Liquefaction Fragility Functions for NZ Houses

Nathan McDougall

Tonkin+Taylor

Background

- EQC is developing a model (RiskScape) for predicting financial losses in natural disaster scenarios

- T+T has developed earthquake shaking and liquefaction components using fragility functions

- These fragility functions provide a probabilistic estimate for losses associated with earthquake damage to NZ Houses (1 & 2 Storey) on Flat land

Development of Flat Land Building Fragility Functions

for NZ Residential Houses

Building Damage Claim Amounts
From the Canterbury and Kaikoura Earthquakes

+ Private Insurer Data

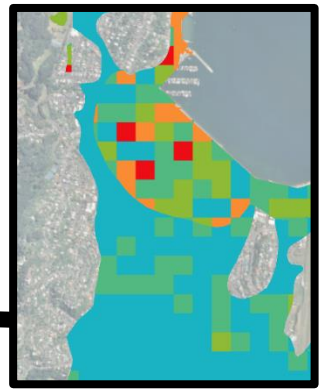
Historic Building Portfolio

- Floor Area
- Construction Era
- Foundation Type
- Estimated $ Value
- Etc.

$$\$ = fn(\text{house}, \text{shaking}, \text{liquefaction})$$

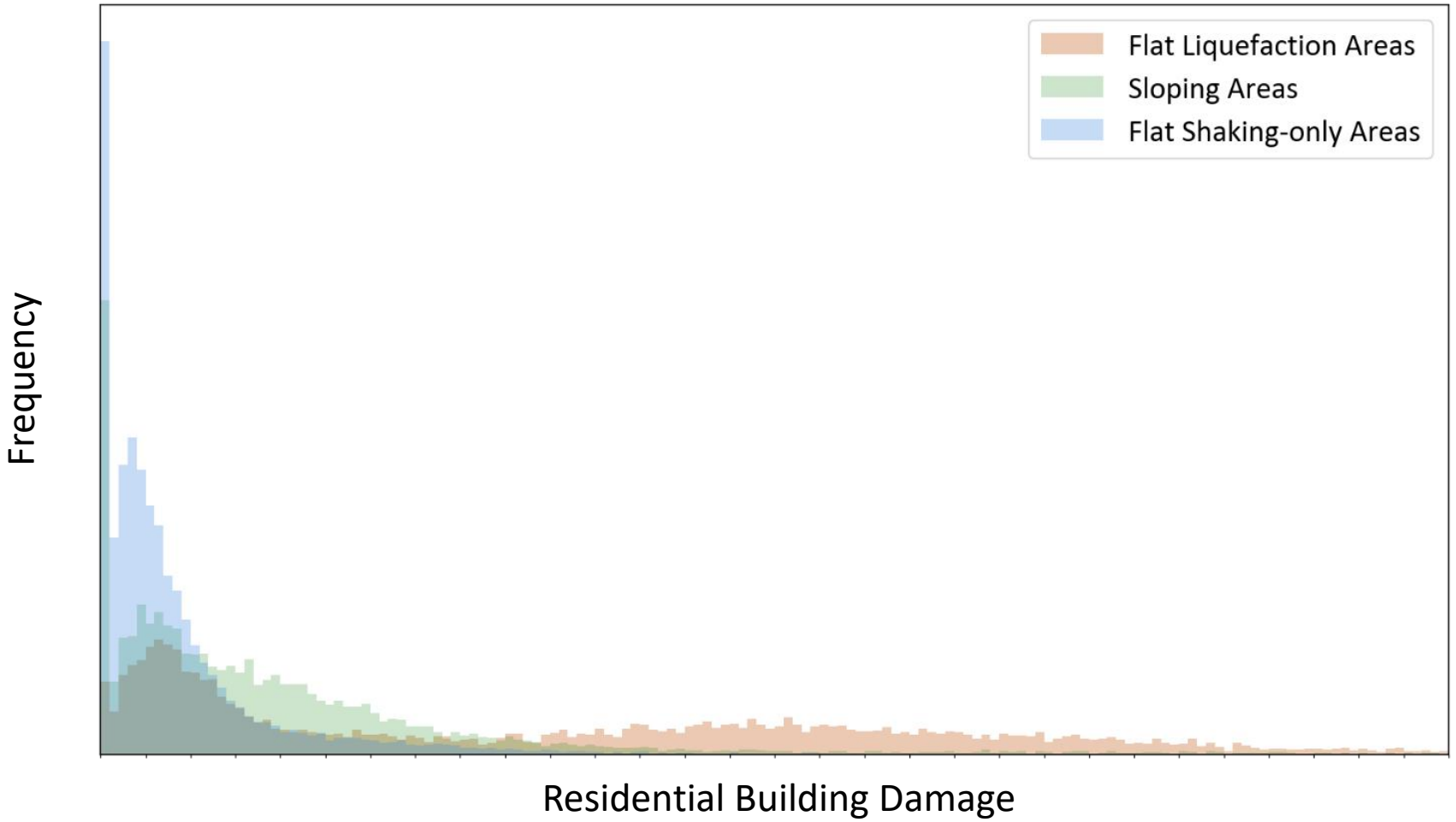
Shaking Intensity Models (PGA)

- Bradley 2014
- O'Rourke & Milashuk 2011
- Kaikoura - Monitoring Stations

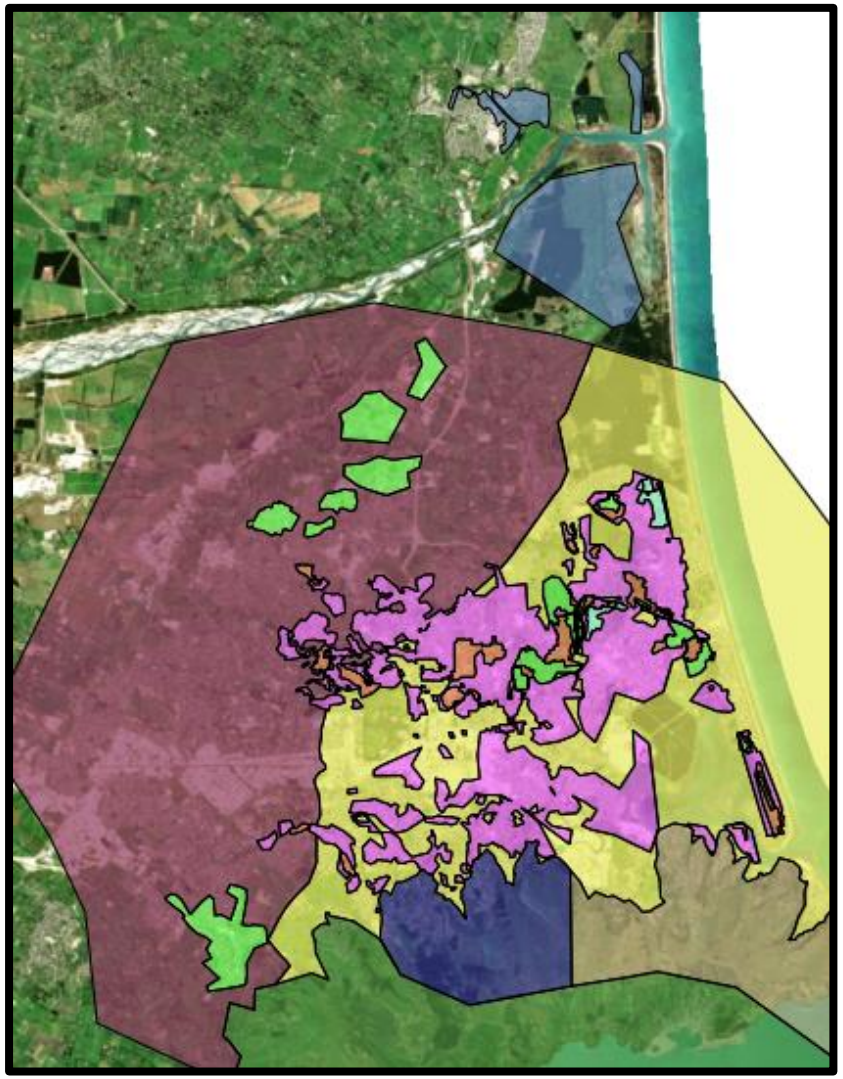


Liquefaction models
Liquefaction Severity Number

Residential Building Damage Breakdown



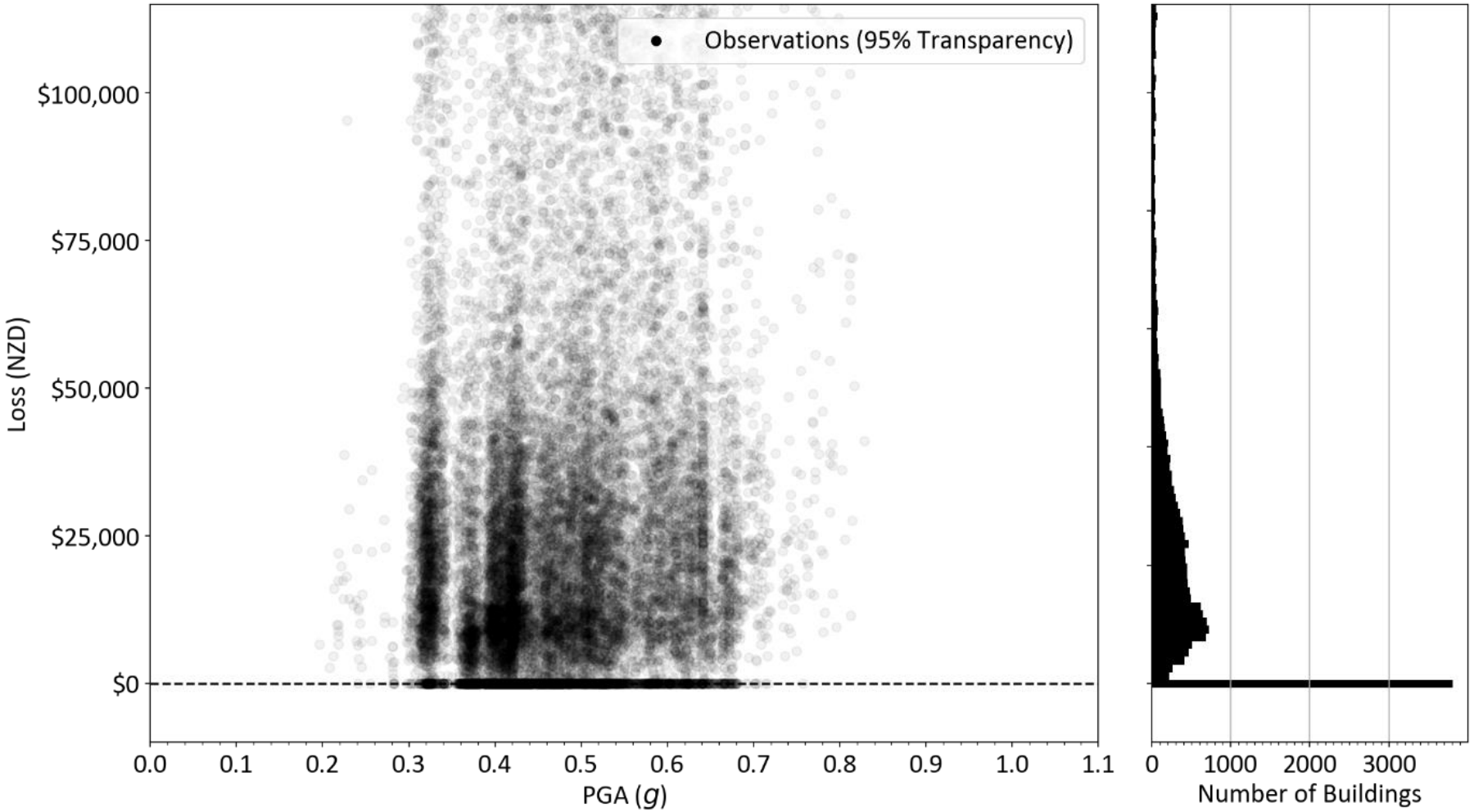
Determining dominant earthquake and damage cause



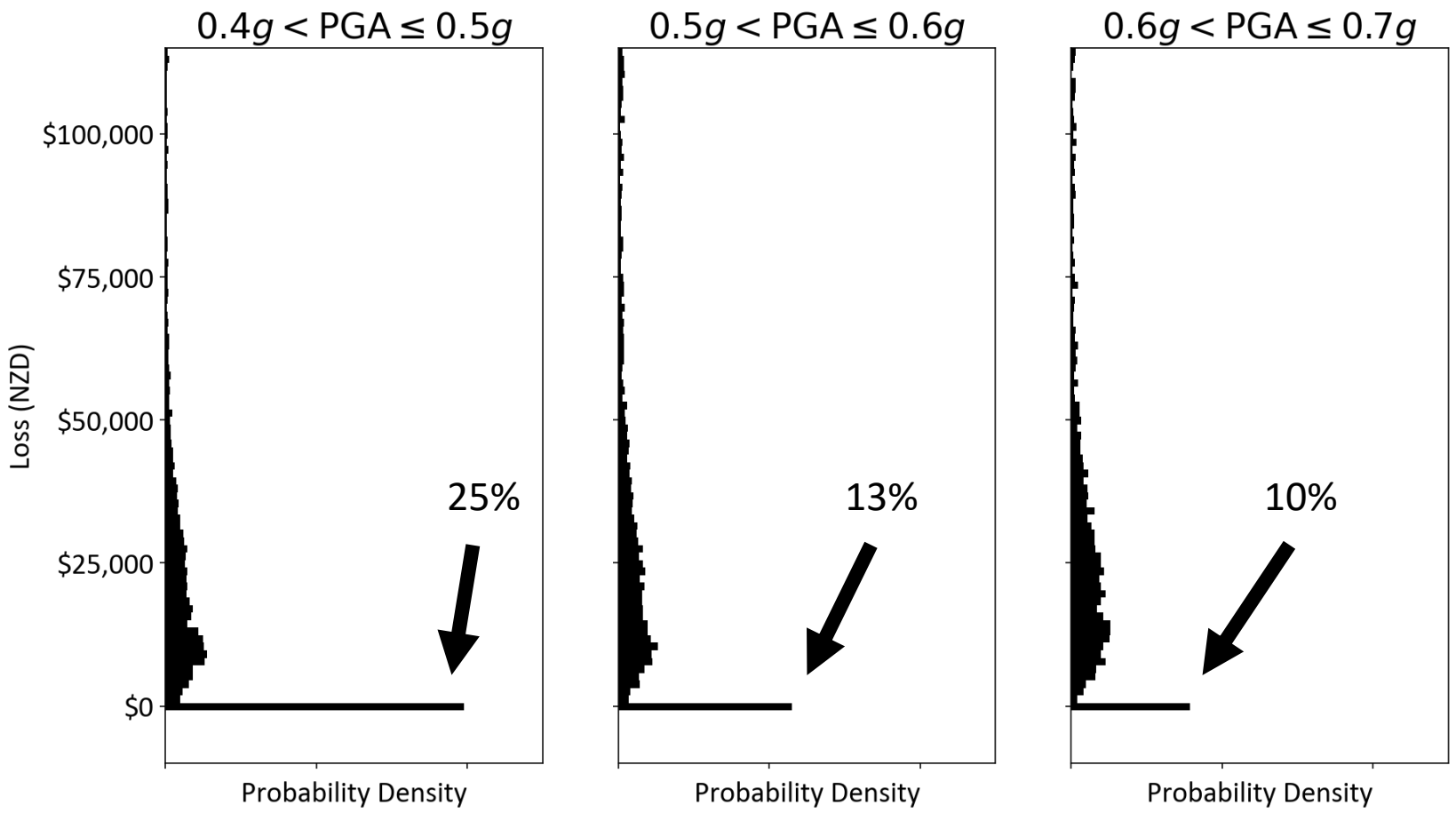
Shaking Fragility Functions

A quick overview

Insurance claims loss data (Shaking only)



Loss by PGA


0.4g < PGA ≤ 0.5g
0.5g < PGA ≤ 0.6g
0.6g < PGA ≤ 0.7g
$100,000
$75,000
$50,000
$25,000
$0
Loss (NZD)
25%
13%
10%
Probability Density
Probability Density
Probability Density

Shake fragility functions

(for shaking only portfolio)

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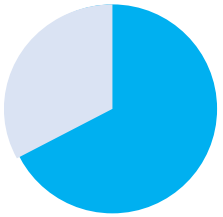
One-Step Approach

Probability Density

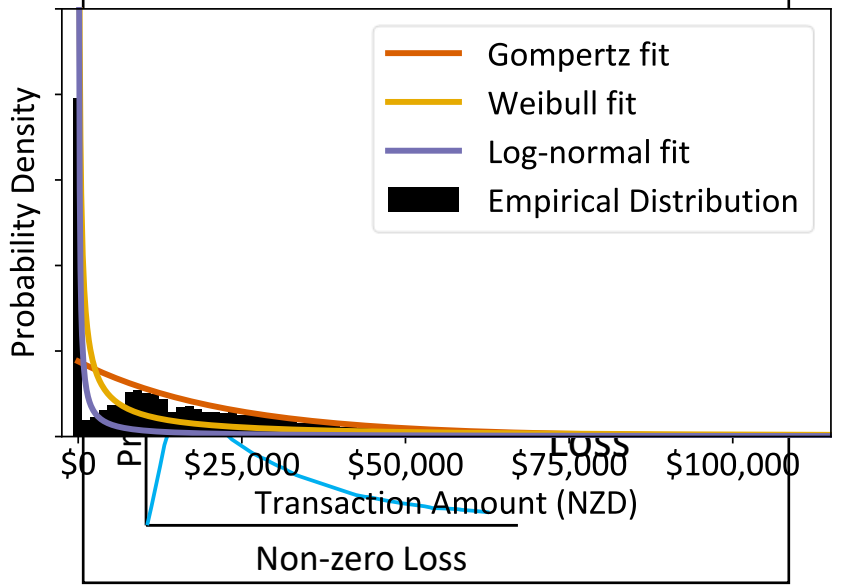
Loss

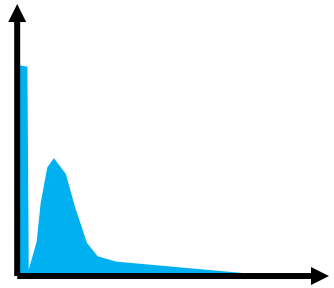
Distribution of Loss (including zero)

Two-Step Approach

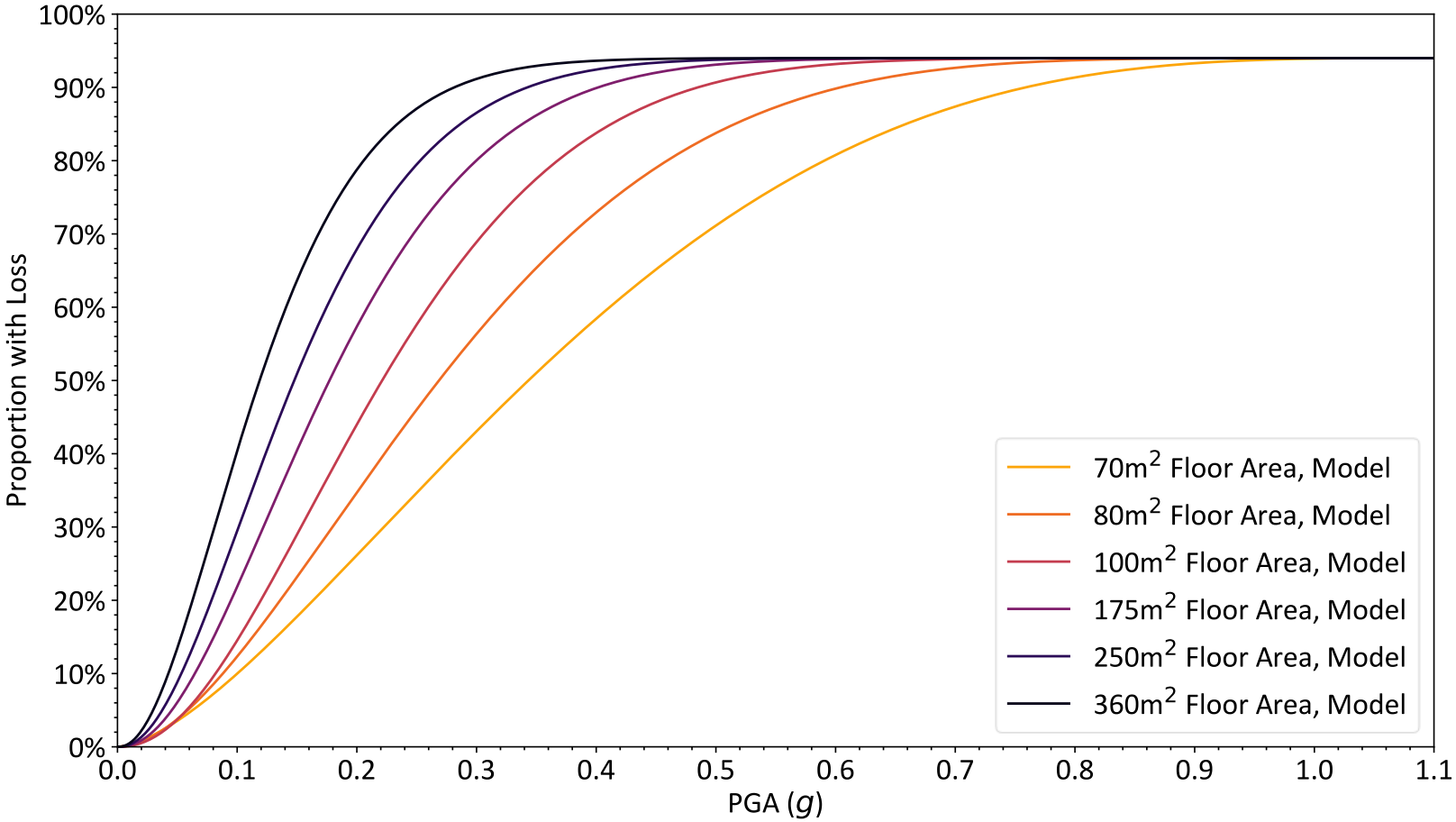


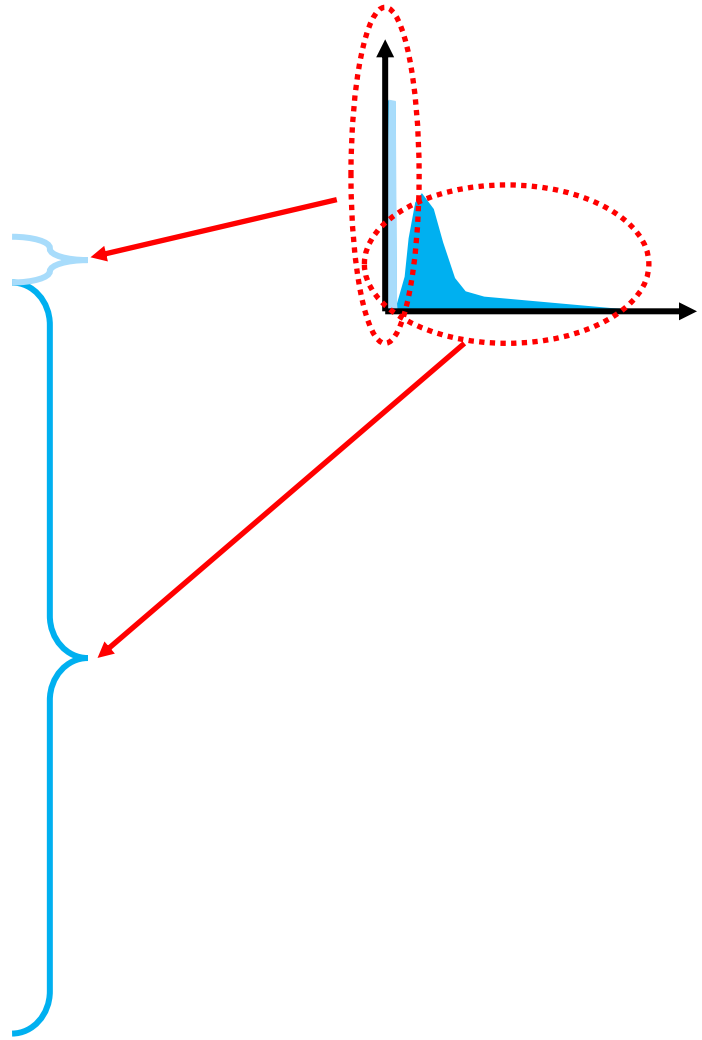
Probability of Non-zero Loss



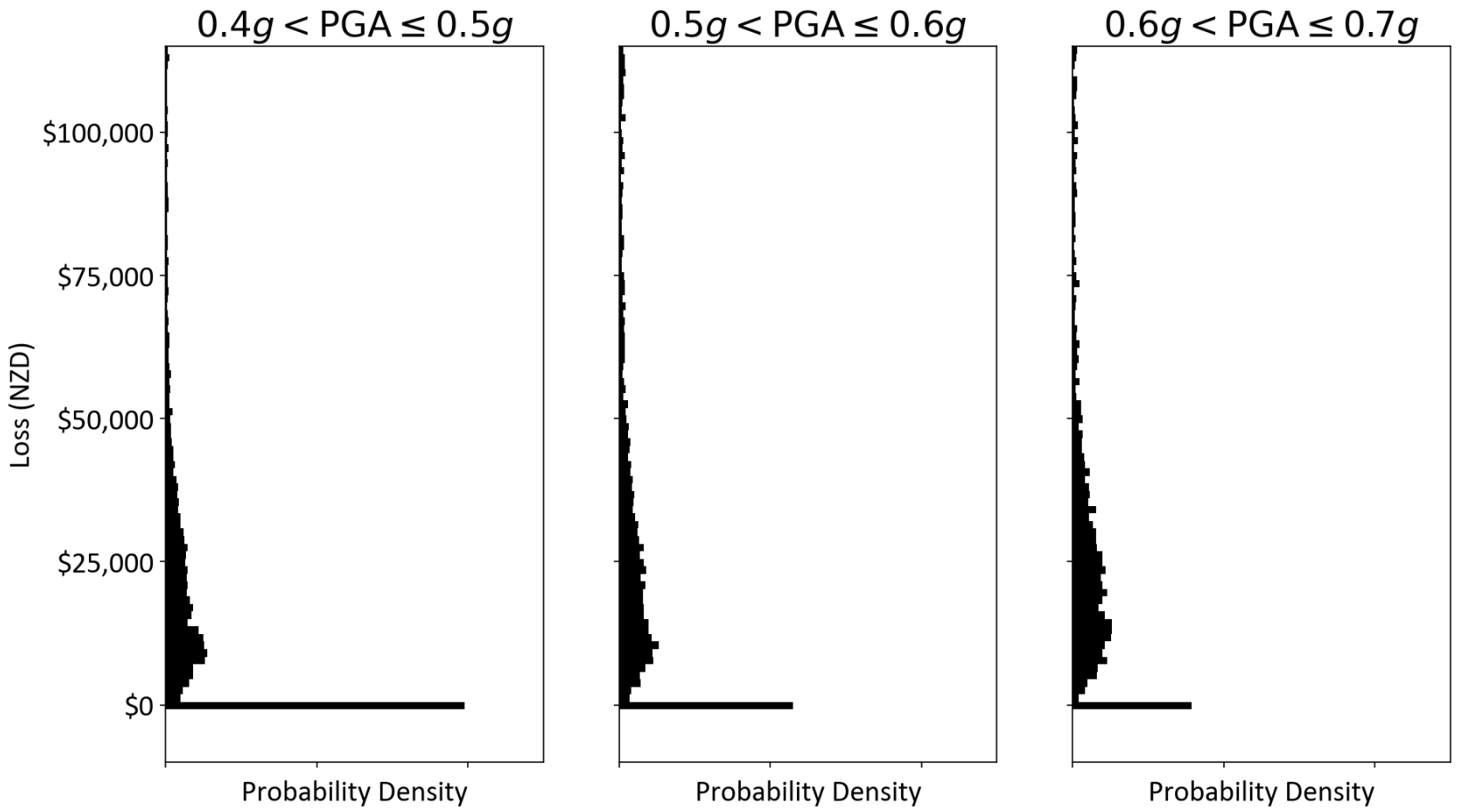


Probability of loss by PGA





Loss by PGA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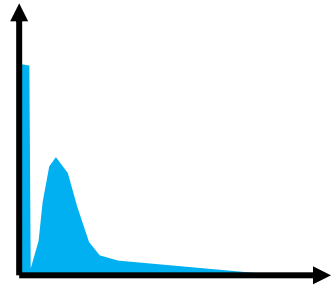
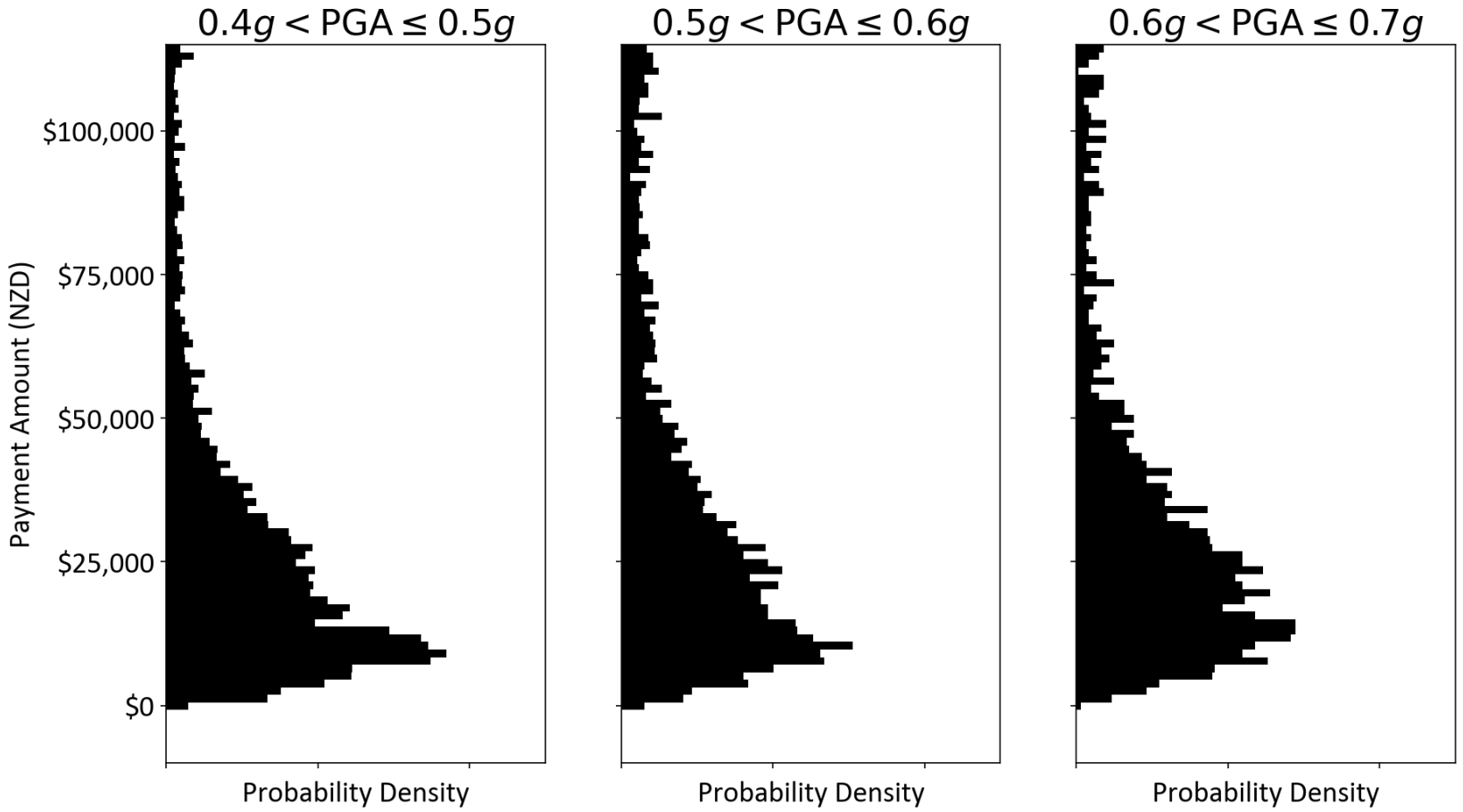
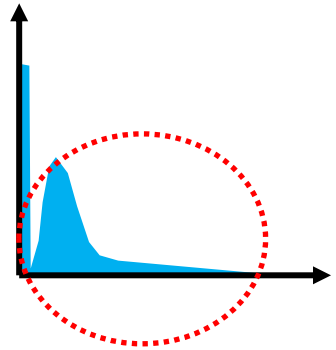
$100,000
$75,000
$50,000
$25,000
$0
Loss (NZD)
Probability Density
Probability Density
Probability Density

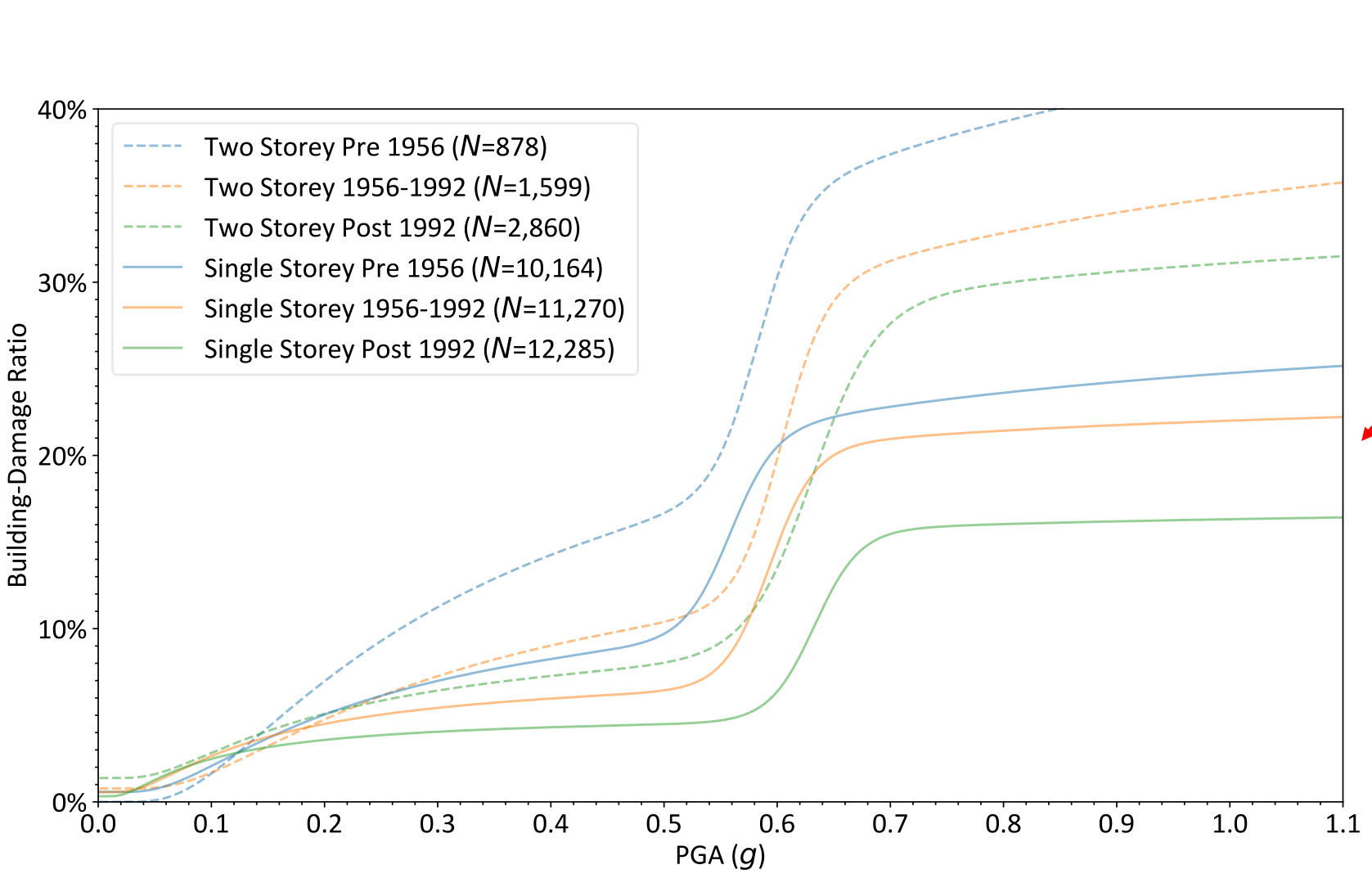


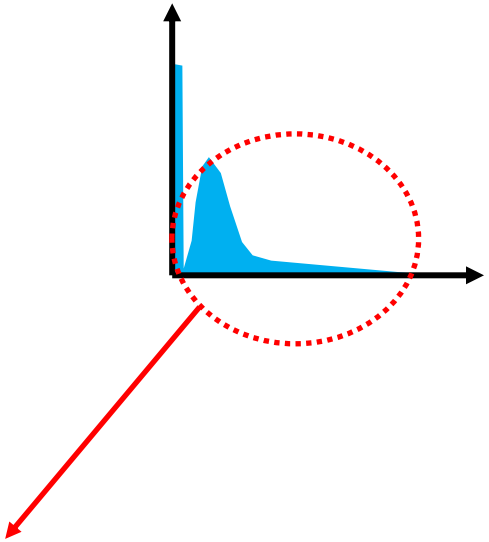
Non-Zero Loss by PGA



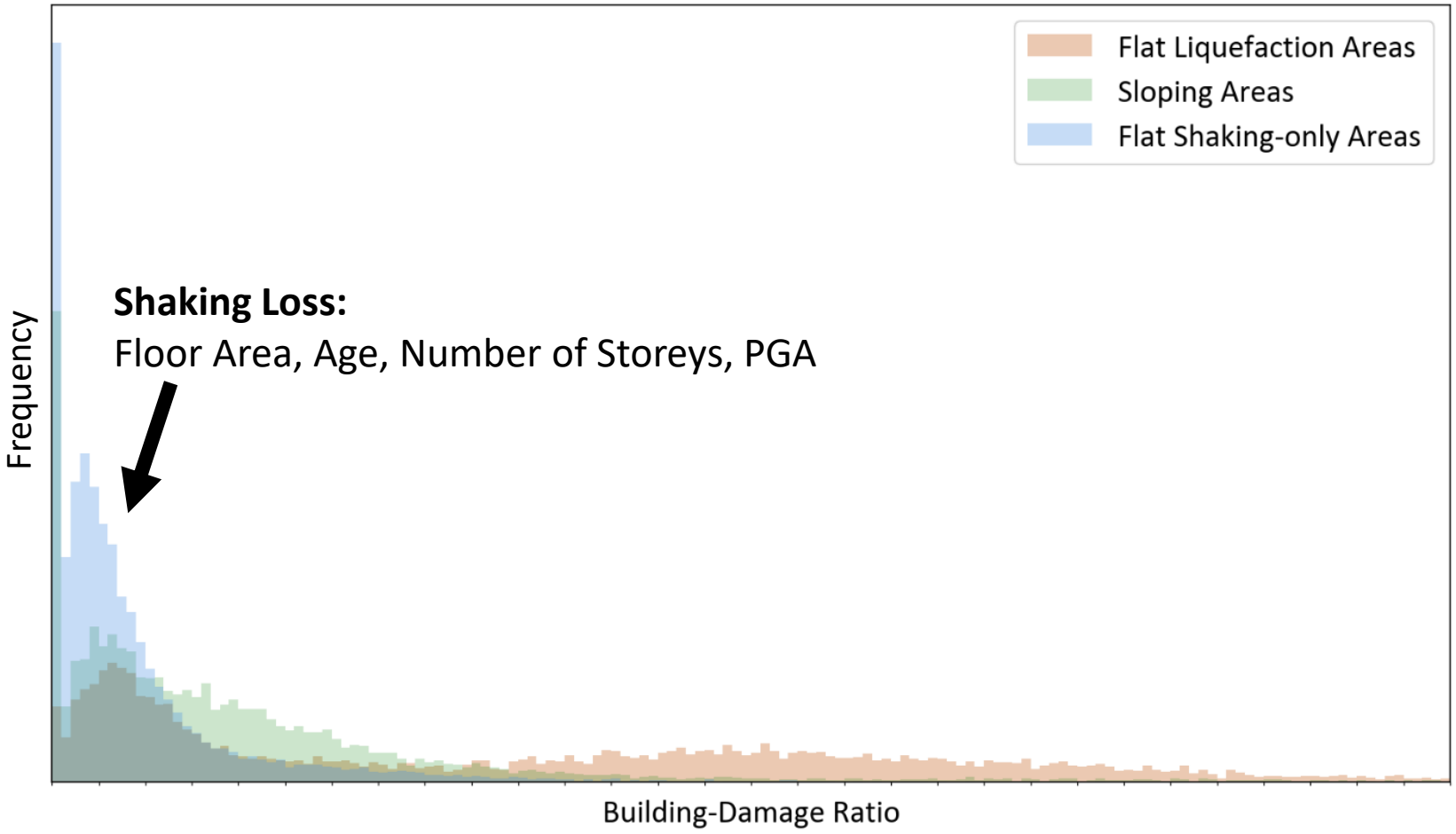


Combined Effects



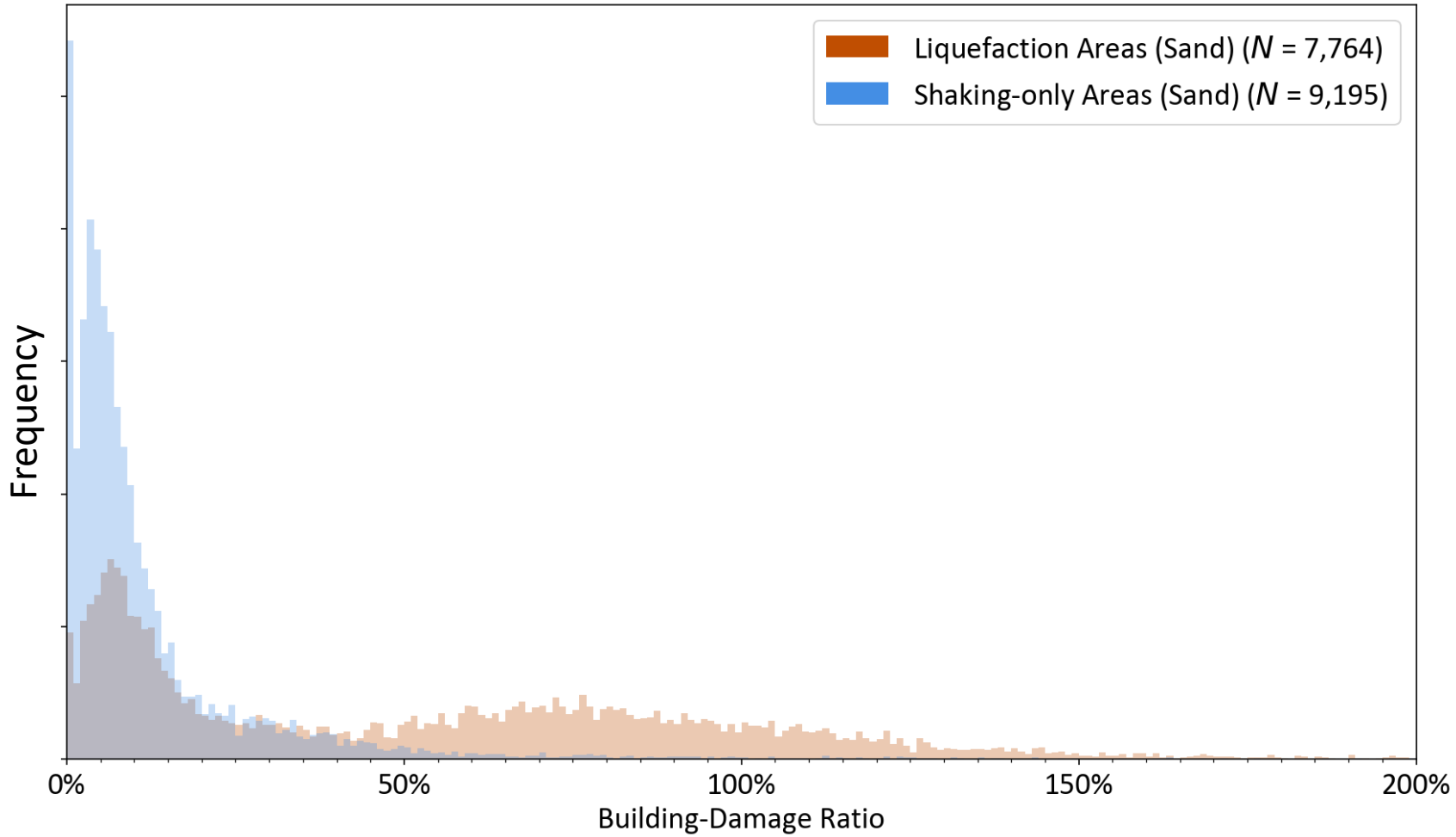


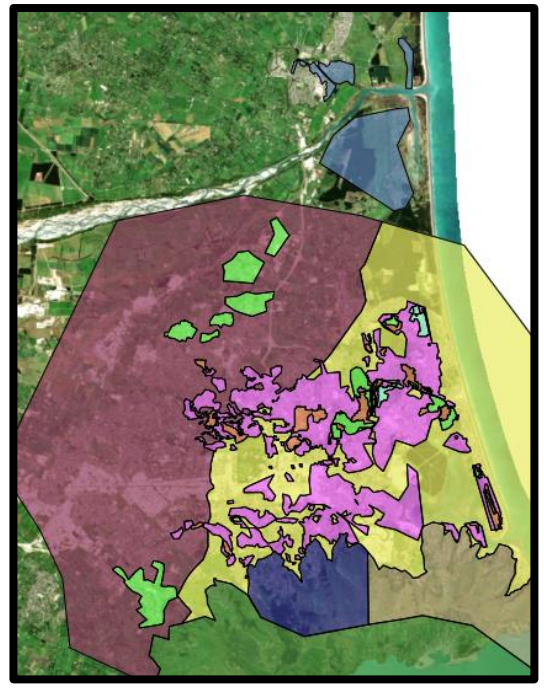
Conclusion


Flat Liquefaction Areas
Sloping Areas
Flat Shaking-only Areas
Shaking Loss:
Floor Area, Age, Number of Storeys, PGA
Frequency
Building-Damage Ratio

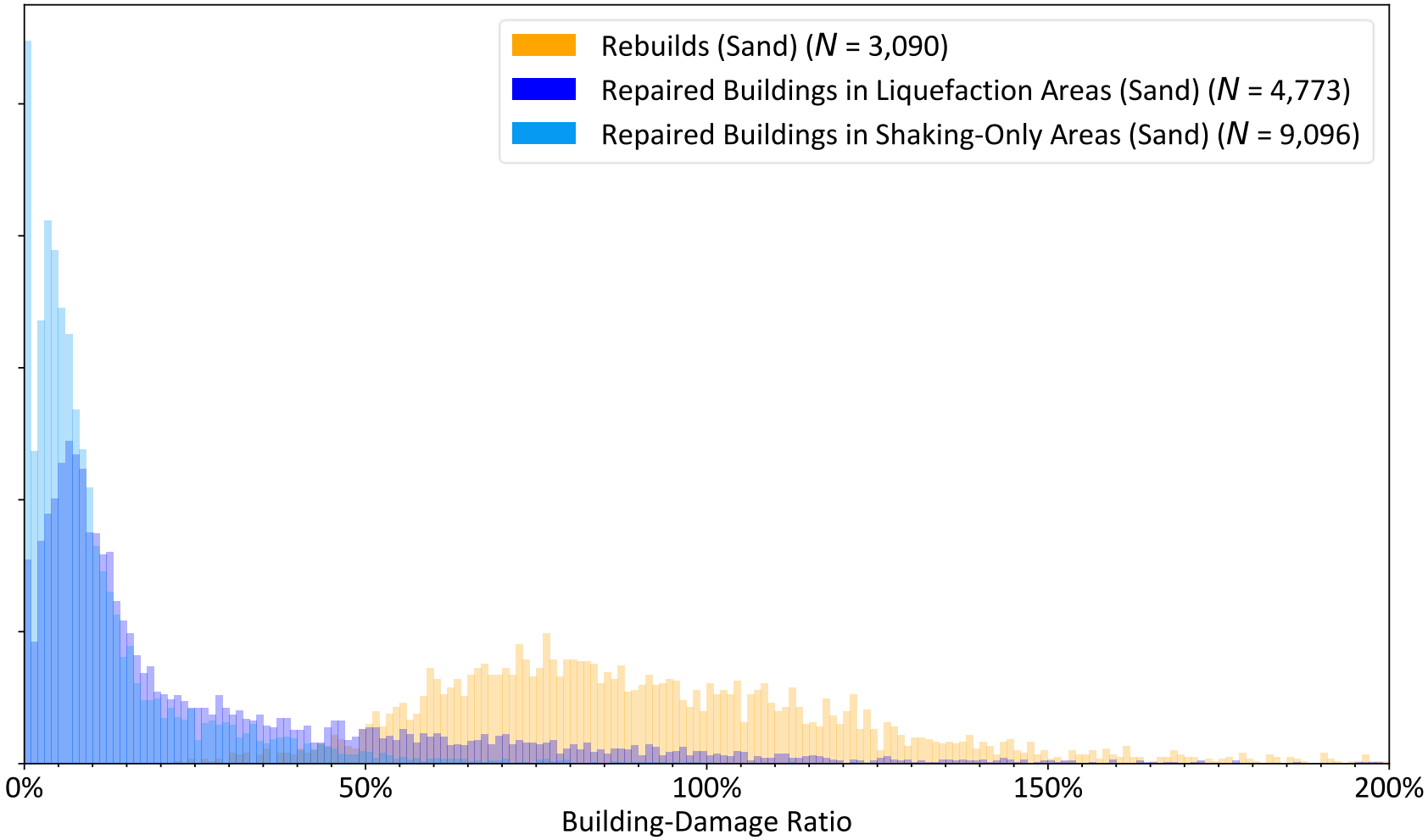
Liquefaction Fragility Functions

Shaking vs. Liquefaction





Shaking vs. Liquefaction
Repairs and Rebuilds



Liquefaction fragility functions

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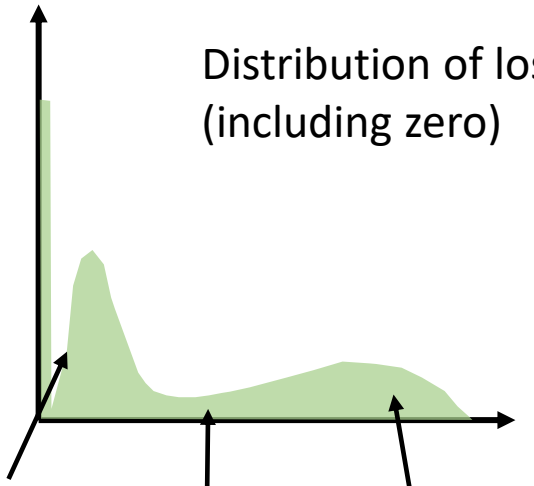
One-Step Approach



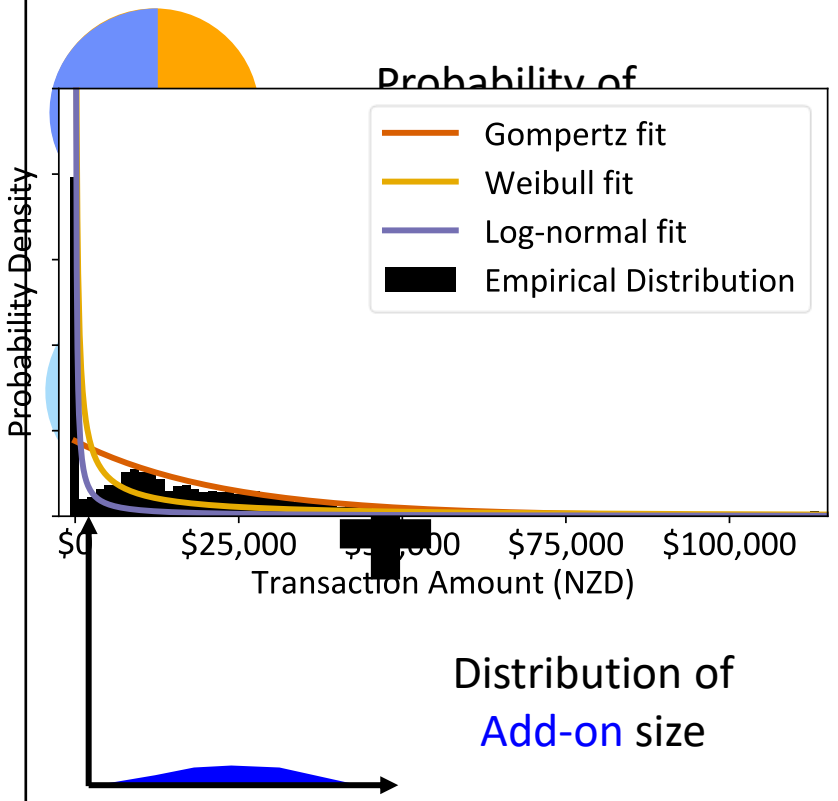
Distribution of loss (including zero)

Shake only

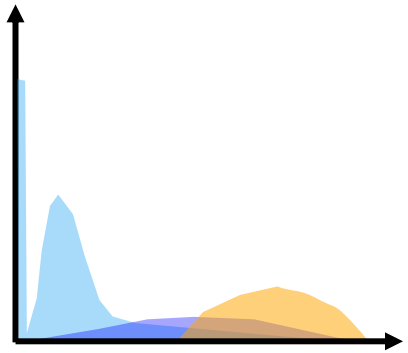
Shake loss + additional liquefaction loss (add-on)

Liquefaction causes a rebuild: loss = 100%

Three-Step Approach



Distribution of Add-on size



Proportion of Rebuilds

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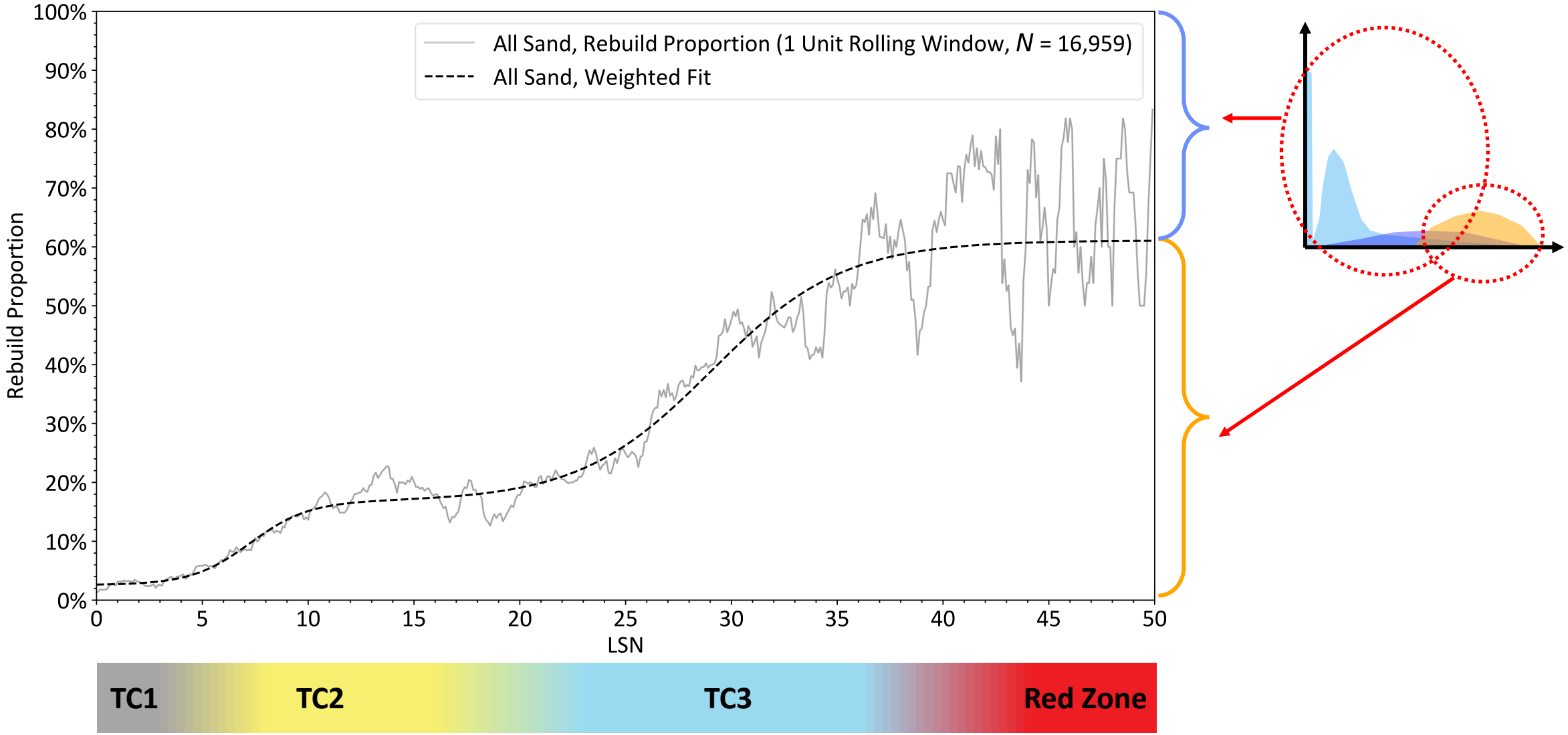
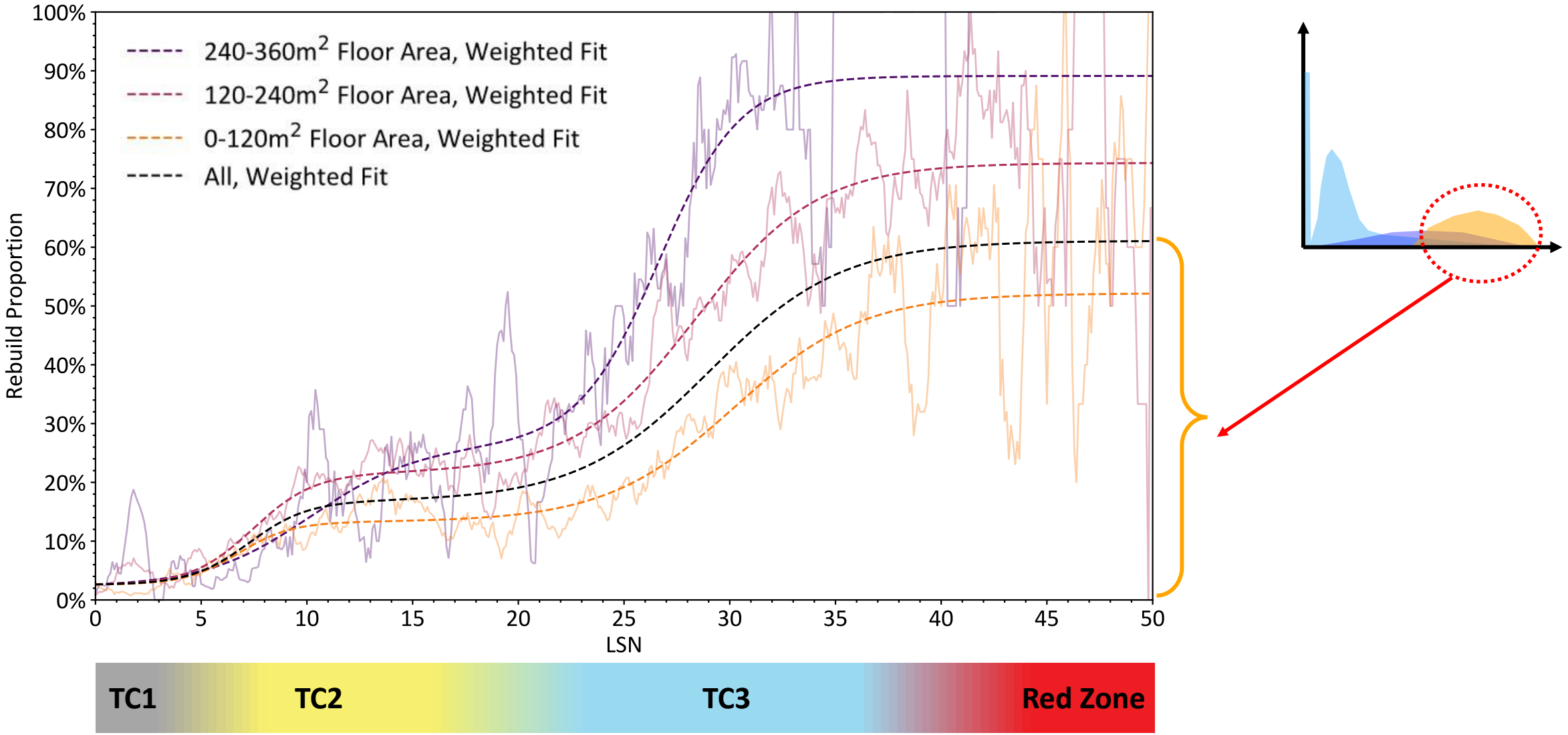
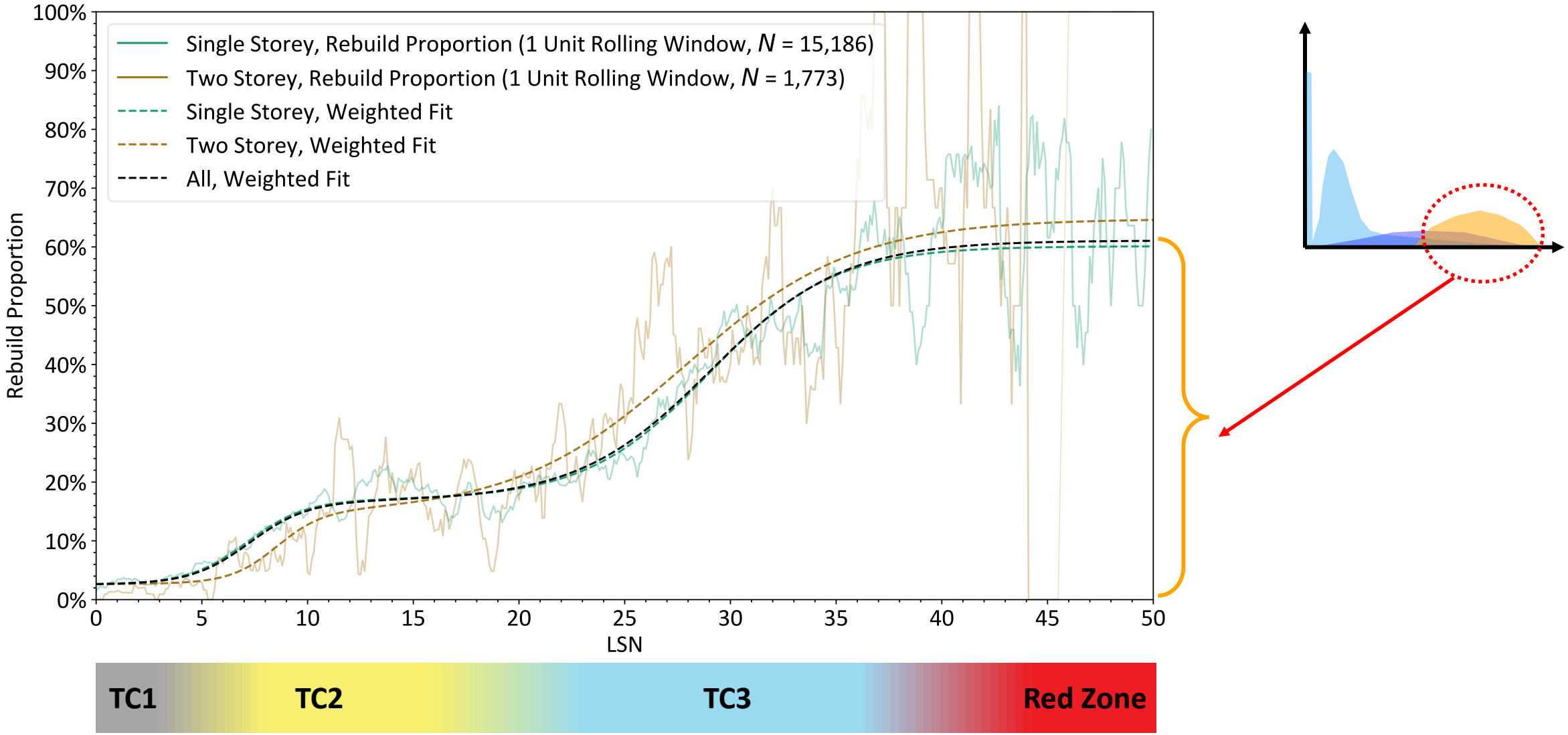


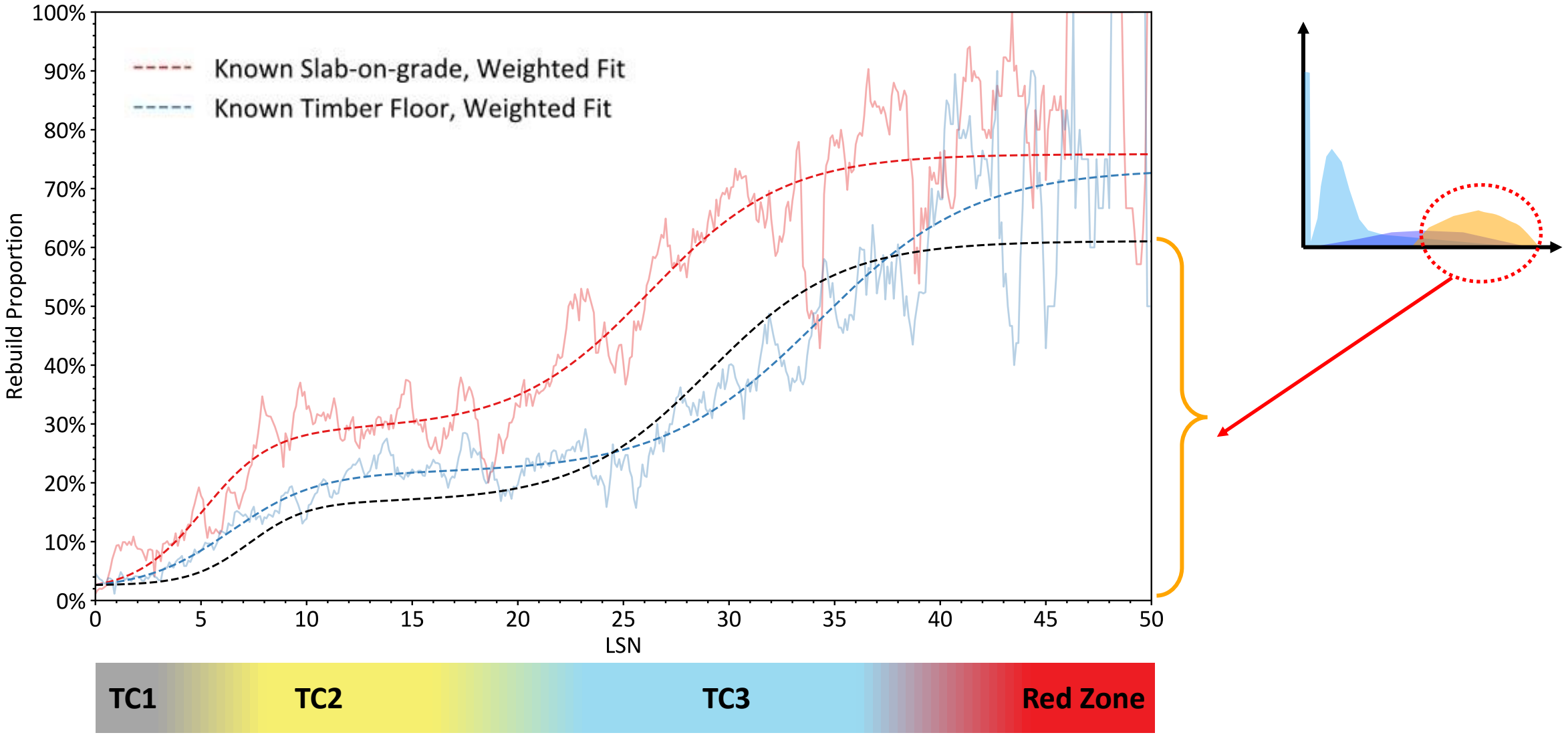
Effect of Floor Area on Rebuilds



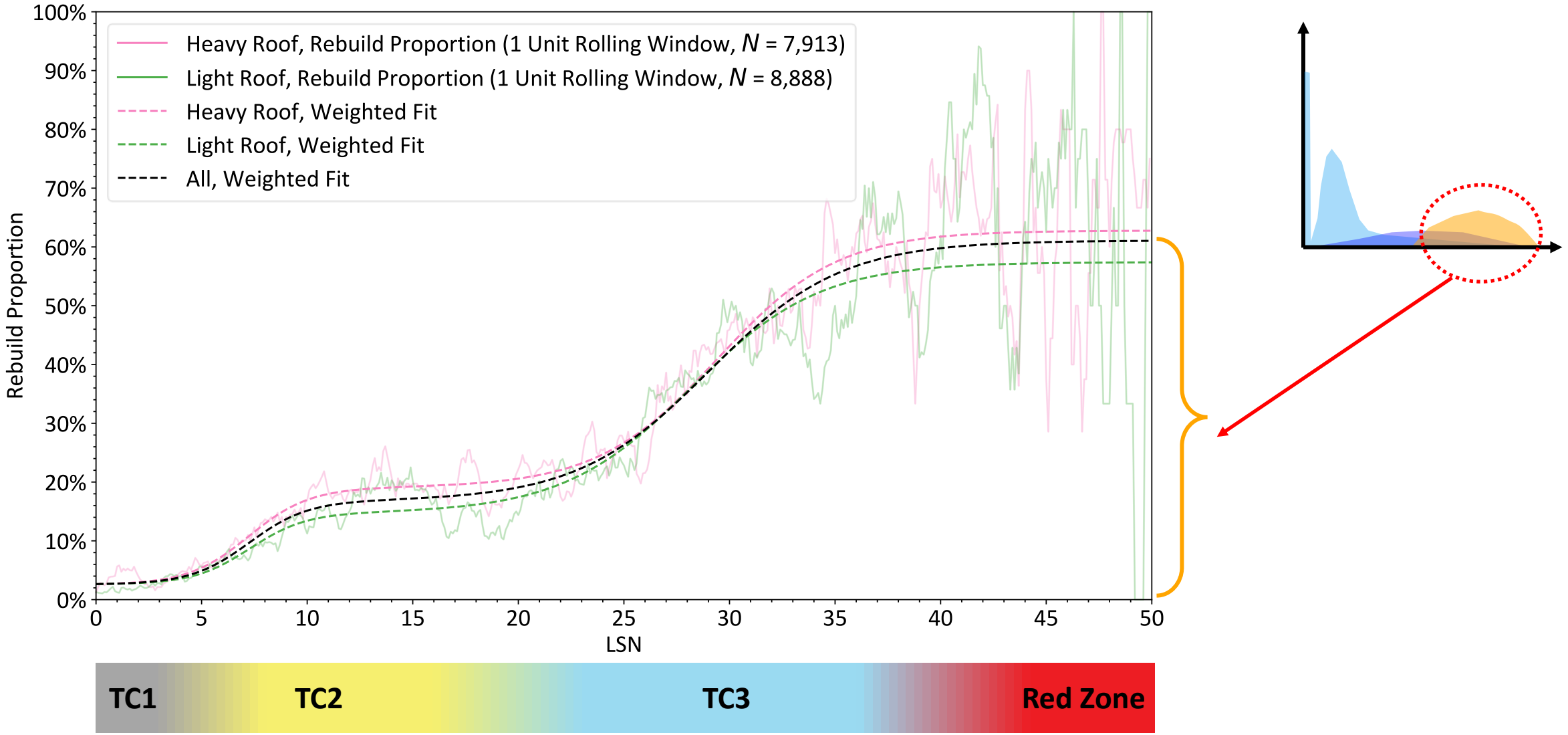
Effect of Number of Storeys



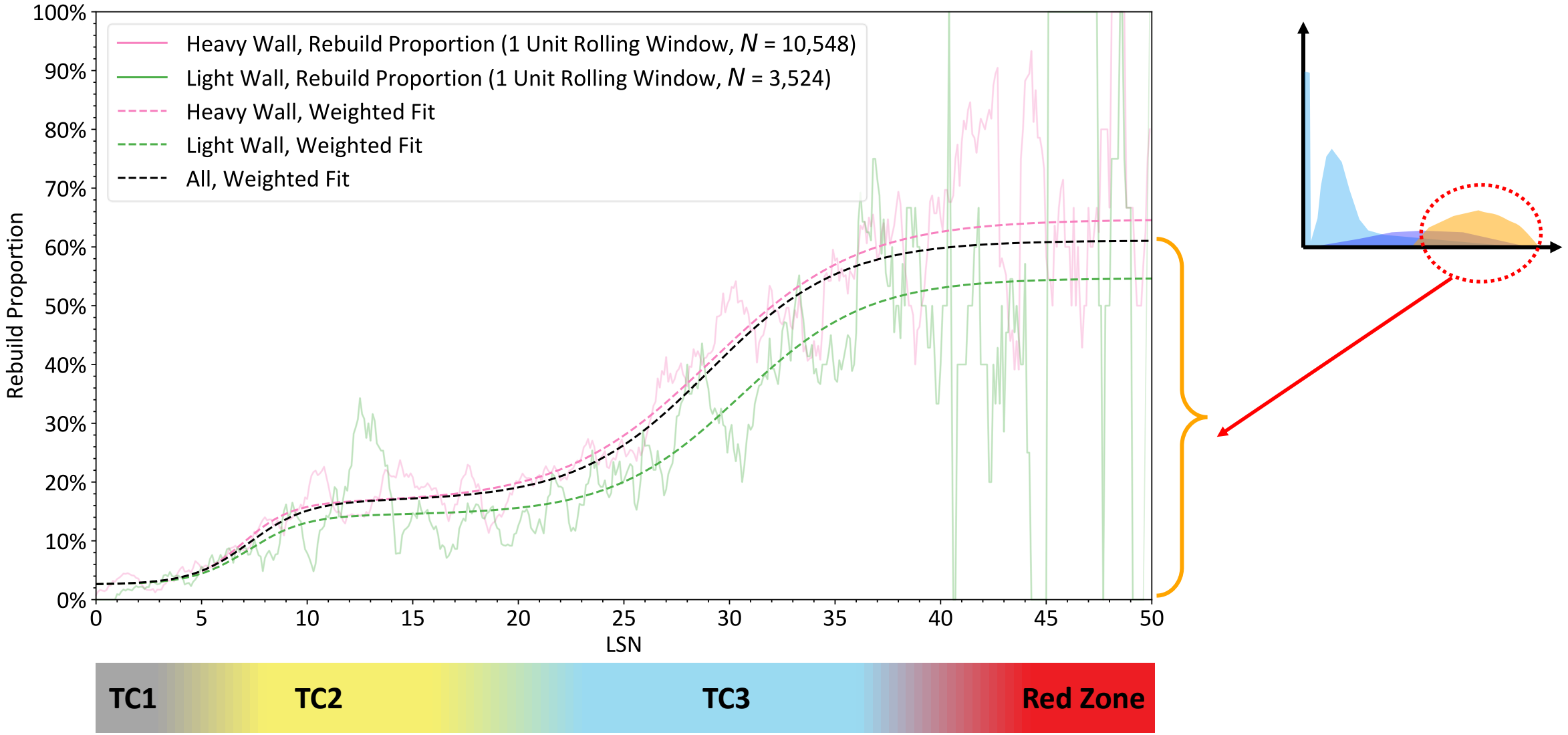
Effect of Foundation Type on Rebuilds



Effect of Roof Weight on Rebuilds



Effect of Cladding Weight on Rebuilds



Cladding Weight & Foundation Type

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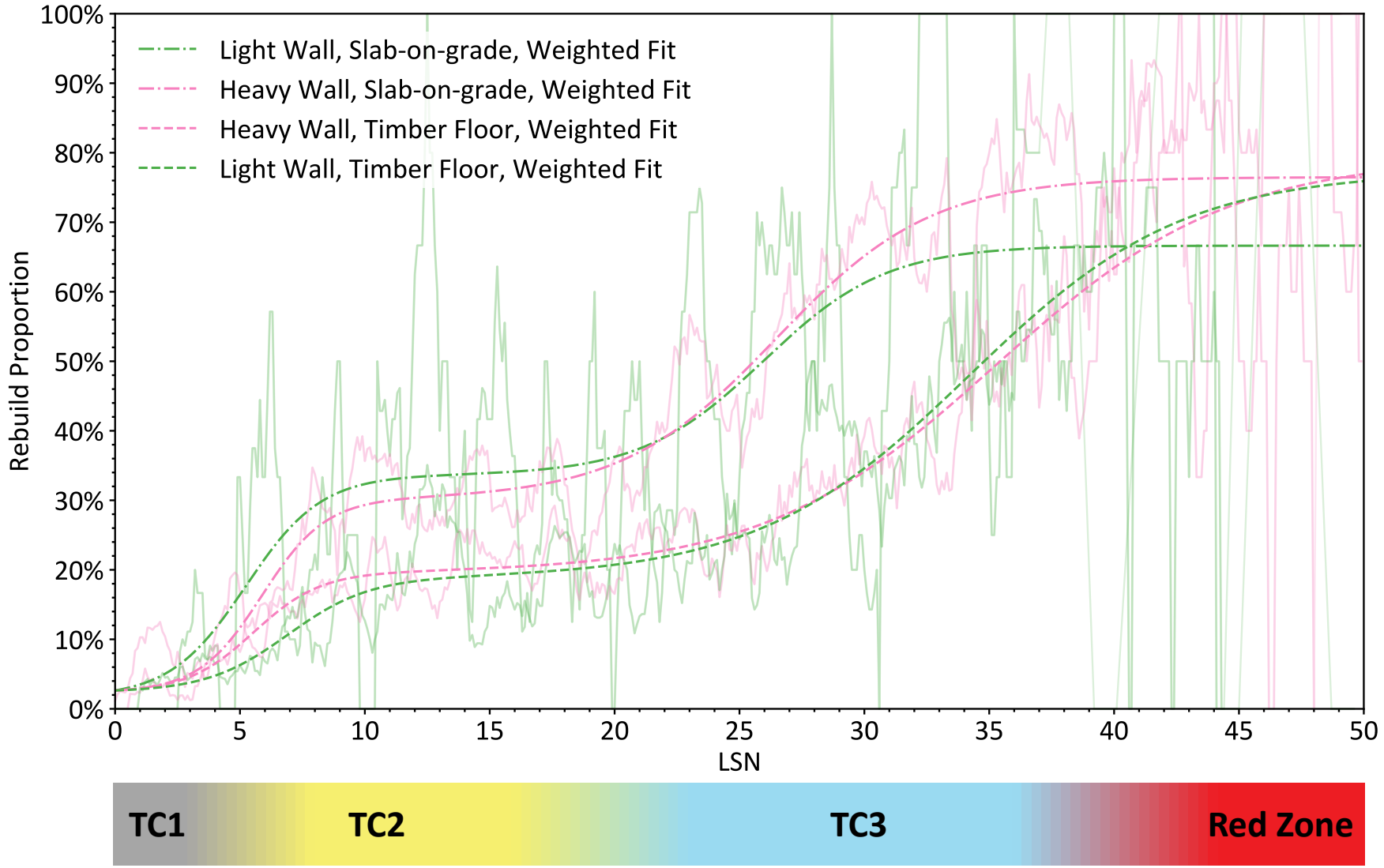
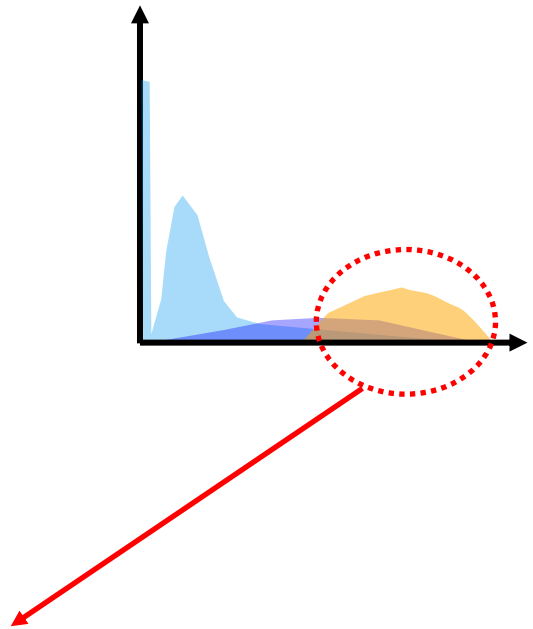
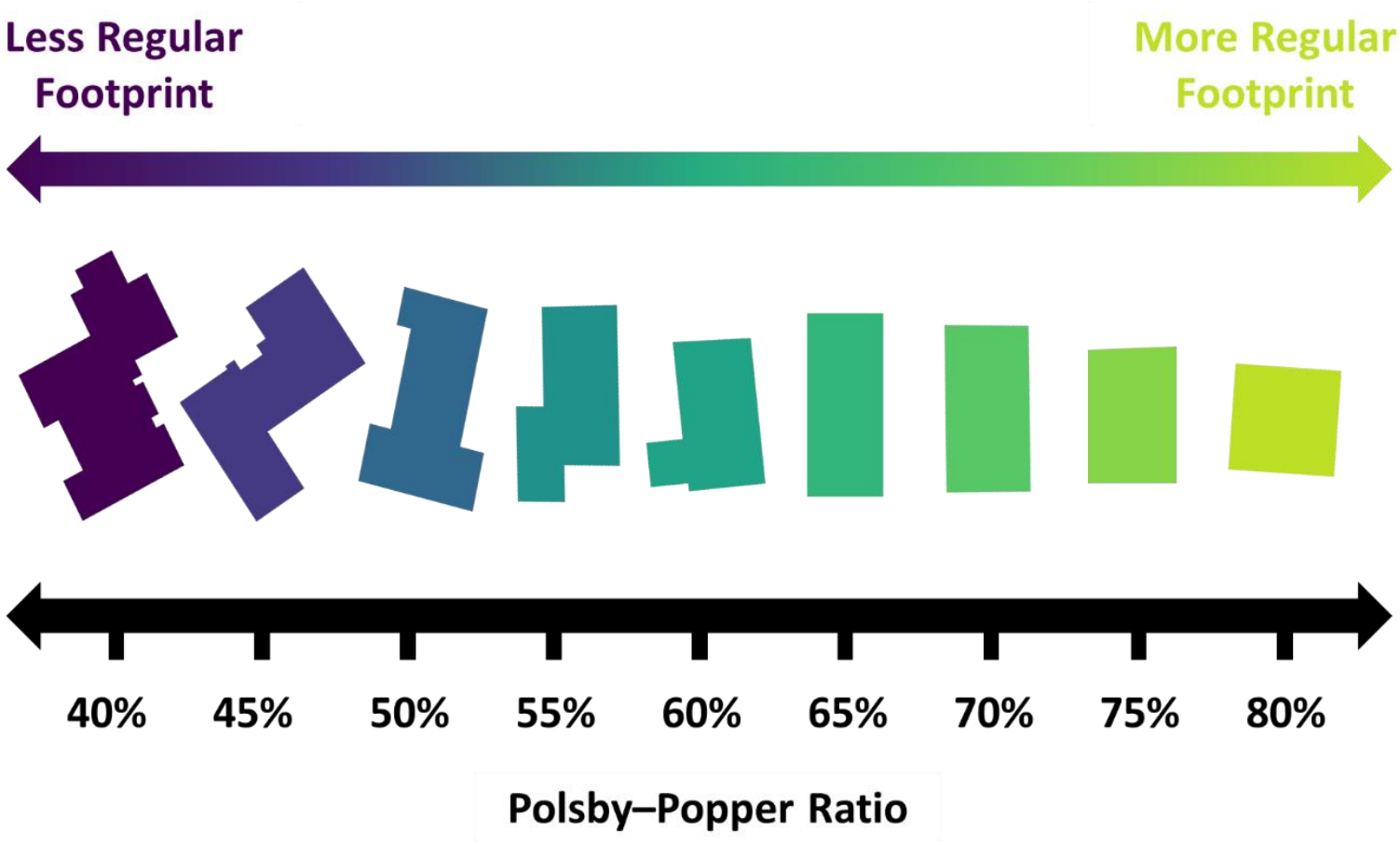
Simultaneous Comparison

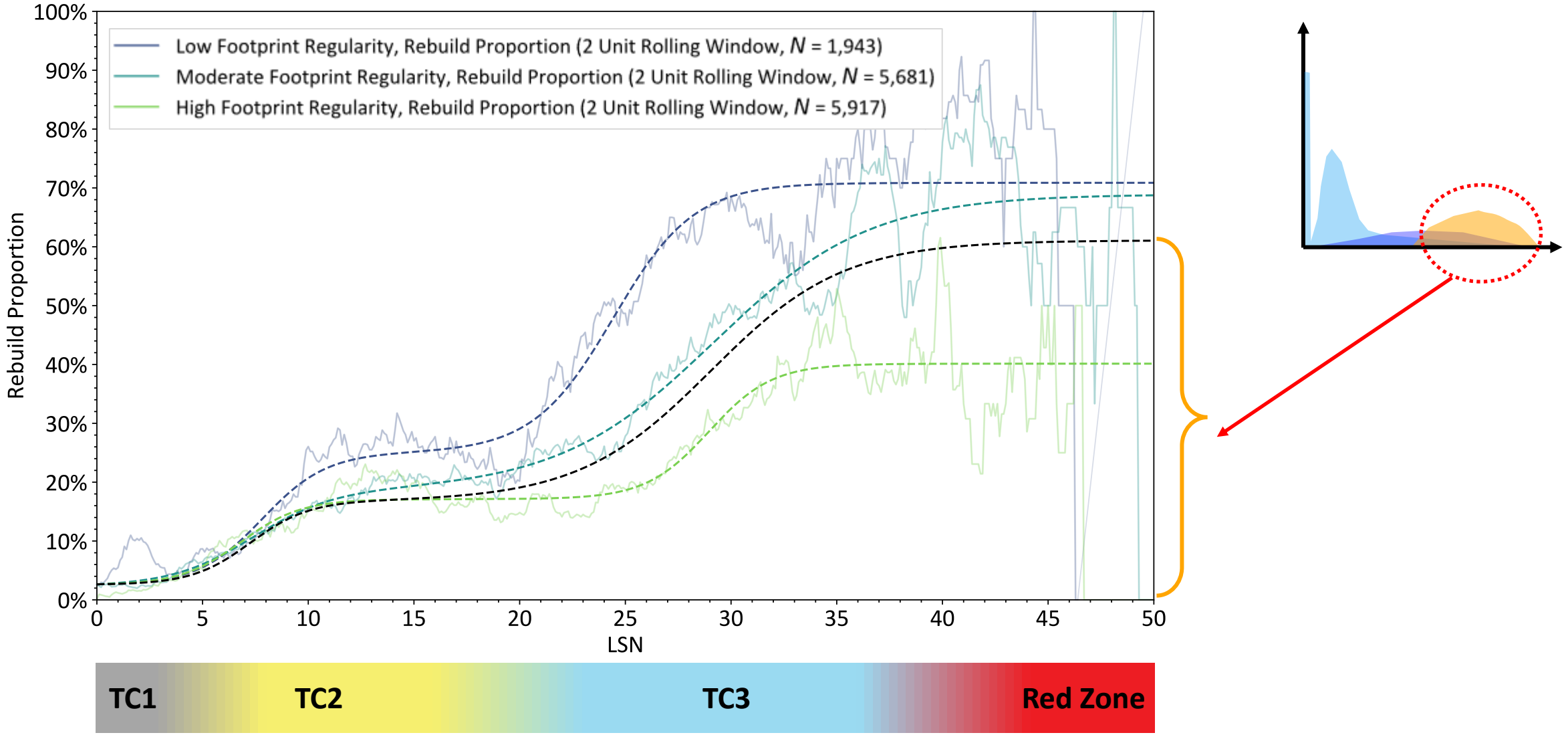




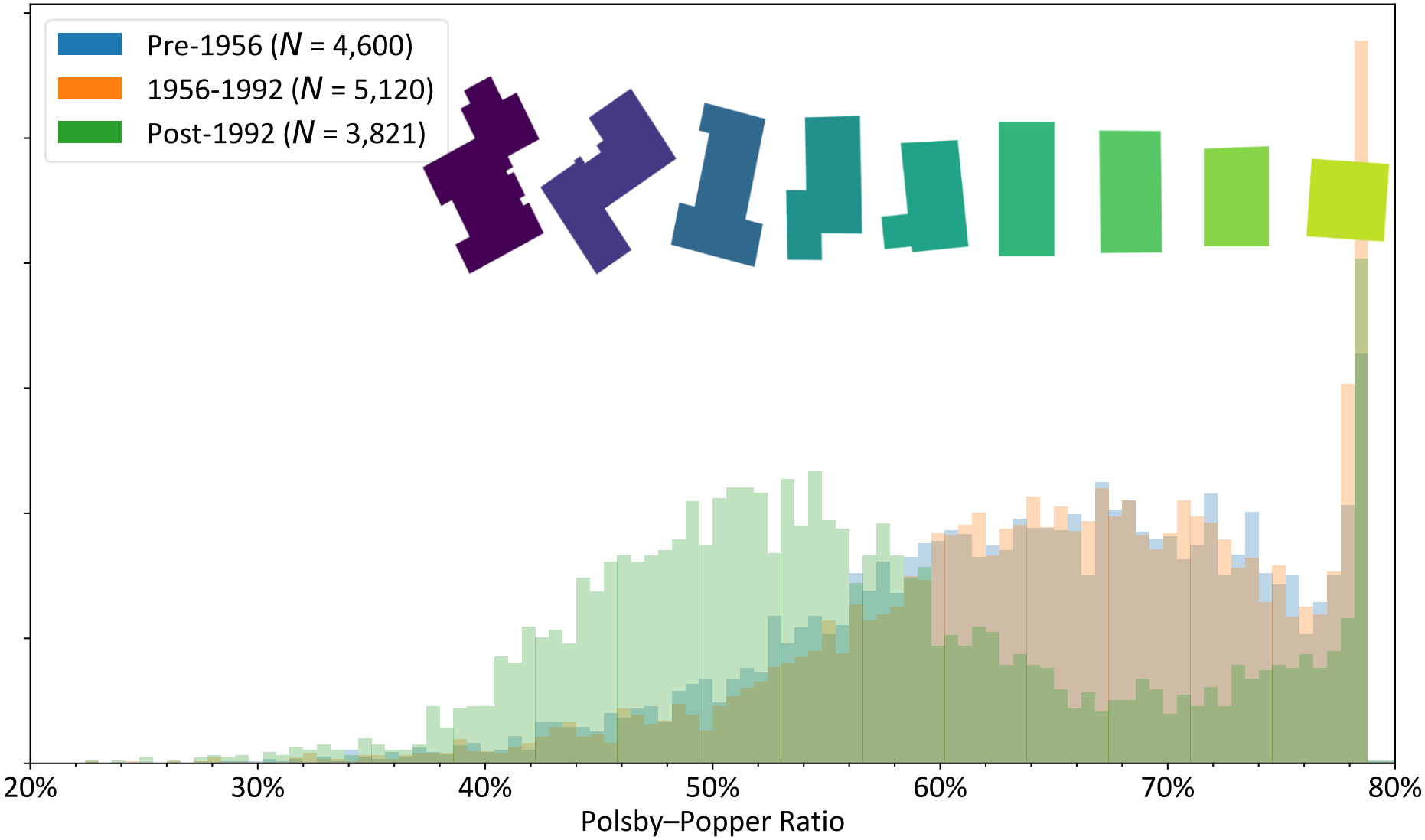
Building shape (regularity)



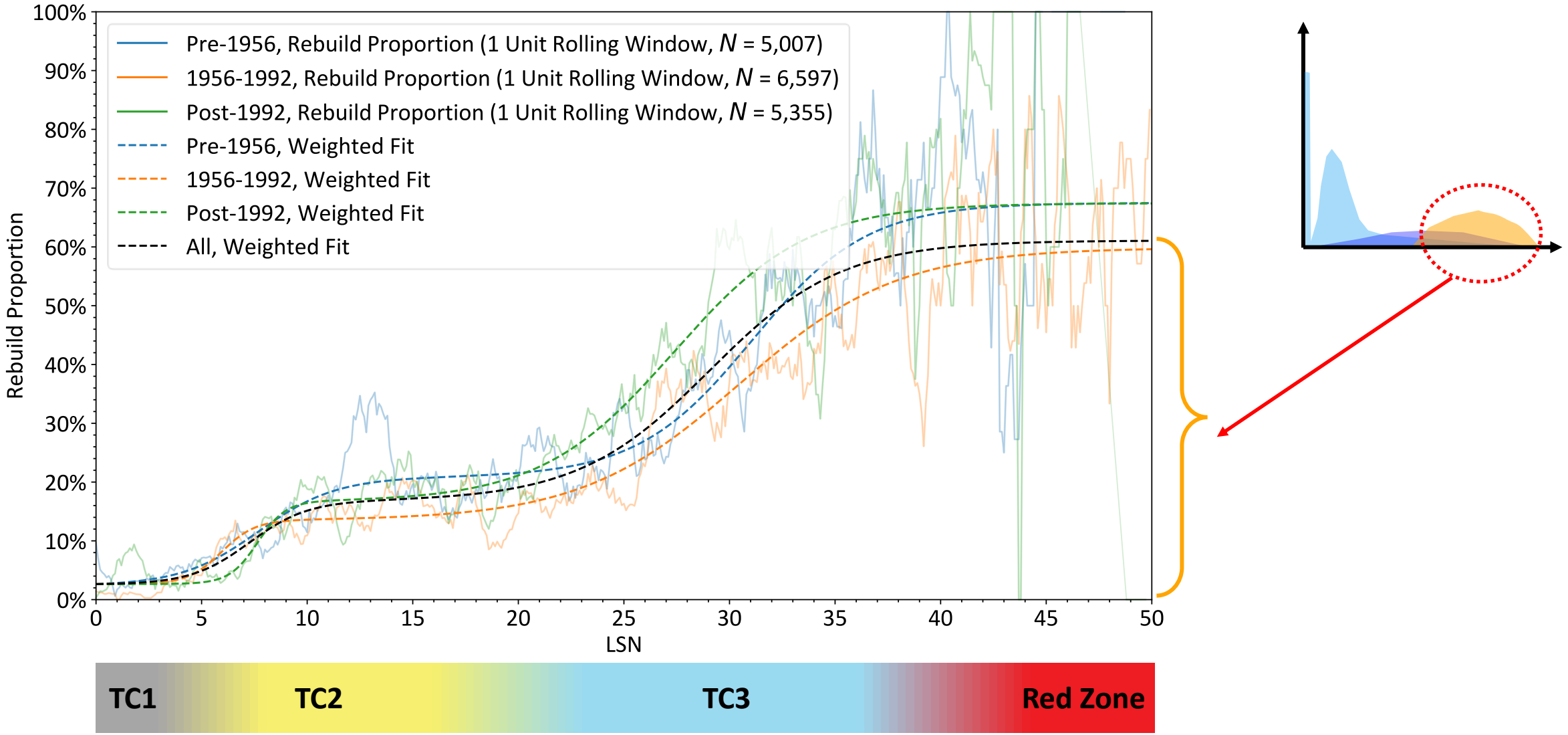
Effect of Footprint Regularity



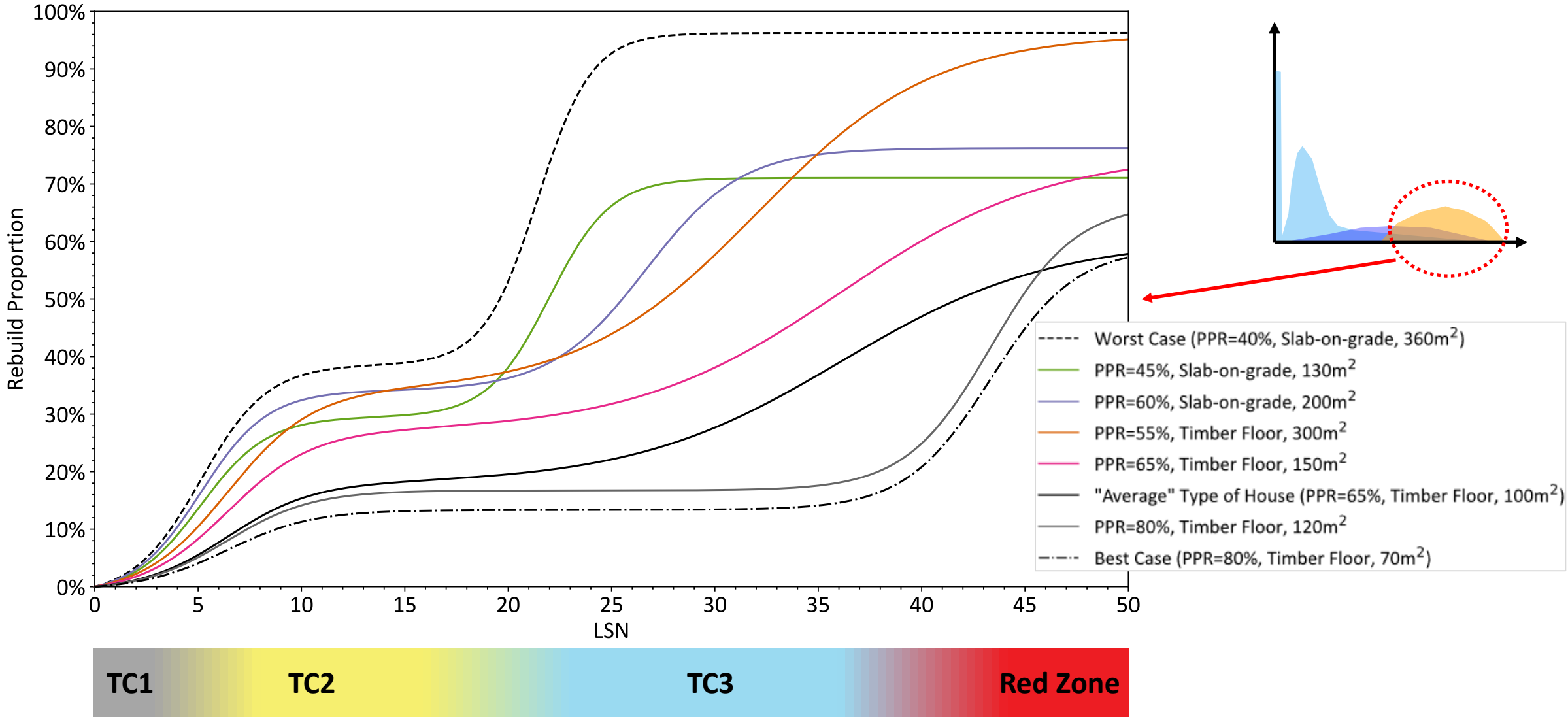
NZ's Footprints are changing…



Effect of Building Construction Era



Combined Attributes



Liquefaction fragility functions

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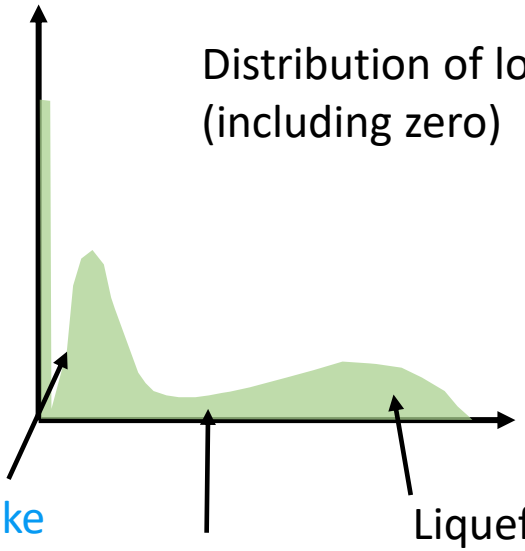
One-Step Approach

Distribution of loss (including zero)



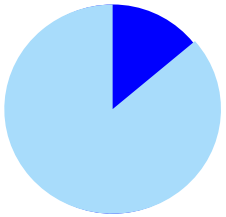
Shake only

Shake loss + additional liquefaction loss (add-on)

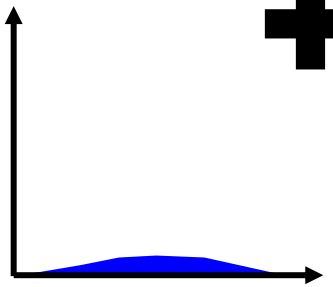
Liquefaction causes a rebuild: loss = 100%

Three-Step Approach

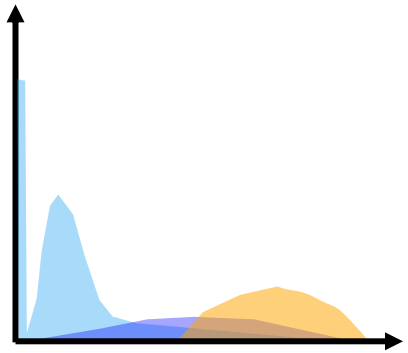
Probability of Liquefaction Rebuild



Probability of Add-on, vs. Probability of Shake Only



Distribution of Add-on size



Additional Loss Proportion

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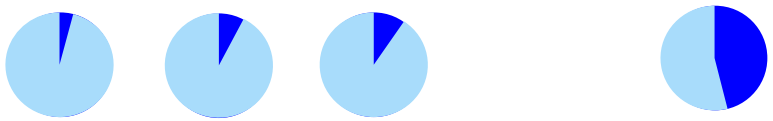
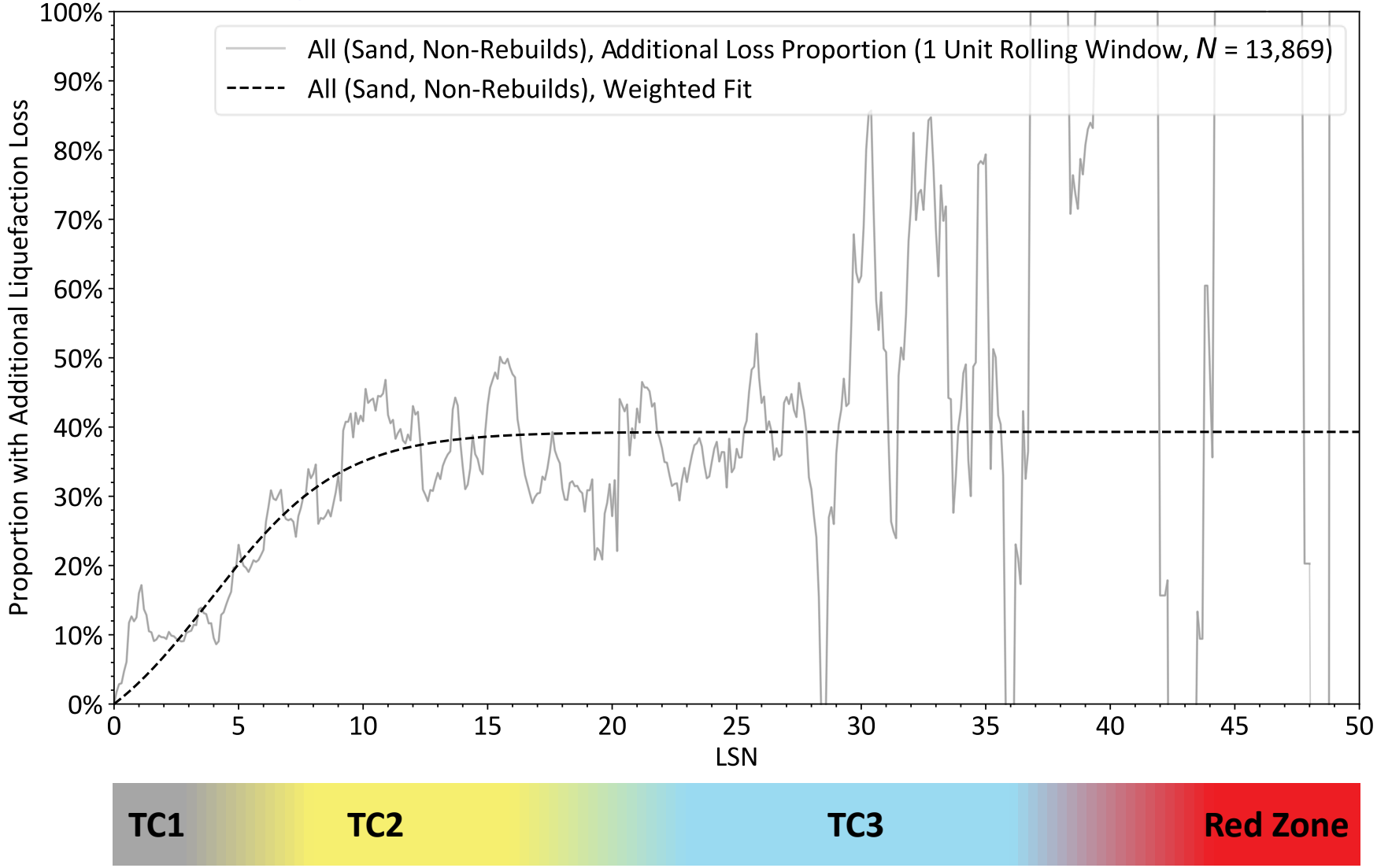
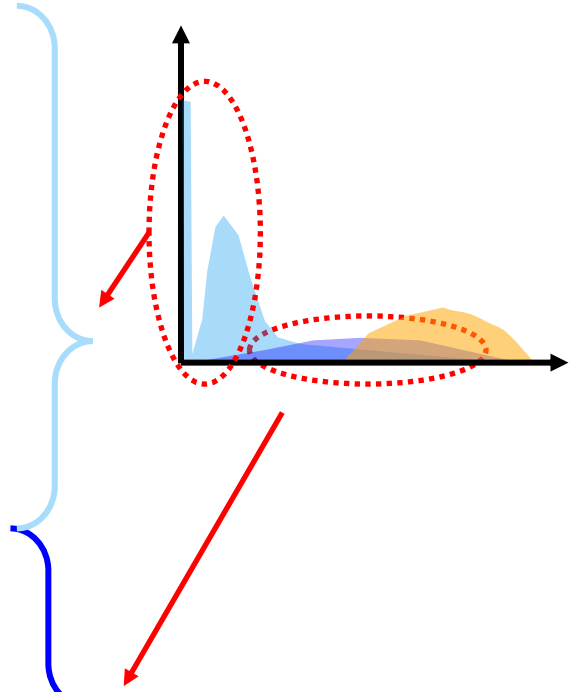
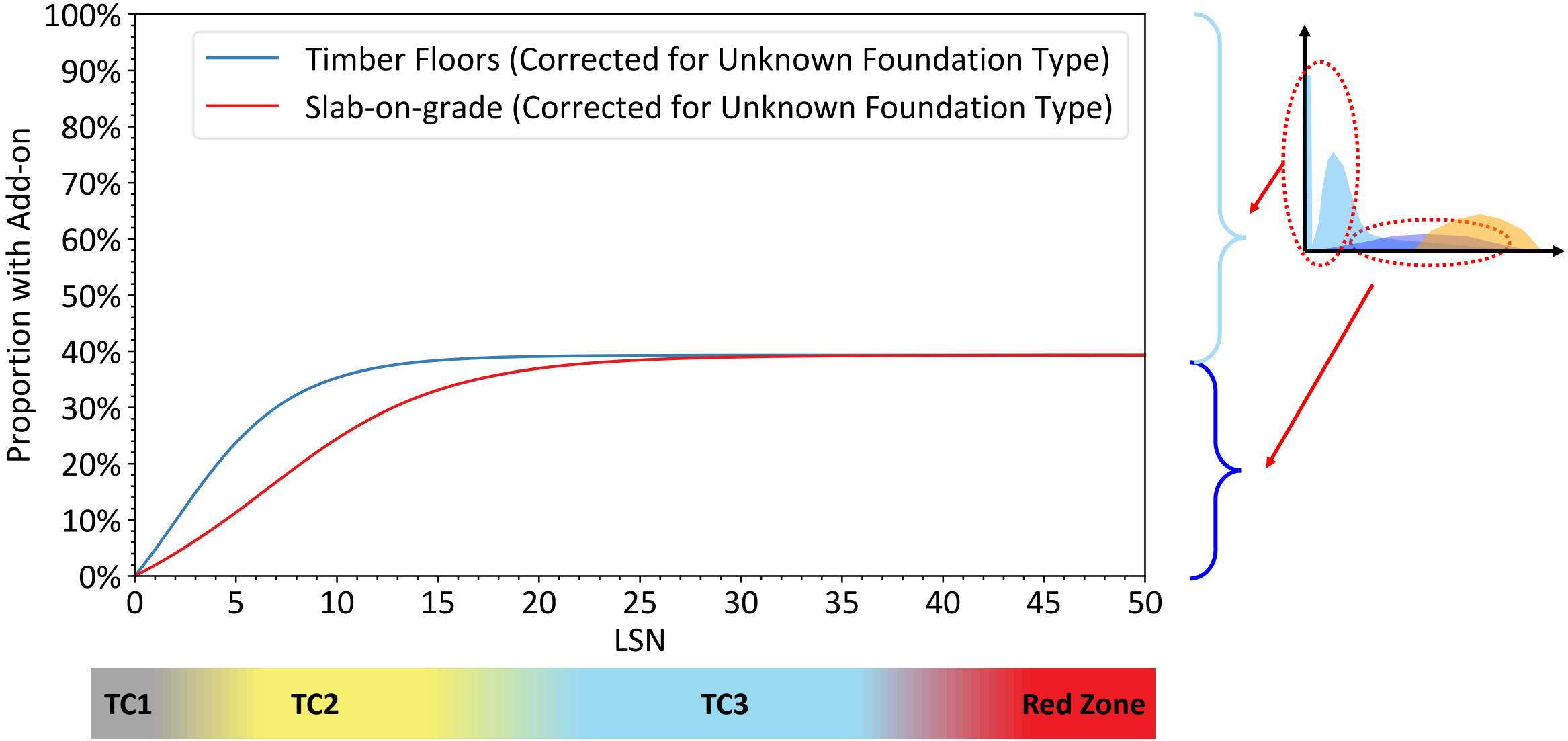




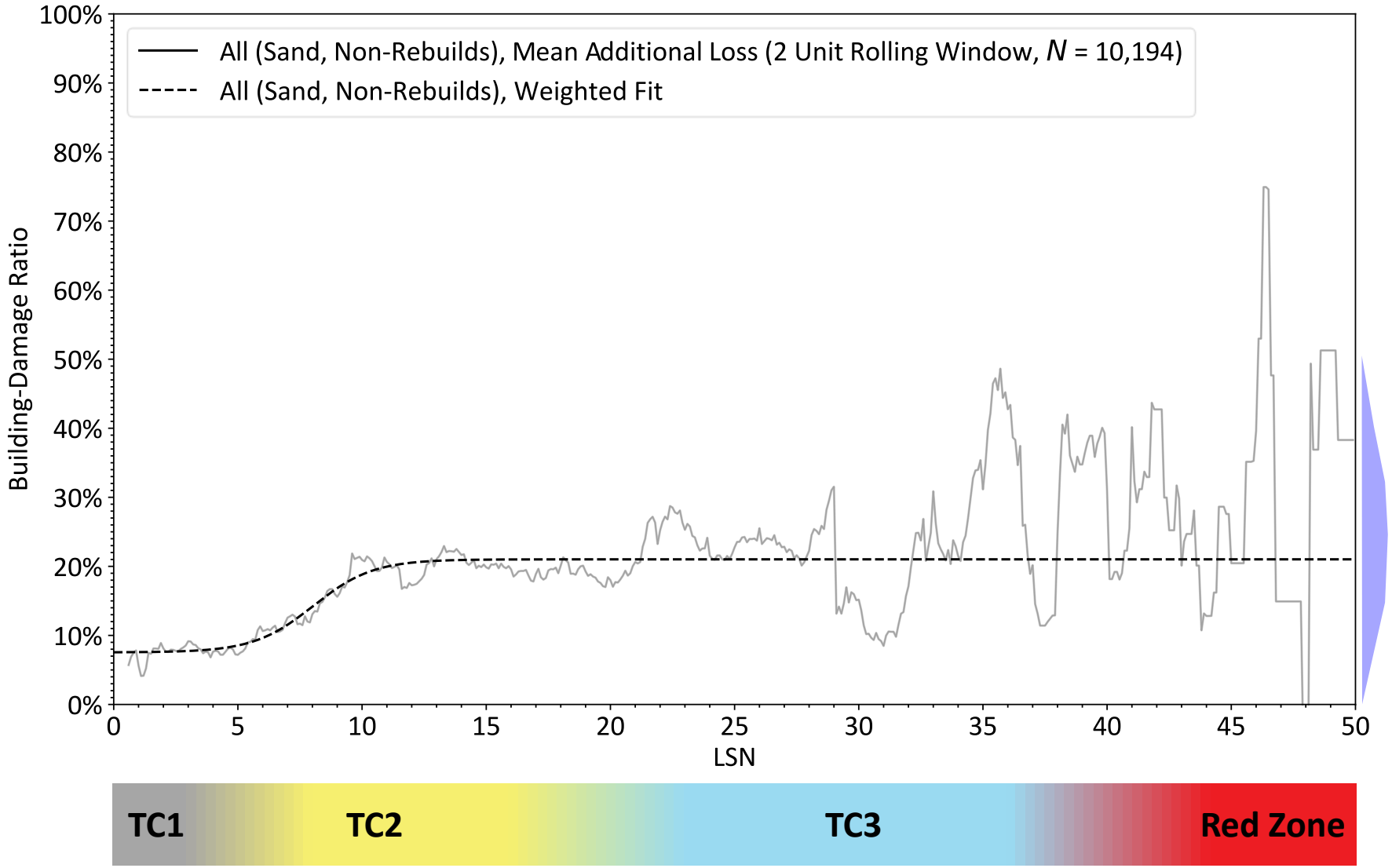


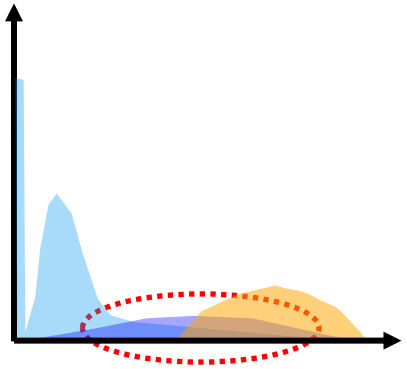
Effect of Foundation Type

On Additional Loss Proportion



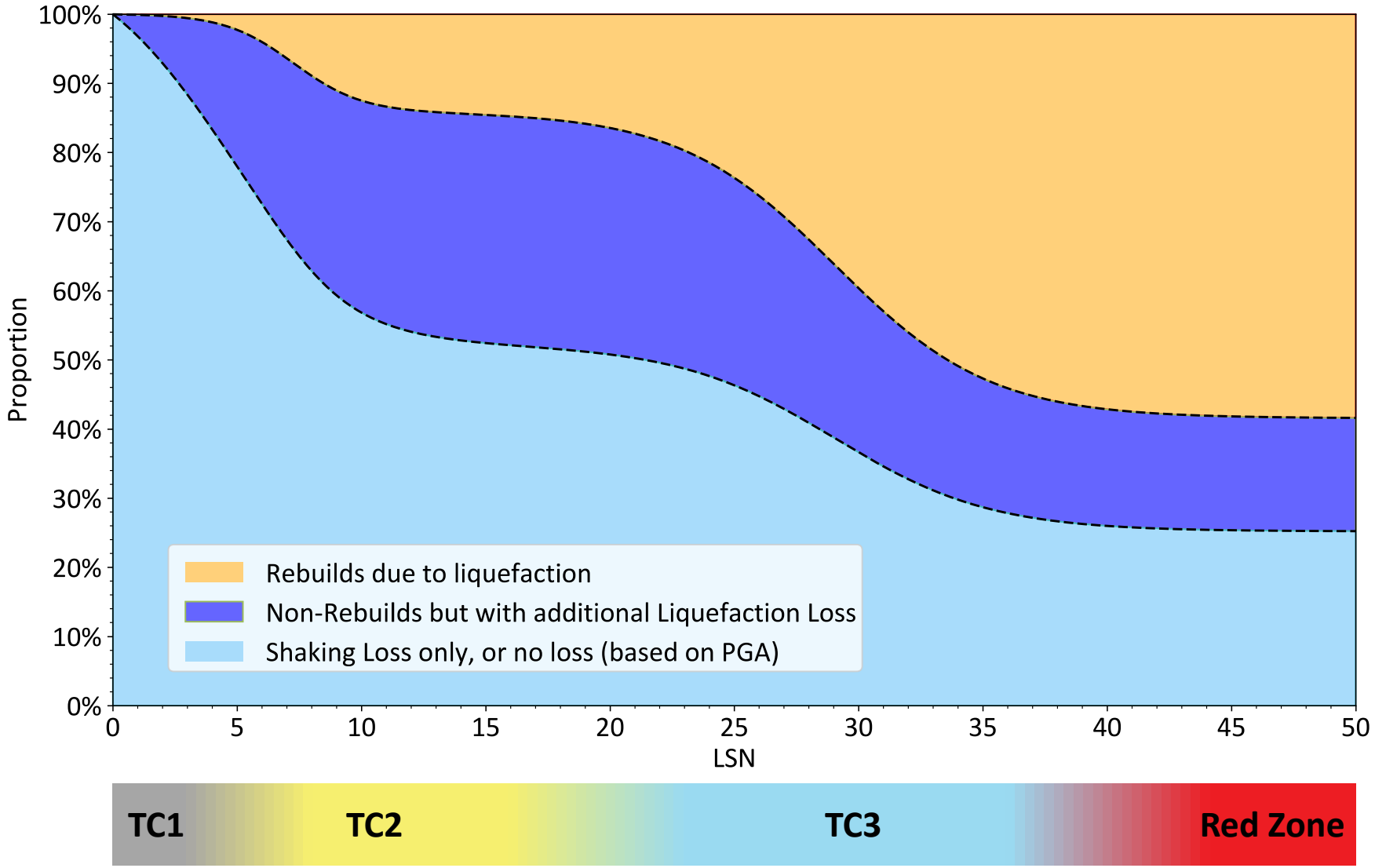
Additional Loss – Average Size

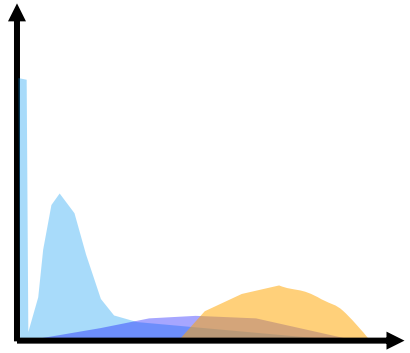




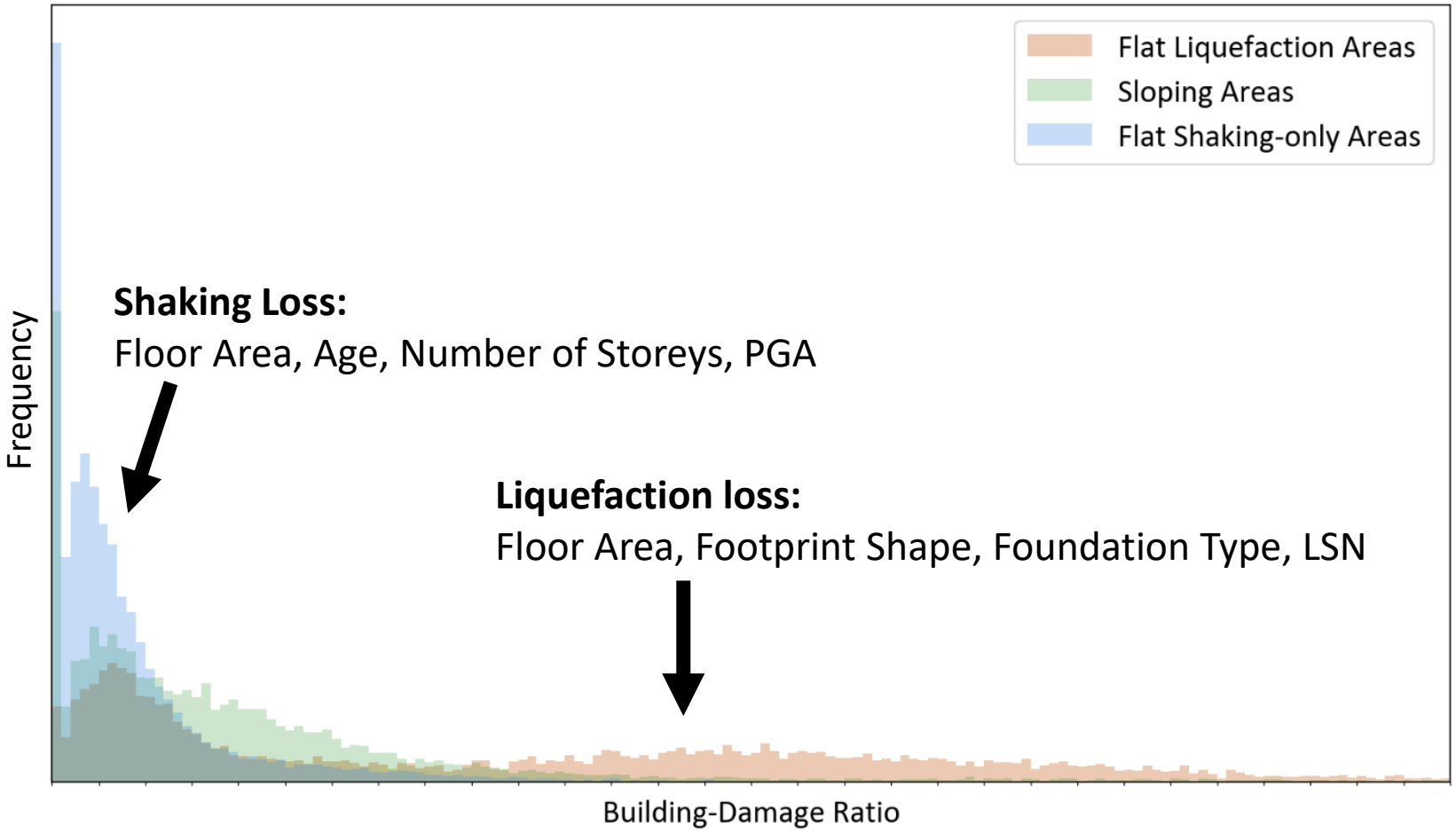
Total Loss
=
Shake Loss
+
Additional Liquefaction Loss

Liquefaction Losses – Overall Picture





Conclusions



Questions?

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