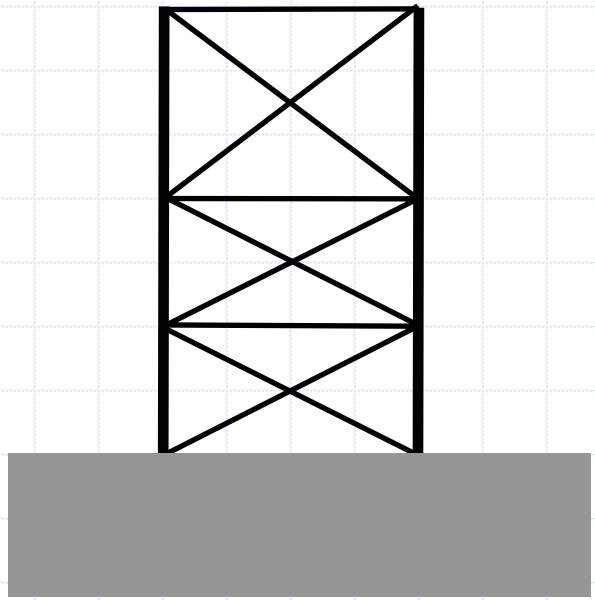
Chunkier Columns?



Column Size

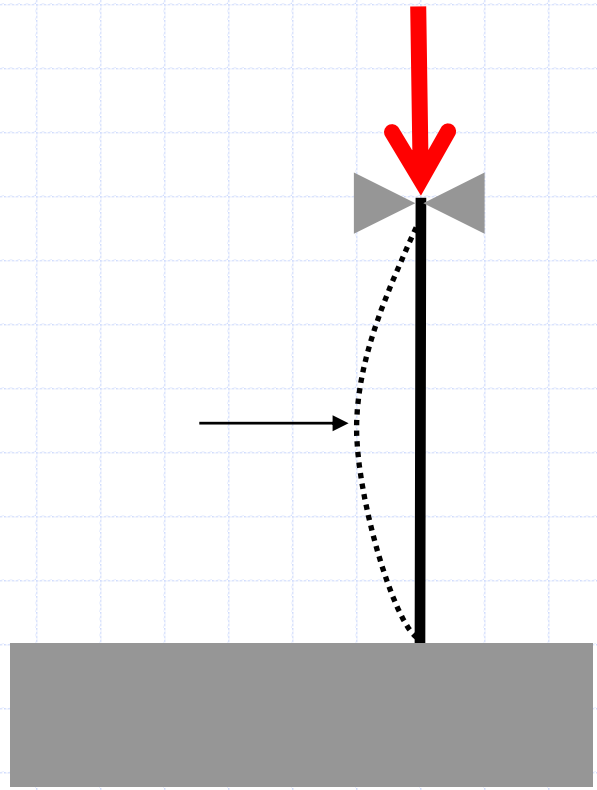
Usually there is a mix of lateral and vertical load.

Maybe we could widen it a bit to take care of the some lateral load and make the columns chunkier to take the vertical load.



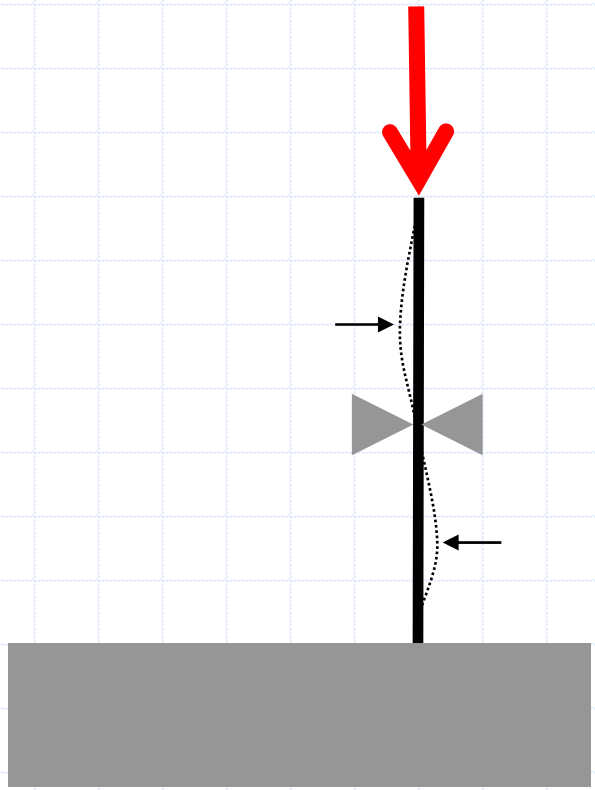
Getting the Most out of Your Columns

If your column is long it could buckle. Where might you hold it to keep it from buckling?



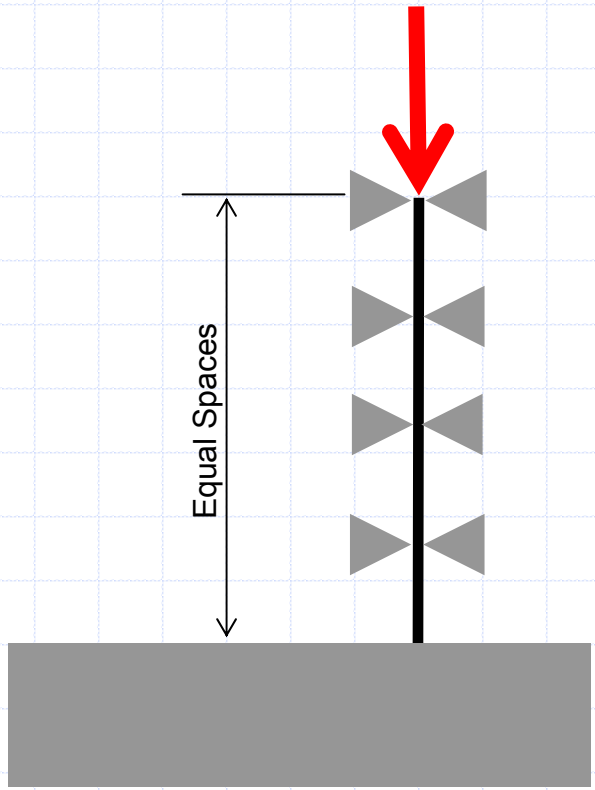
Secondary Buckling Mode

Now how do we keep it from buckling?



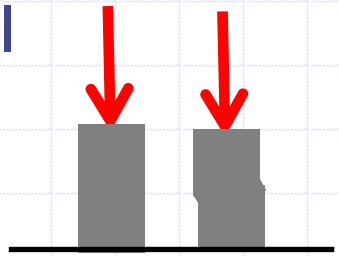
How Many braces Do We Need?

Each time we add the support midway between the existing (lateral) supports.



Column Failure Modes.

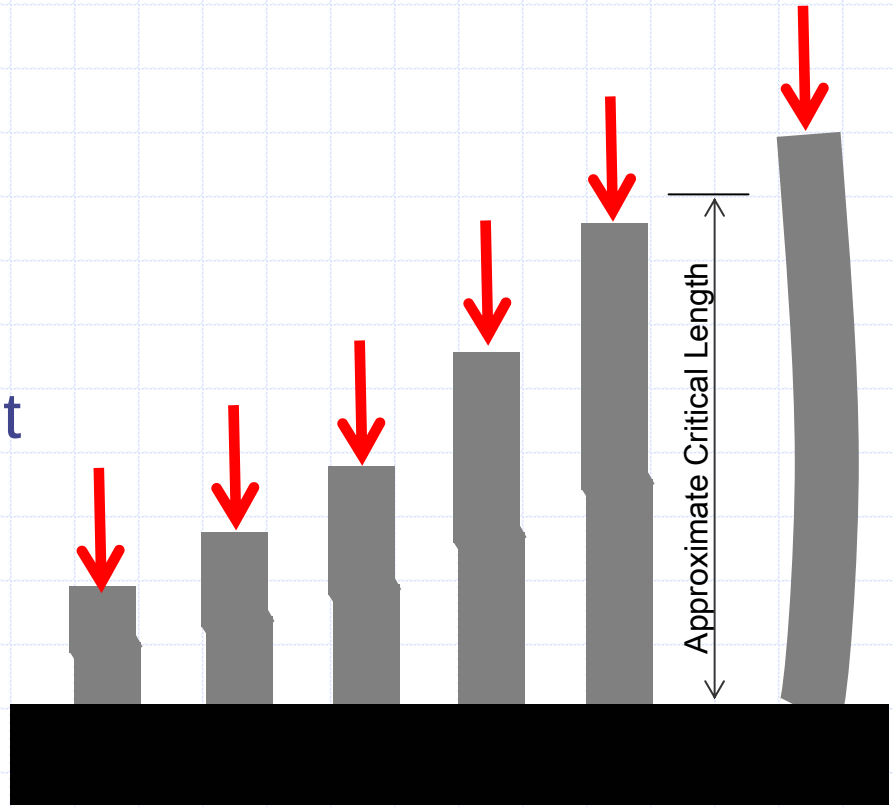
- Crushing of the material



- Buckling

A Column's Critical Unbraced Segment Length.

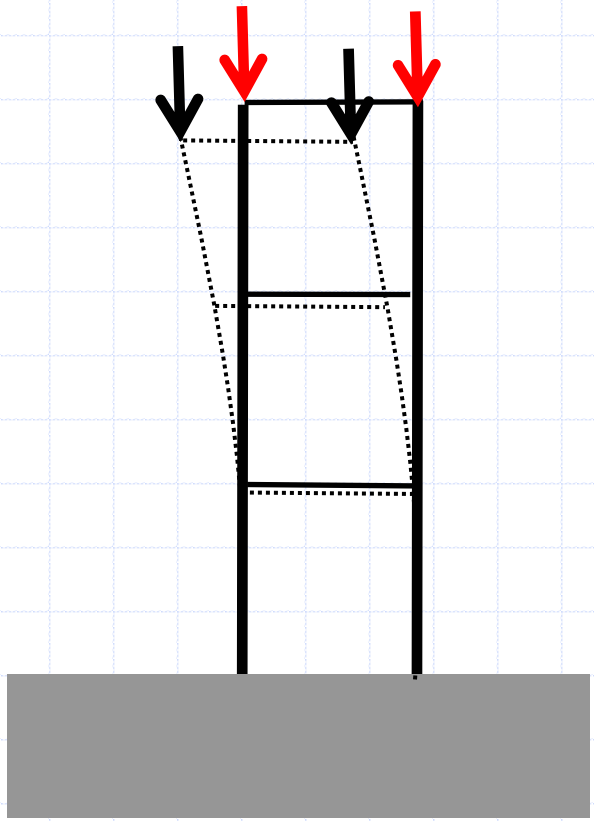
Start with a short column. Keep increasing its length until the mode of failure is by buckling. The critical length is the maximum length the column before it fails due to buckling.



Bracing the Column

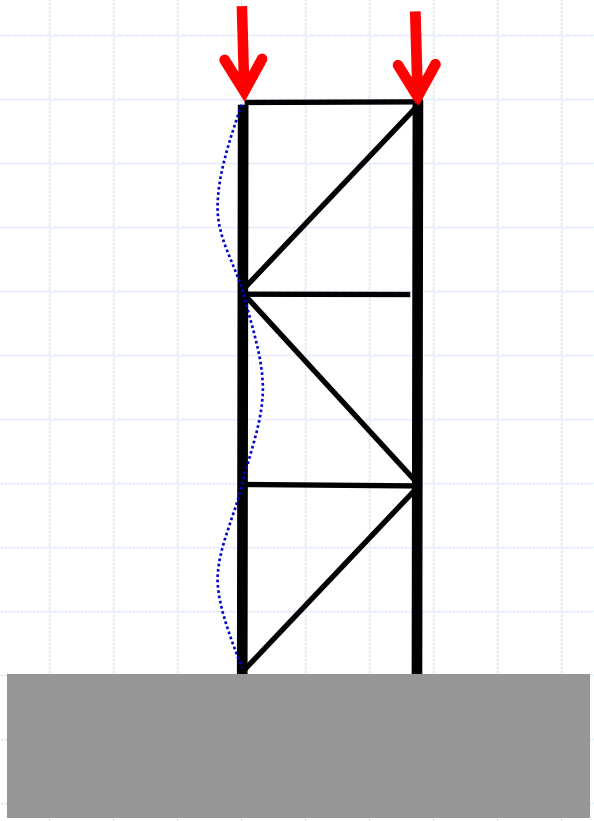
Provide bracing such that no column segment exceeds the critical length of the column?

Have I done that here?

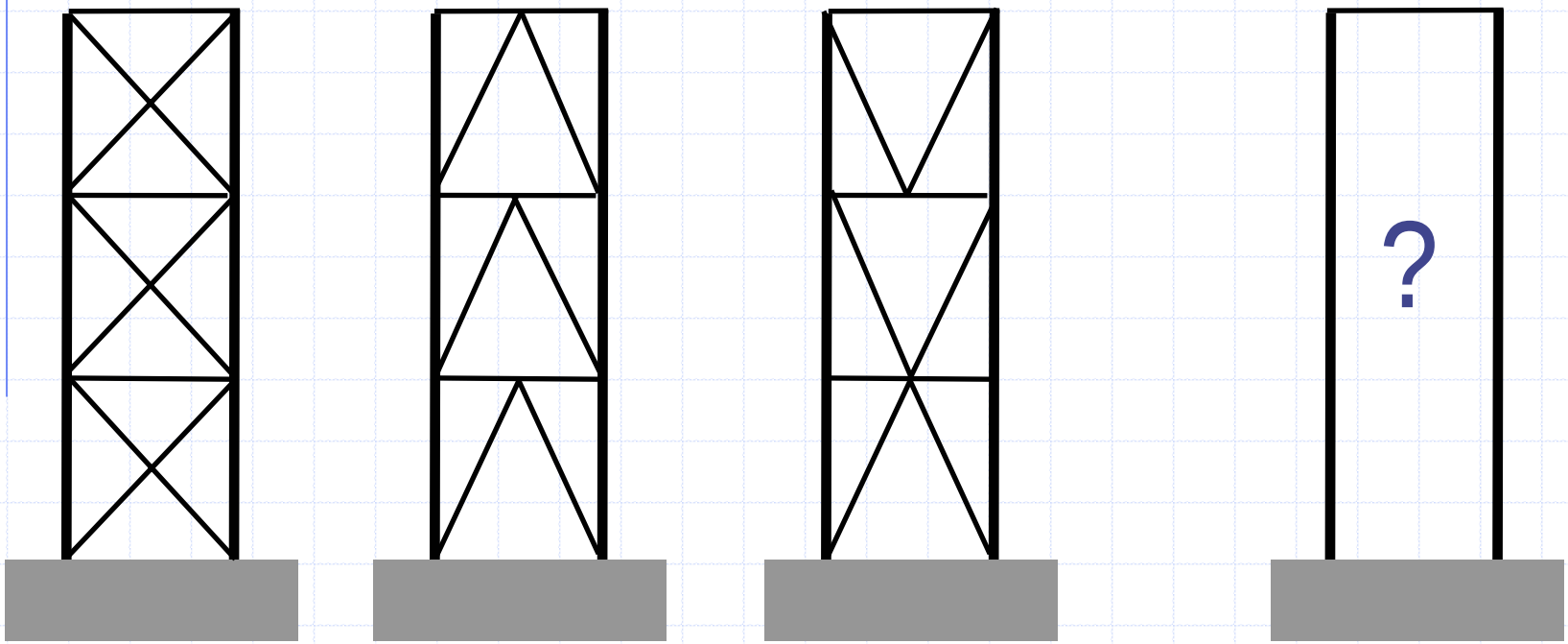


Use Diagonal Bracing

For stability against "sidesway" you might want to add diagonal bracing.



Other Diagonal Bracing Schemes



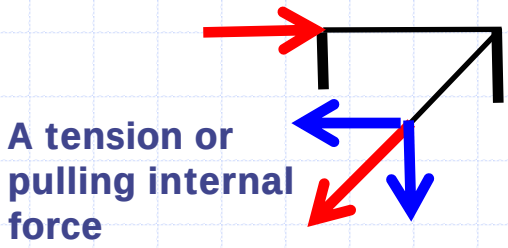
X- Braced

Inverted V

V with and Inverted V at base

Invent One !

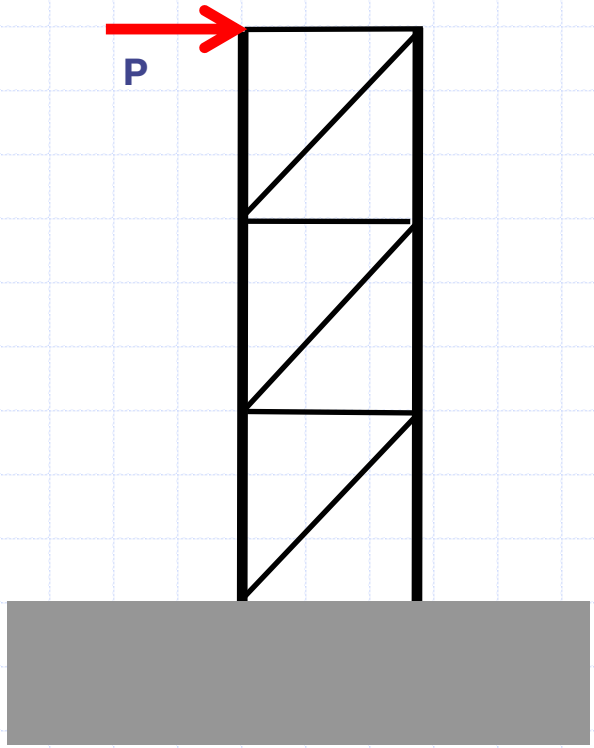
Designing the Lateral Braces



How do we design an optimal bracing configuration?

Let's assume the wind comes from the left.

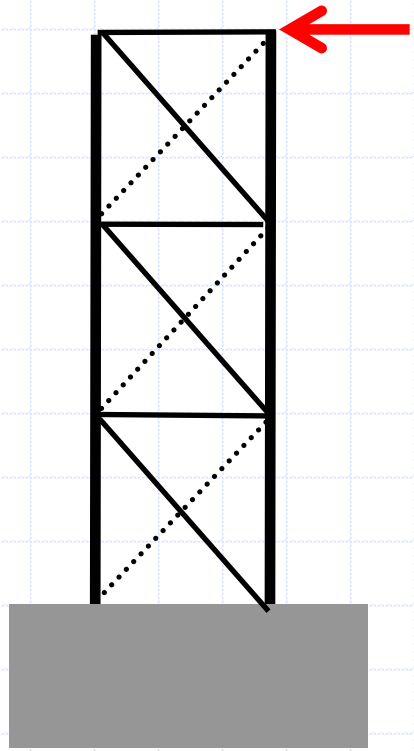
If the wind only came from the left, we could place the diagonals such that each bracing element was in tension.



Procedure for Designing X-Braces

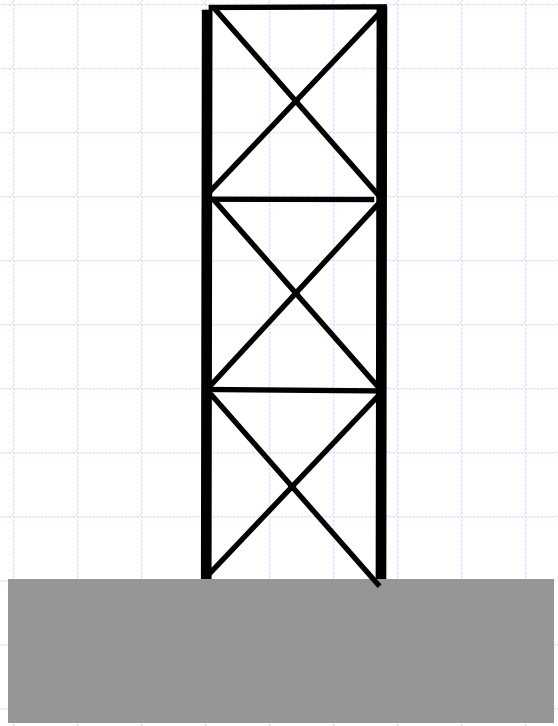
Design the diagonals to resist the tension created by the window coming from the left.

Reverse the direction of the wind and design tension bracing again neglecting the existing braces.



Why are X-Braced Towers so popular?

It is usually more efficient to design redundant tension bracing than to design a single element (member) that can act both as a tension brace and a compression strut.



End of Show 1 Series 2