

# Full-Scale Structural and Nonstructural Building System Performance during Earthquakes & Post-Earthquake Fire

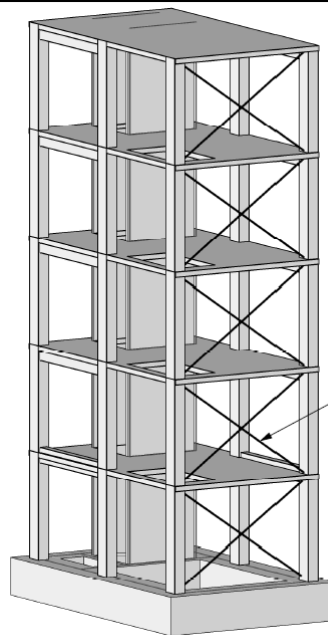
A Joint Venture between Academe,  
Industry and Government

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Englekirk & Sabol Consulting Structural Engineers, Inc.



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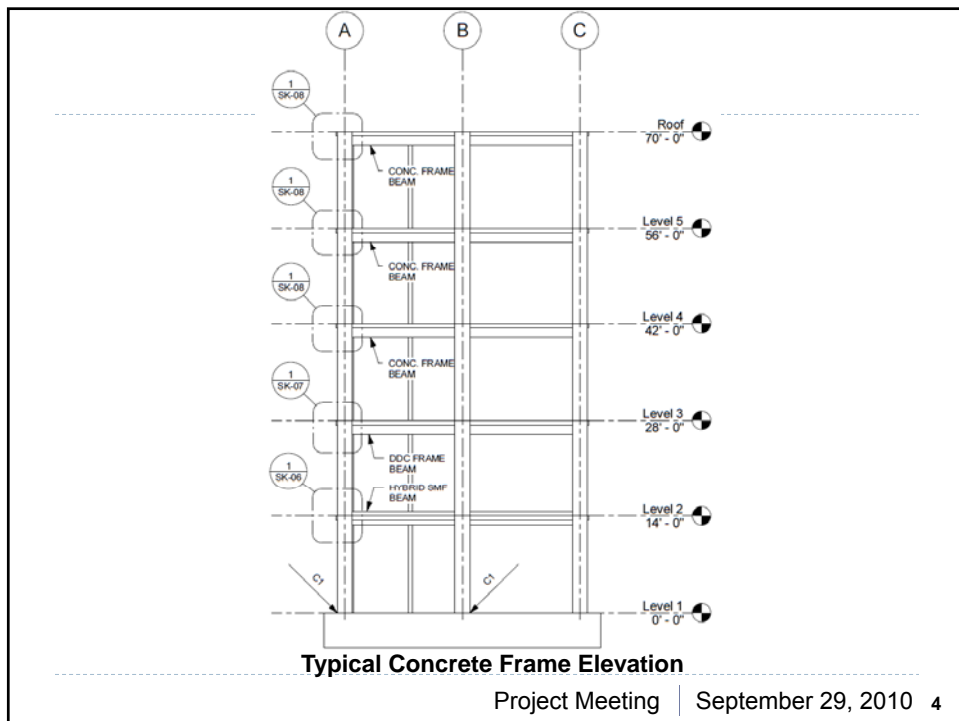
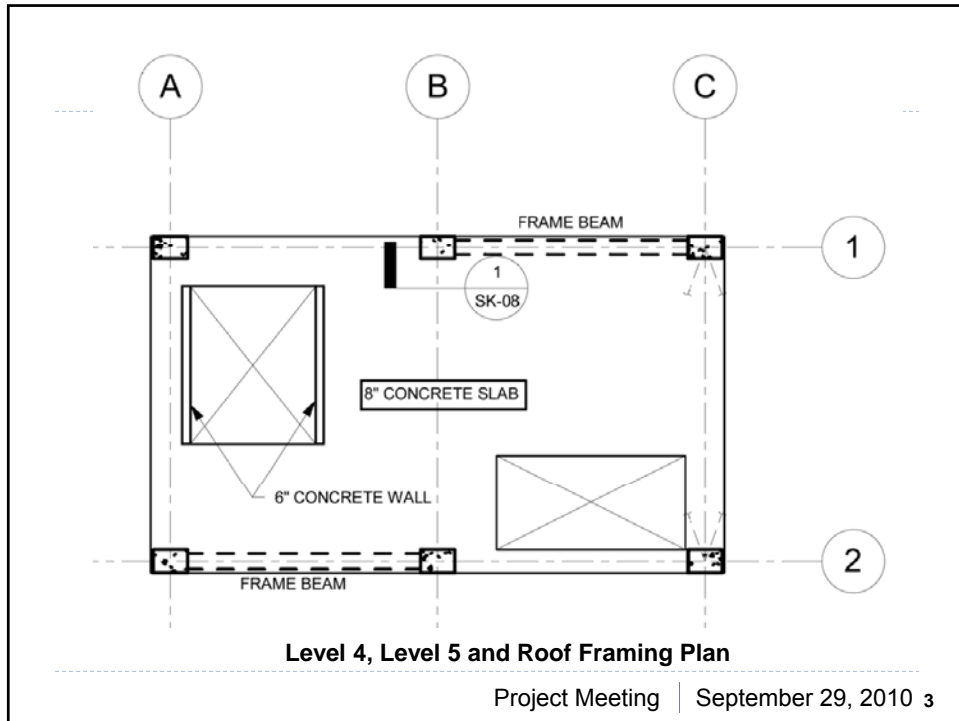
## Building Design and Construction



Typical 1- $\frac{1}{2}$ "  $\phi$   
A36 rod  
bracing

3-D View – Test Specimen A

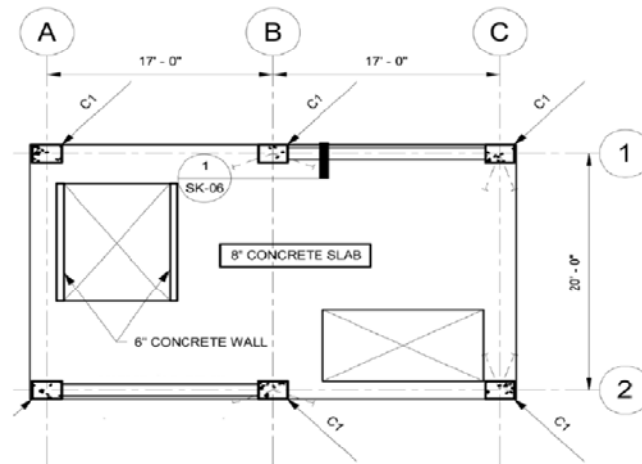
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## Design Basis

Structural Weight Per Floor= 123 kips

Total Weight Per Floor= Structural weight + Non structural elements = 1?? Kips



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## Design Basis

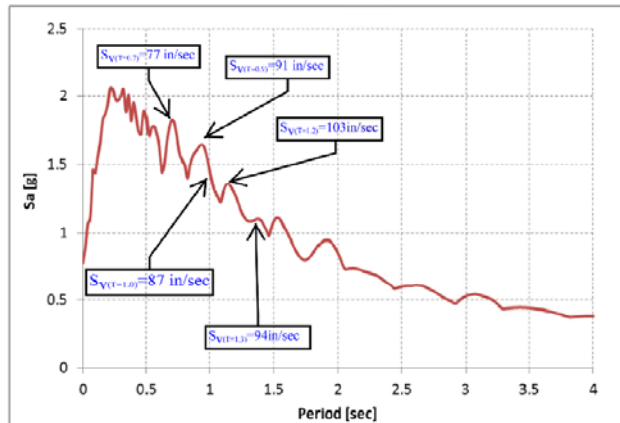
### Seismic Design Criteria

- MCE peak spectral velocity (5% damped) = 87 in/sec on site class D
- 7 ground motion time histories were developed with target spectral acceleration  $S_{m1}=1.4g$
- All ground motions were used to analyze the building
- Denali record is selected as the input ground motion for the testing

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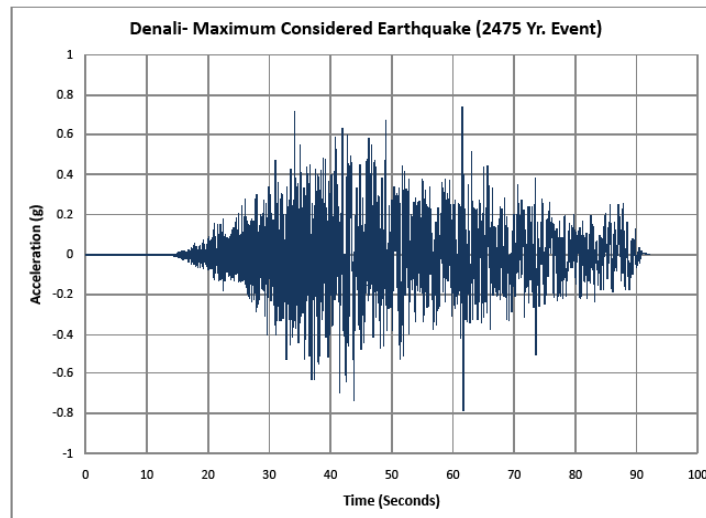
## Design Basis

Denali - Pump Station #10 – MCE Spectra



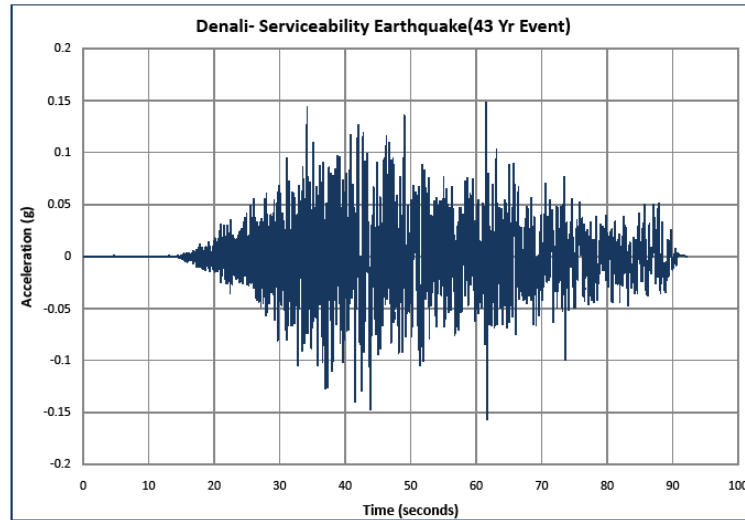
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## Design Basis



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## Design Basis

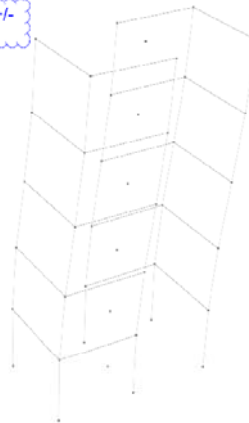


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## Design Basis

Design Objective

Story Drift of 2.5 %+/-



DEFLECTED SHAPE SHOWING ELEMENT USAGE RATIOS  
 Structure = DO-170-K-220R building 8 stories 173 kips  
 Analysis Series = MSE 2% Ray 2 (MSE level earth quake with 5% Rayleigh damping from 0.7-2T)  
 Load Case = 21 = 11 + Dead  
 Time Period = 0.24 sec  
 Limit state group = beam deformation  
 Minimum usage ratio for each color: 0.0 0.7 0.8 0.9 1

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## Design Basis

### Performance Based (PB) vs. Prescriptive Based (PBD):

Seismic Base Shear:

$$V_{PB} = 0.06W \text{ (Frame Beam with 3\#7 bars)}$$

$$V_{PBD} = 0.12W \text{ (Frame Beam with 3\#10 bars)}$$

### Response\* Comparison PB vs. PBD:

	PB	PBD
Floor Acceleration (g)	0.7	0.7
Story Drift (%)	3.6	4.0
Beam Deformation (%)	3.5	3.5

\* 5% damped system  
170 kips/floor

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## Design Basis

### Impact of Damping on Response\* (Design Interest):

% Rayleigh Damping	5%	2%
Floor Acceleration (g)	0.7	0.75
Story Drift (%)	3.6	5.6
Beam Deformation (%)	3.5	5.6

\* 170 kips/floor

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## Design Basis

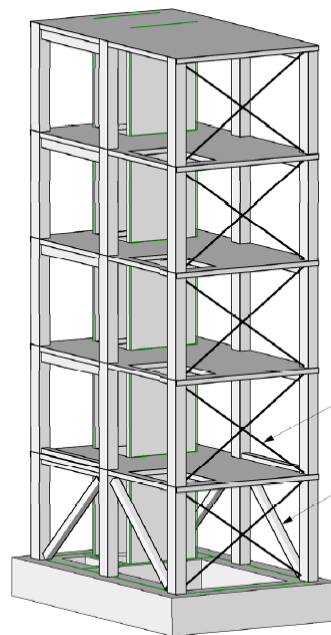
### Impact of Building Weight on Response\*:

Weight per floor (kips)	170	149	137	123
Max Story Drift (%)	3.6	3.7	4.0	4.0
Floor Accelerations (g)	0.7	0.7	0.7	0.7

\* 5% damped system

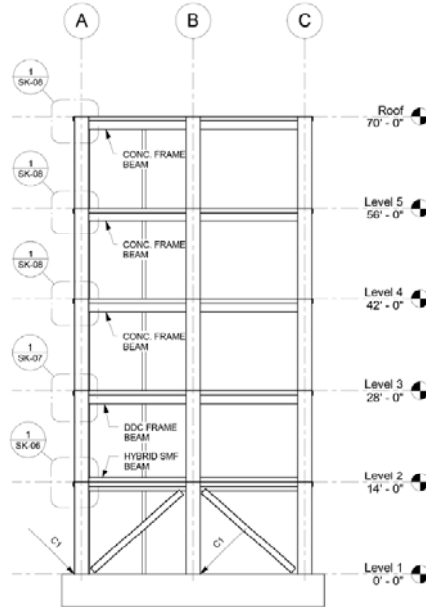
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## Alternative Design (Base Isolation)



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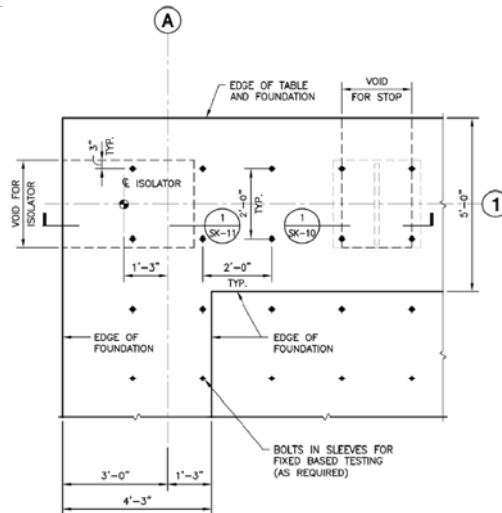
## Alternative Design (Base Isolation)



Typical Concrete Frame Elevation – Test Specimen A

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## Alternative Design (Base Isolation)

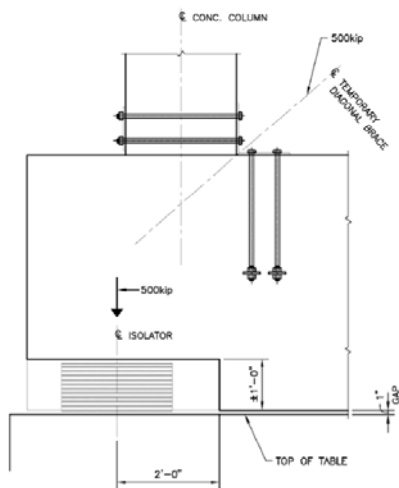


Foundation Detail

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## Alternative Design (Base Isolation)



Isolator Detail

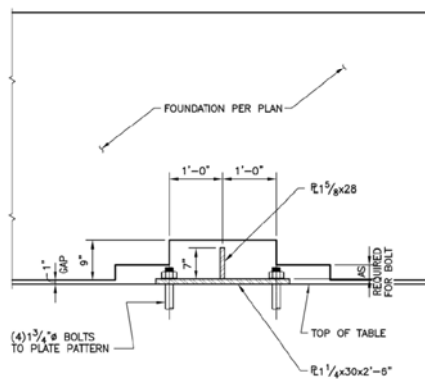


Plate Stop Detail

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## Design Status

- ▶ Concept Complete
- ▶ Earthquake Motion Approved
- ▶ Design Approved

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## Items Requiring Approval

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- Building Weight
  - ❖ Non-Structural Elements
  - ❖ Curtain Wall
- Base Isolation & Funding of Base Isolation

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## Next Step

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- ▶ Complete Design Development – 12/1/10
- ▶ Pricing – 12/1/10
- ▶ Funding – 1/1/11

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# Questions?

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# The Englekirk Companies

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