MAPPING DEMAND PARAMETERS IN HIGH-FRICTION SLIDING ISOLATED HOUSES TO IDENTIFY REGIONS FOR IMPLEMENTATION IN THE WESTERN US

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Traditional low-rise light-frame structures:

are vulnerable to costly earthquake damage\(^1\)

• $20 Billion in Northridge EQ


can lead to many displaced persons when damaged\(^2\)

• 100,000 in Northridge EQ


Challenges for Isolating Houses

Isolation made expensive by:
• Isolators, moat, pipes, required component testing, peer review, limited payoff in superstructure design forces

How can we reduce the cost?
• Use common, inexpensive materials
• Reduce the anticipated isolation displacements
• Tailor isolator characteristics to the superstructure
Sliding Isolation Systems

1) Isolated Base: Dish Surface

2) Isolated Base: Flat Surface
Parametric Study: $\text{MCE}_R$ intensity

- Peak Displacement
- Residual Displacement
- Force

Graphs showing the relationship between friction ($\mu$) and peak/displacement/residual displacement/force for different types of surfaces:
- Conventional
- Low-$\mu$ dish
- High-$\mu$ dish
- High-$\mu$ flat

For various values of $K$ (0 kN/m, 105 kN/m, 175 kN/m).
High Friction Isolation vs. Conventional Isolation

<table>
<thead>
<tr>
<th>Conventional</th>
<th>High Friction</th>
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<tbody>
<tr>
<td>Heavy structures</td>
<td>Proposed for Light frame structures</td>
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<tr>
<td>Low base shear in moderate events</td>
<td>The same base shear in all events</td>
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<tr>
<td>High base shear in rare events</td>
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\[
\mu = 0.2 \quad \mu = 0.1
\]

- MCE
- DBE

Disp. [cm]

V / W
Testing Program → Damage Free House

Component (Stanford) ~ 350 tests
10 interfaces
1.7 MPa → 14 MPa (250 → 2000 psi)
Cyclic – sinusoidal
0 → 30 cm/s (12 in/s)

Shake Table (NEES@Berkeley) ~ 80 tests
Flat and Dish isolators
Cyclic + Ground motions

Proof of Concept (NEES@UCSD) ~ 20 tests
Structure on isolation system
Flat and Dish isolators
Ground motions
Do we expect damage to light frame structures with high friction sliders?

OSB sheathing, typical architectural layout

$T_{\text{fixed}} = 0.2s$
Floor Accelerations

(a) Peak Floor Acceleration

(b) Normalized

\[ MCE_R \]
MCE_R Probability of Collapse

Fixed Base

[Map showing probability of collapse]
DBE Story Drift Ratio

High-μ Dish

Fixed Base
MCE_R Story Drift Ratio

High-μ Dish

Fixed Base

Mean SDR [%]
- 0.0 - 0.1
- 0.1 - 0.3
- 0.3 - 0.5
- 0.5 - 1.0
- 1.0 - 3.5
DBE Peak Floor Acceleration

High-$\mu$ Dish  Fixed Base
MCE$_R$ Peak Floor Acceleration

High-$\mu$ Dish

Fixed Base
$MCE_R$ Isolator Displacement

- **Low-μ Dish**
- **High-μ Dish**
- **High-μ Flat**

![Map of Mean Isolator Displacement (cm)](image_url)
Where should we consider isolating light frame structures?

Substantial Benefit: SDR > 0.5% at DBE

Benefit: SDR > 0.15% at DBE

Most of the west coast can benefit from high-friction sliding isolation!
Summary of High-Friction Sliding Isolation Research and Development

Parametric Study

Component Tests

Proof-of-Concept Tests

Incremental Dynamic Analysis

Mapping EDPs

Implementation
Acknowledgements

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