# IT2 – Cd=R Task Group

*Progress Report:*

PUC– August 15, 2018

nehrp

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# Persons Involved

- Sandy Hohener, Bob Pekelnicky, John Gillengerten, John Hooper, Jon Heintz, Charlie Kircher, David Bonneville, Jim Harris, Bonnie Manley, Phil Line, Ed Huston, Dawn Lehman, Mike Tong, Jiqiu Yuan, Kelly Cobeen

- Others providing data: Jay Harris, Ben Schafer

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# Scope/ Charges

Task 1: Create a comprehensive list of ASCE 7-16 seismic provisions that use estimated seismic drift or permitted drift as a parameter. Develop recommendations for revision.

1. List seismic provisions in ASCE 7-16 that incorporate seismic drift - Chapters 12, 13, 15, 16, 17,18
2. Describe intent of provisions, history of provisions if available
3. Describe in concept any required realignment of designer calculation of estimated drift
4. Describe in concept any required realignment of permitted drift
5. Develop recommendations for items for which the task group has adequate information
6. Where applicable, identify any further information or study (beyond capability of task group) that is required to provide recommendations

# Scope/ Charges

Task 2: Compile information on estimation of seismic drift from available numerical studies and example implementations of design provisions. Develop recommendations for better alignment between estimated drift and the intent of drift limits.

1. Solicit design example problems with available design drift calculations.
2. Solicit numerical study data on estimated drifts (actual drift values, not ratios)
3. Review alignment between numerical study and example problem estimation of drift and make recommendations for better alignment.

# Scope/ Charges

- Bonus Question 1 – Is DE an appropriate level at which to estimate and limit drift, or is other level such as $MCE_R$ is more appropriate to drift objectives?
- Bonus Question 2 – Is peak drift averaged over ground motion records an appropriate indicator, or is it desirable to set a higher level (i.e. mean plus one sigma)?
- Bonus Question 3 – Are different Cd factors required for lower stories?
- Bonus Question 4 – Are different Cd factors required for low-rise, mid-rise and high-rise?

# Task 1 – Current Uses of Drift Limits

- Summary spreadsheet of ASCE 7-16 provisions has been developed by Pekelnicky, Hohener and Gillengerten
- Research into reasons/objectives for drift limits has been collected

# Task 2 – Data Comparing Design Drift Estimates to NLRHA & Test Data

- ATC-116 - wood shear wall – Kircher, Pang
- MKA – varying systems - Hooper
- Degenkolb – varying systems – Hohener & Pekelnicky
- NIST – SMF, SCBF, EBF – Harris
- NEES CFS – CFS shear wall – Schafer
- UW – SCBF – Hsiao, Lehman, Roeder

# Task 2 – Data Comparing Design Drift Estimates to NLRHA & Test Data

## Is ASCE 7-16 underestimating peak drift?

| Structure Model | Structure Type | DE Estimated Roof Drift | | NLRHA Average Peak Roof Drift DE | | Underestimated? | |
|---|---|---|---|---|---|---|---|
| | | Drift (in) | Drift Ratio % | Drift (in) | Drift Ratio % | Ratio | Yes/No |
| ATC-116 MFD3B | Wood Shear Wall KC Calc | 5 to 8 | 1.0 to 1.6 | 4.15 | 0.9 | 1.1 to 1.8 | **No** |
| | Wood Shear Wall JH Calc | 7.8 | 1.6 | 4.15 | 0.9 | 1.88 | **No** |

Data courtesy of W. Pang, Charlie Kircher.

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# Task 2 – Data Comparing Design Drift Estimates to NLRHA & Test Data

## Is ASCE 7-16 underestimating peak drift?

| Structure Model | Structure Type | DE Estimated Roof Drift x 1.5 | | NLRHA Average Peak Roof Drift MCE | | Underestimated? | |
|---|---|---|---|---|---|---|---|
| | | (in) | % | (in) | % | Ratio | Yes/ No |
| MKA1 NS | Composite BRBF – 240 ft. | 122 | 4.2 | 33.7 | 1.2 | 3.6 | No |
| MKA1 EW | Composite SMF – 240 ft. | 74 | 2.6 | 25.7 | 0.9 | 2.9 | No |
| MKA2 NS | BRBF – 240 ft. | 57 | 1.9 | 19.4 | 0.7 | 2.9 | No |
| MKA2 EW | BRBF – 240 ft. | 76 | 2.6 | 21.8 | 0.8 | 3.2 | No |
| MKA3 NS | Concrete SW – 400 ft. | 63 | 1.3 | 39.8 | 0.8 | 1.6 | No |
| MKA3 EW | Concrete SW – 400 ft. | 55 | 1.1 | 31.0 | 0.6 | 1.8 | No |

Data courtesy of John Hooper, MKA

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# Task 2 – Data Comparing Design Drift Estimates to NLRHA & Test Data

## Is ASCE 7-16 underestimating peak drift?

| Structure Model | Structure Type | DE Estimated Story Drift x 1.5 | | NLRHA Average Peak Roof Drift MCE | Underestimated? | |
|---|---|---|---|---|---|---|
| | | | % | % | Ratio | Yes/ No |
| Degenkolb1EW | SMRF (Sideplate) | Roof | 1.29% | 1.37% | 0.94 | Close |
| | | 5th | 1.61% | 1.60% | 1.01 | Close |
| | | 4th | 1.60% | 1.57% | 1.01 | Close |
| | | 3rd | 1.52% | 1.56% | 0.97 | Close |
| | | 2nd | 1.02% | 1.25% | 0.82 | Yes |

Data courtesy of Sandy Hohener, Bob Pekelnicky, Degenkolb.

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# Task 2 – Data Comparing Design Drift Estimates to NLRHA & Test Data

## Is ASCE 7-16 underestimating peak drift?

| Structure Model | Structure Type | DE Estimated Story Drift x 1.5 | | NLRHA Average Peak Roof Drift MCE | Underestimated? | |
|---|---|---|---|---|---|---|
| | | | % | % | Ratio | Yes/ No |
| Degenkolb1NS | BRBF | Roof | 1.22% | 1.11% | 1.10 | Close |
| | | 5th | 1.26% | 1.31% | 0.96 | Close |
| | | 4th | 1.16% | 1.41% | 0.82 | Yes |
| | | 3rd | 1.11% | 1.45% | 0.76 | Yes |
| | | 2nd | 0.87% | 1.10% | 0.79 | Yes |

Data courtesy of Sandy Hohener, Bob Pekelnicky, Degenkolb.

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# Task 2 – Data Comparing Design Drift Estimates to NLRHA & Test Data

## Is ASCE 7-16 underestimating peak drift?

| Structure Model | Structure Type | DE Estimated Story Drift x 1.5 | | NLRHA Average Peak Roof Drift MCE | Underestimated? | |
|---|---|---|---|---|---|---|
| | | | % | % | Ratio | Yes/ No |
| Degenkolb #2 | Concrete Shear Wall | Roof | 2.12% | 2.24% | 0.94 | Close |
| | | Level 6 | 2.06% | 2.14% | 0.96 | Close |
| | | Level 5 | 1.95% | 1.99% | 0.98 | Close |
| | | Level 4 | 1.76% | 1.79% | 0.98 | Close |
| | | Level 3 | 1.34% | 1.48% | 0.90 | Close |
| | | Level 2 | 0.57% | 0.92% | 0.62 | Yes |

Data courtesy of Sandy Hohener, Bob Pekelnicky, Degenkolb.

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# Task 2 – Data Comparing Design Drift Estimates to NLRHA & Test Data

## Is ASCE 7-16 underestimating peak drift?

| Structure Model | Structure Type | Story | DE Estimated Story Drift | | NLRHA Average Peak Story Drift at DE | | Under-estimated? | |
|---|---|---|---|---|---|---|---|---|
| | | | (in) | % | (in) | % | Ratio | Yes/No |
| NIST 1863-1 MC8 ELF Design | Steel Moment Frame | 8 | 2.25 | 1.3 | | 2.3 | 0.56 | **Yes** |
| | | 7 | 2.83 | 1.7 | | 2.3 | 0.74 | **Yes** |
| | | 6 | 2.81 | 1.7 | | 2.2 | 0.77 | **Yes** |
| | | 5 | 3.00 | 1.8 | | 2.2 | 0.82 | **Yes** |
| | | 4 | 3.06 | 1.8 | | 2.3 | 0.78 | **Yes** |
| | | 3 | 3.11 | 1.9 | | 2.4 | 0.79 | **Yes** |
| | | 2 | 2.96 | 1.8 | | 2.4 | 0.75 | **Yes** |
| | | 1 | 2.93 | 1.4 | | 2.2 | 0.63 | **Yes** |

Data courtesy of NIST, Jay Harris

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# Task 2 – Data Comparing Design Drift Estimates to NLRHA & Test Data

## Is ASCE 7-16 underestimating peak drift?

| Structure Model | Structure Type | Story | DE Estimated Story Drift | | NLRHA Approx. Average Peak Story Drift at DE | | Under-estimated? | |
|---|---|---|---|---|---|---|---|---|
| | | | (in) | % | (in) | % | Ratio | Yes/No |
| NIST 1863-1 MC8 RSA Design | Steel Moment Frame | 8 | 1.84 | 1.1 | | 3 | 0.37 | **Yes** |
| | | 7 | 2.38 | 1.4 | | 3 | 0.46 | **Yes** |
| | | 6 | 2.75 | 1.6 | | 3 | 0.53 | **Yes** |
| | | 5 | 2.92 | 1.7 | | 4 | 0.42 | **Yes** |
| | | 4 | 2.90 | 1.7 | | 6 | 0.28 | **Yes** |
| | | 3 | 2.99 | 1.8 | | 8 | 0.22 | **Yes** |
| | | 2 | 2.86 | 1.7 | | 8 | 0.21 | **Yes** |
| | | 1 | 2.84 | 1.3 | | 8 | 0.16 | **Yes** |

Data courtesy of NIST, Jay Harris

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# Task 2 – Data Comparing Design Drift Estimates to NLRHA & Test Data

## Is ASCE 7-16 underestimating peak drift?

| Structure Model | Structure Type | Condition | Story | DE Estimated Story Drift | | Shake Table Test Peak Story Drift | | Underestimated? | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Drift (in) | Drift Ratio % | Drift (in) | Drift Ratio % | Ratio | Yes/No |
| CFS-NEES | CFS Shear Wall | DE no finishes | 2 | | 1.2 | | 0.8 | 1.5 | No |
| | | | 1 | | 2.4 | | 1.2 | 2.0 | No |
| | | DE with finishes | 2 | | 1.2 | | 0.25 | 4.8 | No |
| | | | 1 | | 2.4 | | 0.5 | 4.8 | No |
| | | MCE w/ finishes | 2 | | 1.2 | | 0.7 | 1.7 | No |
| | | | 1 | | 2.4 | | 0.7 | 3.4 | No |

Data courtesy of Ben Schafer

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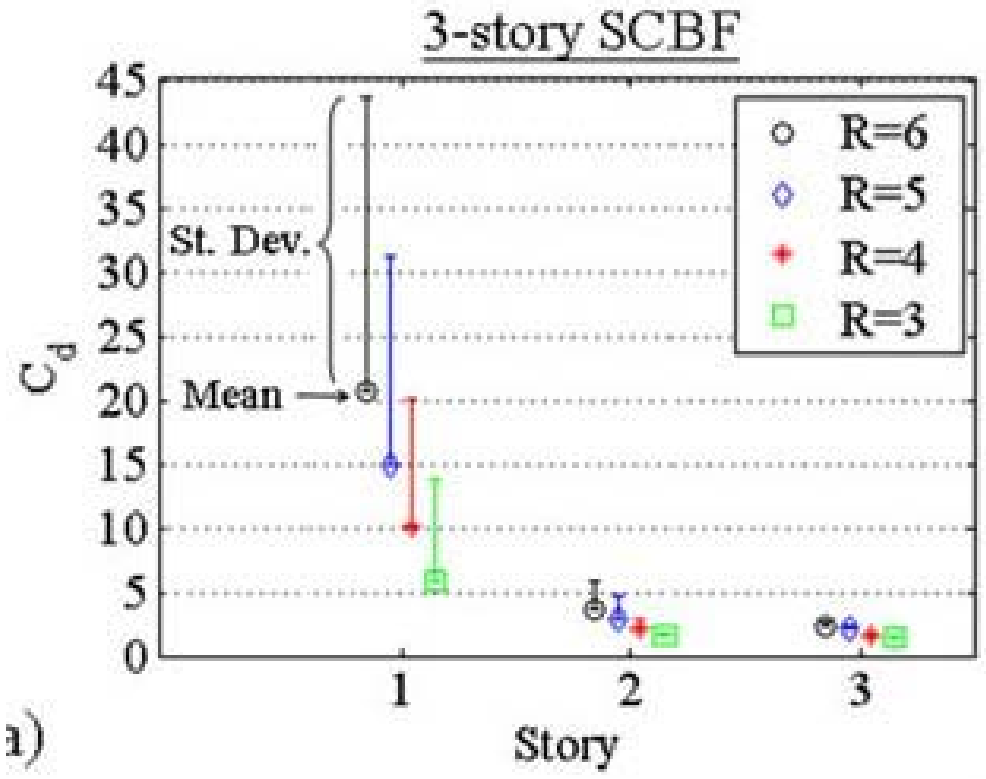
# Task 2 – Data Comparing Design Drift Estimates to NLRHA & Test Data




ASCE 7-16:
R=6
$C_d$=5

Data courtesy of Hsiao, Lehman and Roeder

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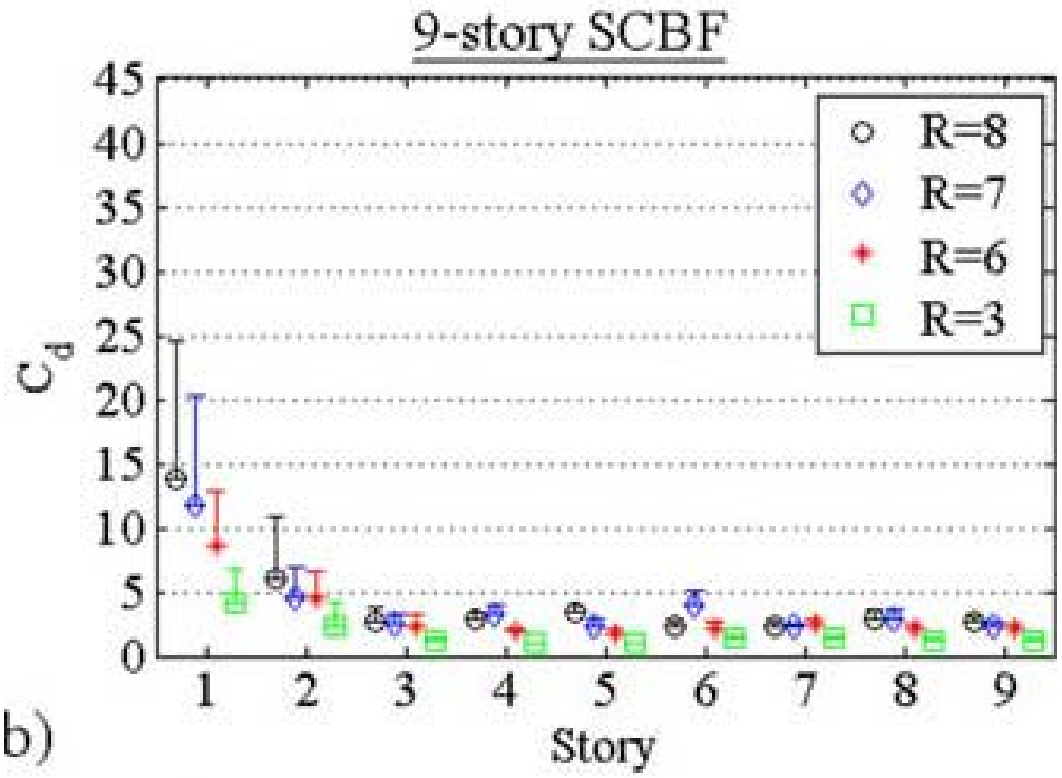


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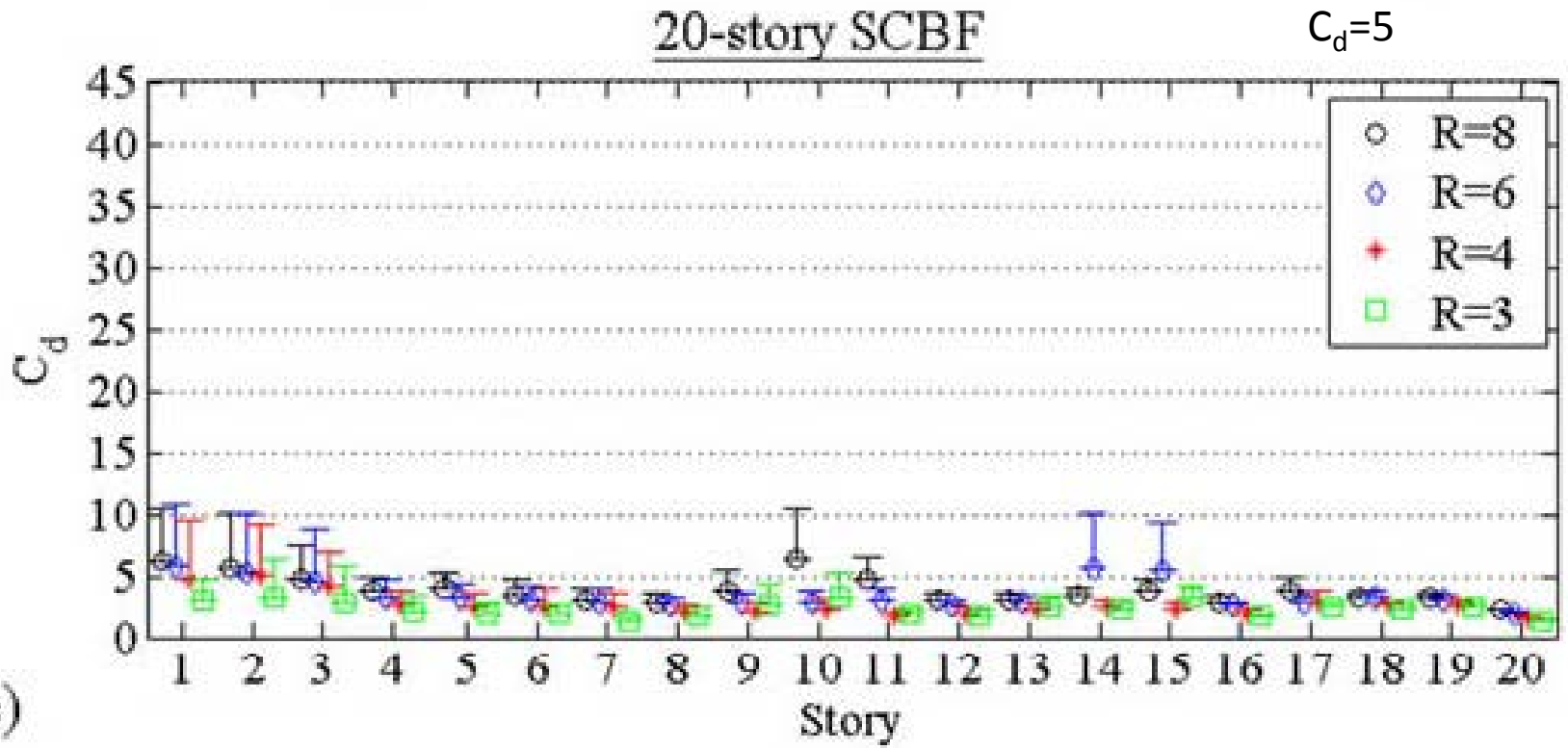


Lehman and Roeder

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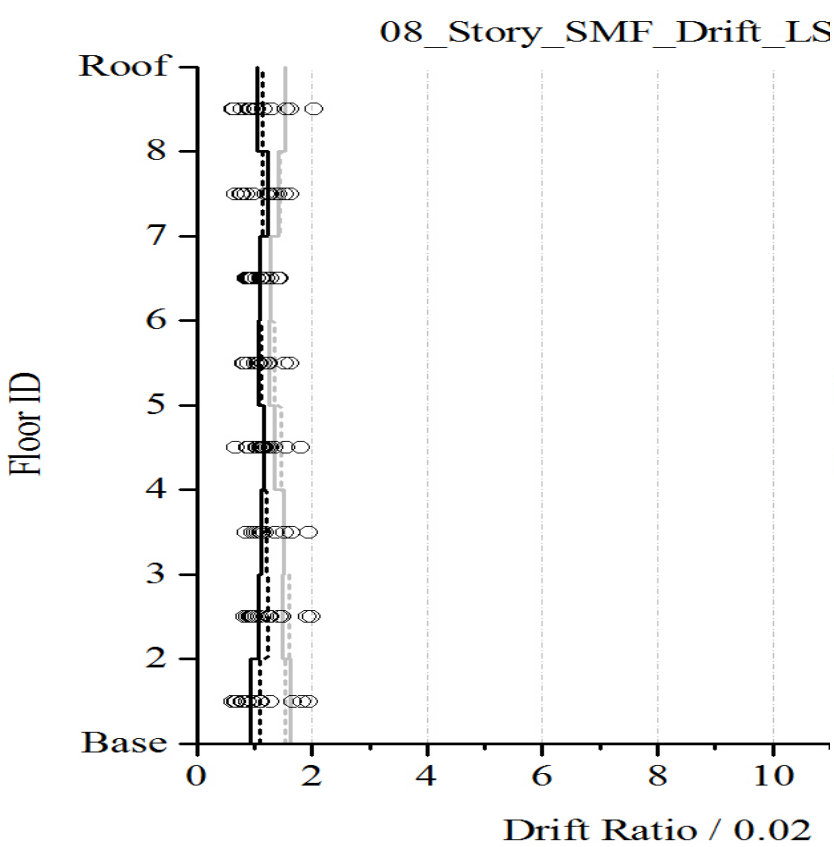
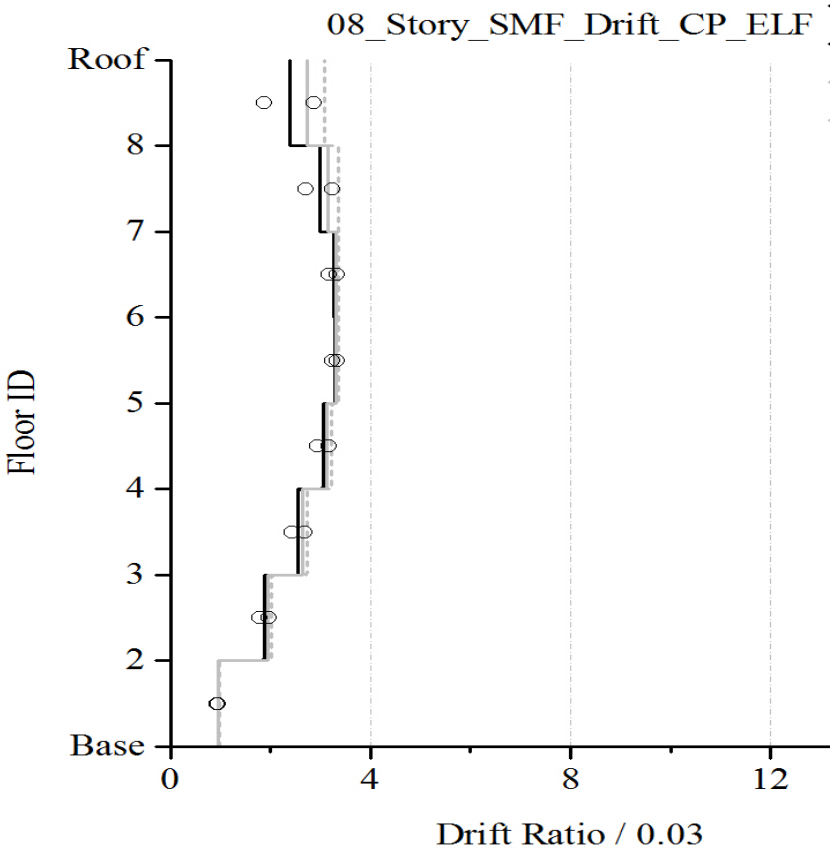
# Bonus Question 1

- Is DE an appropriate level at which to estimate and limit drift, or is other level such as $MCE_R$ is more appropriate to drift objectives?




Data courtesy of Jay Harris

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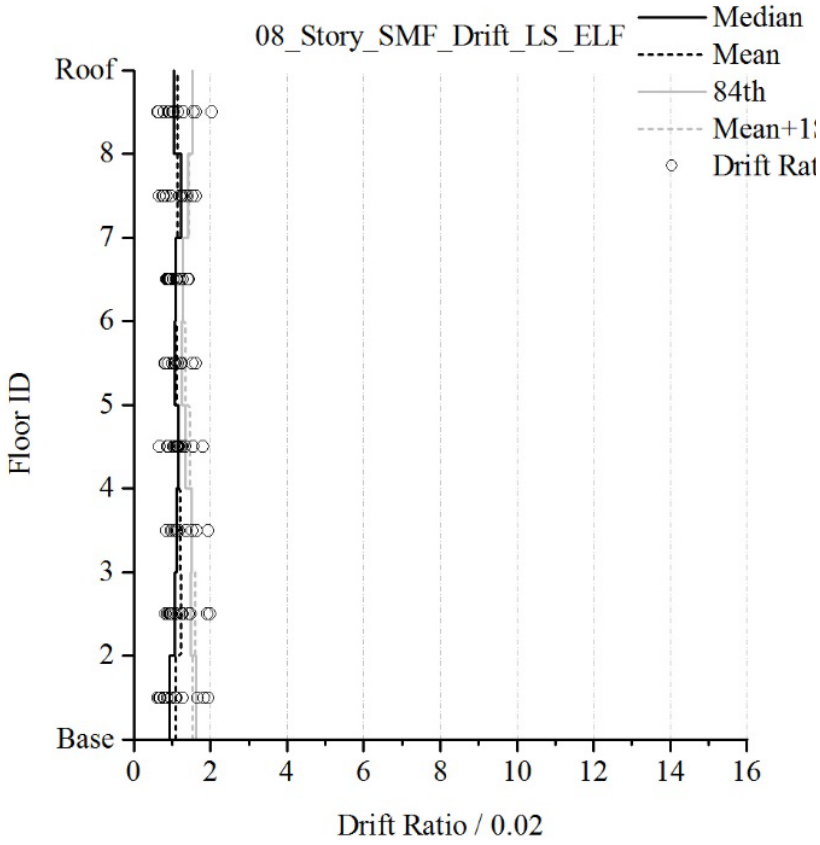
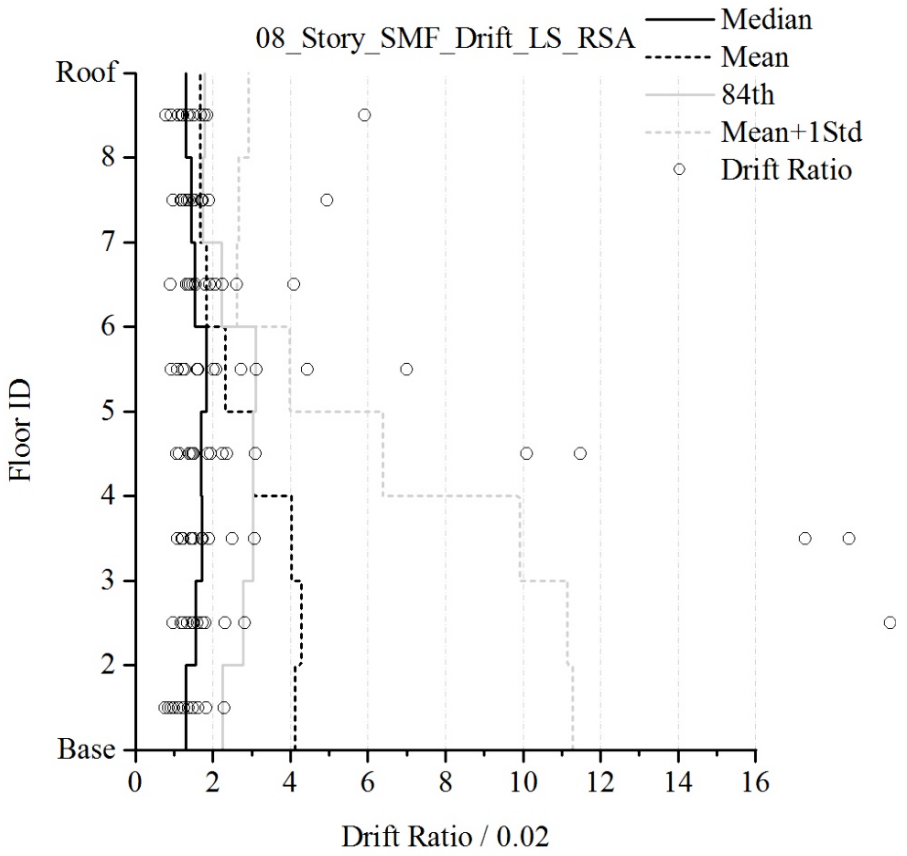
# Bonus Question 2

Is peak drift averaged over ground motion records an appropriate indicator, or is it desirable to set a higher level (i.e. mean plus one sigma)?




Data courtesy of Jay Harris

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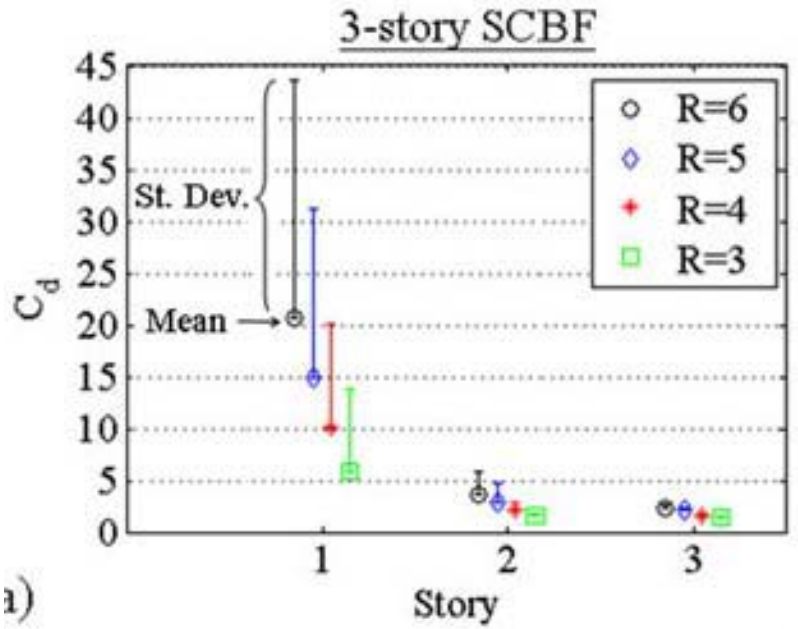
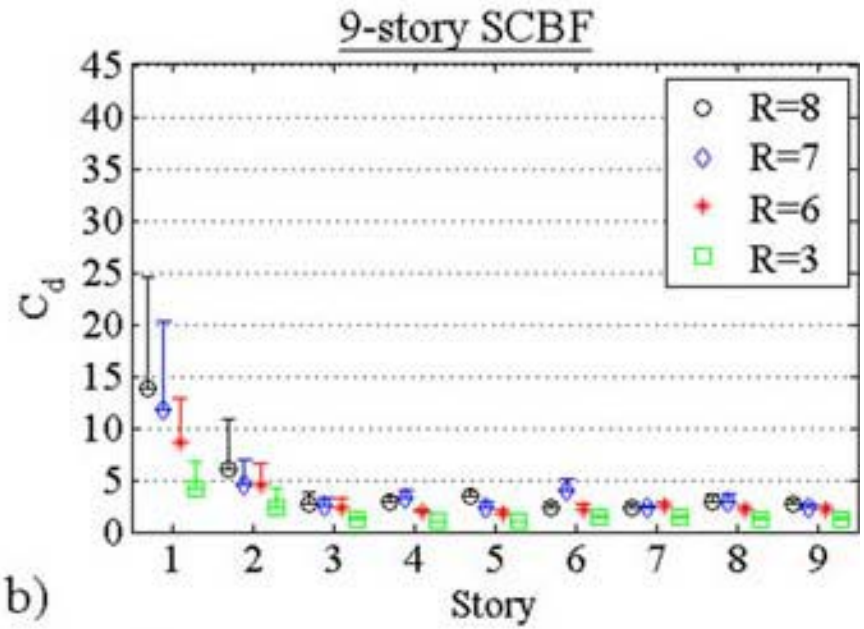
# Bonus Questions 3 & 4

Are different $C_d$ factors required for lower stories? Are different $C_d$ factors required for low-rise, mid-rise and high-rise?

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