Design Strategies for Bridges in Low to Moderate Seismic Zones

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Objectives

- Develop systematic strategies to ensure adequate seismic performance
- In many instances, seismic performance can assessed using more simplified modeling techniques

Discussion Topics

- Performance Goals
  - AASHTO Specifications
  - AASHTO Guide Specifications
- Bridges in Moderate Seismic Zones
  - BEN4 Ramp Bridge, Las Vegas
  - Lake Mead SB Bridge, Las Vegas
  - East ParkCenter Bridge, Boise

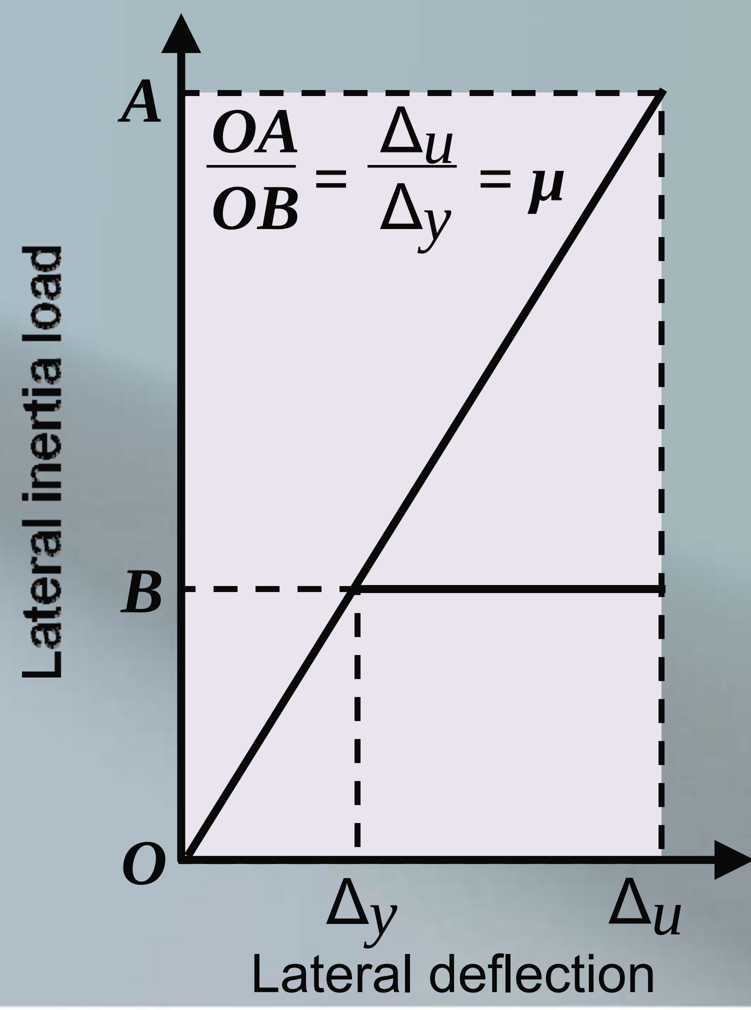
AASHTO Specifications

- Force Based Design
- Performance objective
  - Design Capacity > Elastic Seismic Demand
- Modify Elastic Seismic Demand with "R" factor which is an indicator of ductility

AASHTO Specifications

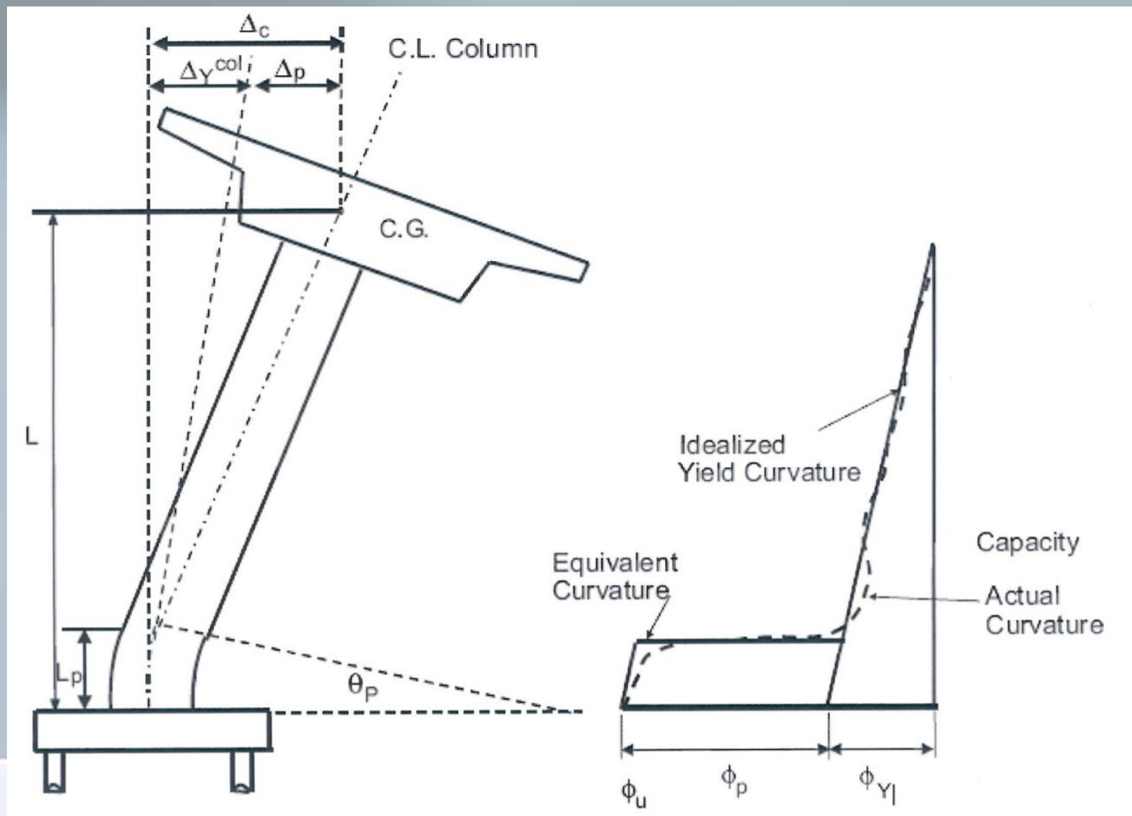
- Response modification factor

$$R = \frac{F_A}{F_B}$$



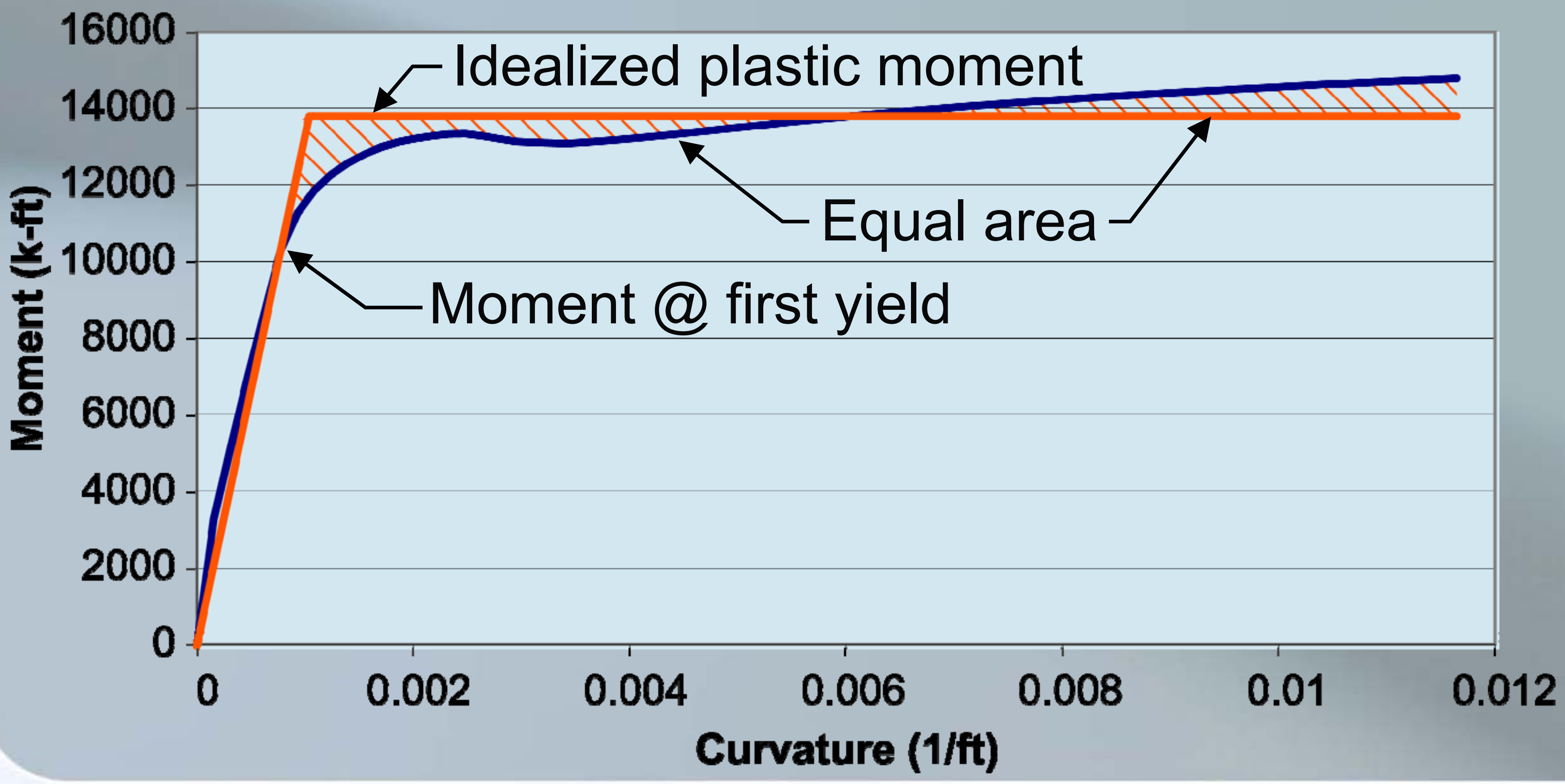
Guide Specifications

- Displacement Based Design
- Prescribed member ductility factor to estimate displacement capacity



Guide Specifications

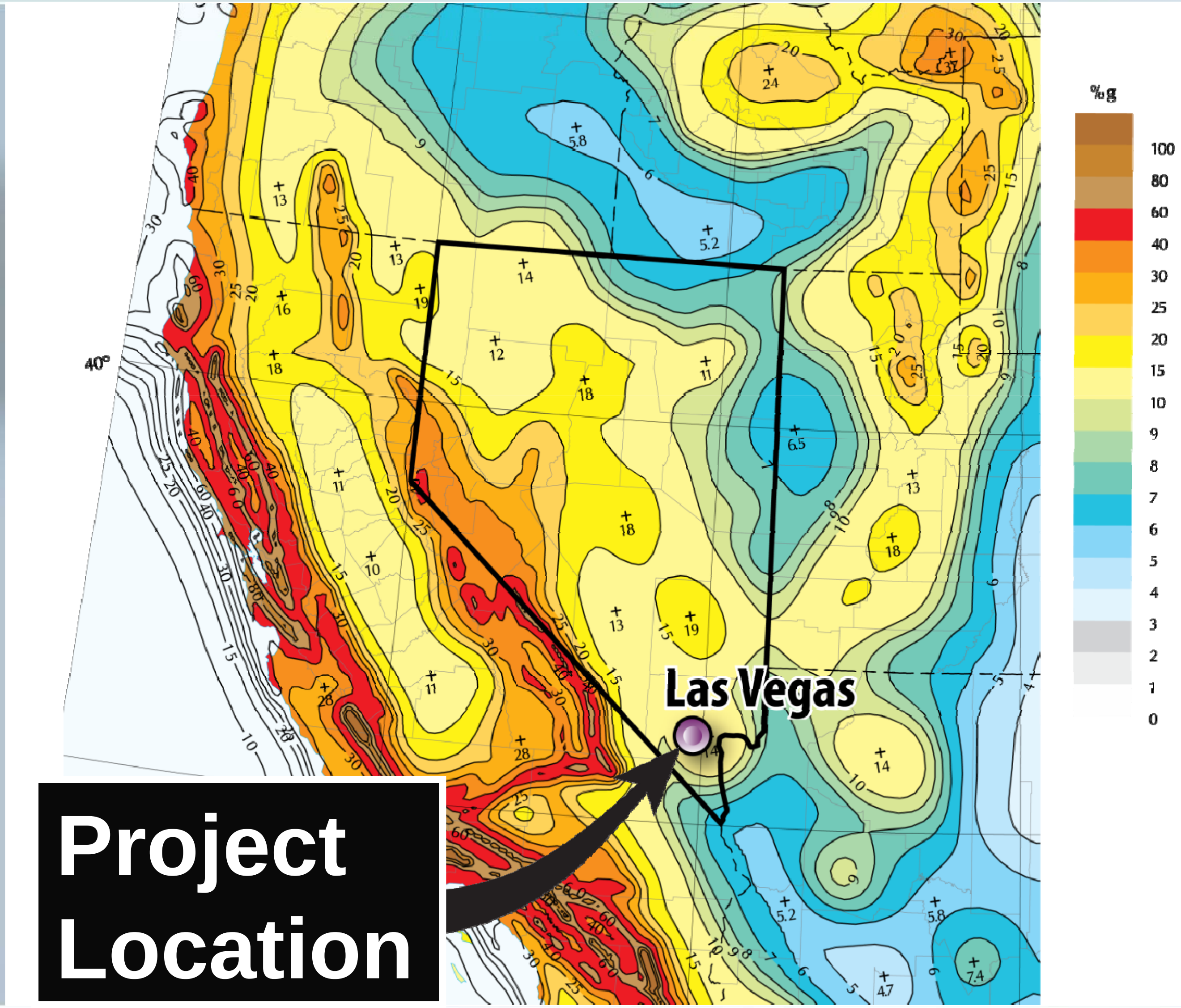
- Verify displacement capacity with Moment Curvature Analysis or equation



Interstate 15 Bridges

- BEN4 Ramp Bridge
- Lake Mead SB Bridge

Location


Las Vegas
Project Location
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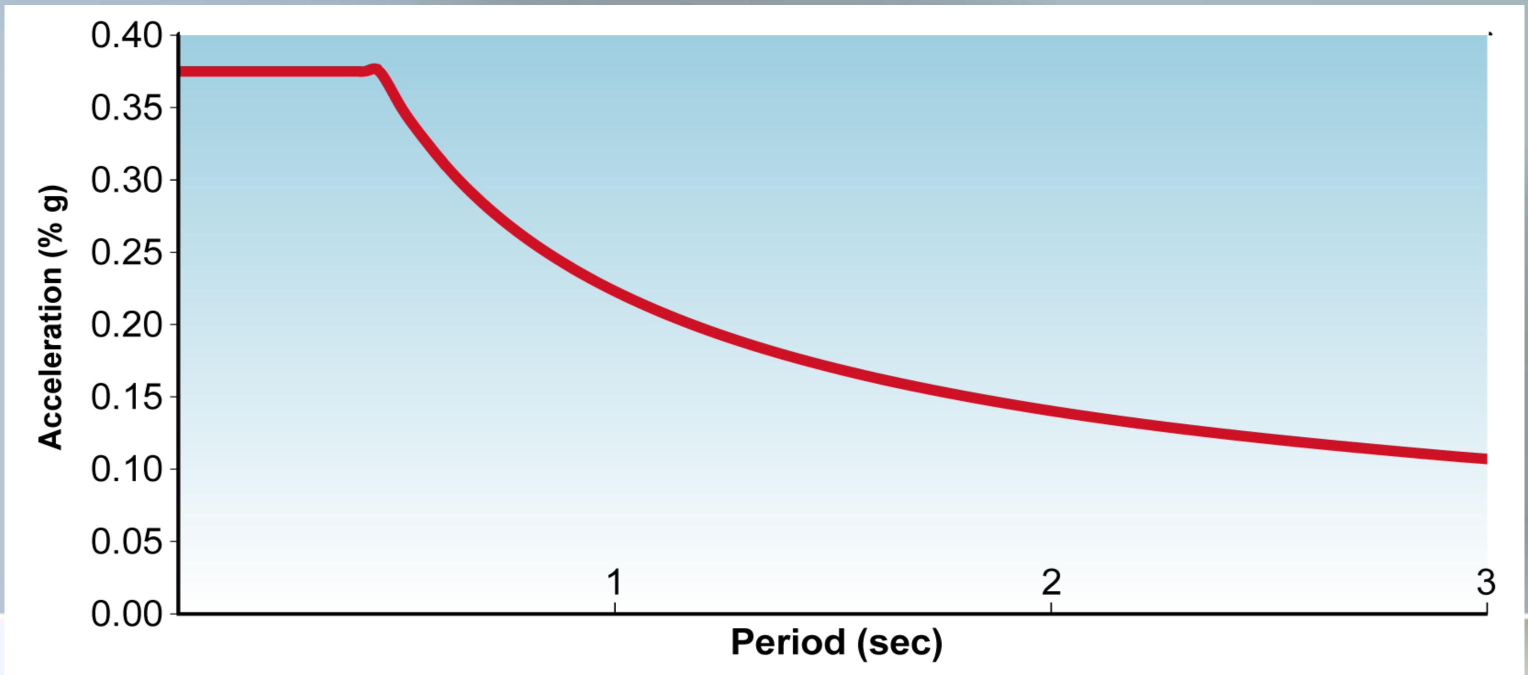
Seismic Design Parameters

- AASHTO Response Spectrum
- Peak bedrock ground acceleration, 0.15g
- Site coefficient, 1.2
- Importance factor, 1.0



Performance Goals

- Designed in accordance with *AASHTO Standard Specifications, 17th Edition*
- Elastic Shaft Response
- “R” factors
  - BEN4: R = 3
  - Lake Mead: R = 5

Seismic Design Strategy

- Strategy 1) Fixed base model and free to translate at abutments.
- Strategy 2) Use a reasonable pier foundation element. Free to translate at abutments.
- Strategy 3) Iterate pier foundation springs and abutment springs.

BEN4 Ramp Bridge

BEN4 Ramp Bridge

- Post tensioned box girder superstructure
- 114 ft, 152 ft and 109 ft spans
- 29 ft wide
- No skew
- Horizontal curve with radius = 1200 ft

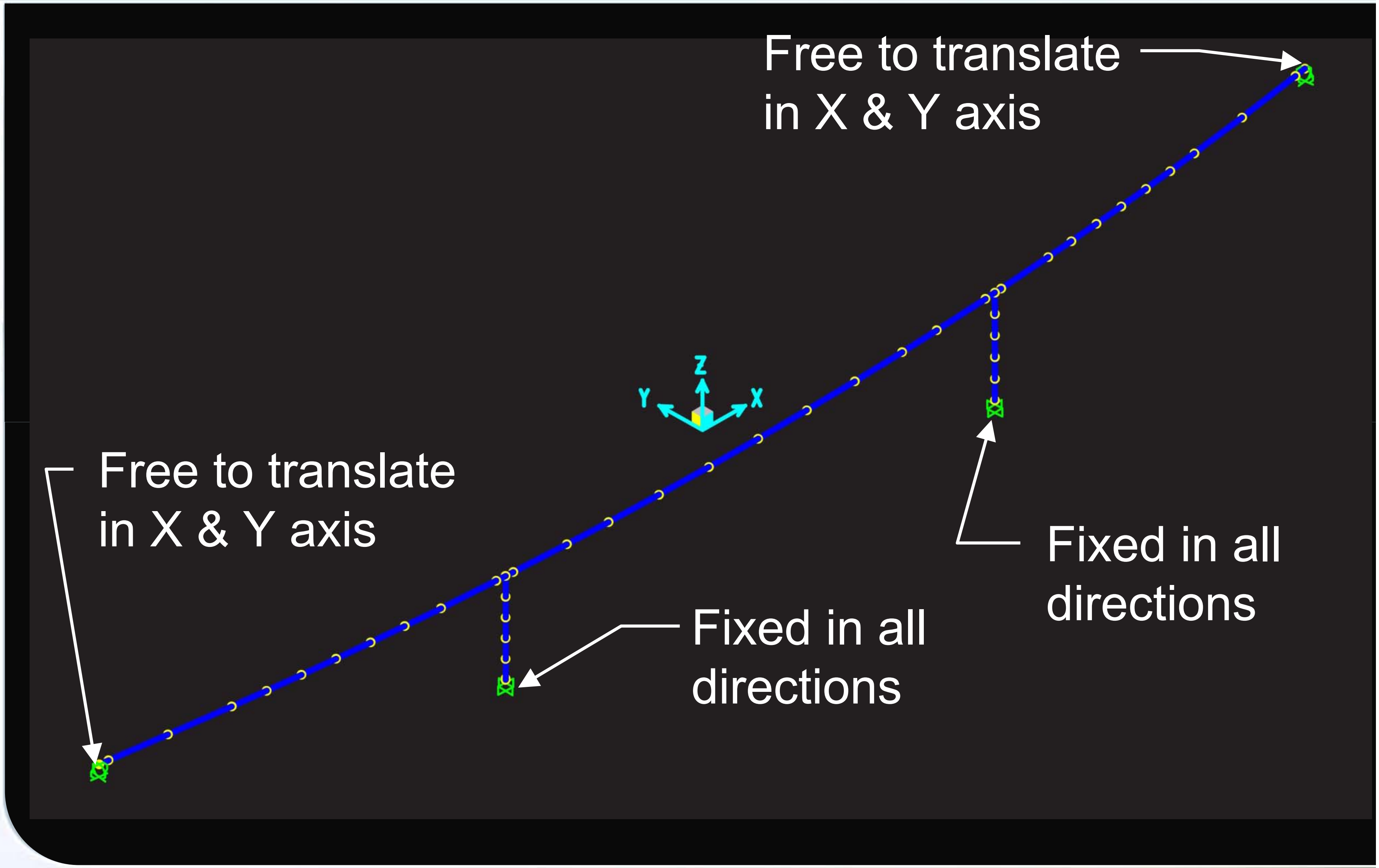
Abutments 1 and 2

- Seat abutment, fixed in transverse direction
- Supported on three cast in place drilled shafts (3 ft diameter)

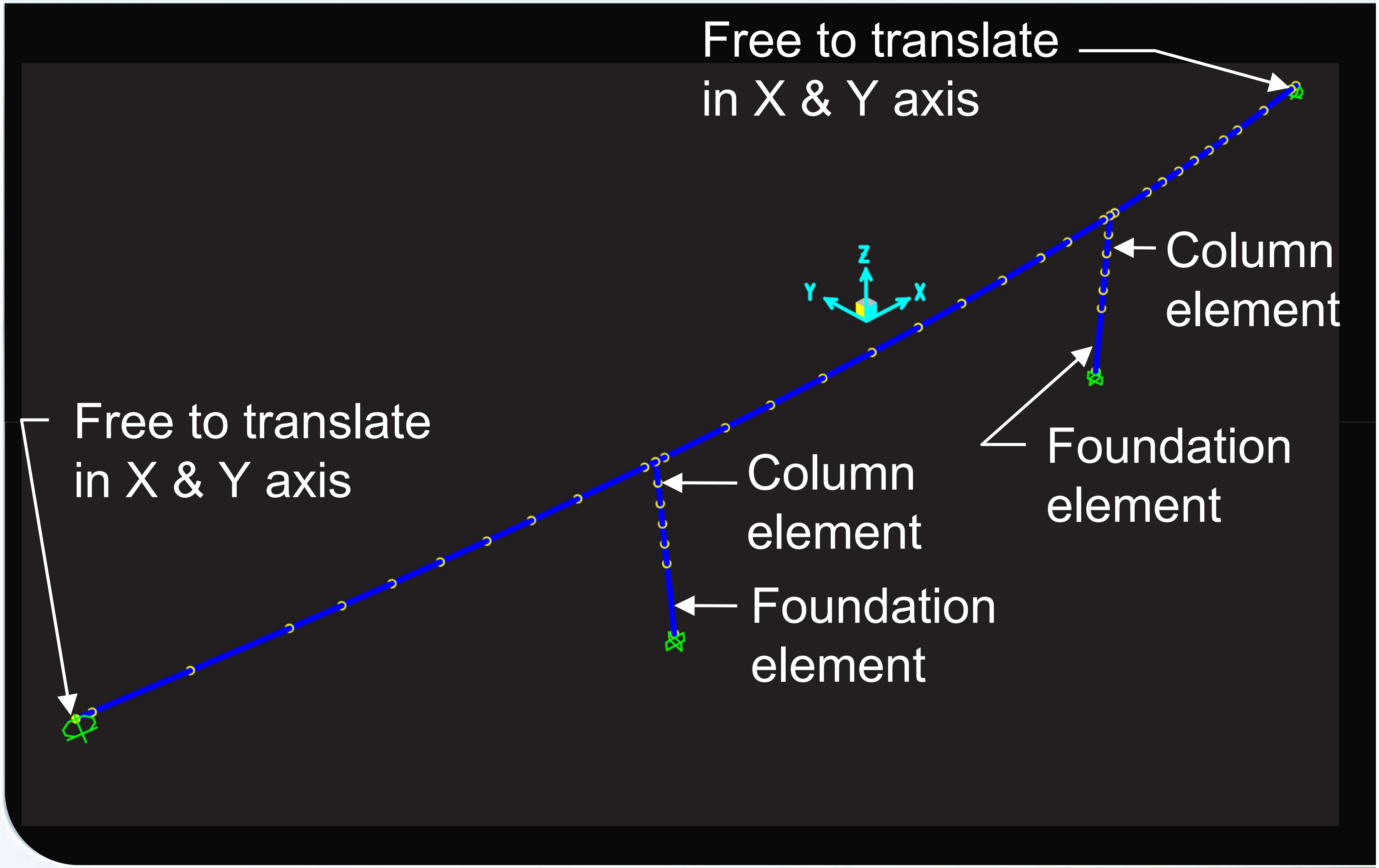
Piers 1 and 2

- 5 ft – 6 in octagonal single column
- Approximately 21 ft high columns
- Founded on five cast-in-place drilled shafts (5 ft diameter)

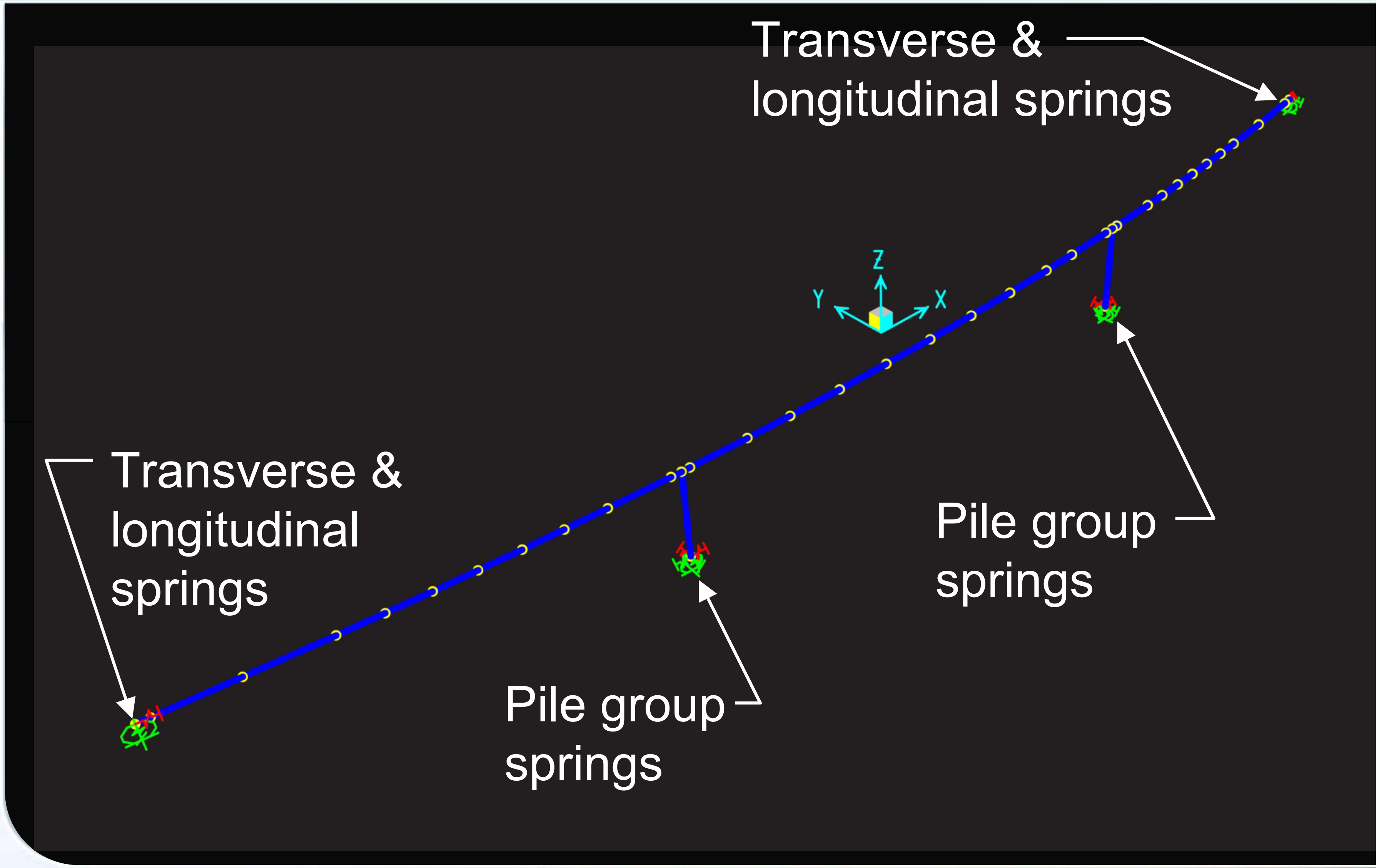
Seismic Model - 1



Seismic Model - 2

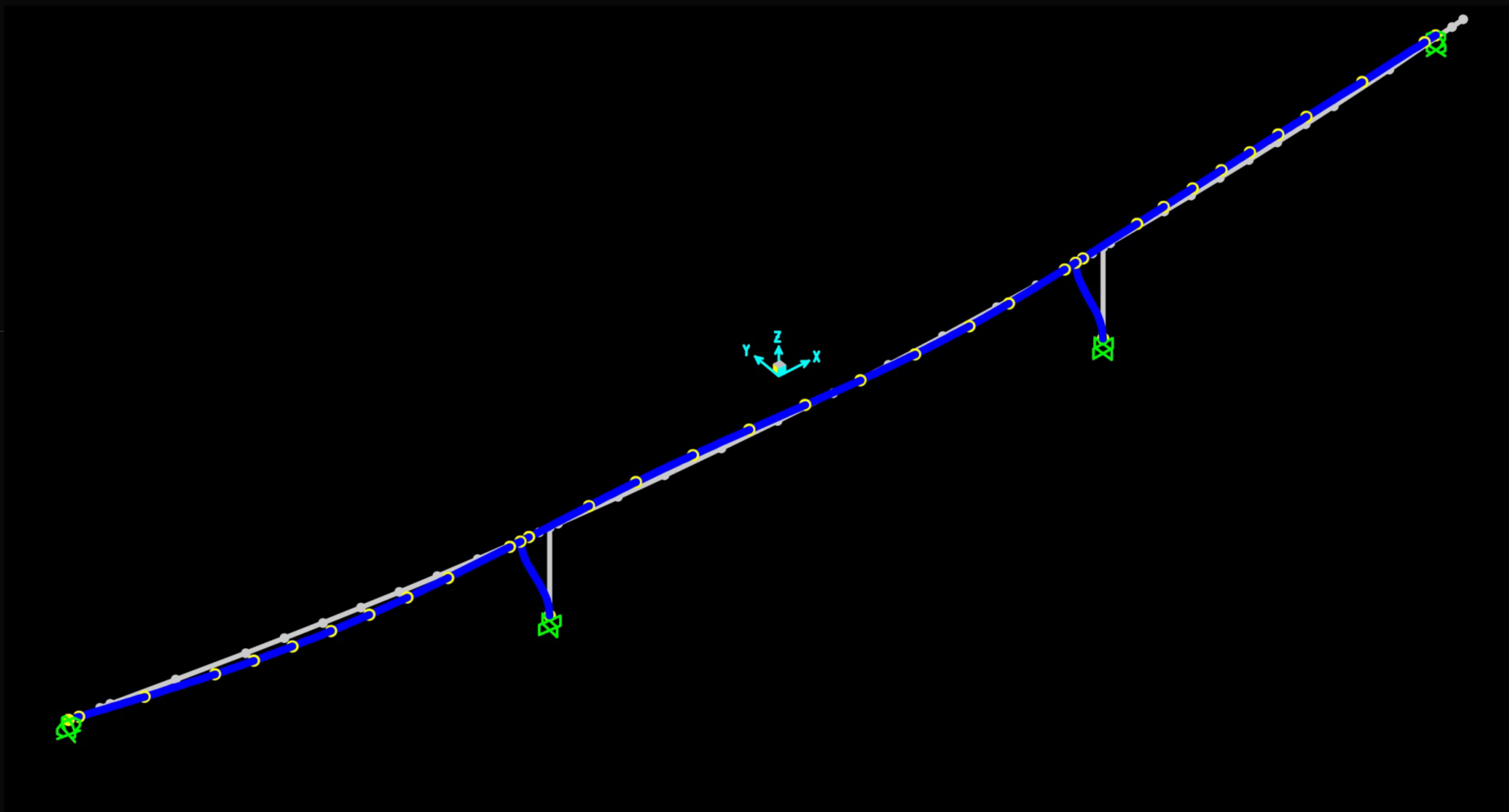


Seismic Model - 3



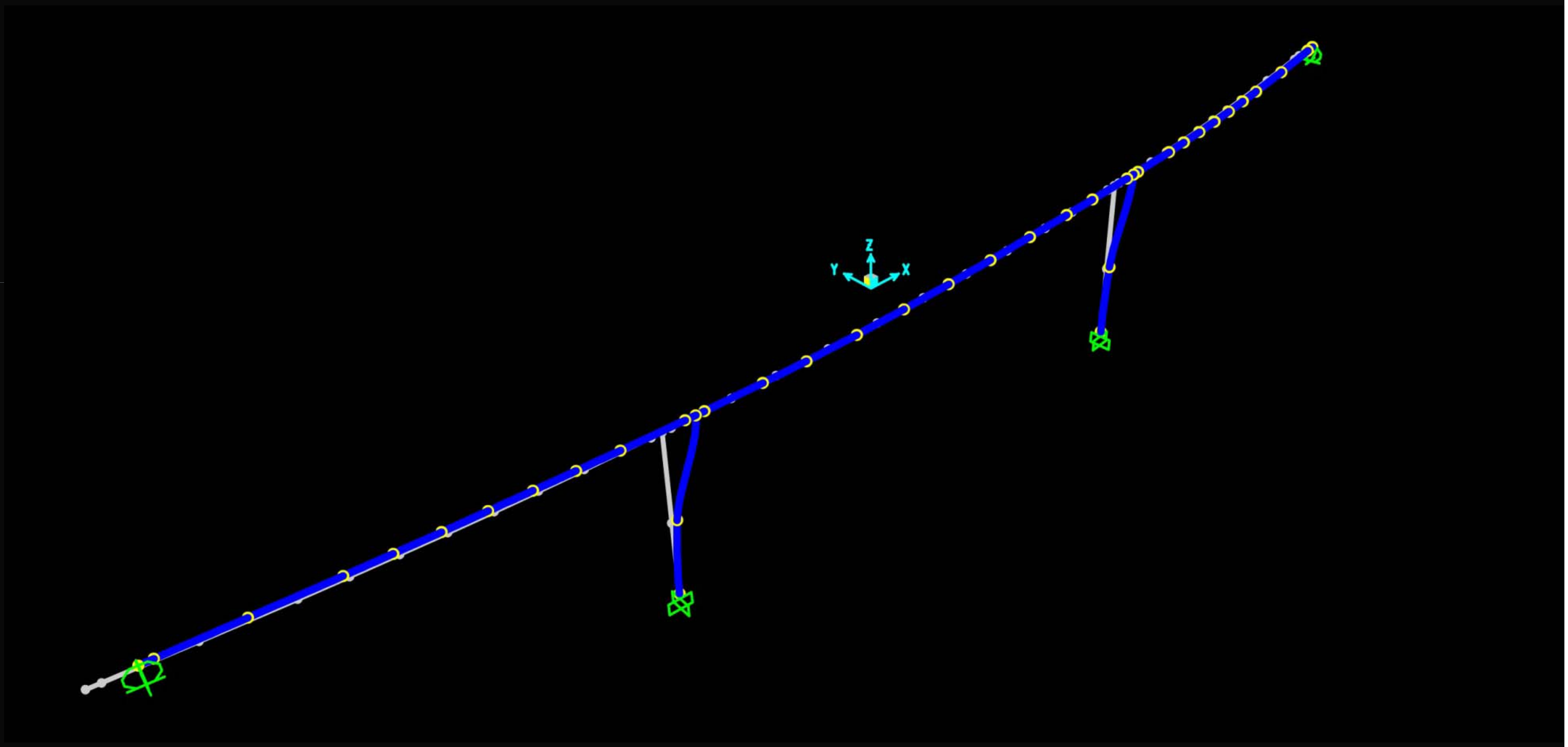
Seismic Model 1 – Long. Mode

T=0.55 Sec



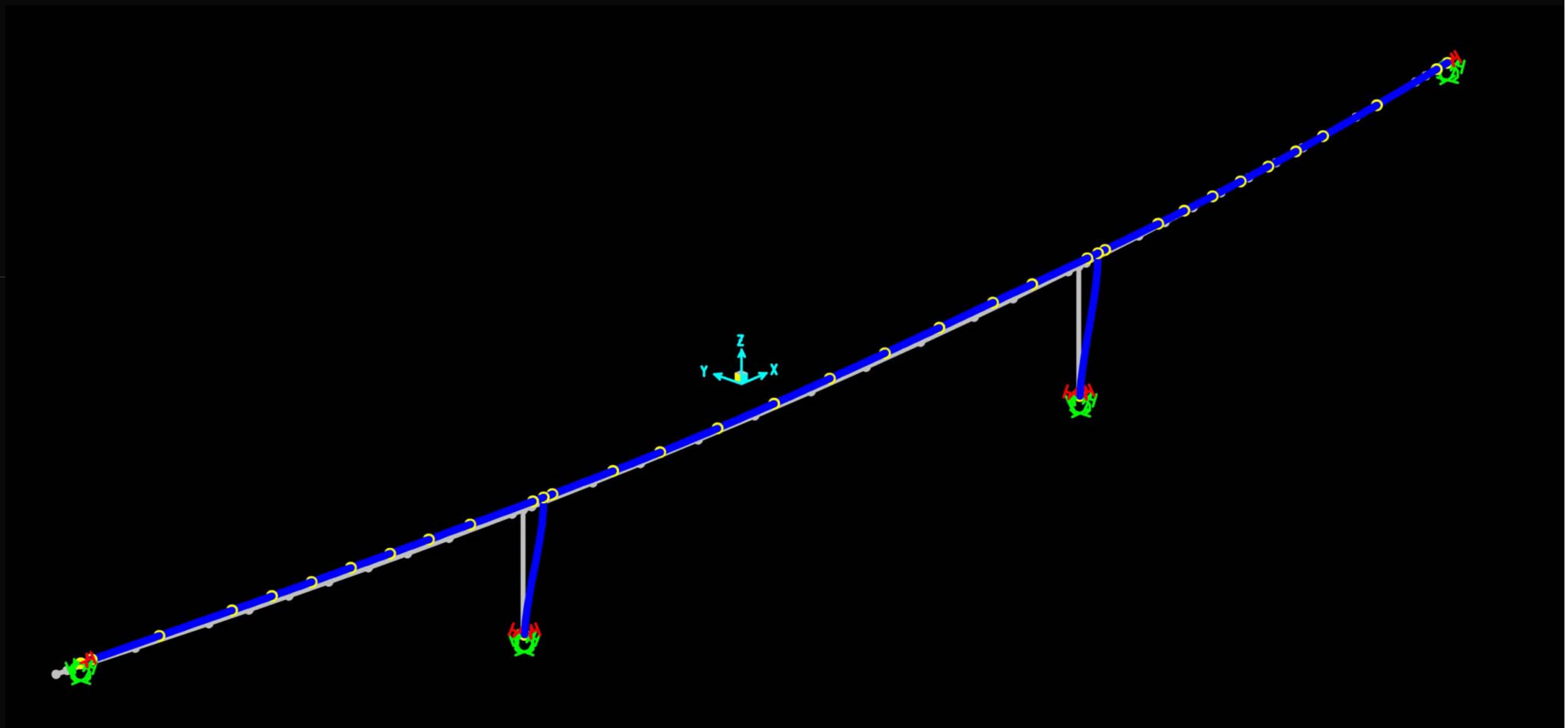
Seismic Model 2 – Long. Mode

T=1.25 Sec



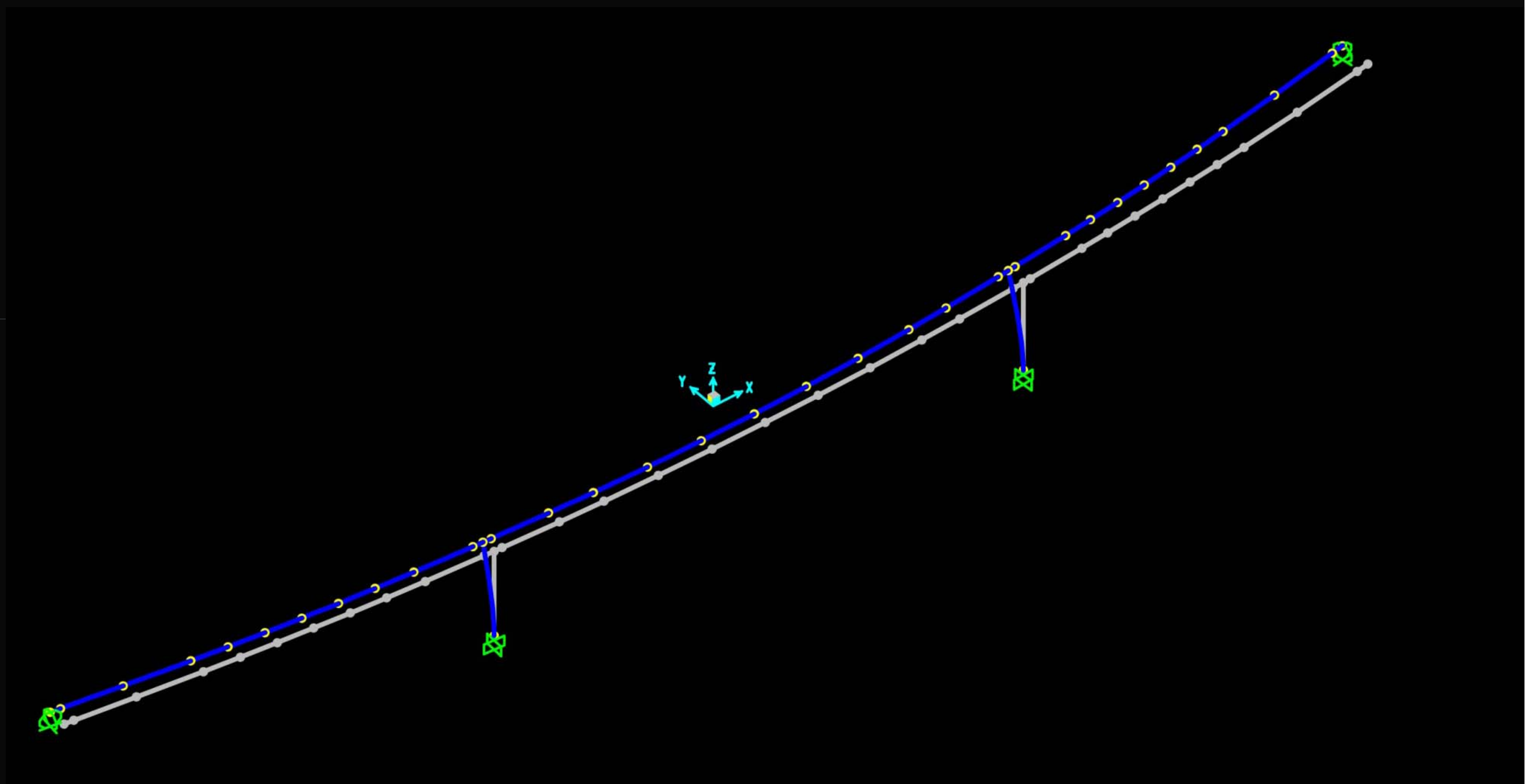
Seismic Model 3 – Long. Mode

T=1.02 Sec

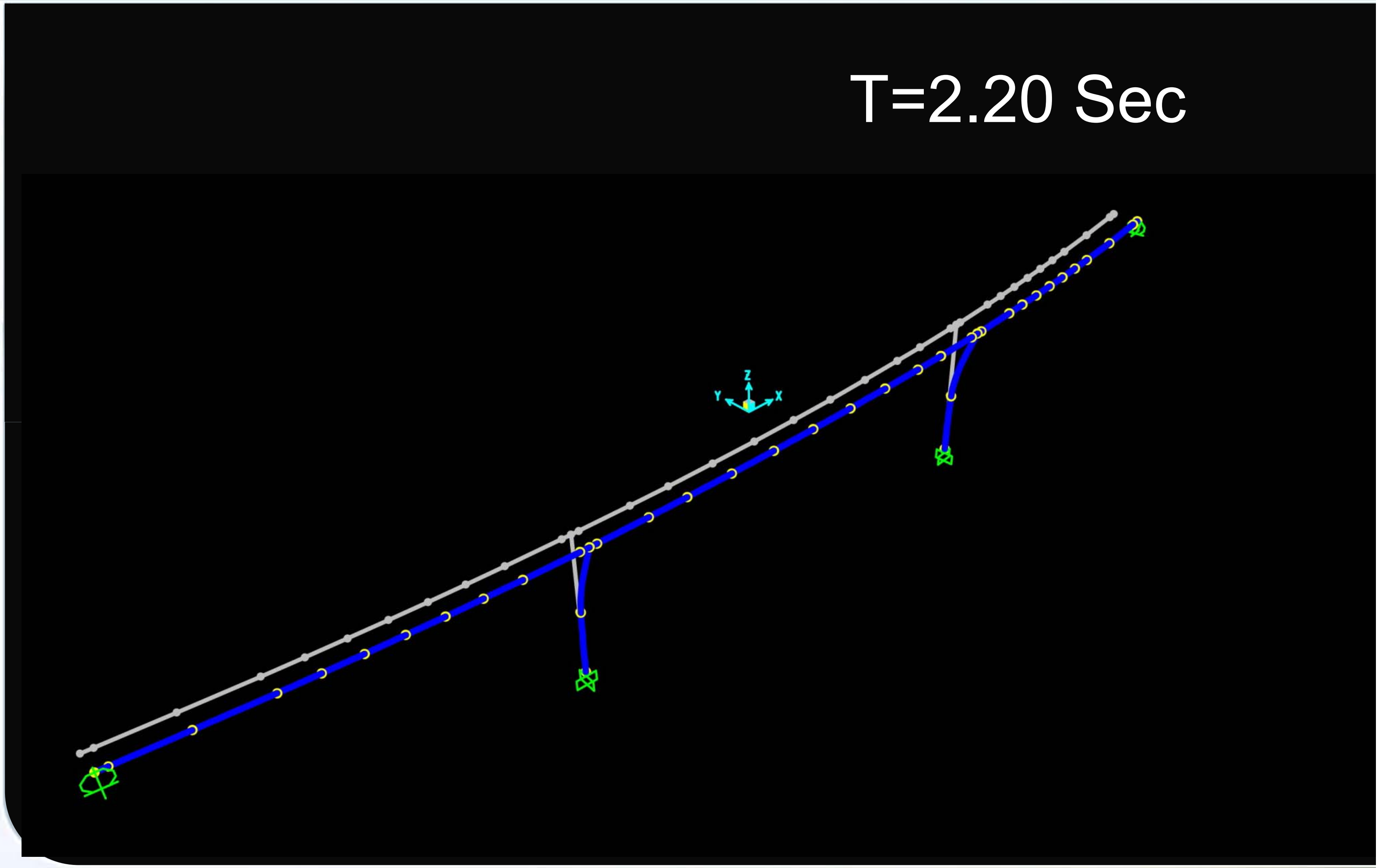


Seismic Model 1 – Trans. Mode

T=1.06 Sec

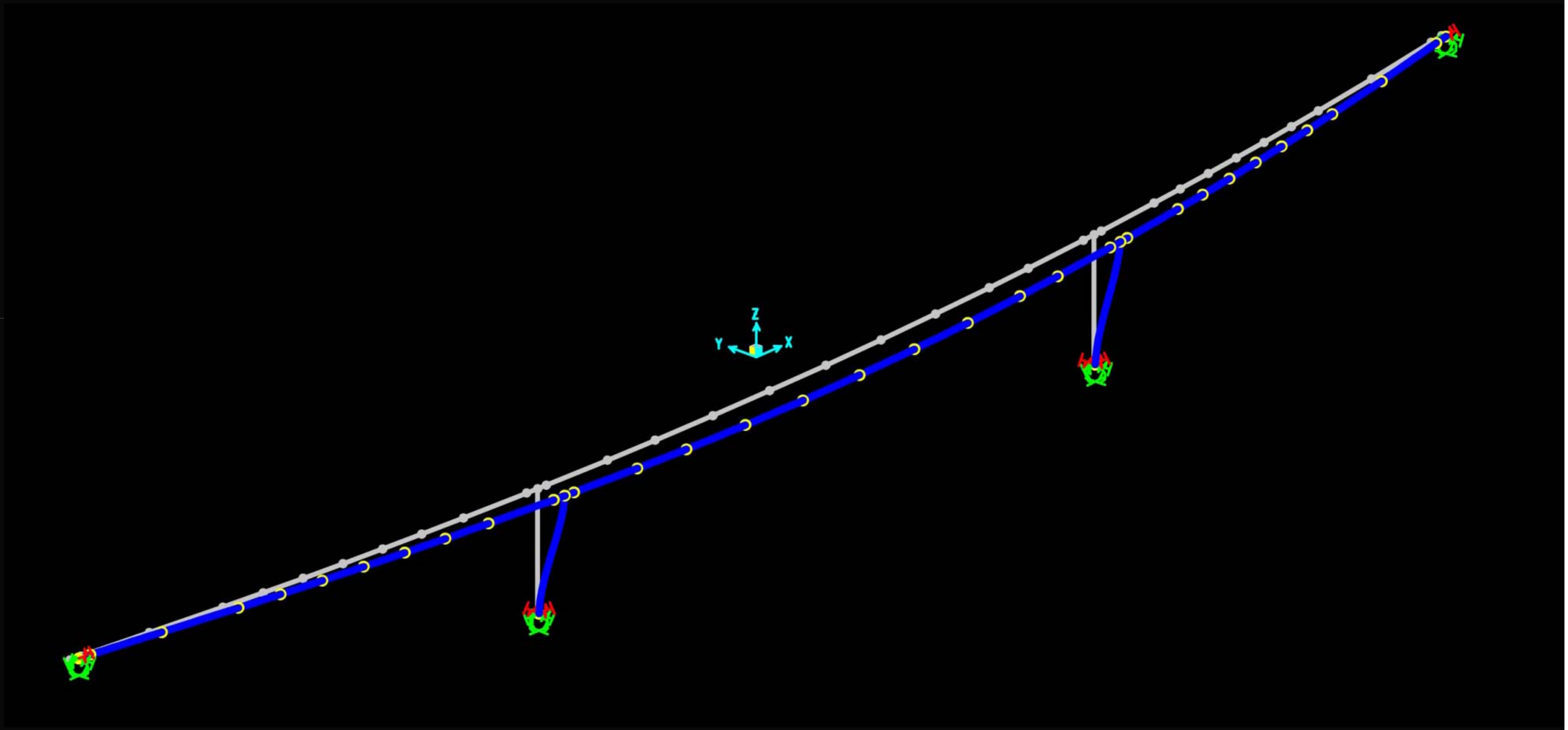


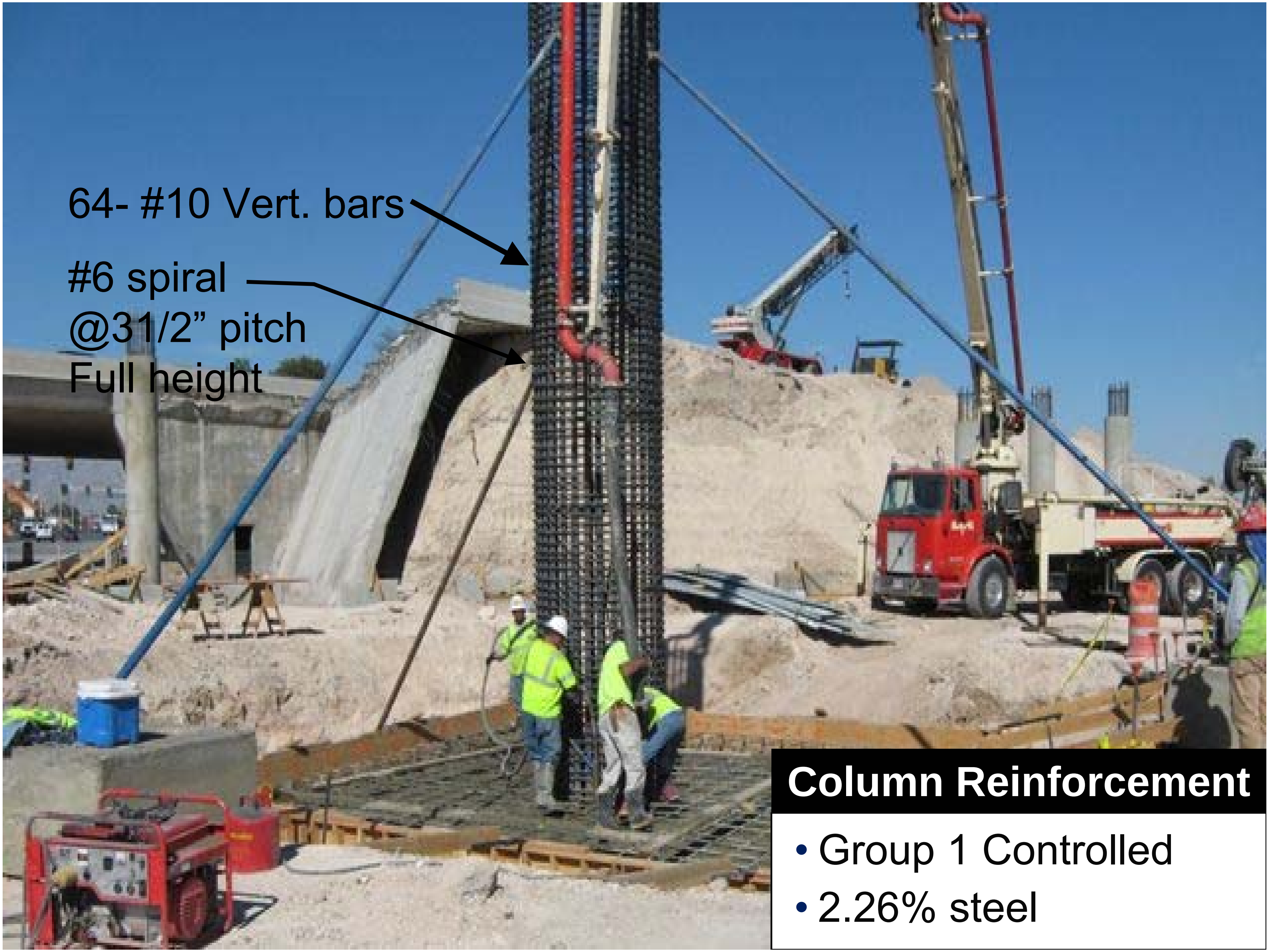
Seismic Model 2 – Trans. Mode



Seismic Model 3 – Trans. Mode

T=0.87 Sec





Column Reinforcement

- Group 1 Controlled
- 2.26% steel

Lake Mead SB Bridge

Lake Mead SB Bridge

- Twin north – south bridges. Two separate structures.
- Post tensioned box girder superstructure
- 129 ft – 6in and 64 ft – 3 in spans
- Varies from 86 ft to 93 ft
- 20 degree skew
- Horizontal tangent alignment

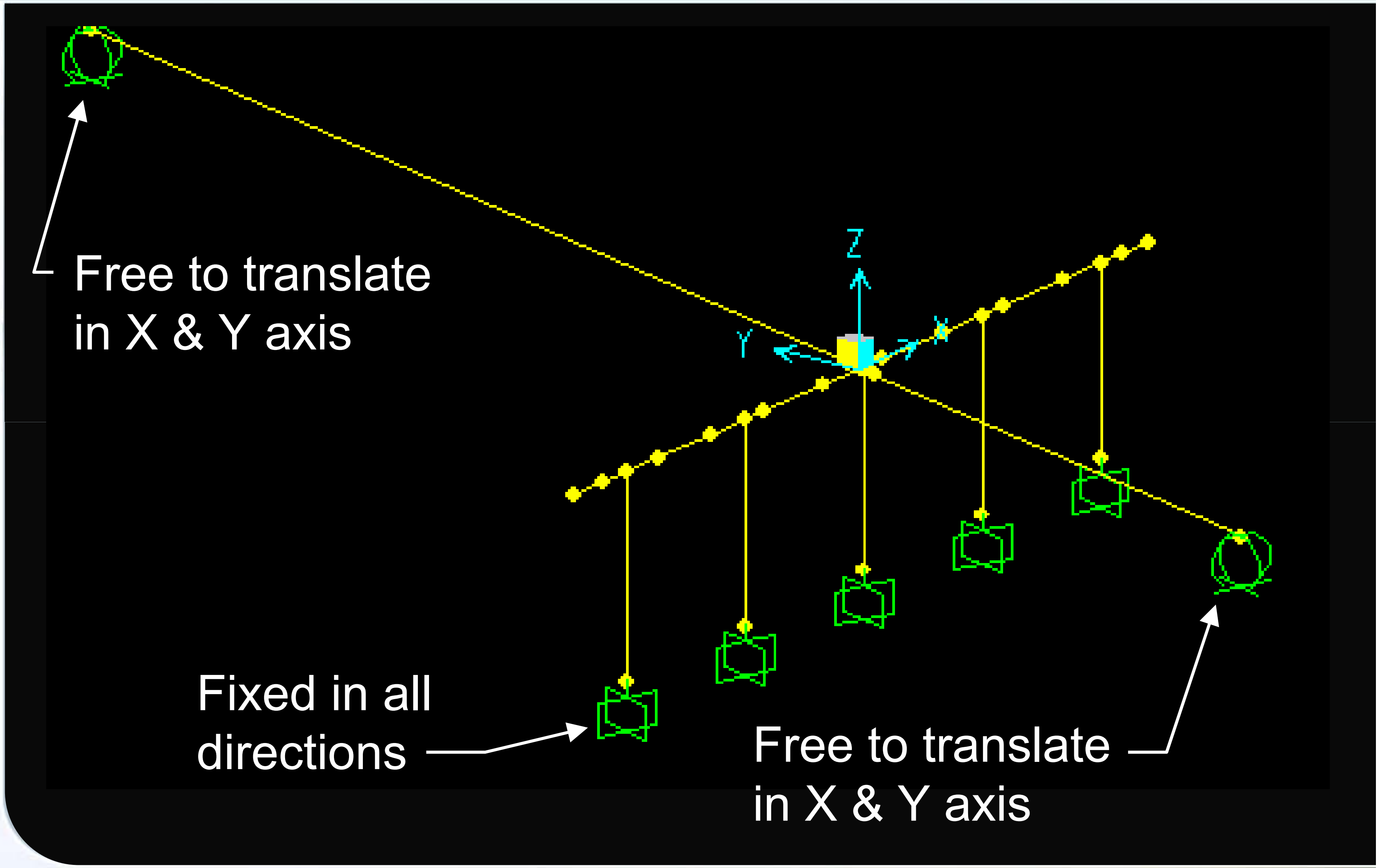
Abutments 1 and 2

- Semi-integral abutment, fixed in transverse direction
- Supported on multiple cast-in-place drilled shafts (3 ft diameter)

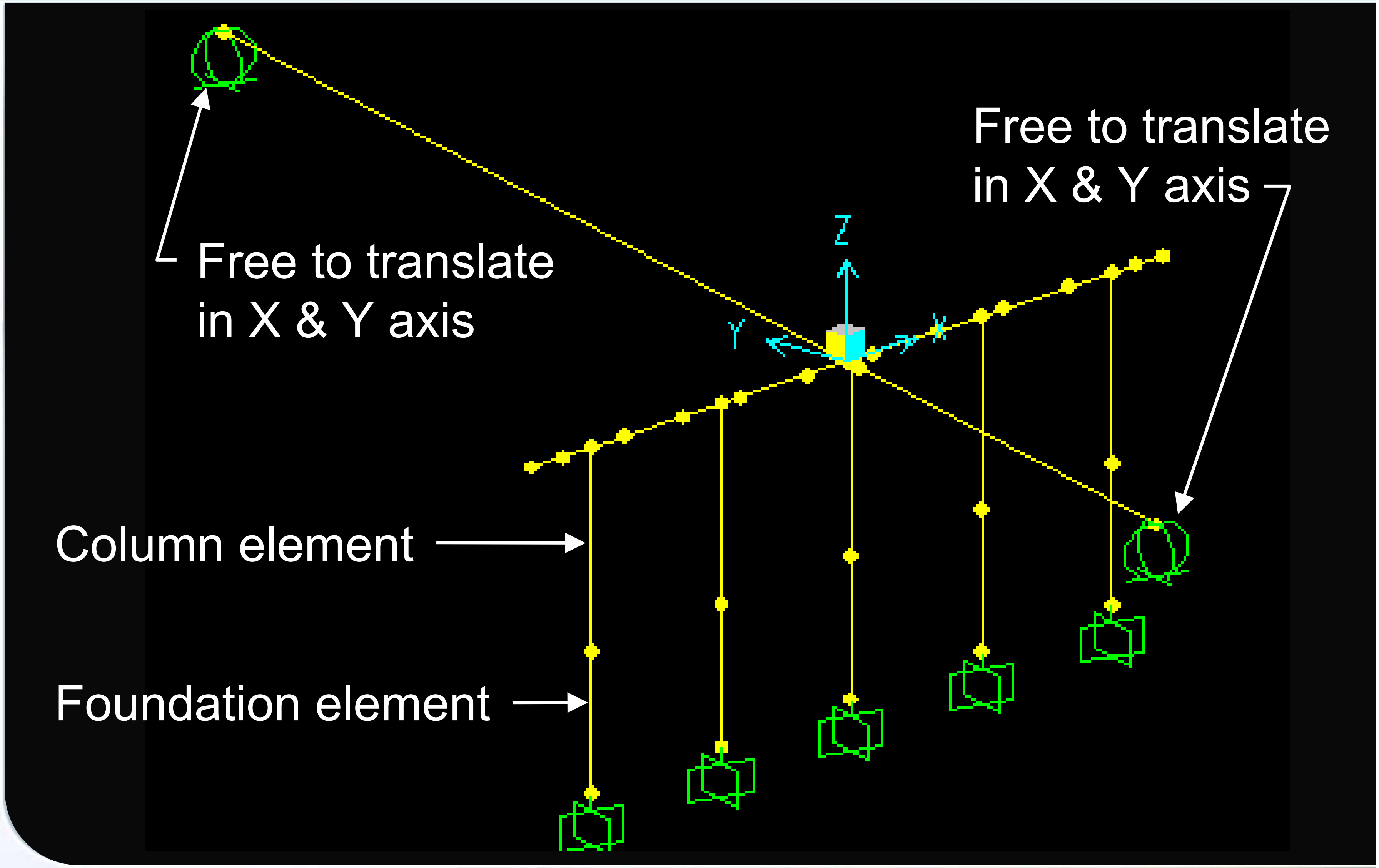
Pier 1

- Multiple column bent consisting of 4 ft octagonal columns supported on a 6 ft diameter cast-in-place concrete drilled shaft
- Approximately 20 ft high columns

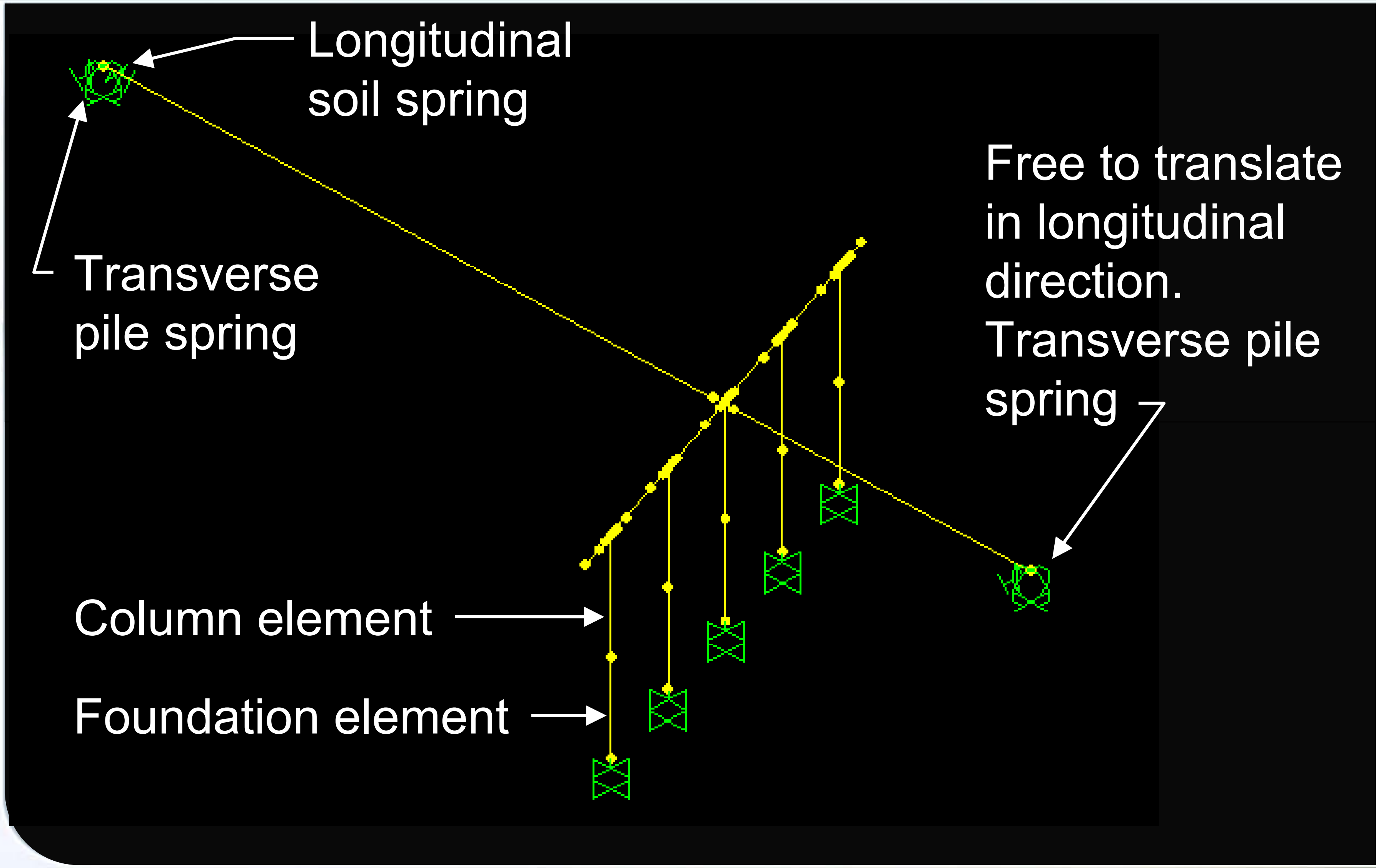
Seismic Model - 1



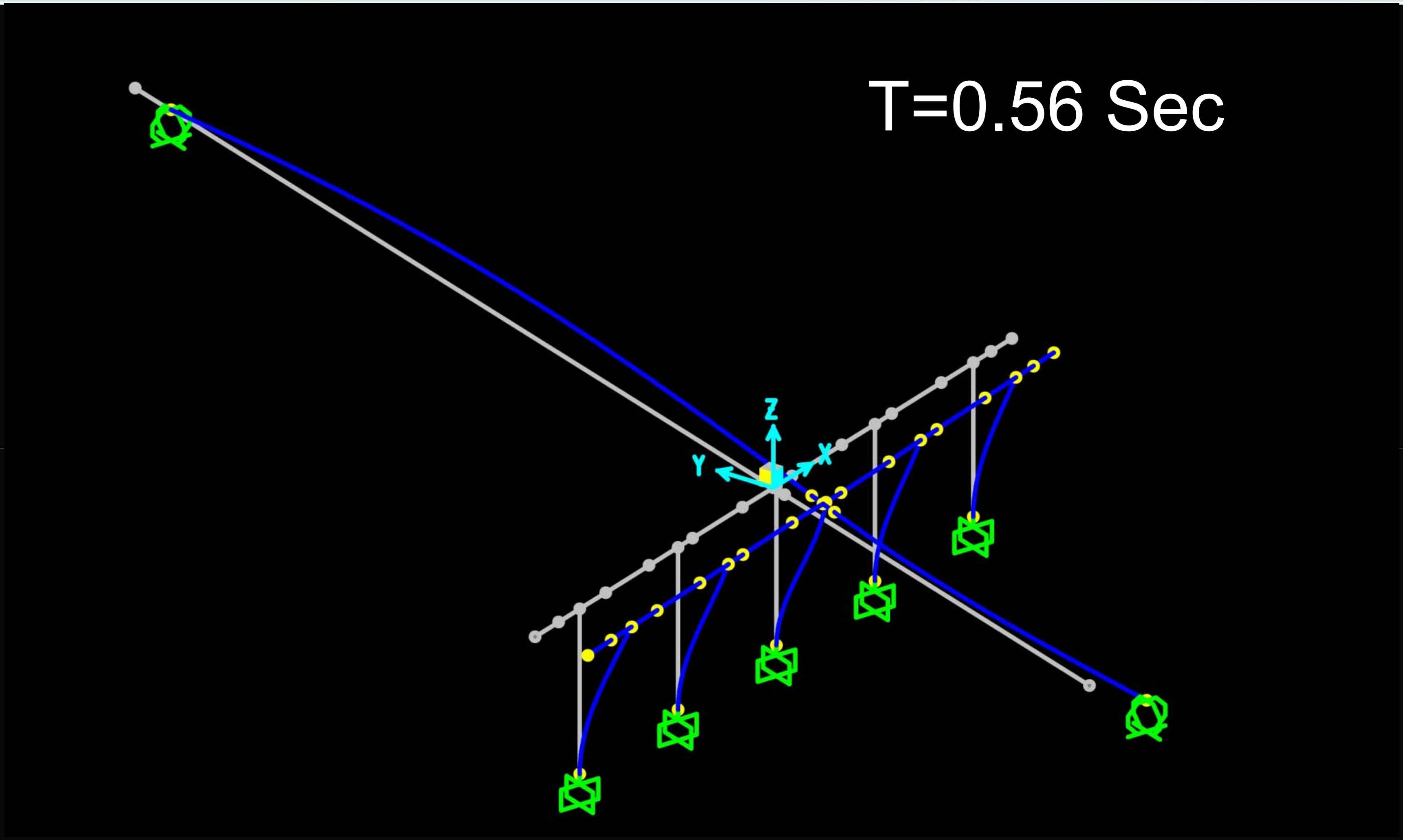
Seismic Model - 2



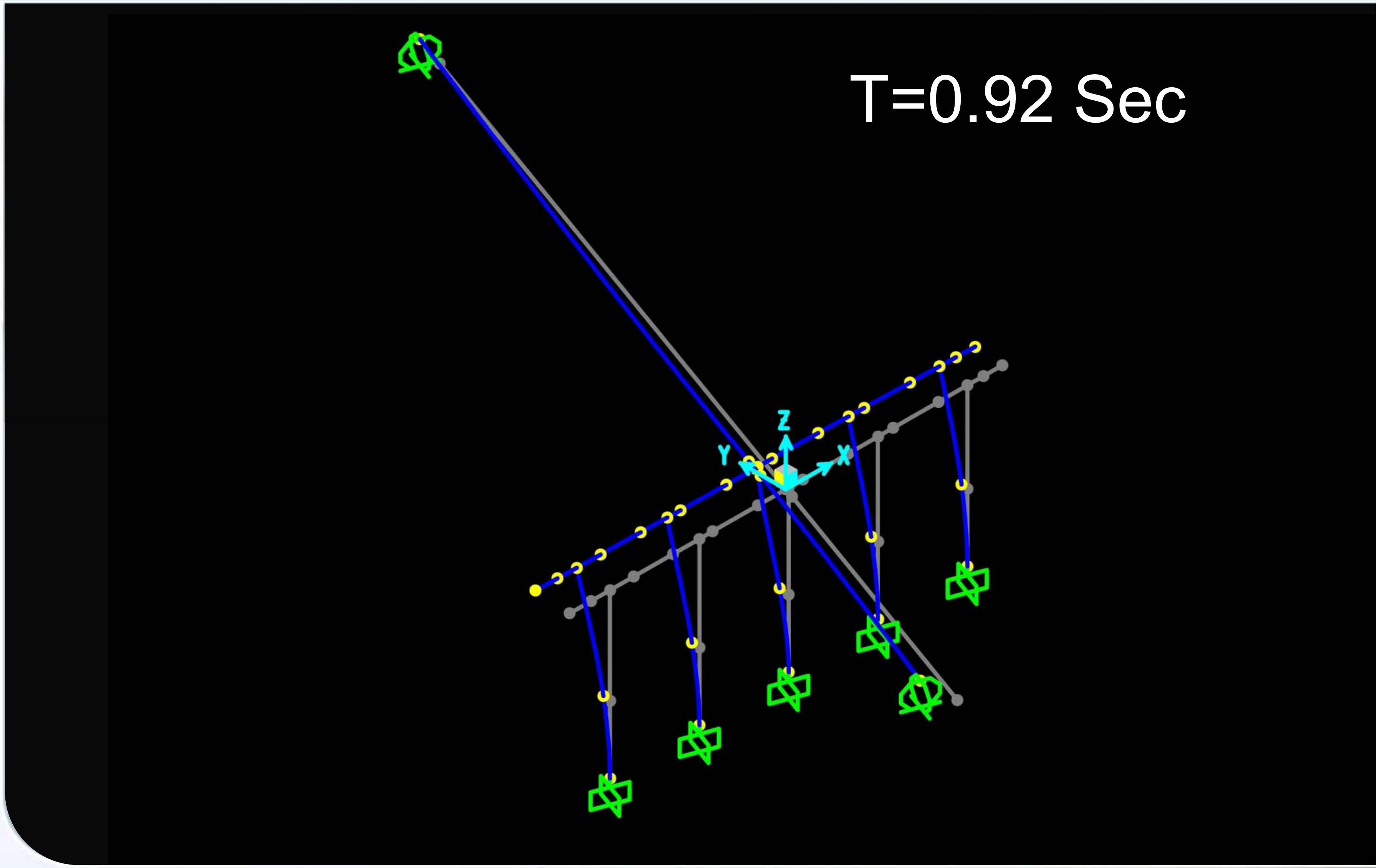
Seismic Model - 3



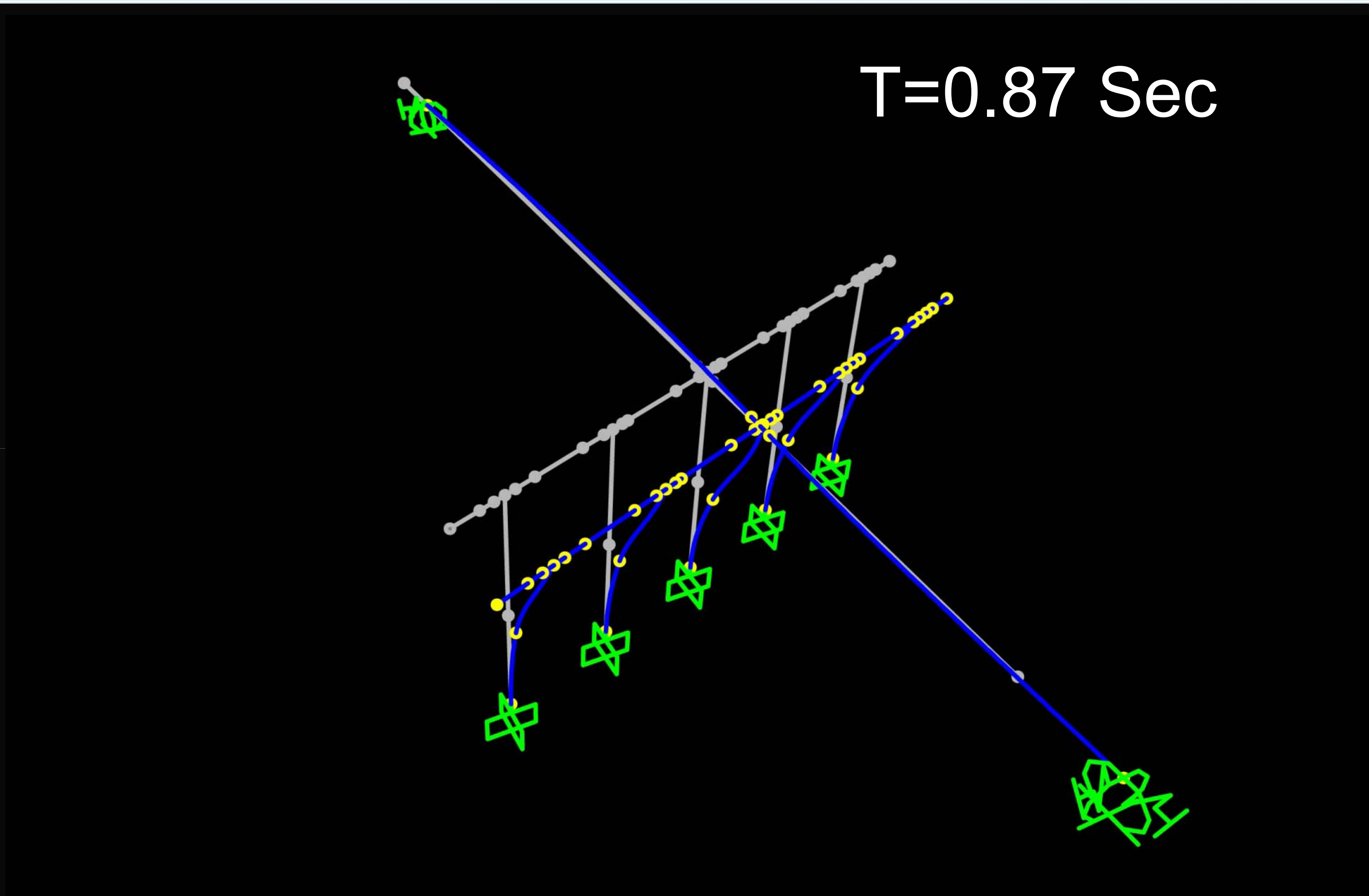
Seismic Model 1 – Long. Mode



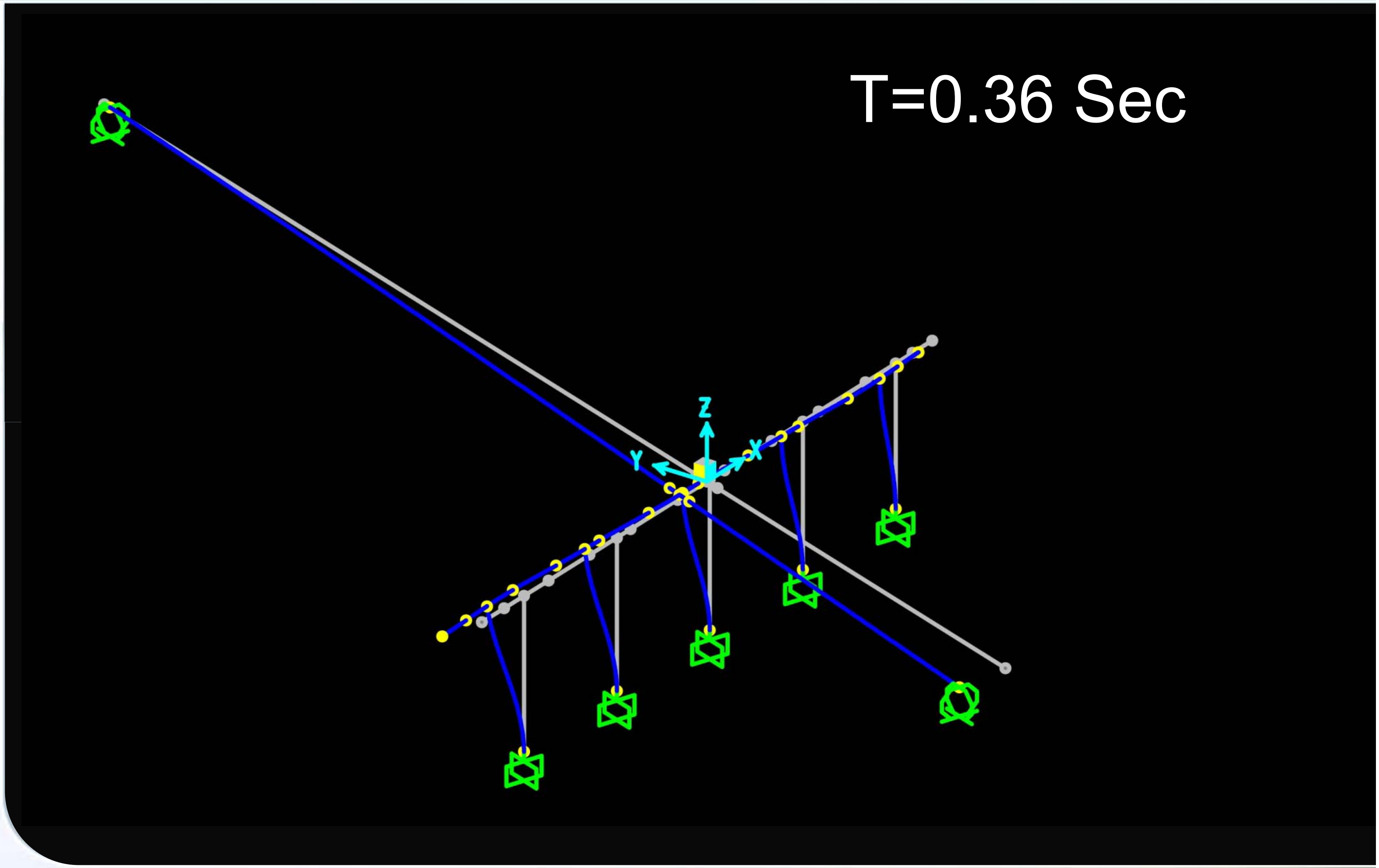
Seismic Model 2 – Long. Mode



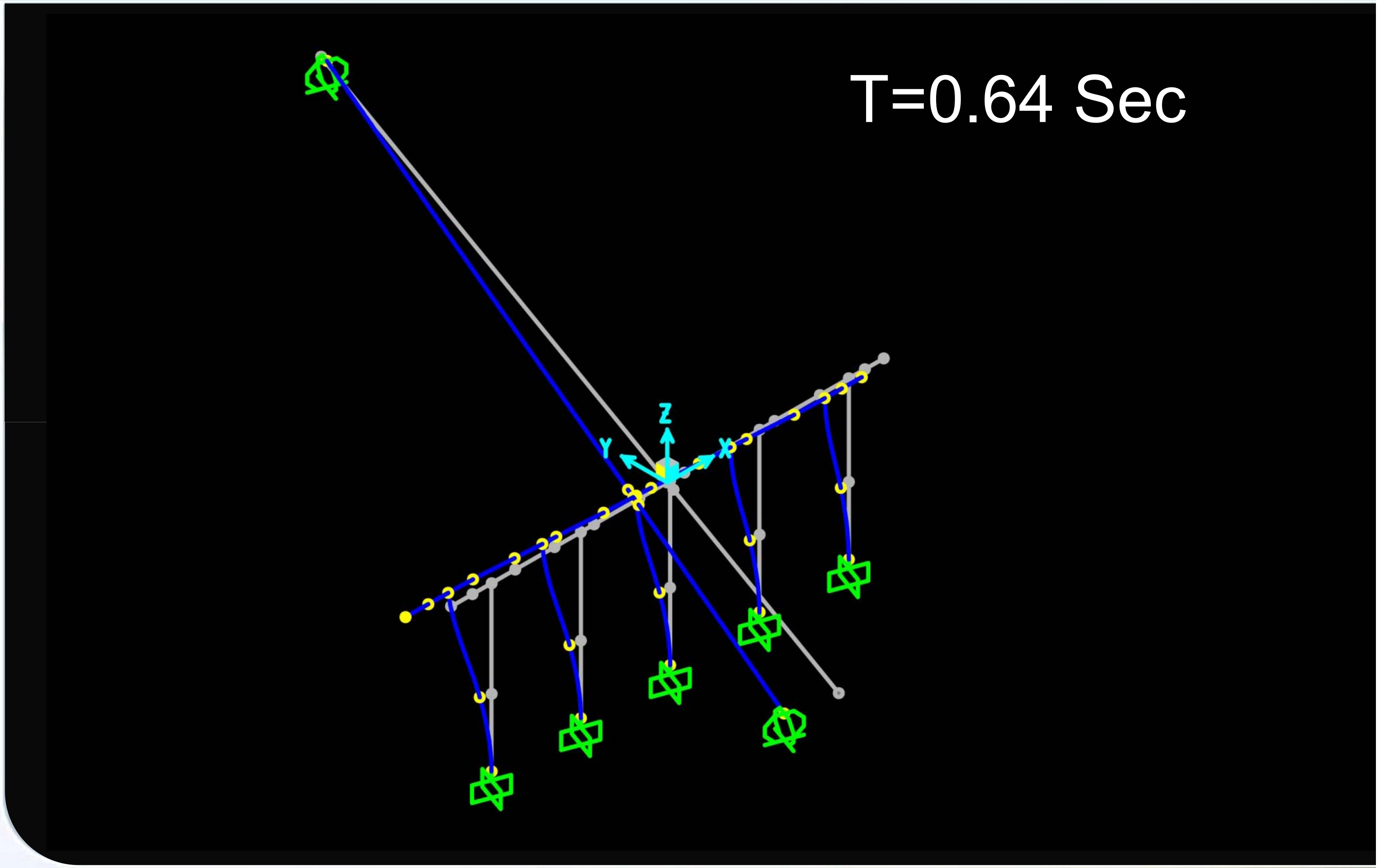
Seismic Model 3 – Long. Mode



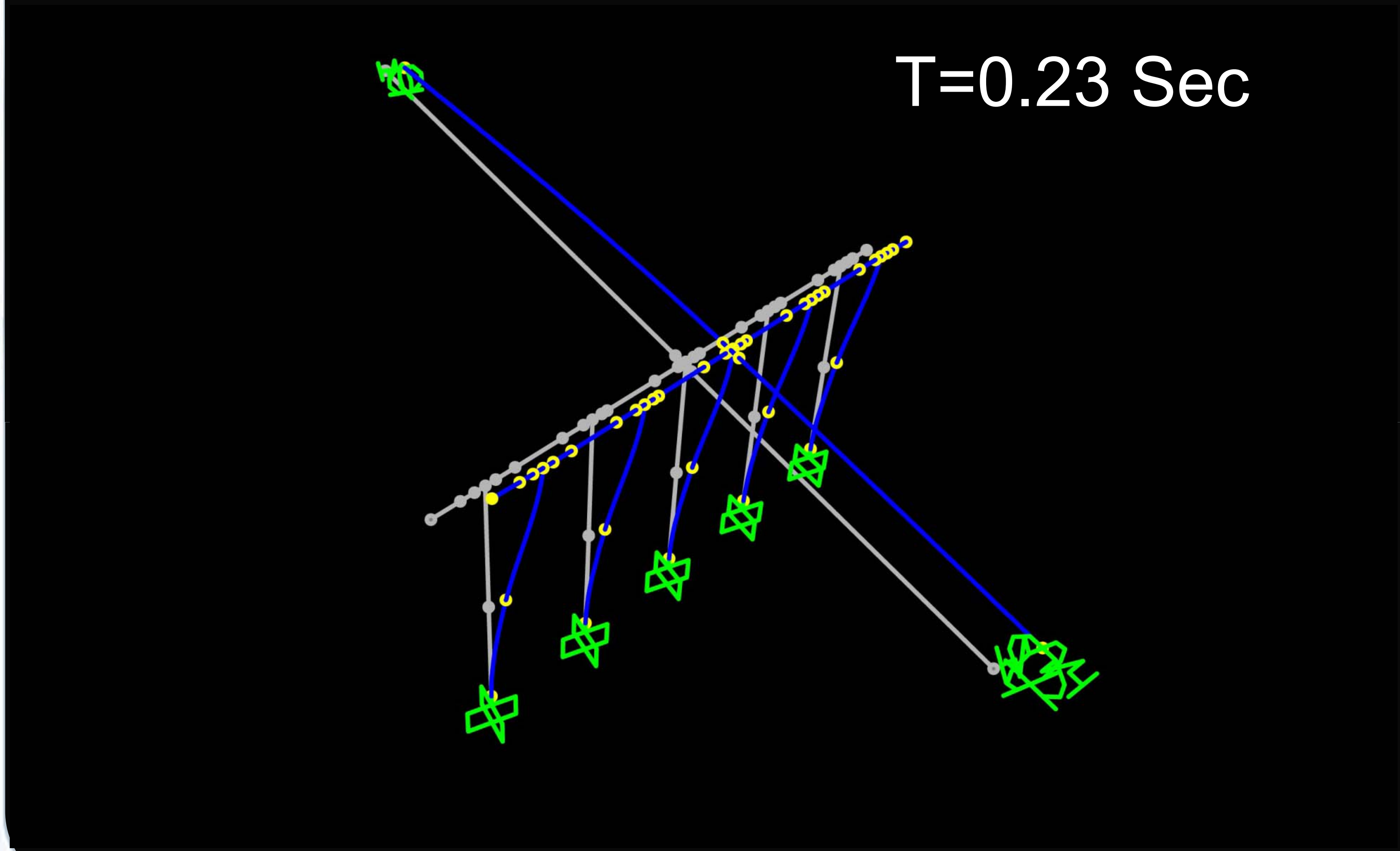
Seismic Model 1 – Trans. Mode



Seismic Model 2 – Trans. Mode



Seismic Model 3 – Trans. Mode

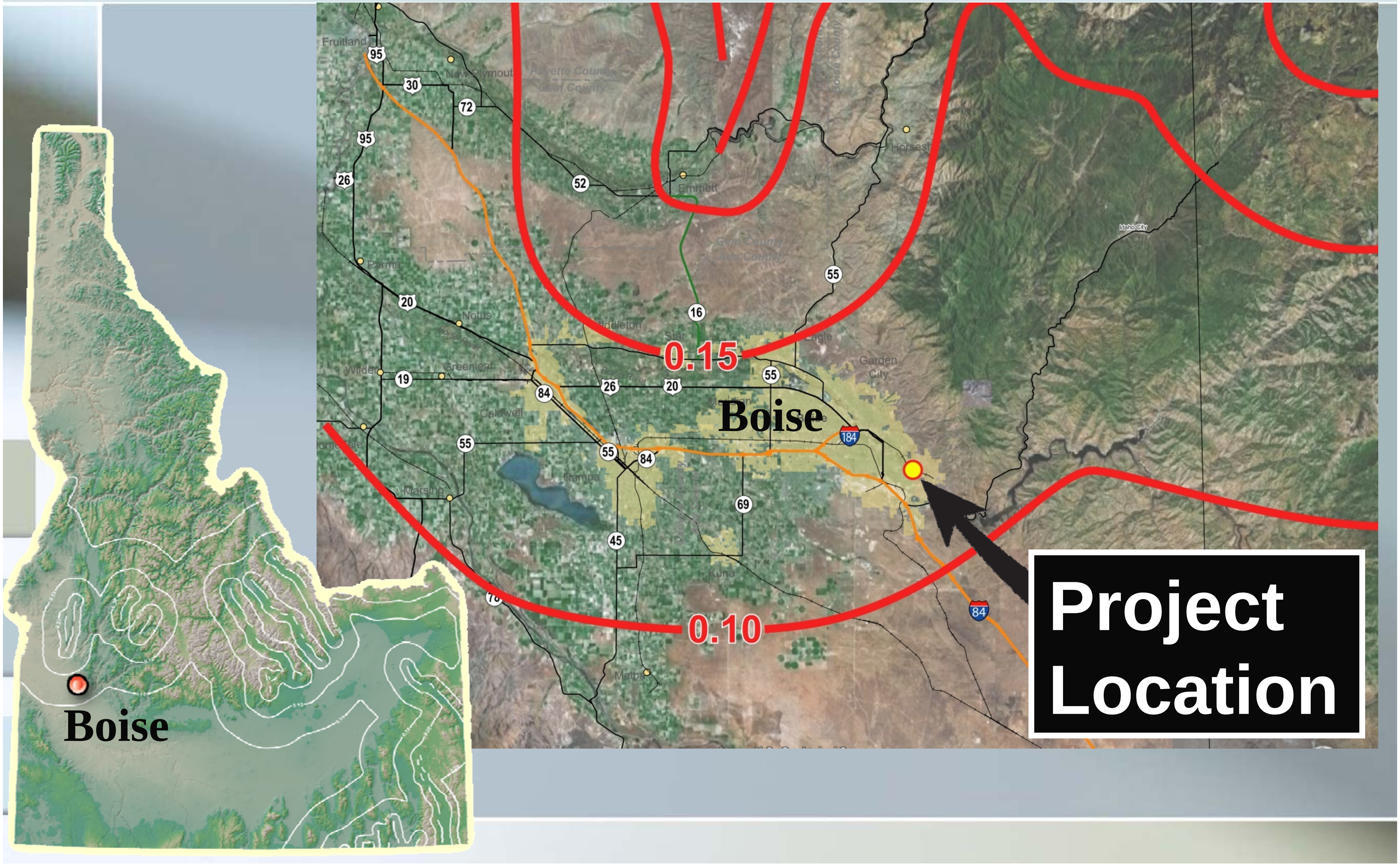


Column Reinforcement

- Group 1 Controlled
- 1.39% Steel

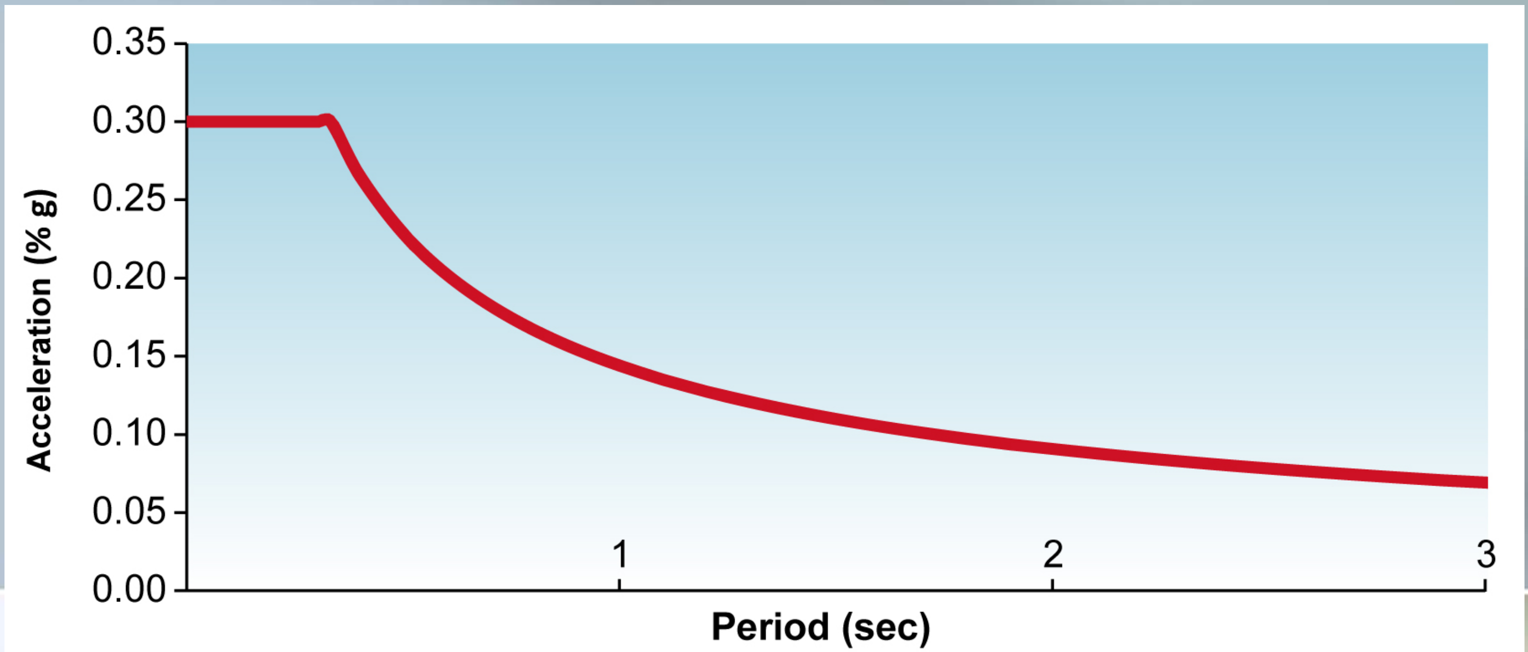
East ParkCenter Bridge

Location



Seismic Design Parameters

- AASHTO Response Spectrum
- Peak bedrock ground acceleration, 0.12g
- Site coefficient, 1.0
- Importance factor, 1.0



East ParkCenter Bridge

- Steel plate girder superstructure
- 240 ft and 200 ft spans
- 76 ft wide including sidewalks
- No skew
- Horizontal tangent alignment

Abutment 1

- Seat abutment, fixed in transverse direction
- Supported on two rows of driven steel HP 12x74 piles
- Pedestrian tunnel located in approach fill
- Footing supports one leg of precast concrete tunnel arch

Abutment 2

- Seat abutment, fixed in transverse direction
- Cast-in-place concrete cantilevered wingwalls
- Supported on two rows of driven steel HP 12x74 piles

Pier 1

- 3 ft - 6 inch wide by 76 ft long wall
- Approximately 10 ft high
- Founded on 3 rows of driven steel HP12x74 piles

Performance Goals

- Designed in accordance with *AASHTO LRFD Bridge Design Specifications, 3rd Edition*
- Due to moderate seismicity and steel superstructure, expect 1% reinforcement on effective section
- Do not consider abutments in earthquake resisting system (longitudinal direction)

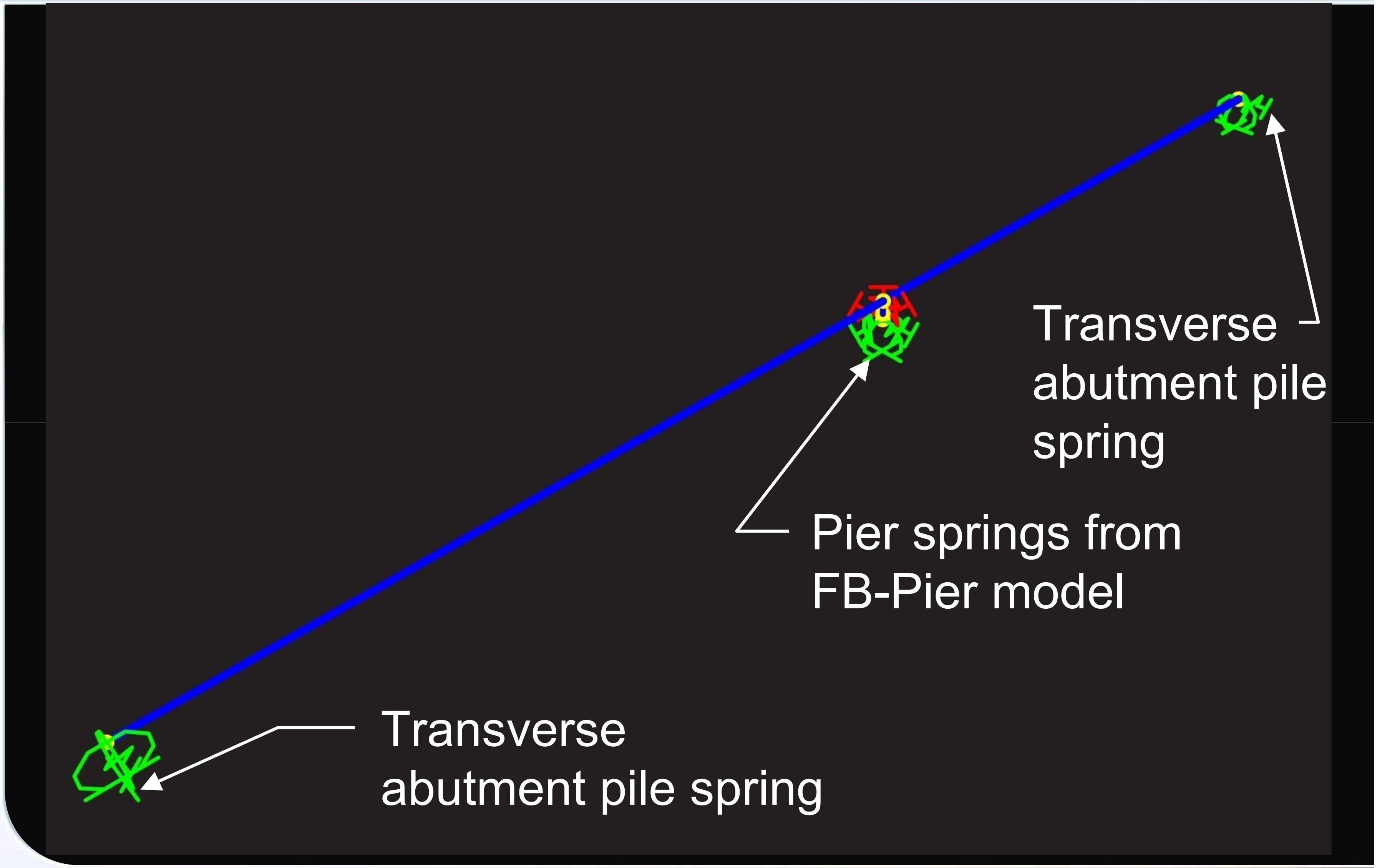
Performance Goals

- Elastic Pile Response
- R factors
  - Longitudinal, R = 3
  - Transverse, R = 1

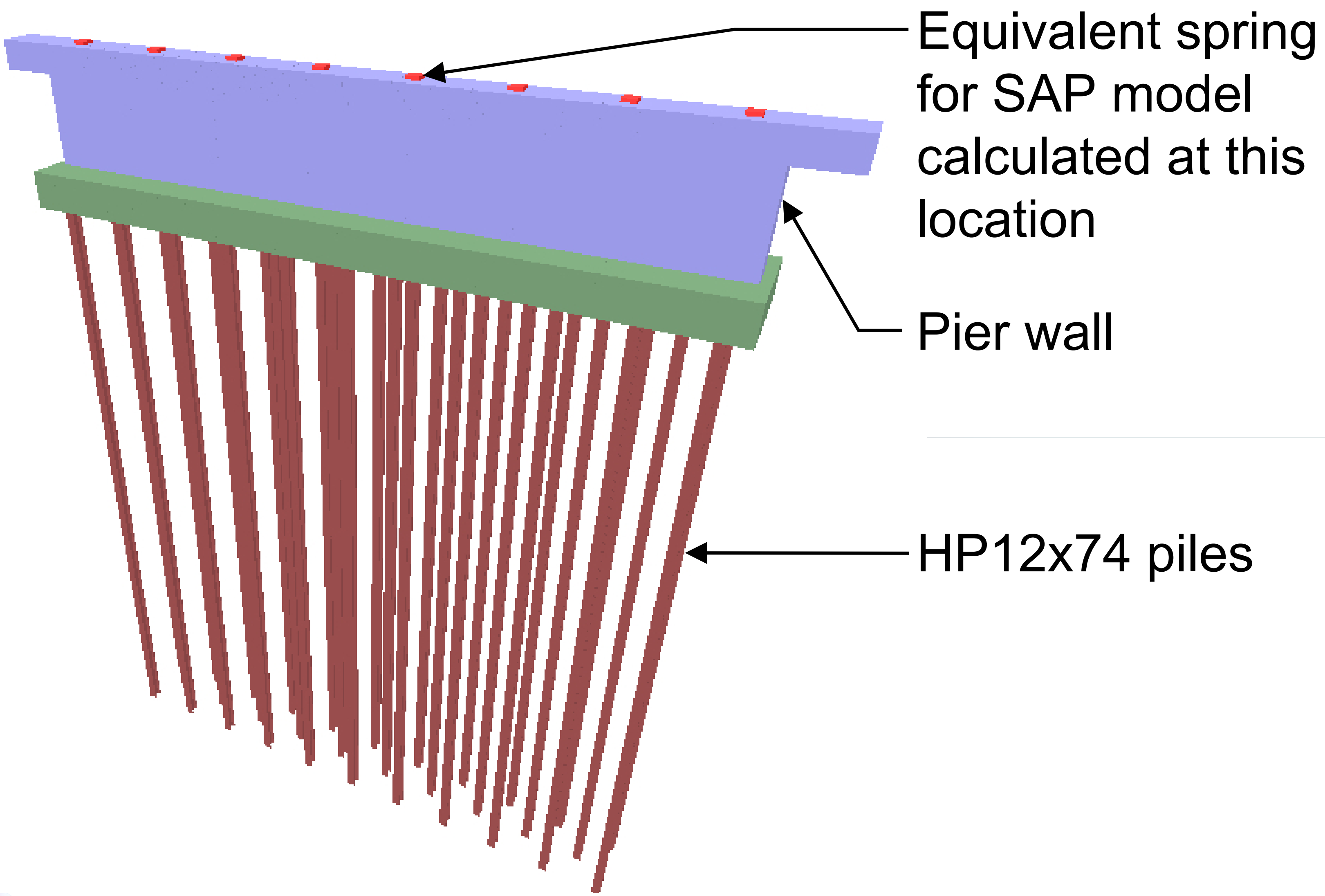
Seismic Design Strategy

- Simplified seismic model with superstructure elements and substructure springs
- Model pier using FB Pier
- Use effective wall section properties
- Transverse abutment pile springs determined using LPILE

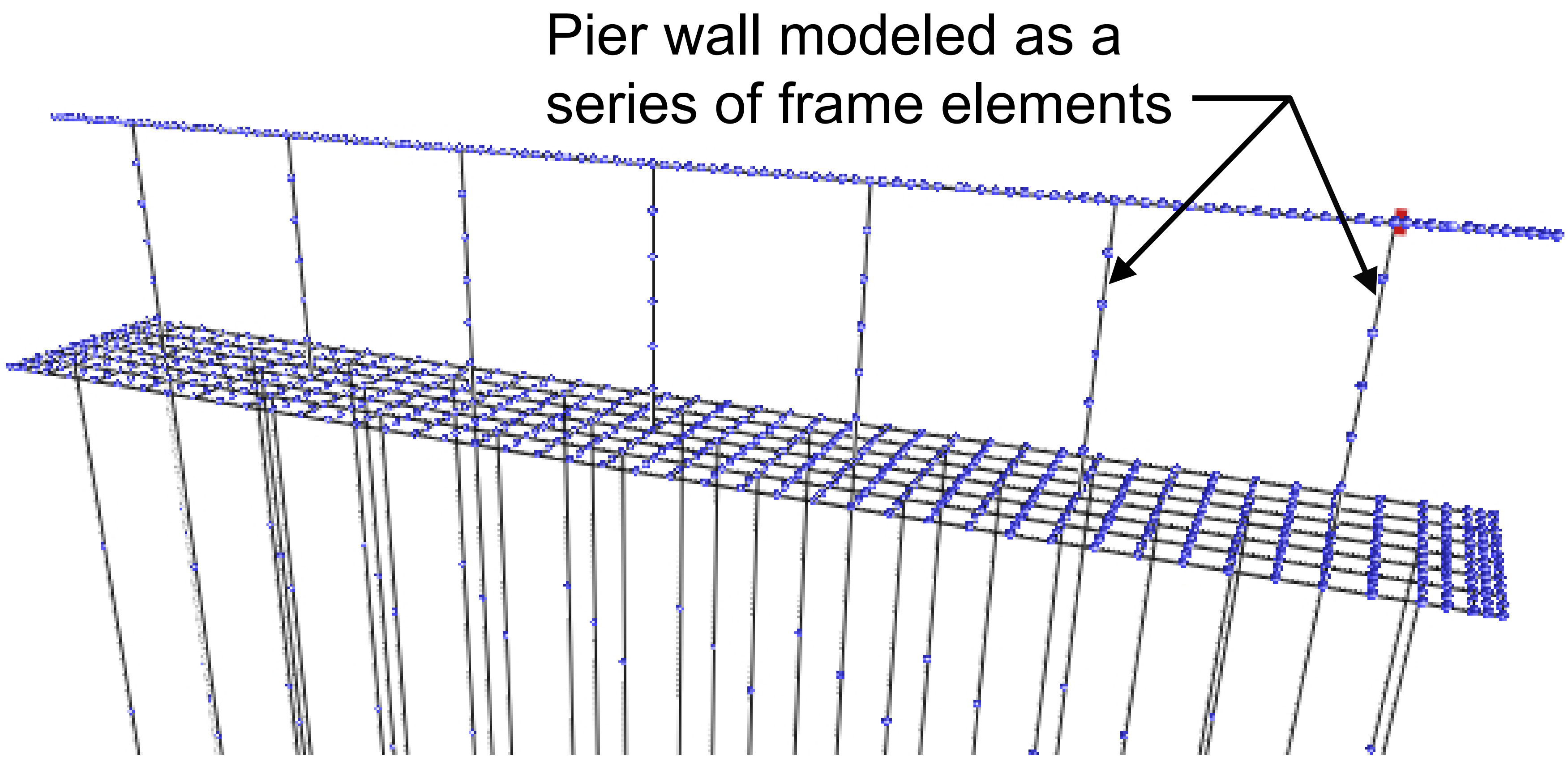
Seismic Model



FB Pier Model



FB Pier Model



Wall Reinforcement

- 1.0% Steel on Effective Section
- Strength I Controlled

Recommendations

- In zones of moderate seismicity, design substructure for static forces prior to seismic design.
- Begin seismic modeling with most conservative assumption and include more refined analysis as required.
- Use of a substructure model developed for static load case designs can be easily adapted for seismic analysis.

QUESTIONS?