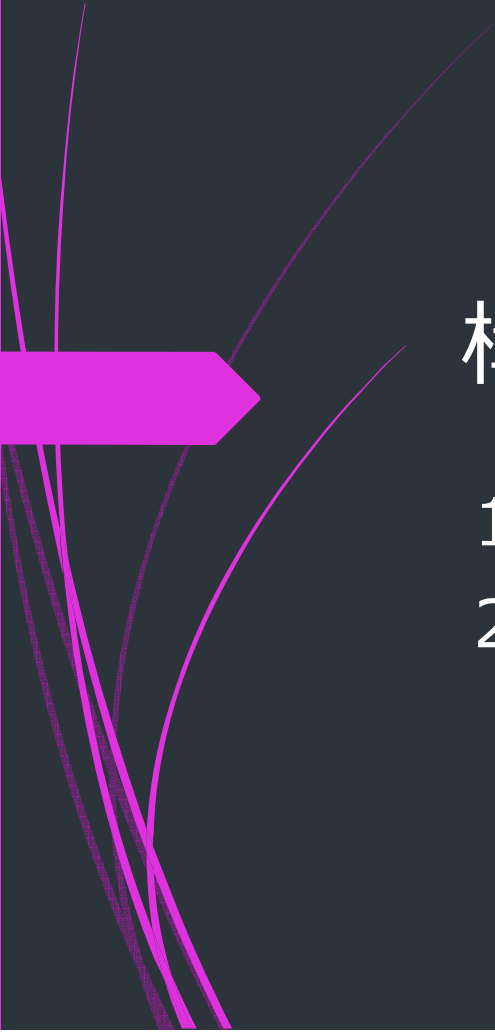


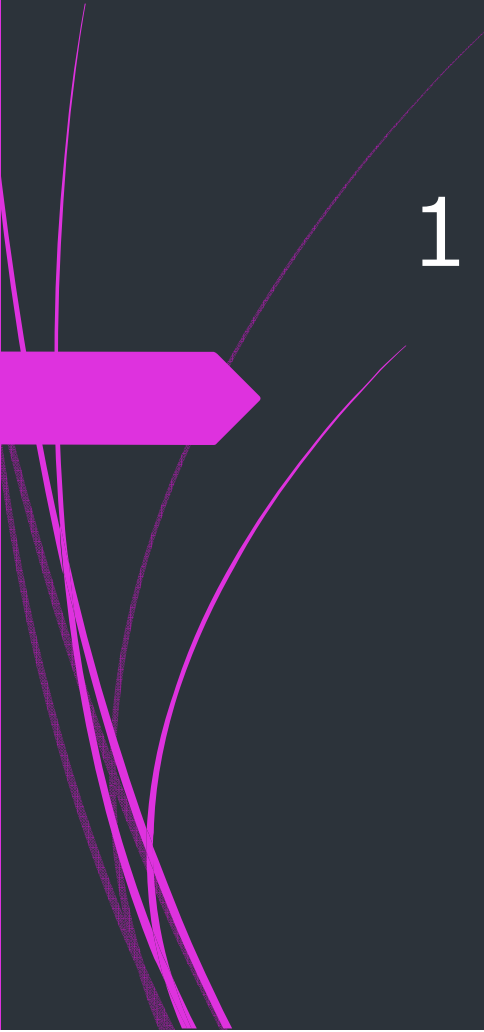


## 11.2 性能評価の事例



## 構成

1. 簡易解析による強度ベースの性能評価事例
2. 非線形時刻歴応答解析による時間ベースの性能評価事例



# 1. 簡易解析による強度ベースの 性能評価事例

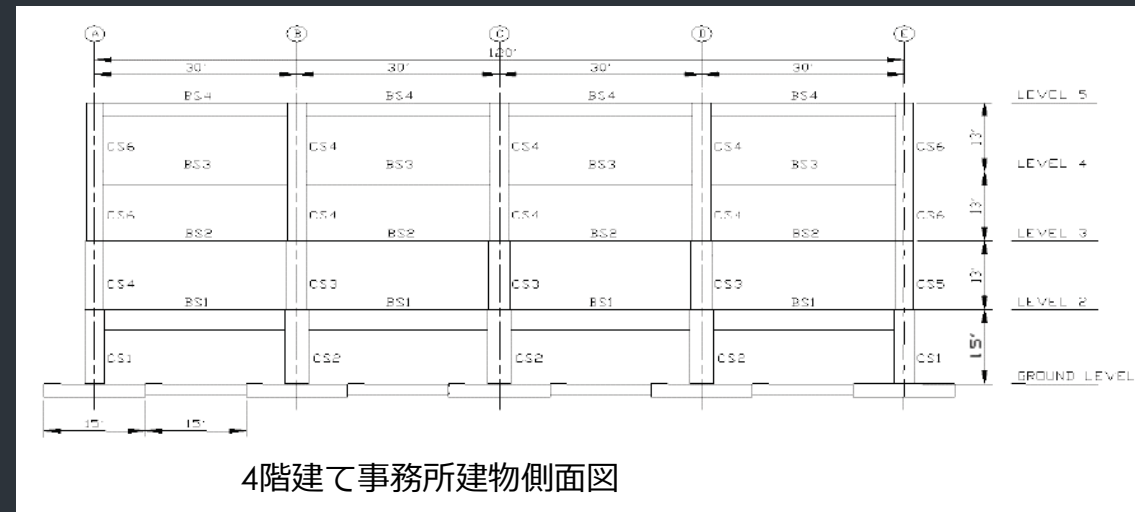
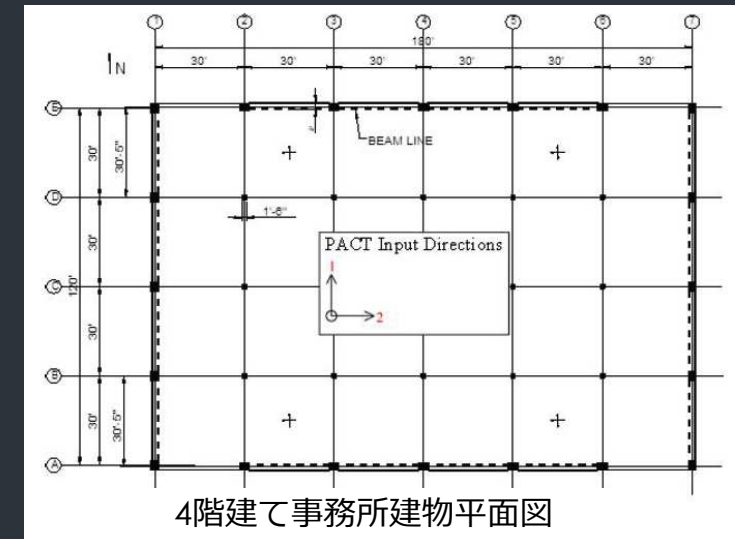


## 評価の対象

- 事務所建物を対象に再現期間475年（50年間の超過確率10%）の地震動に対する補修費用の中央値を求める

# 対象とする建物とサイト

- 地盤種別：D(表層30mのせん断波速度259m/s)
- 建物平面：120'×180'
- 階高：15' (1階)、13' (2～4階)
- 鉄筋コンクリート造骨組み構造  
(外周部：モーメント骨組み)



# 非構造および設備

- ▶ 外周部窓
- ▶ 石膏ボード製間仕切り壁
- ▶ 吊り天井
- ▶ スプリンクラーシステム（配管含む）
- ▶ エレベータ
- ▶ 屋根タイル
- ▶ 冷・温水配管
- ▶ 空調ダクト

## 建物情報

- 階数：4
- 建替え費用：\$ 250/sf×86,400sf= \$ 21,600,000
- 建替え時間：550日
- 構造建替え費用：\$ 100/sf×86,400sf= \$ 8,460,00
- 最大人口密度：0.001人/sf（デフォルト値）

# 構造要素のフラジリティ規定（柱－梁接合部）

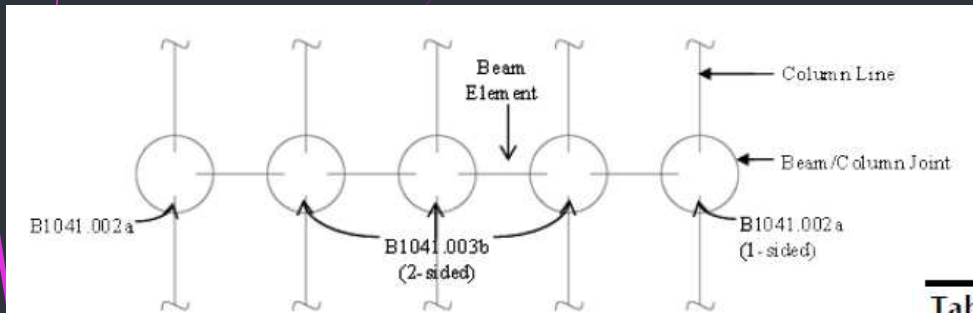


Figure 4-6 Illustration of reinforced concrete element fragility specifications.

同一フラジリティグループ  
(同一構造仕様)

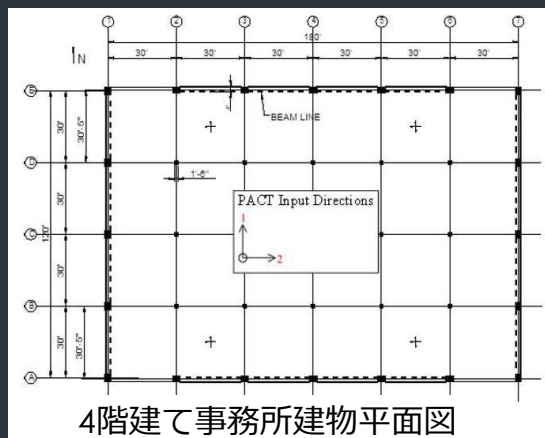


Table 4-1 Fragility Group Selections for the Beam/Column Components

| Joint Location | Fragility Classification Number | Input Direction |
|----------------|---------------------------------|-----------------|
| A-1            | B1041.002a                      | 1               |
| A-2            | B1041.002a                      | 2               |
| A-6            | B1041.002a                      | 2               |
| A-7            | B1041.002a                      | 1               |
| E-1            | B1041.002a                      | 1               |
| E-2            | B1041.002a                      | 2               |
| E-6            | B1041.002a                      | 2               |
| E-7            | B1041.002a                      | 1               |
| A-3            | B1041.003b                      | 2               |
| A-4            | B1041.003b                      | 2               |

| Joint Location | Fragility Classification Number | Input Direction |
|----------------|---------------------------------|-----------------|
| A-5            | B1041.003b                      | 2               |
| B-1            | B1041.003b                      | 1               |
| B-7            | B1041.003b                      | 1               |
| C-1            | B1041.003b                      | 1               |
| C-7            | B1041.003b                      | 1               |
| D-1            | B1041.003b                      | 1               |
| D-7            | B1041.003b                      | 1               |
| E-3            | B1041.003b                      | 2               |
| E-4            | B1041.003b                      | 2               |
| E-5            | B1041.003b                      | 2               |



## 構造要素の性能規定（柱－梁接合部）

- ▶ 同一構造仕様だが配置方向が異なるため作用荷重が異なる。

同一フラジリティグループ  
あっても性能グループは異なる

Table 4-2 Performance Group Quantities for Reinforced Concrete Elements

| Fragility Classification Number | Direction | Number Per Floor |
|---------------------------------|-----------|------------------|
| B1041.002a                      | 1         | 4                |
| B1041.002a                      | 2         | 4                |
| B1041.003b                      | 1         | 6                |
| B1041.003b                      | 2         | 6                |

# 非構造のフラジリティ規定

- ▶ カーテンウォール
- ▶ 屋根タイル
- ▶ 間仕切り壁（石膏ボード）
- ▶ 吊り天井
- ▶ 吊り照明
- ▶ 水道配管
- ▶ 温水配管
- ▶ 下水配管
- ▶ -----

|                                                         | N                        | O           | P                                                                                                | Q                         | R                                                                   | S                                                         | T                                                   | U           | V               |
|---------------------------------------------------------|--------------------------|-------------|--------------------------------------------------------------------------------------------------|---------------------------|---------------------------------------------------------------------|-----------------------------------------------------------|-----------------------------------------------------|-------------|-----------------|
| 1                                                       | Compile                  |             | Processing of Incomplete Data                                                                    |                           | Processing of Zero Data                                             |                                                           | Sum Fragility by Floor                              |             |                 |
| <input checked="" type="radio"/> Ignore Incomplete Data |                          |             | <input checked="" type="radio"/> Exclude Zero Data <input checked="" type="radio"/> List as Zero |                           | <input checked="" type="radio"/> Sum Components by Building & Floor |                                                           |                                                     |             |                 |
| <input type="radio"/> Include Incomplete Data           |                          |             | <input type="radio"/> Include Zero Data <input type="radio"/> "Not Typically Included"           |                           | <input type="radio"/> Sum Components by Floor                       |                                                           |                                                     |             |                 |
|                                                         |                          |             |                                                                                                  |                           | <input type="radio"/> List All Components                           |                                                           |                                                     |             |                 |
| 2                                                       |                          |             |                                                                                                  |                           |                                                                     |                                                           |                                                     |             |                 |
| 3                                                       |                          |             |                                                                                                  |                           |                                                                     |                                                           |                                                     |             |                 |
| 4                                                       |                          |             |                                                                                                  |                           |                                                                     |                                                           |                                                     |             |                 |
| 5                                                       |                          |             |                                                                                                  |                           |                                                                     |                                                           |                                                     |             |                 |
| 6                                                       | COMPONENT SUMMARY MATRIX |             |                                                                                                  |                           |                                                                     |                                                           |                                                     |             |                 |
| 7                                                       | OCCUPANCY                |             |                                                                                                  |                           | Fragility Number                                                    | Fragility Name                                            | Assumed<br>Quantity per<br>component<br>within PACT | Quantity    |                 |
| 8                                                       | Type                     | Occupancy # | Floor<br>Name                                                                                    | Component<br>Area (sq ft) |                                                                     |                                                           |                                                     | Directional | Non Directional |
| 9                                                       | ▼                        | ▼           | ▼                                                                                                | ▼                         | ▼                                                                   | ▼                                                         | ▼                                                   | ▼           | ▼               |
| 44                                                      | OFFICE                   | 1           | 3rd                                                                                              | 21600                     | B2022.001                                                           | B2022.001 Curtain Walls - Generic Midrise Stick-Built Cur | 30 SF                                               | 216.00      | --              |
| 45                                                      | OFFICE                   | 1           | 3rd                                                                                              | 21600                     | B3011.011                                                           | B3011.011 Concrete tile roof, tiles secured and complian  | 100 SF                                              | --          | 58.32           |
| 46                                                      | OFFICE                   | 1           | 3rd                                                                                              | 21600                     | C1011.001a                                                          | C1011.001a Wall Partition, Type: Gypsum with metal stud   | 100 LF                                              | 21.60       | --              |
| 47                                                      | OFFICE                   | 1           | 3rd                                                                                              | 21600                     | C3011.002c                                                          | C3011.002c Wall Partition, Type: Gypsum + Ceramic Tile,   | 100 LF                                              | 1.63        | --              |
| 48                                                      | OFFICE                   | 1           | 3rd                                                                                              | 21600                     | C3032.003b                                                          | C3032.003b Suspended Ceiling, SDC D,E (Ip=1.0), Area (A)  | 600 SF                                              | --          | 32.40           |
| 49                                                      | OFFICE                   | 1           | 3rd                                                                                              | 21600                     | C3034.002                                                           | C3034.002 Independent Pendant Lighting - seismically ra   | 1 EA                                                | --          | 324.00          |
| 50                                                      | OFFICE                   | 1           | 3rd                                                                                              | 21600                     | D2021.013a                                                          | D2021.013a Cold Water Piping (dia > 2.5 inches), SDC D,E, | 1000 LF                                             | --          | 0.32            |
| 51                                                      | OFFICE                   | 1           | 3rd                                                                                              | 21600                     | D2022.013a                                                          | D2022.013a Hot Water Piping - Small Diameter Threaded     | 1000 LF                                             | --          | 1.81            |
| 52                                                      | OFFICE                   | 1           | 3rd                                                                                              | 21600                     | D2022.023a                                                          | D2022.023a Hot Water Piping - Large Diameter Welded S     | 1000 LF                                             | --          | 0.65            |
| 53                                                      | OFFICE                   | 1           | 3rd                                                                                              | 21600                     | D2031.013b                                                          | D2031.013b Sanitary Waste Piping - Cast Iron w/flexible c | 1000 LF                                             | --          | 1.23            |
| 54                                                      | OFFICE                   | 1           | 3rd                                                                                              | 21600                     | D3041.021c                                                          | D3041.021c HVAC Stainless Steel Ducting less than 6 sq. f | 1000 LF                                             | --          | 0.43            |
| 55                                                      | OFFICE                   | 1           | 3rd                                                                                              | 21600                     | D3041.032c                                                          | D3041.032c HVAC Drops / Diffusers without ceilings - sup  | 10 EA                                               | --          | 19.44           |
| 56                                                      | OFFICE                   | 1           | 3rd                                                                                              | 21600                     | D3041.041b                                                          | D3041.041b Variable Air Volume (VAV) box with in-line c   | 10 EA                                               | --          | 10.80           |
| 57                                                      | OFFICE                   | 1           | 3rd                                                                                              | 21600                     | D4011.033a                                                          | D4011.033a Fire Sprinkler Drop Standard Threaded Steel    | 100 EA                                              | --          | 1.94            |
| 58                                                      | OFFICE                   | 1           | 3rd                                                                                              | 21600                     | E2022.001                                                           | E2022.001 Modular office work stations.                   | 1 EA                                                | --          | 151.20          |
| 59                                                      | OFFICE                   | 1           | 3rd                                                                                              | 21600                     | E2022.102a                                                          | E2022.102a Bookcase, 2 shelves, unanchored laterally      | 1 EA                                                | --          | 43.20           |
| 60                                                      | OFFICE                   | 1           | 3rd                                                                                              | 21600                     | E2022.112a                                                          | E2022.112a Vertical Filing Cabinet, 2 drawer, unanchored  | 1 EA                                                | --          | 17.28           |

Figure 4-11 Normative Quantity Estimation tool, Component Summary Matrix showing nonstructural inventory.

# 非構造の性能規定

- ポステンフラット  
スラブー柱
- 屋根タイル
- 吊り天井
- 吊り照明
- エレベータ
- 水道配管
- 温水配管
- 下水配管
- ----

フラジリティNo.

標準量（単位長さ  
/面積当たり）

照査指標

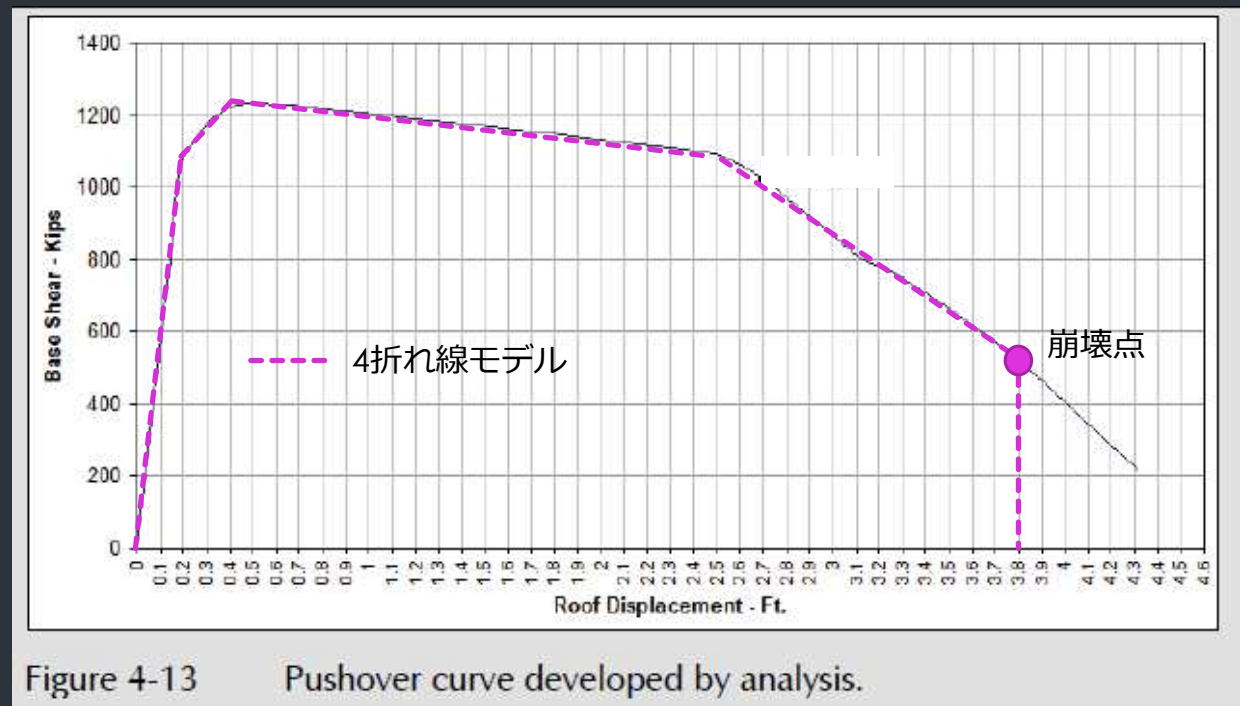
| No.        | Component Type                                                  | Performance Group Quantities | Quantity Dispersion | Fragility Correlated                | Population Model  | Demand Parameters |
|------------|-----------------------------------------------------------------|------------------------------|---------------------|-------------------------------------|-------------------|-------------------|
| B1049.031  | Post-tensioned concrete flat slabs-columns with shear re...     | 15.00                        | 0.00                | <input type="checkbox"/>            | Commercial Office | Story Drift Ratio |
| B1049.032  | Post-tensioned concrete flat slabs-columns with shear re...     | 0.00                         | 0.00                | <input type="checkbox"/>            | Commercial Office | Story Drift Ratio |
| B3011.011  | Concrete tile roof, tiles secured and compliant with UBC54      | 0                            | 0.00                | <input type="checkbox"/>            | Commercial Office | Acceleration      |
| C3032.003b | Suspended Ceiling - SDC D,E (p=1.0), Area (A): 250 < A ...      | 32.40                        | 0.00                | <input type="checkbox"/>            | Commercial Office | Acceleration      |
| C3034.002  | Independent Pendant Lighting - seismically rated                | 324.00                       | 0.00                | <input type="checkbox"/>            | Commercial Office | Acceleration      |
| D1014.011  | Traction Elevator - Applies to most California installations... | 1.00                         | 0.00                | <input type="checkbox"/>            | Commercial Office | Acceleration      |
| D2021.013a | Cold Water Piping (dia > 2.5 inches), SDC D,E,F, PIPIN...       | 0.32                         | 0.00                | <input checked="" type="checkbox"/> | Commercial Office | Acceleration      |
| D2022.013a | Hot Water Piping - Small Diameter Threaded Steel - (2.5 ...     | 1.81                         | 0.00                | <input checked="" type="checkbox"/> | Commercial Office | Acceleration      |
| D2031.013b | Sanitary Waste Piping - Cast Iron w/flexible couplings, 5 ...   | 1.23                         | 0.00                | <input checked="" type="checkbox"/> | Commercial Office | Acceleration      |
| D3031.021c | Cooling Tower - Capacity: 350 to <750 Ton - Unanchore...        | 0.00                         | 0.00                | <input type="checkbox"/>            | Commercial Office | Acceleration      |
| D3041.021c | HVAC Stainless Steel Ducting less than 6 sq. ft in cross ...    | 0.43                         | 0.00                | <input type="checkbox"/>            | Commercial Office | Acceleration      |
| D3041.032c | HVAC Drops / Diffusers without ceilings - supported by d...     | 0.15                         | 0.00                | <input type="checkbox"/>            | Commercial Office | Acceleration      |
| D3041.041b | Variable Air Volume (VAV) box with in-line coil, SDC C          | 10.80                        | 0.00                | <input type="checkbox"/>            | Commercial Office | Acceleration      |
| D3052.013b | Air Handling Unit - Capacity: <5000 CFM - Equipment tha...      | 16                           | 0.00                | <input type="checkbox"/>            | Commercial Office | Acceleration      |
| D3052.013b | Air Handling Unit - Capacity: <5000 CFM - Equipment tha...      | 0.00                         | 0.00                | <input type="checkbox"/>            | None              | Acceleration      |
| D4011.033a | Fire Sprinkler Drop Standard Threaded Steel - Dropping i...     | 1.94                         | 0.00                | <input type="checkbox"/>            | Commercial Office | Acceleration      |

Figure 4-12

PACT Performance Groups tab for floor 1, non-directional.

## 崩壊フラジリティ算定のための 静的非線形解析（プッシュオーバー解析）

- ➡ 1および2方向の  
剛性と強度は同様  
⇒ 1つの解析結果

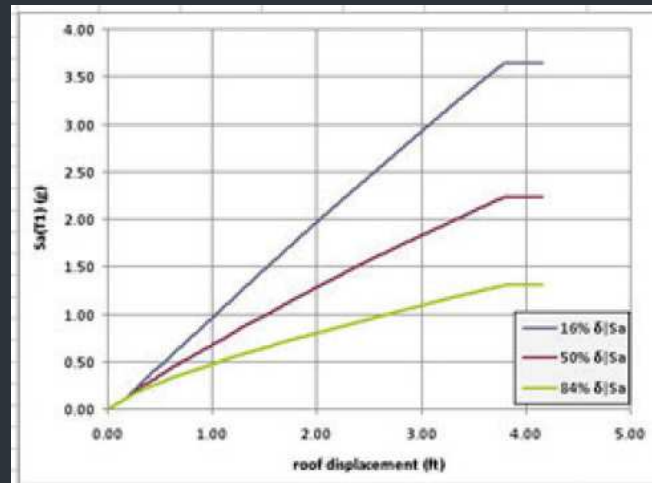


# 崩壊フラジリティー解析ツール“SPO2IDA”

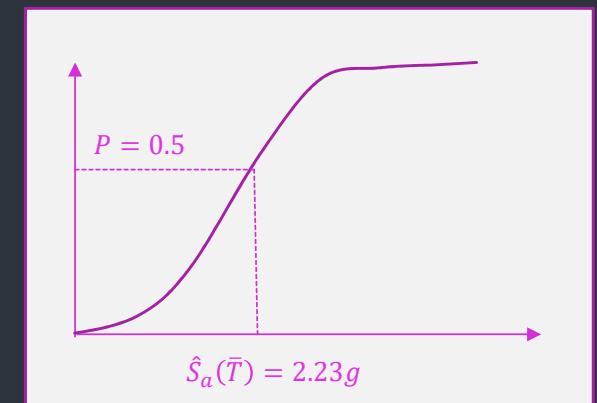
- ▶ 1自由度系モデルによる増加型動的非線形解析

⇒ 応答スペクトル値を増加させて地震応答解析

⇒ 同一百分位にある応答スペクトル値と屋根の最大応答変位をプロット



- ▶ 中央値2.23g
- ▶ 分散0.6(デフォルト値)





# 地震ハザード

➡ モーダル解析  $\Rightarrow T_1^X = T_1^Y = 1.13$  秒  $\therefore \bar{T} = 1.13$  秒

➡ Java Ground Motion Calculator (USGS)

<http://earthquake.usgs.gov/hazards/designmaps/>

The screenshot shows the 'Seismic Hazard Curves and Uniform Hazard Response Spectra' application window. The 'Select Analysis Option' dropdown is set to 'Probabilistic hazard curves'. The 'Region and DataSet Selection' section shows 'Geographic Region' as 'Conterminous 48 States' and 'Data Edition' as '2002 Data'. The 'Lat/Lon' section has 'Latitude (Degrees)' set to 33.996 and 'Longitude (Degrees)' set to -118.162. The 'Basic Hazard Curve' section shows 'Select Hazard Curve' as 'Hazard Curve for 1.0sec'. The 'Single Hazard Curve Value' section has 'Return Period (Years)' set to 10. The 'Output for All Calculations' section displays a table of ground motion values and frequency of exceedance.

| Ground Motion (g) | Frequency of Exceedance (per year) |
|-------------------|------------------------------------|
| 0.002             | 7.5855E-01                         |
| 0.004             | 6.4518E-01                         |
| 0.006             | 5.2142E-01                         |
| 0.008             | 4.0407E-01                         |
| 0.013             | 3.0233E-01                         |
| 0.019             | 2.2048E-01                         |
| 0.029             | 1.5411E-01                         |
| 0.043             | 1.0169E-01                         |
| 0.064             | 6.2262E-02                         |
| 0.096             | 3.4926E-02                         |
| 0.144             | 1.7497E-02                         |
| 0.216             | 7.576E-03                          |
| 0.324             | 2.7752E-03                         |

USGS science for a changing world

# ハザード曲線（応答加速度）

- ▶ 再現期間475年地震の年発生確率： $1/475 = 0.002105$

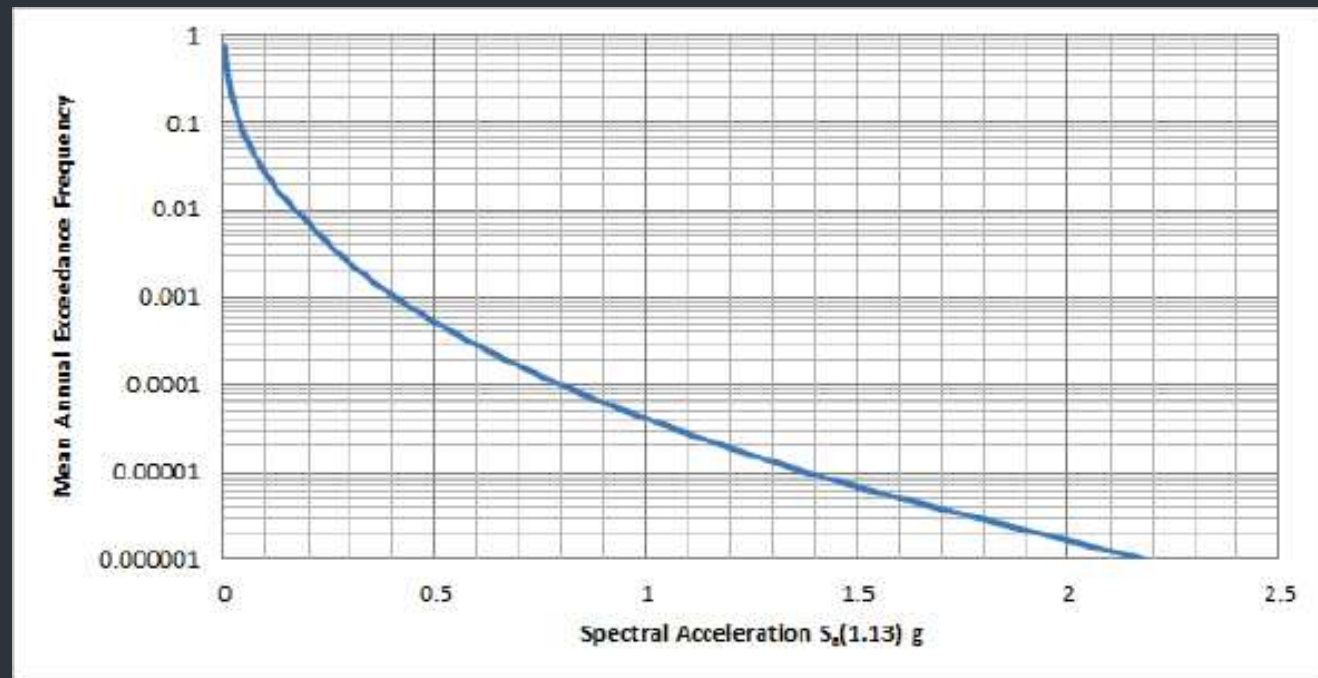


Figure 4-18 Seismic hazard curve for  $S_a(T = 1.13s)$ , Site Class D.

# ハザード曲線（地表面最大加速度）

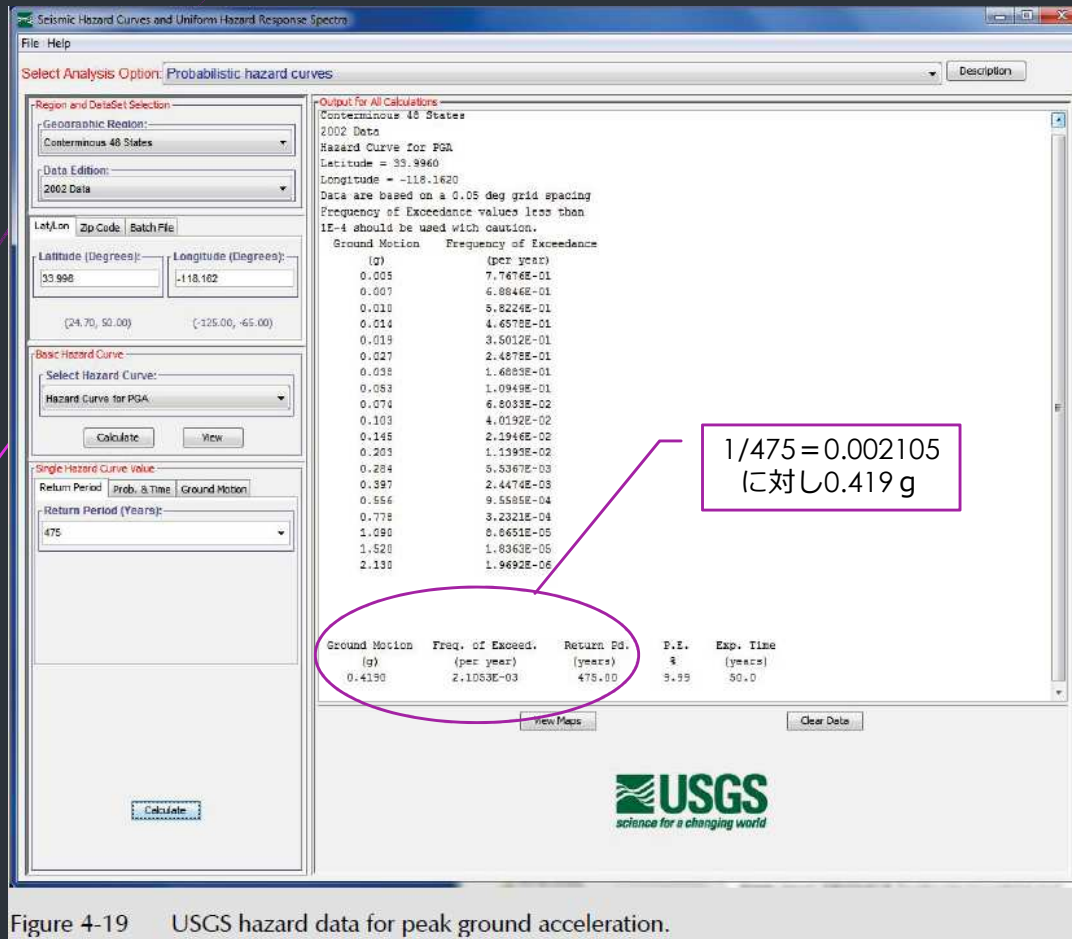


Figure 4-19 USGS hazard data for peak ground acceleration.

サイト用に調整  
 $0.419\text{g} \times 1.1 = 0.461\text{g}$



# 建物の応答計算

## 水平荷重

$$H = C_1 C_2 S_a(T_1) W_1$$

$$C_1 = C_2 = 1.0$$

$$S_a(T_1) = S_a(1.13s) = 0.648g$$

$$W_1 = 8366kip$$

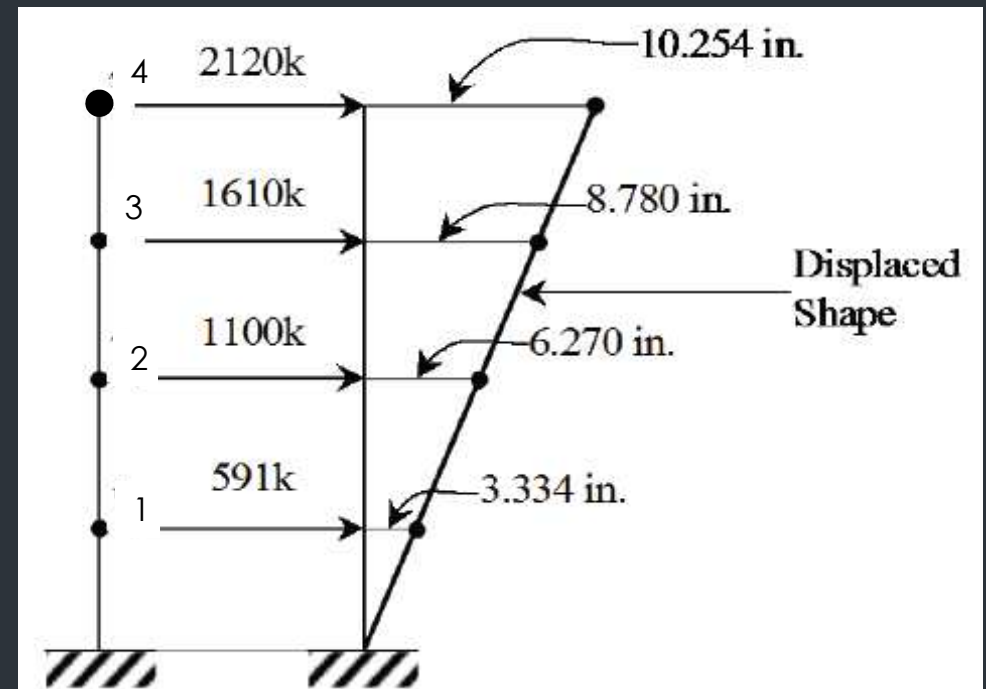
## 変位と変形角

$$\Delta_2 = \frac{3.334}{180} = 0.01852$$

$$\Delta_3 = \frac{6.270 - 3.334}{156} = 0.01882$$

$$\Delta_4 = \frac{8.780 - 6.270}{156} = 0.0161$$

$$\Delta_5 = \frac{10.254 - 8.780}{156} = 0.00945$$



# 応答層間変形角の修正： 塑性化と高次モードを考慮

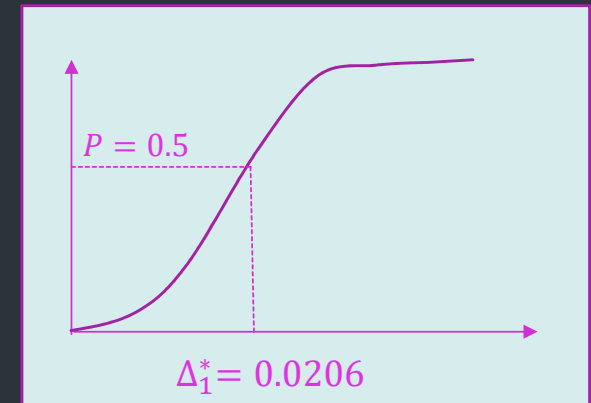


Table 4-7 層間変形角の中央値

| Story | $\Delta$ | $\frac{h_{i+1}}{H}$ | $\ln H_{\Delta_i}$ | $H_{\Delta_i}$ | $\Delta^*$ |
|-------|----------|---------------------|--------------------|----------------|------------|
| 1     | 0.01852  | 0.28                | 0.1073             | 1.113          | 0.0206     |
| 2     | 0.01882  | 0.52                | -0.0707            | 0.9317         | 0.0175     |
| 3     | 0.01610  | 0.76                | 0.01708            | 1.0172         | 0.0164     |
| 4     | 0.00945  | 1.00                | 0.3694             | 1.4469         | 0.0137     |

$\beta_{SD} = 0.59$  (1次固有周期 $T_1$ と $S$  (弾性水平荷重の降伏荷重に対する比) から決まるデフォルト値)

# 床応答加速度

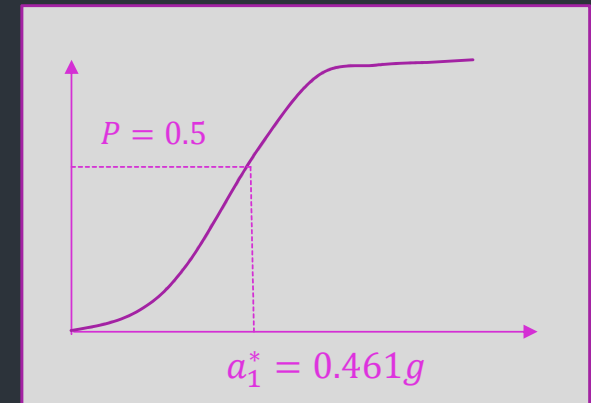


Table 4-8

床応答加速度の中央値

| Floor | PGA   | $\frac{h_i}{H}$ | $\ln H_{A_i}$ | $H_{A_i}$ | $a_i^*$ |
|-------|-------|-----------------|---------------|-----------|---------|
| 1     | 0.461 | -               | -             | -         | 0.461   |
| 2     | 0.461 | 0.28            | -0.04062      | 0.9602    | 0.443   |
| 3     | 0.461 | 0.52            | -0.05000      | 0.9512    | 0.439   |
| 4     | 0.461 | 0.76            | -0.05934      | 0.9424    | 0.434   |
| Roof  | 0.461 | 1.00            | -0.06870      | 0.9336    | 0.430   |

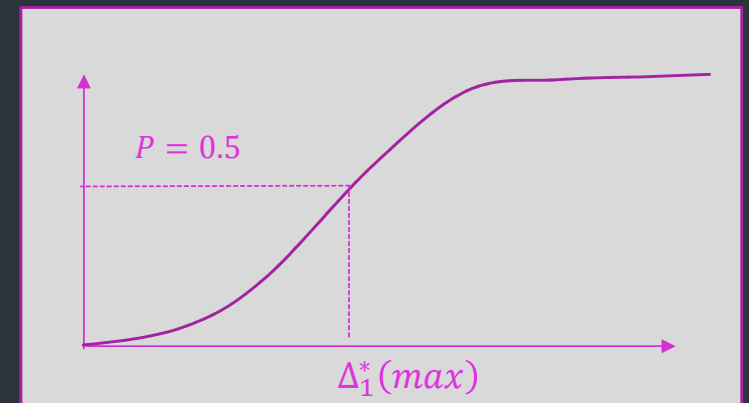
$\beta_{FA} = 0.48$  (1次固有周期 $T_1$ と $S$  (弾性水平荷重の降伏荷重に対する比) から決まるデフォルト値)

## 残留変形角（建物全体として）

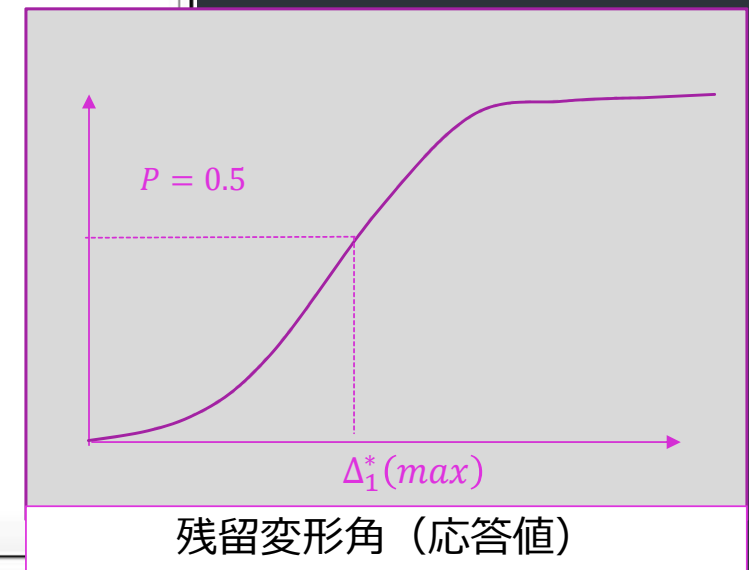
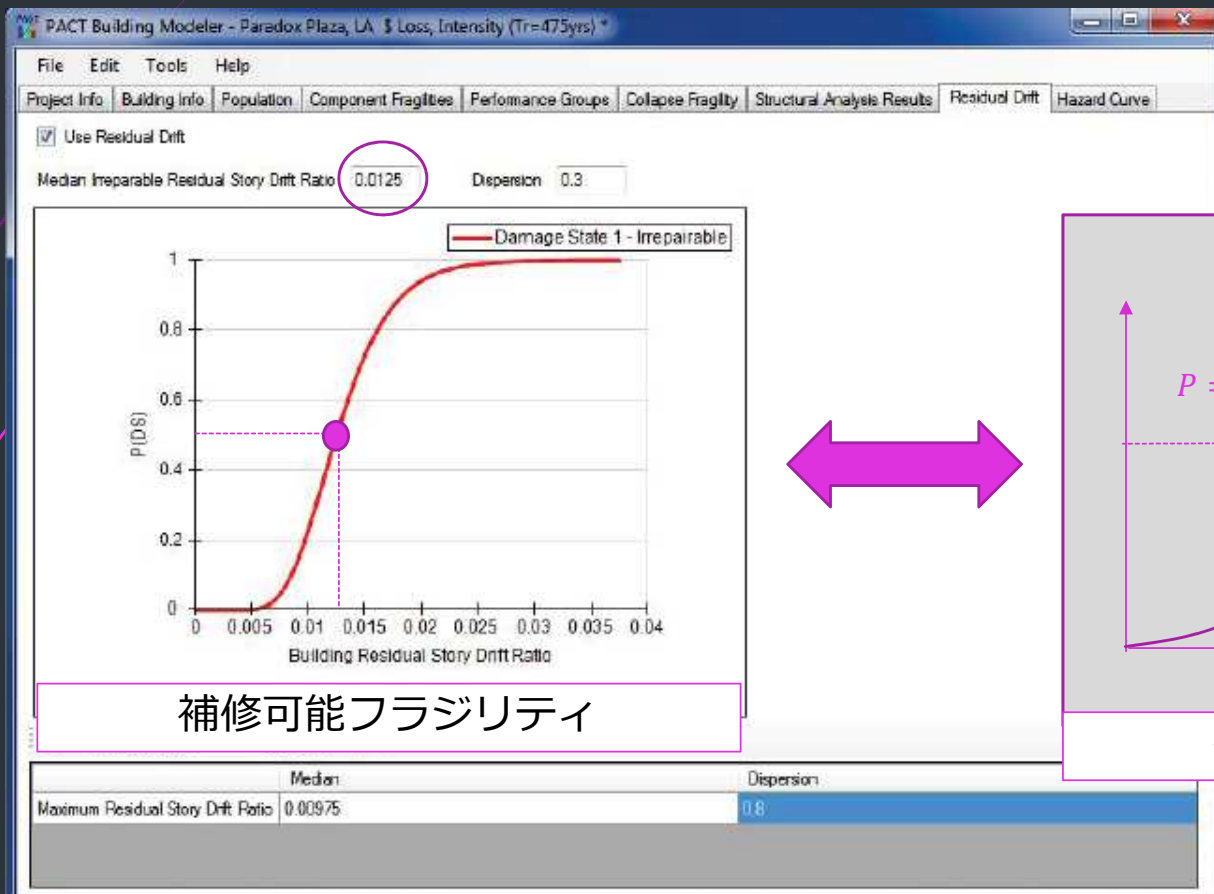
$$\rightarrow \Delta_y = \frac{2.268}{648} = 0.00350$$

$$\rightarrow \Delta_r^*(max) = 0.206 - 3(0.0035) = 0.0101$$

$\beta_{RD} = 0.8$ （簡易計算によっているため分散は大きい値をとっている）

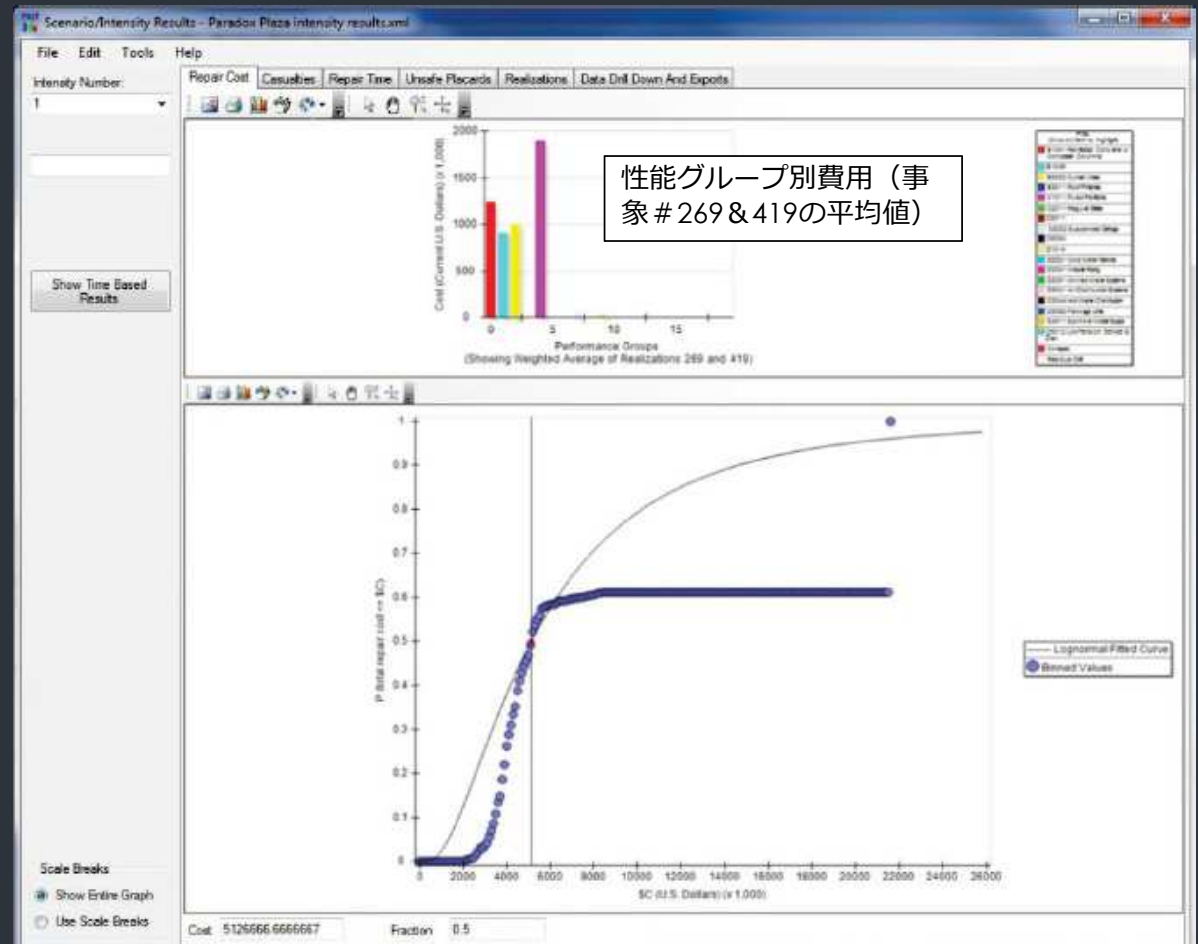


# 補修判定フラジリティ



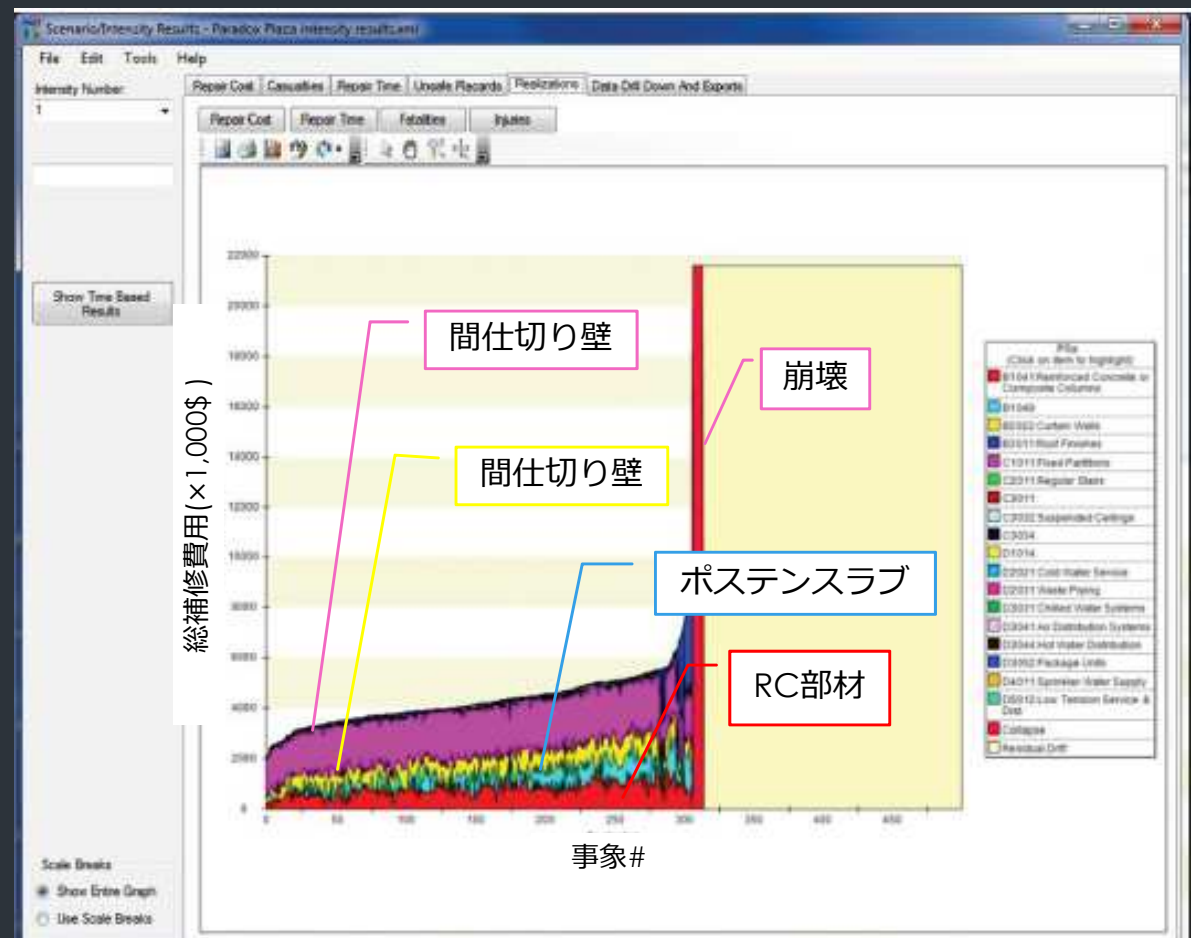
# 性能照査一補修費用

- ▶ フラジリティグループによる補修費用寄与
- ▶ 補修費用中央値  
\$5,130,000(建替え費用の23.7%)

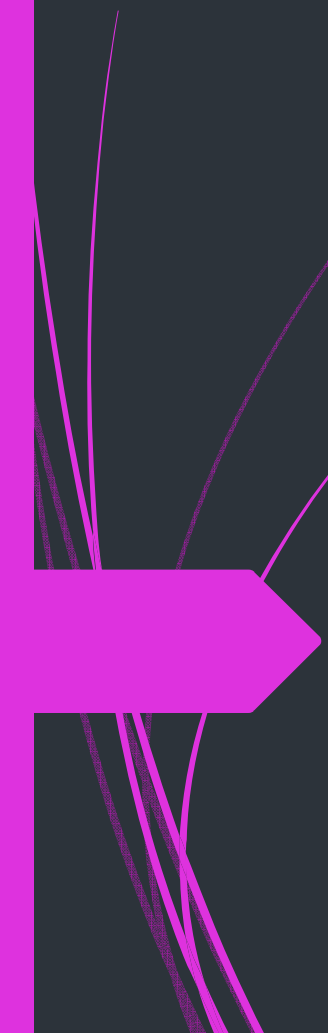


# 500事象に対する補修費用

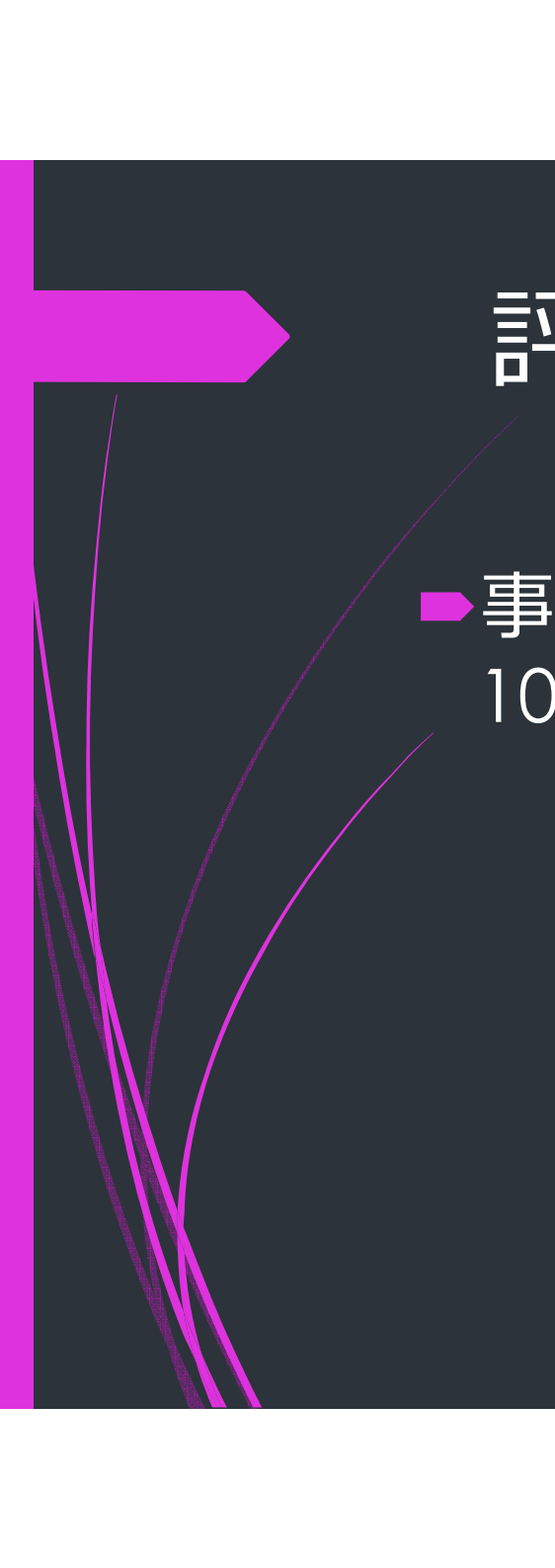
- ➡ 崩壊よりも残留変位による影響が支配的



## 2. 非線形時刻歴応答解析 による時間ベースの性 能評価事例

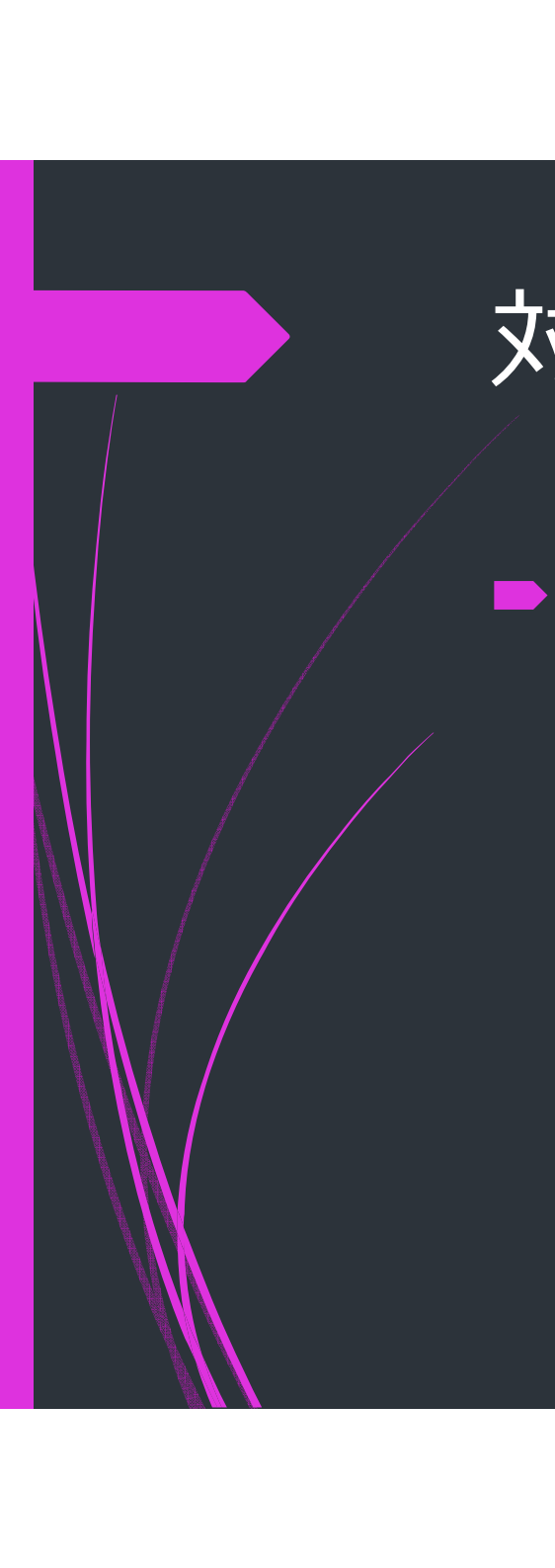






# 評価の目的

- 事務所建物を対象に30年間での非超過確率が10%となる補修費用の最大損失期待値を求める

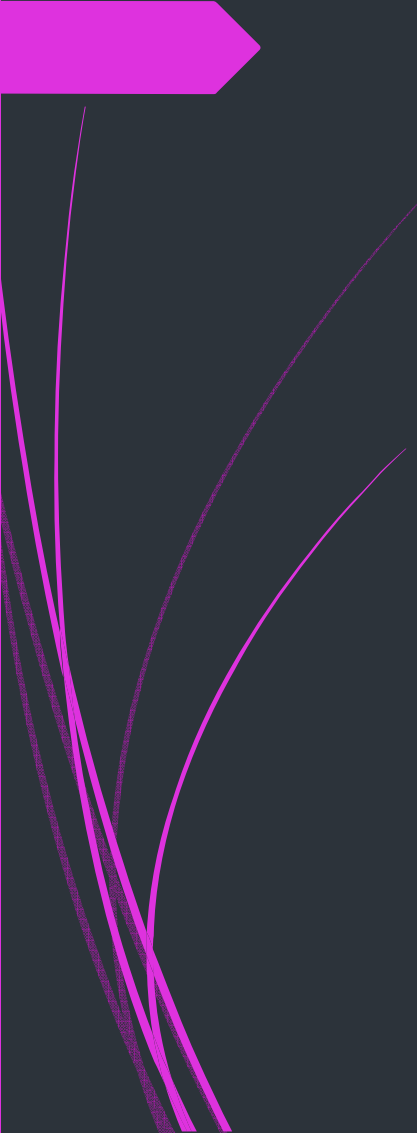


# 対象とする建物とサイト

- ➡ 11.1の簡易解析による性能評価例と同じ建物

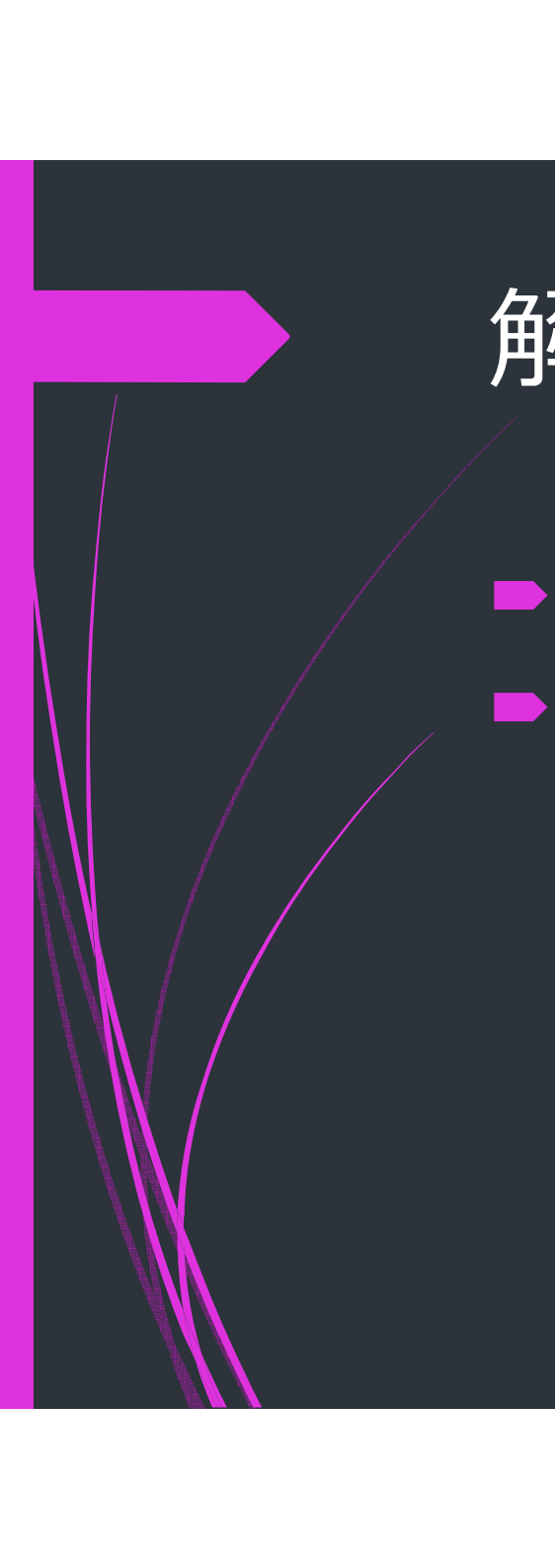
# 評価の表現形式と性能指標

- 年平均補修費用を基に
- 30年間の超過確率10%となる補修費用



## 簡易解析ベースと異なる性能評価モデル

- 性能の変動をより詳細に調べるため要素が非相関となる性能グループ特定
- 部分崩壊を考慮
- 8地震強度レベル×7地震動
- 評価指標値：各層の各方向最大層間変位、最大床応答加速度、最大残留変形角



# 解析方法 & 解析モデル

- 非線形時刻歴応答解析
- 3次元解析モデル

# 地震ハザード

- ▶ 11.1と同様のハザード曲線
- ▶  $T_1^X = T_1^Y = 1.13$ 秒  
 $\therefore \bar{T} = 1.13$ 秒

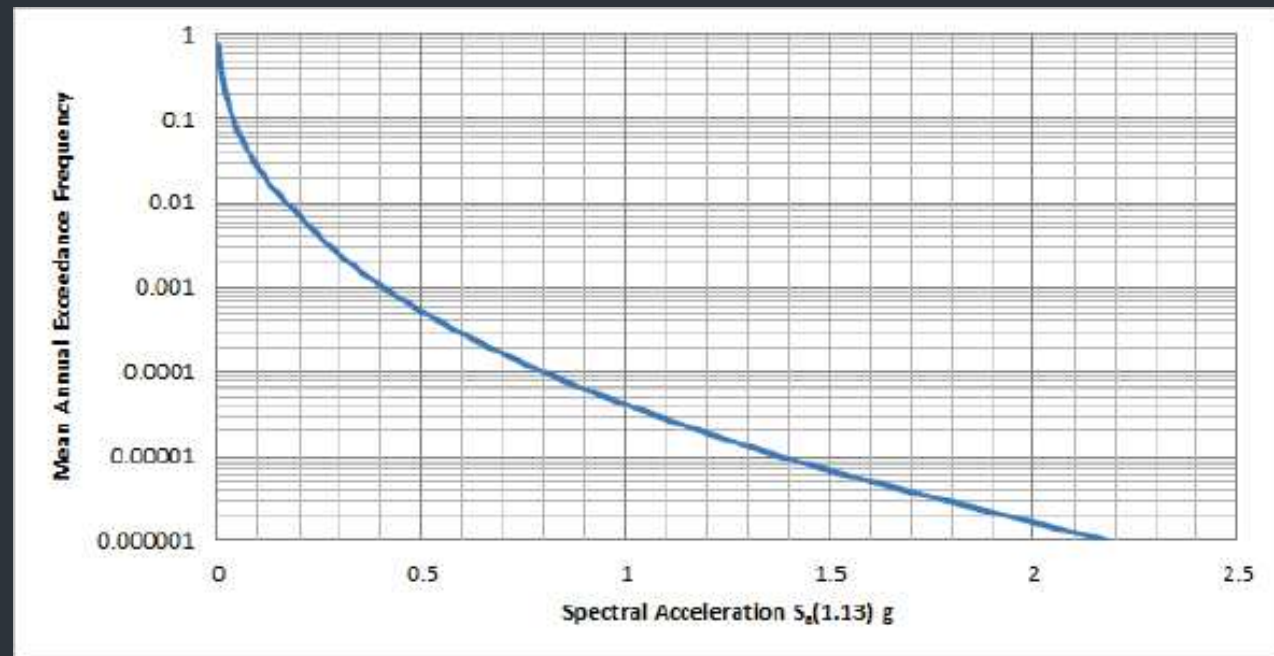


Figure 4-18 Seismic hazard curve for  $S_a(T = 1.13s)$ , Site Class D.

# 地震ハザード曲線の分割

| Spectral Segment | $\bar{S}_a$ | $\lambda$ |
|------------------|-------------|-----------|
| 1                | 0.158       | 0.05364   |
| 2                | 0.387       | 0.00740   |
| 3                | 0.615       | 0.00170   |
| 4                | 0.843       | 0.00050   |
| 5                | 1.071       | 0.00018   |
| 6                | 1.299       | 0.000101  |
| 7                | 1.528       | 0.0000435 |
| 8                | 1.756       | 0.0000311 |

- ➡  $S_a^{min} = 0.044g$  ( $=0.05/\bar{T}$ )
- ➡  $S_a^{max} = 1.87g$  (崩壊強度中央値の2倍)
- ➡  $\Delta S_a(\bar{T}) = \frac{1.87 - 0.044}{8} = 0.228g$

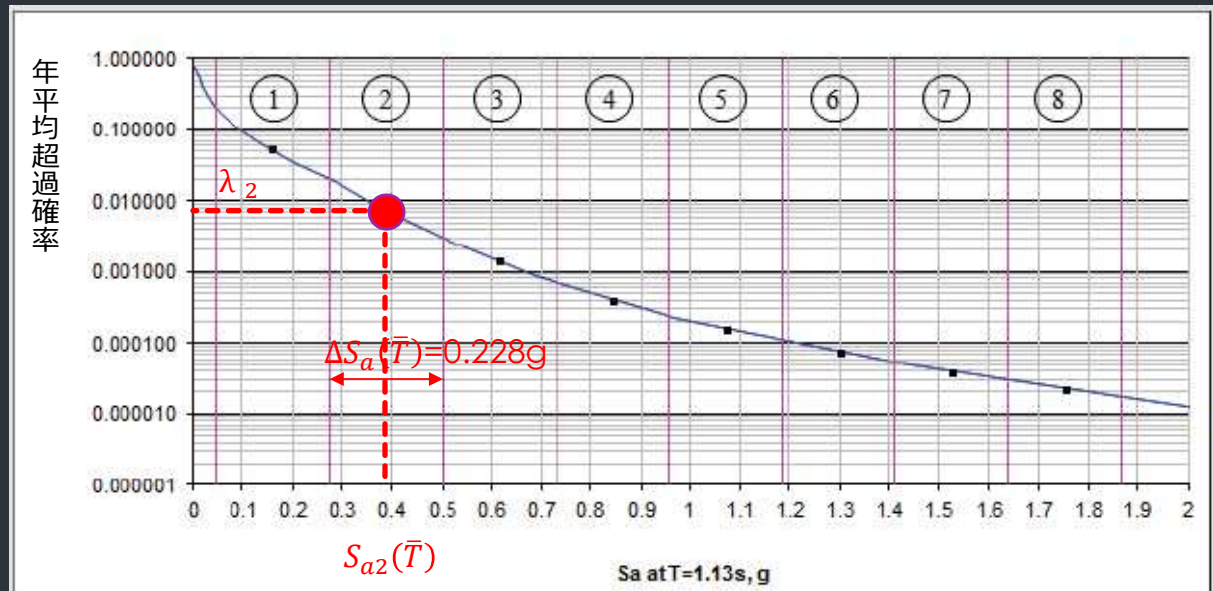
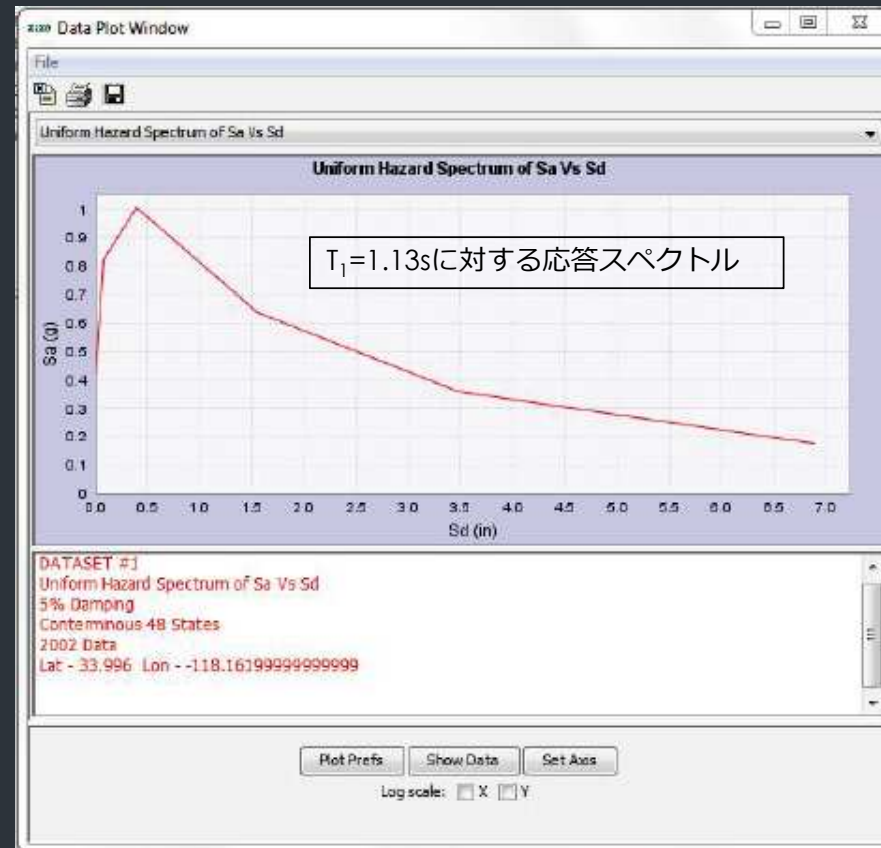


Figure 5-2 Segmented seismic hazard curve to be used for time-based assessment.

# 分割①、②に対して：一様ハザードスペクトル(UHS)

- 発生確率の高い地震の場合、UHSまたは条件付き平均スペクトル(CMS)を用いるのがよい
- 発生確率が小さい地震の場合はCMSまたは条件付きスペクトル(CS)を用いるのがよい。





# 分割③～⑧に対して：条件付き平均スペクトル (CMS)

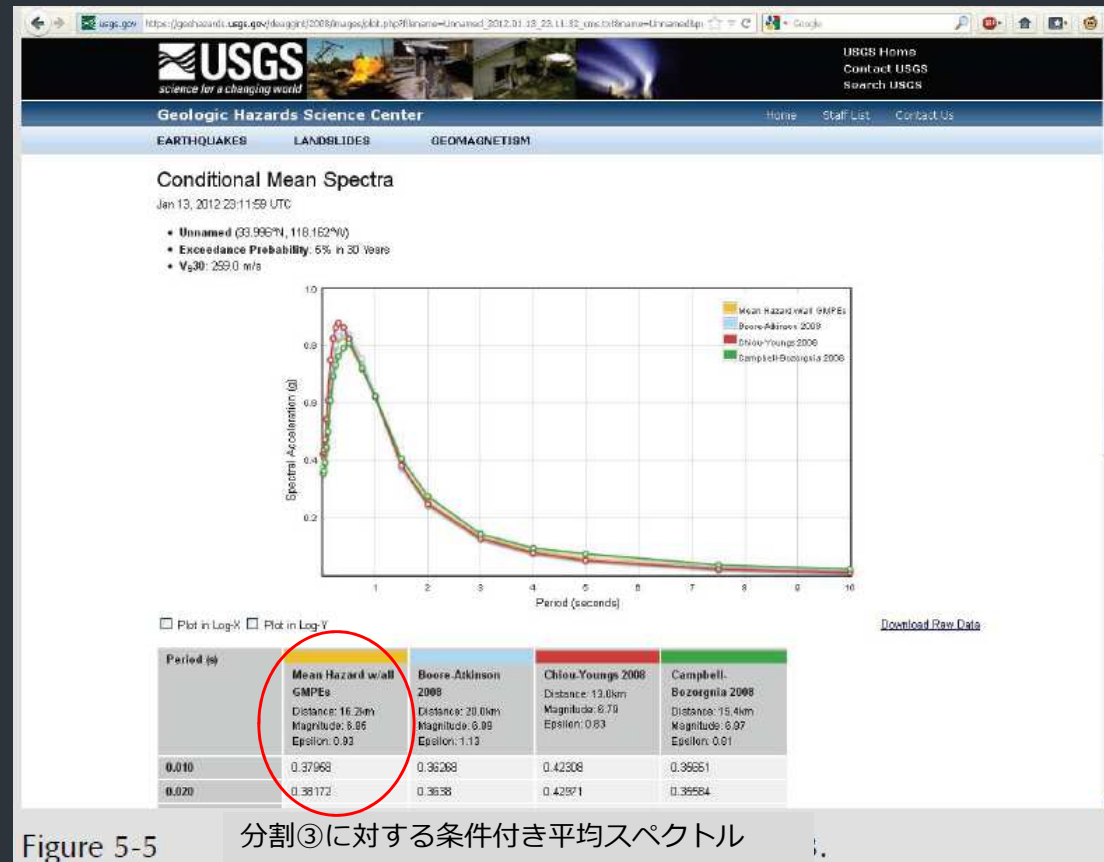


Figure 5-5

分割③に対する条件付き平均スペクトル

# スペクトルに適合させた地震動 (分割②を例に)

1分割当り7つの地震動

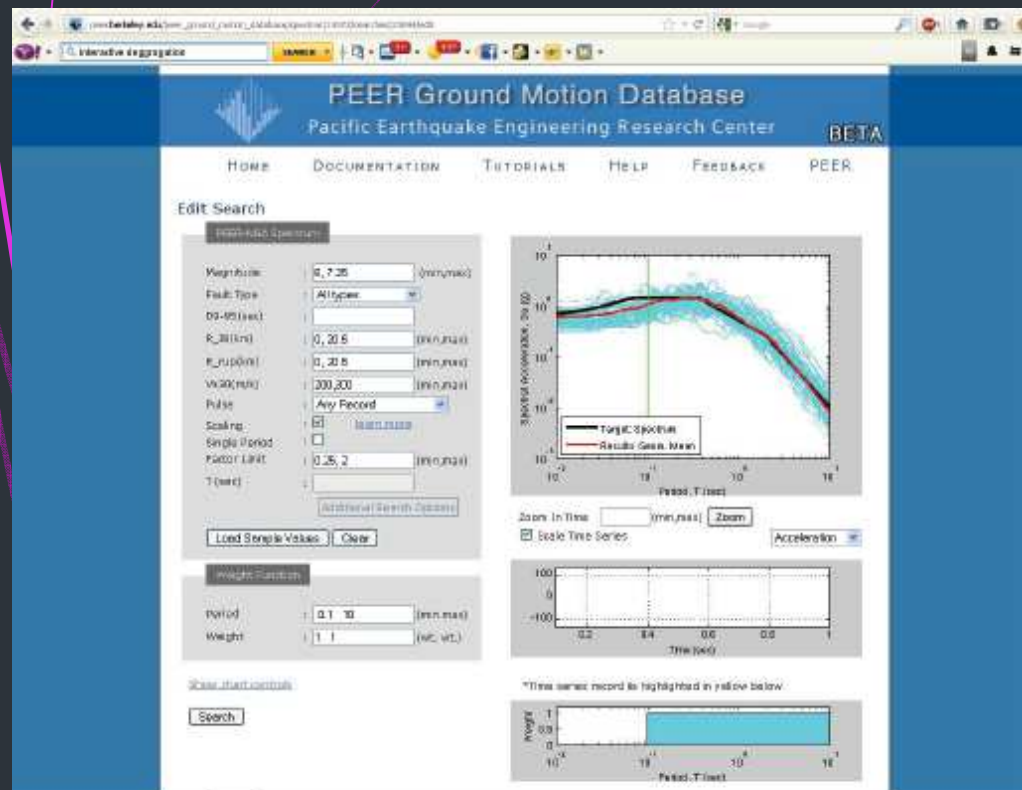


Figure 5-6 PEER scaled record selection tool.

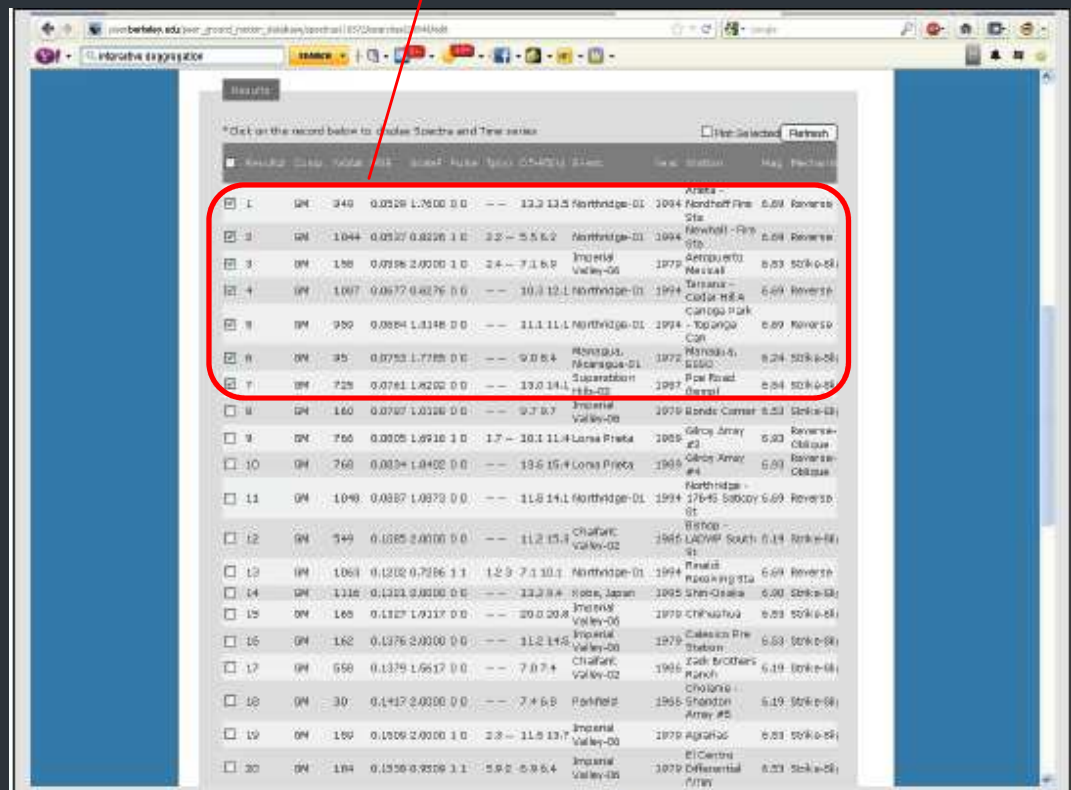


Figure 5-7 Selected records for segment 2.

# 解析結果：応答変位 & 応答加速度の中央値と分散

応答変位

応答加速度

| Intensity 1 $S_a(\bar{T}) = 0.158 \text{ g}$ |        |
|----------------------------------------------|--------|
| Demand Parameter                             | Median |
| $\Delta_4$                                   | 0.002  |
| $\Delta_3$                                   | 0.004  |
| $\Delta_2$                                   | 0.005  |
| $\Delta_1$                                   | 0.005  |
| $a_5$                                        | 0.24   |
| $a_4$                                        | 0.18   |
| $a_3$                                        | 0.19   |
| $a_2$                                        | 0.16   |
| $a_1$                                        | 0.19   |

| Intensity 3 $S_a(\bar{T}) = 0.615 \text{ g}$ |        |
|----------------------------------------------|--------|
| Demand Parameter                             | Median |
| $\Delta_4$                                   | 0.006  |
| $\Delta_3$                                   | 0.013  |
| $\Delta_2$                                   | 0.017  |
| $\Delta_1$                                   | 0.015  |
| $a_5$                                        | 0.43   |
| $a_4$                                        | 0.36   |
| $a_3$                                        | 0.38   |
| $a_2$                                        | 0.43   |
| $a_1$                                        | 0.36   |

| Intensity 8 $S_a(\bar{T}) = 1.756 \text{ g}$ |        |
|----------------------------------------------|--------|
| Demand Parameter                             | Median |
| $\Delta_4$                                   | 0.019  |
| $\Delta_3$                                   | 0.041  |
| $\Delta_2$                                   | 0.069  |
| $\Delta_1$                                   | 0.067  |
| $a_5$                                        | 0.700  |
| $a_4$                                        | 0.800  |
| $a_3$                                        | 0.610  |
| $a_2$                                        | 1.057  |
| $a_1$                                        | 1.000  |

$$\beta_m = \sqrt{(\beta_c)^2 + (\beta_q)^2} = \sqrt{(0.25)^2 + (0.40)^2} = 0.47$$

$\beta_c$  : 施工品質の分散     $\beta_q$  : 非線形解析モデルの分散

# 残留変形角の算定法

- 建物全体としての応答最大変位を抽出
- 残留変形角の算定

$$\Delta_r = 0$$

$$\Delta_{max} < \Delta_y$$

$$\Delta_r = 0.3(\Delta_{max} - \Delta_y) \quad \Delta_y < \Delta_{max} < 4\Delta_y$$

$$\Delta_r = \Delta_{max} - 3(\Delta_y) \quad \Delta_{max} \geq 4\Delta_y$$

# 各レベル各地震動に対する残留変形角

Table 5-6 Residual Drift, Intensity 1

| Intensity 1: $S_a = 0.158g$ |         |         |         |         |         |         |         |
|-----------------------------|---------|---------|---------|---------|---------|---------|---------|
|                             | 1       | 2       | 3       | 4       | 5       | 6       | 7       |
| $\Delta_{max}$              | 0.007   | 0.005   | 0.005   | 0.005   | 0.006   | 0.005   | 0.005   |
| $\Delta_r$                  | 0.00105 | 0.00045 | 0.00045 | 0.00045 | 0.00075 | 0.00045 | 0.00045 |

$$\Delta_r = 0.3(\Delta_{max} - \Delta_y) \quad \because \Delta_y < \Delta_{max} < 4\Delta_y$$

Table 5-7 Residual Drift, Intensity 3

| Intensity 3: $S_a = 0.615g$ |        |       |       |        |        |        |        |
|-----------------------------|--------|-------|-------|--------|--------|--------|--------|
|                             | 1      | 2     | 3     | 4      | 5      | 6      | 7      |
| $\Delta_{max}$              | 0.023  | 0.022 | 0.022 | 0.018  | 0.030  | 0.023  | 0.020  |
| $\Delta_r$                  | 0.0125 | 0.015 | 0.015 | 0.0075 | 0.0195 | 0.0125 | 0.0095 |

$$\Delta_r = \Delta_{max} - 3(\Delta_y) \quad \because \Delta_{max} \geq 4\Delta_y$$

分散 :  $\beta = 0.8$

# 応答値に対する性能計算： 最大層間変形角

- ▶ 性能計算ツール"PACT"での最大層間変形角の入力例
- ▶ 地震強度レベル：3

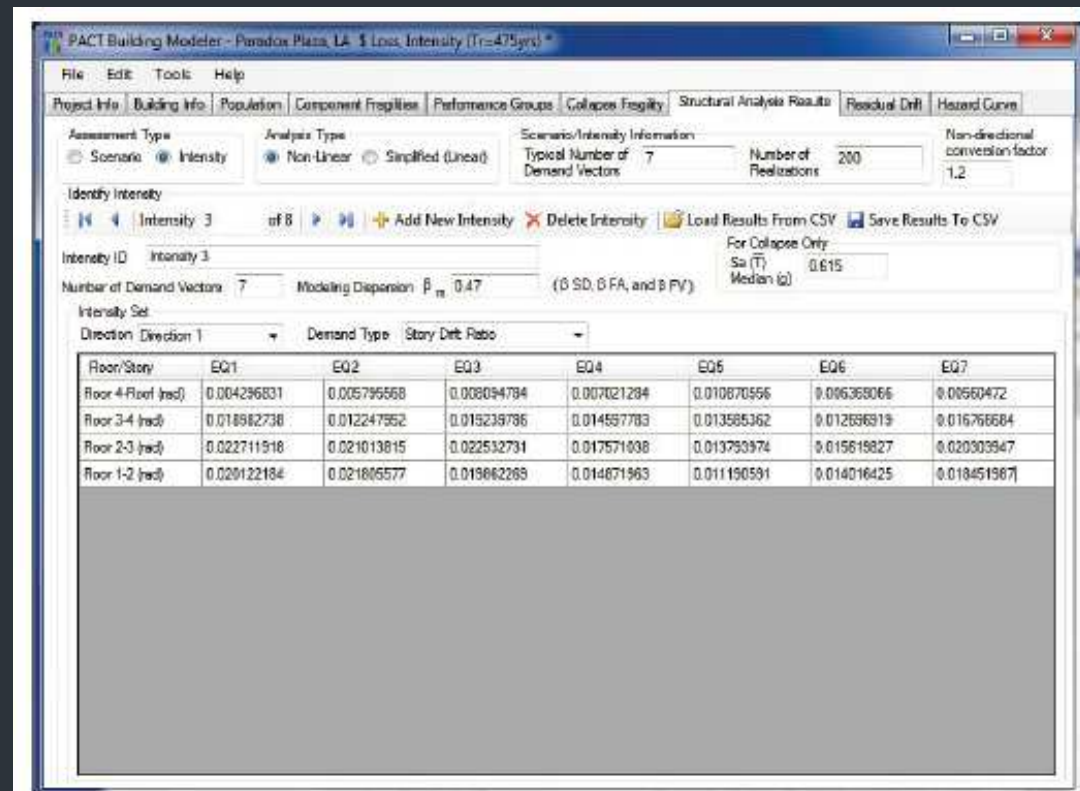
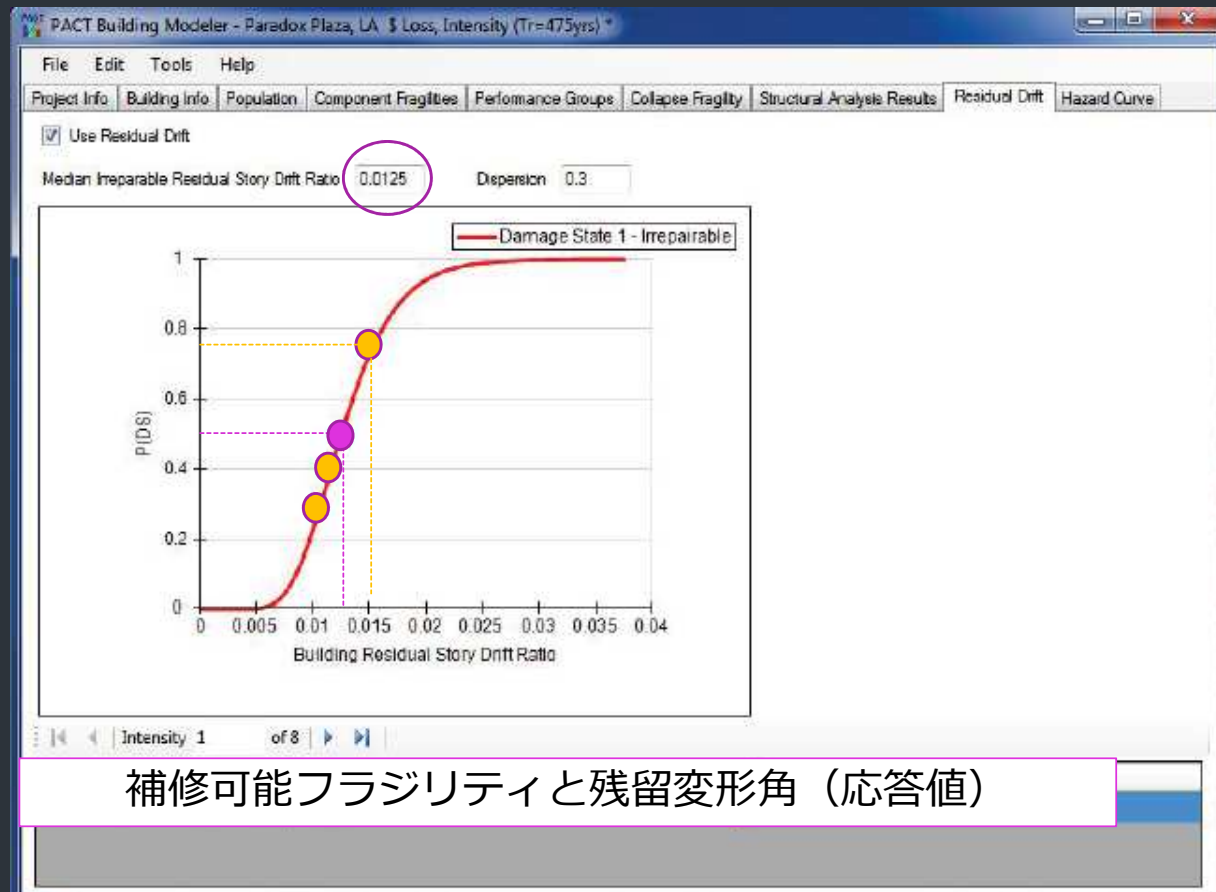


Figure 5-8 PACT Structural Analysis Results tab with drift input for intensity 3.

# 補修判定フラジリティ



$\Delta_1^*(max)$



# 性能照査結果

- 年平均崩壊確率：

0.000157(再現期間6370年)

- 年平均立入り禁止判定確率：

0.0051(再現期間200年)

- 30年間10%非超過確率に相当する再現期間：

$$P_R = \frac{-30}{\ln(1-0.1)} = 285\text{年}$$

- 補修費用期待値：

$1/285 = 0.0035/\text{年}$

∴ **\$3.8M**

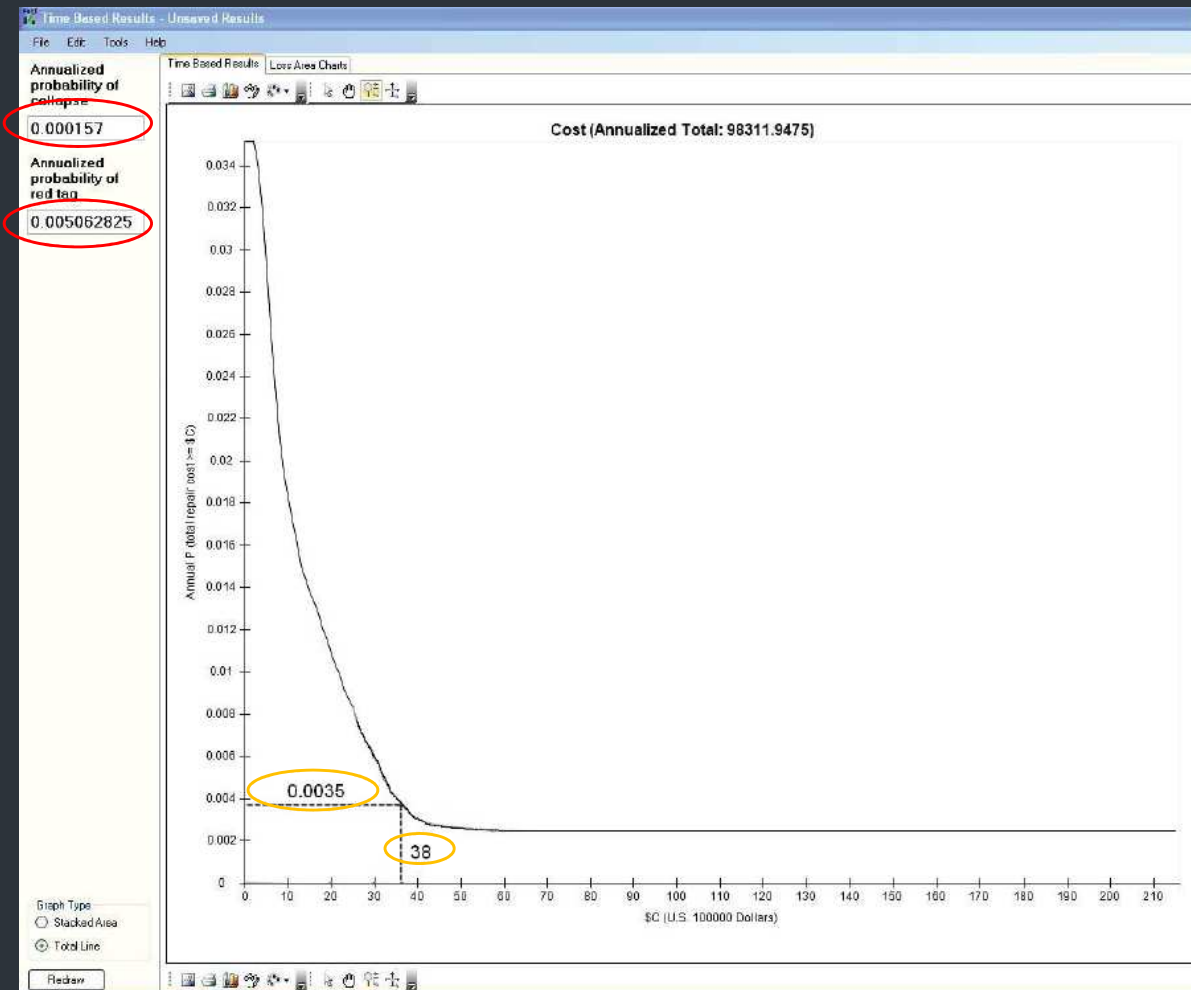


Figure 5-10 PACT Time Based Results tab showing annualized repair cost.