End Station X & Y Seismic Isolation Investigation

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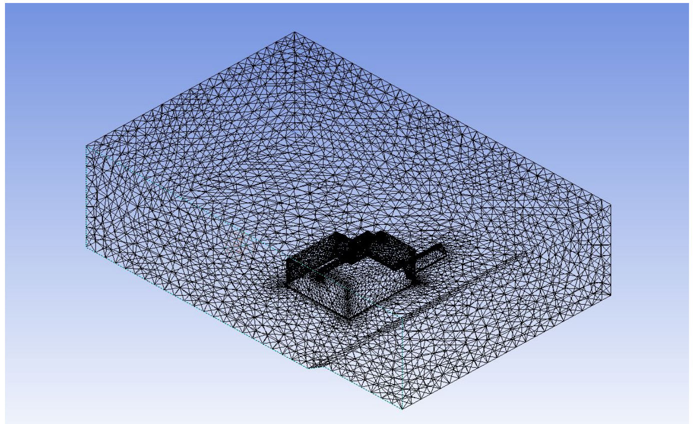
Problem Statement

Wind causes horizontal-tilt coupling on seismic slab

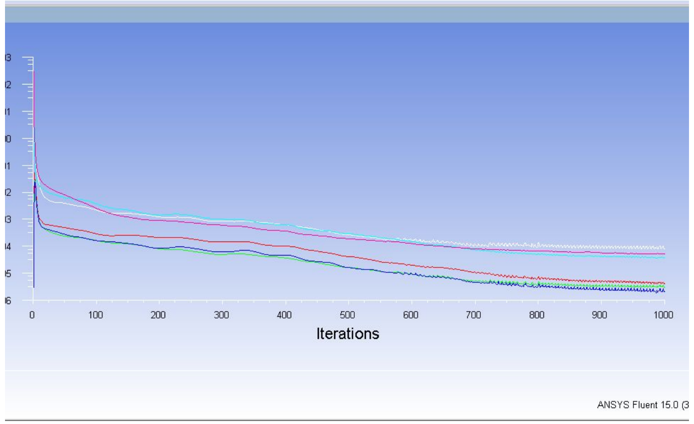
- Will a fence reduce the speed of the wind?
- Does the current test fence make a difference?
- Will a larger fence be more effective?

General Method

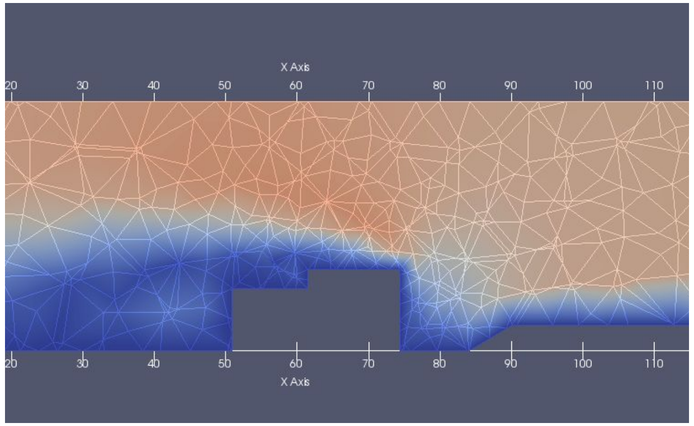
1) Hand/Matlab calculations



2) Meshing the fluid domain



3) Numerical Solution

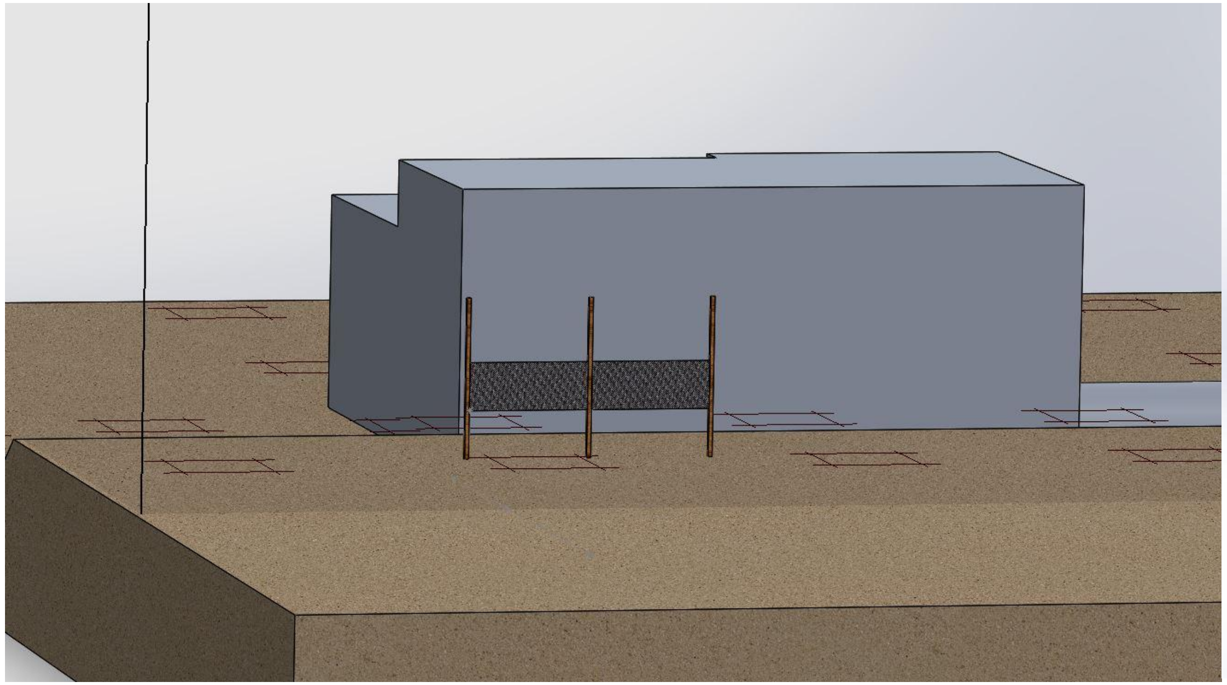


4) Visualization & Validation

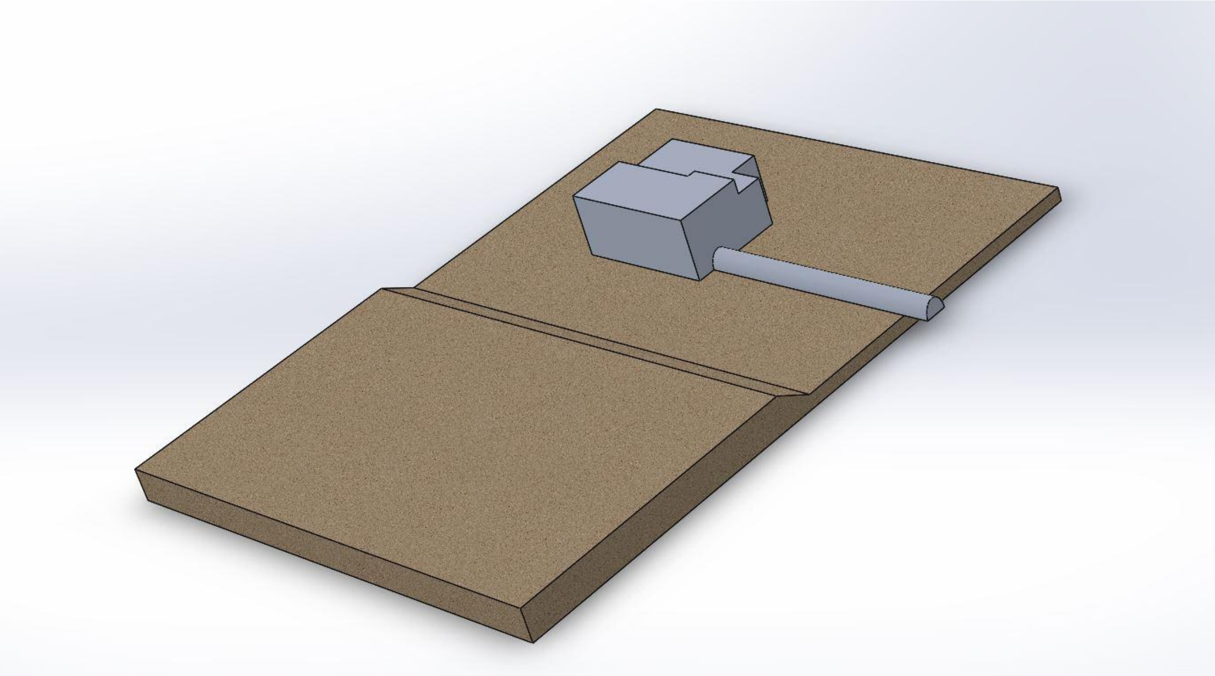
SOLIDWORKS Flow Simulation

More like Solid-doesn't-works

First Model



Computational domain outline + fence



Assembly sans fence

Input Parameters

- 10 m/s steady wind (air)
- 10% turbulence
- Characteristic length ~60ft (side of the building)
- Inviscid on ground
- 50% porosity fence
- Time-dependent

First Results

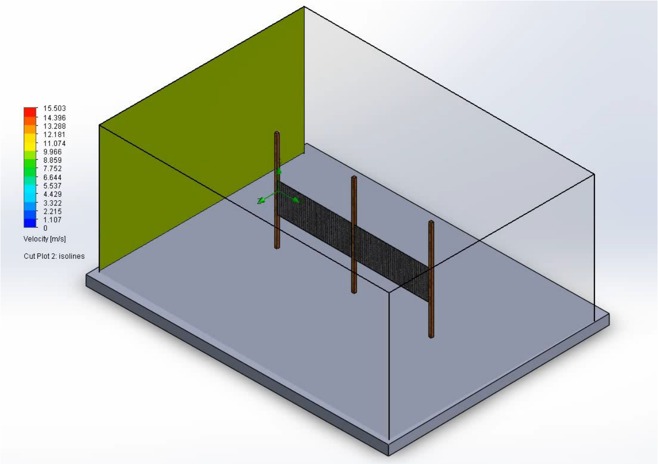
- Only solved 6s (out of 60s)
- Computational domain = too large
- Mesh resolution = too fine
- ~600 Gb of simulation data for 6s

Steady State Attempt

- Inputs:
  - Medium resolution mesh
  - 10% turbulence & characteristic length of 60ft
  - 50% porosity fence
- Results:
  - 3 hour runtime
  - Pretty animations
  - Solidworks failure to see fence

Fence Validation

- Need to revalidate porous media(!!)
- It worked with the fence alone - not with whole sim



- Called Solidworks for help, not helpful

ANSYS Fluent

More options, more problems

Fluent

- Decided to go with the ANSYS solver instead
- Requires more input parameters
    - Need to mesh your own model
    - Setup your solver models and constants
    - Use a different visualizer - Paraview (because Fluent's sucks)

Model & Convergence

Porous Media

In laminar flows through porous media, the pressure drop is typically proportional to velocity

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Assumptions:

- Porous media is an added momentum sink
- Volume blockage is not physically represented
- Effects of porous medium on turbulence is approximated

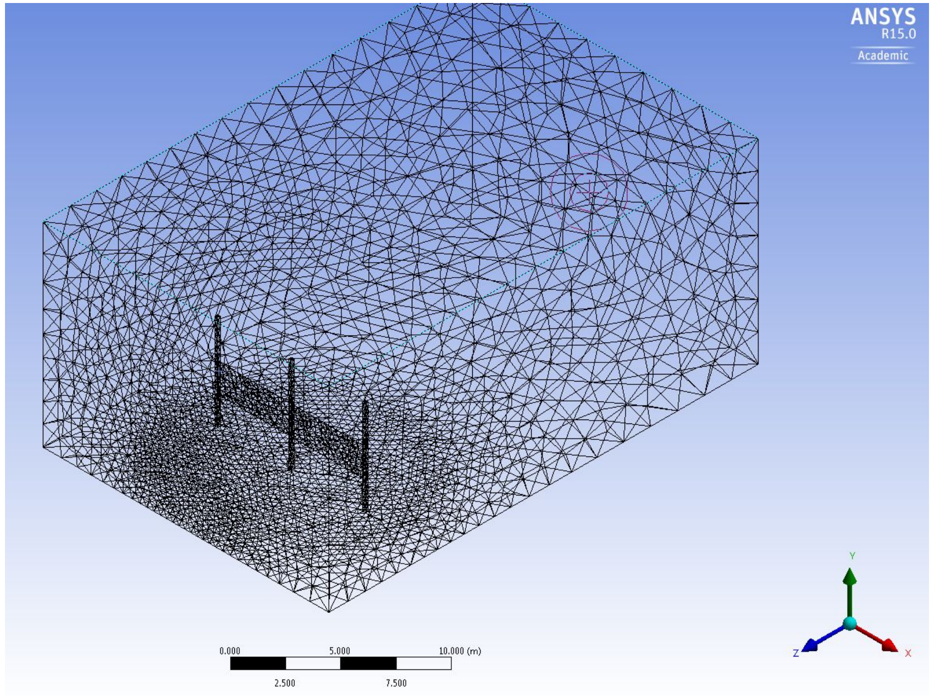
Porous Media

Turbulence in the medium is treated so porous media has no effect on generation or dissipation rates

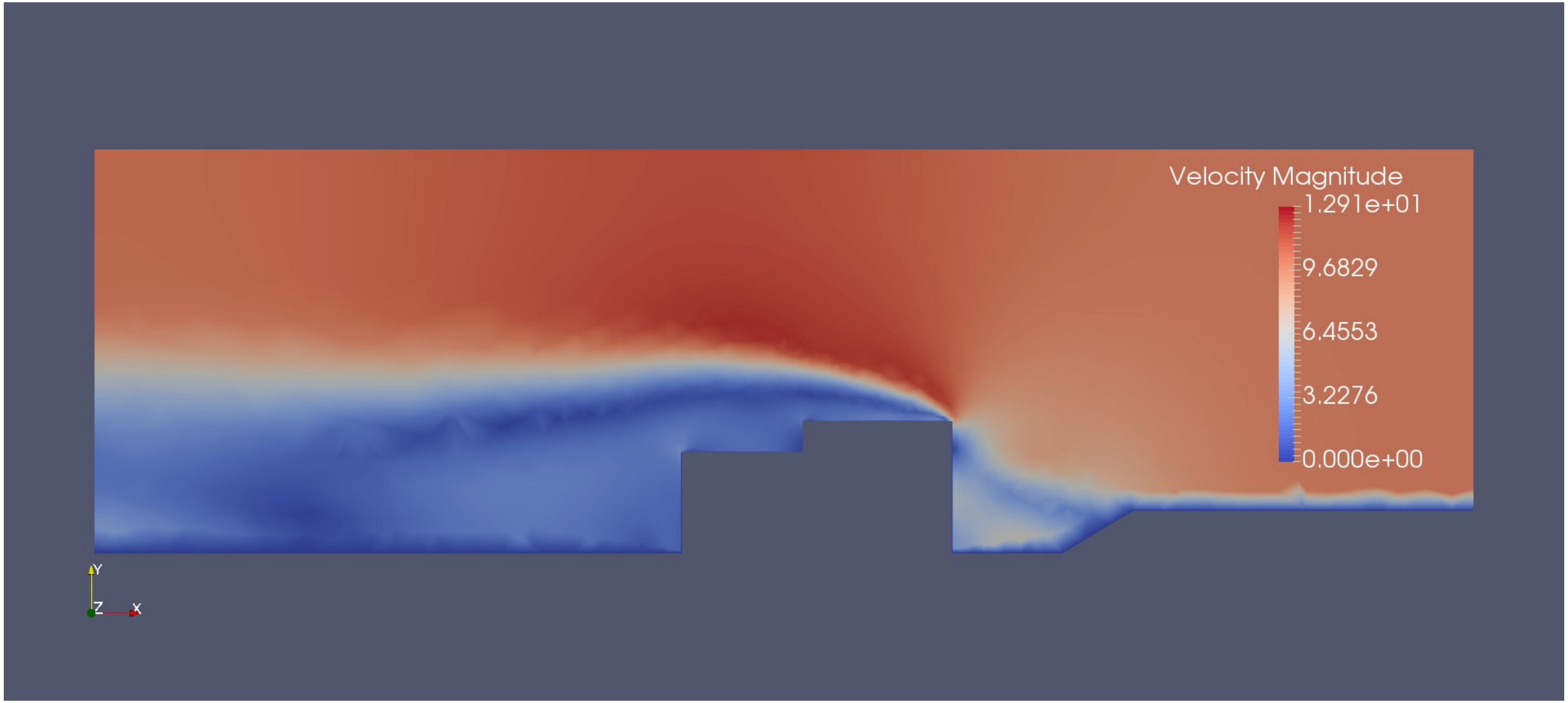
OR

Fluent can suppress any turbulent effects by creating completely laminar flow through

Fluent Fence Validation



Simulation without fence



Full Simulation

The Future

Next Steps

- ~~Figure out why Solidworks is not seeing fence~~
- Compare real data from test fence to validate model
- Add longer fence for comparison

Questions?

Or comments

Turbulence Modeling

The nitty-gritty details

Turbulence Models

Direct Numerical Simulation (DNS)

Large Eddy Simulation (LES)

Reynolds Averaged Navier-Stokes Simulation (RANS)

DNS

- Simulates the entirety of Navier-Stokes (NS) down to Kolmogorov microscales
- Extremely time & computationally expensive
- Not useful for engineering/industrial flows

LES

- Low-pass filter to avoid calculating microscale effects
- Less time & computationally expensive than DNS
- Still a bit too much for what we need

RANS

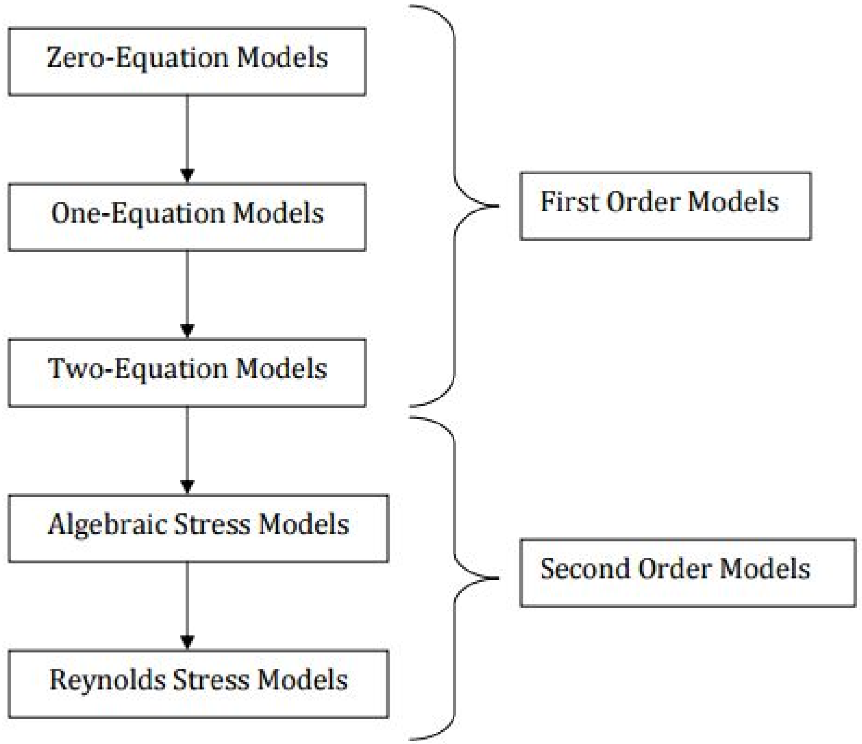
- Averages out the fluctuating turbulence term in NS
- Industry standard for CFD
- Many different models exist within RANS since averaging causes a closure problem
- Chose this model for our numerical solver

Closure Problem in RANS

- NS is a nasty, non-linear, 3D, time-dependent, chaotic PDE
- Averaging creates ~10 new unknowns
- Solving for all variables with fewer equations = closure problem
- Must introduce other methods to close problem

fluxes as a guide to modeling. The turbulent models are as follows, in order of increasing complexity:

- Algebraic (zero equation) models: mixing length (first order model)
- One equation models: k-model, μ_t-model (first order model)
- Two equation models: k-ε, k-kl, k-ω^2, low Re k-ε (first order model)
- Algebraic stress models: ASM (second order model)
- Reynolds stress models: RSM (second order model)



Industry Standards

Spalart-Allmaras (1st order) - Low Reynolds number model; good with adverse pressure gradients; used in turbomachinery & aerospace

k-ε (2nd order) - used for industrial flows; does not like large adverse pressure gradients; useful for bluff bodies

k-ω (2nd order) - most often used in aerospace applications; deals well with adverse pressure gradients