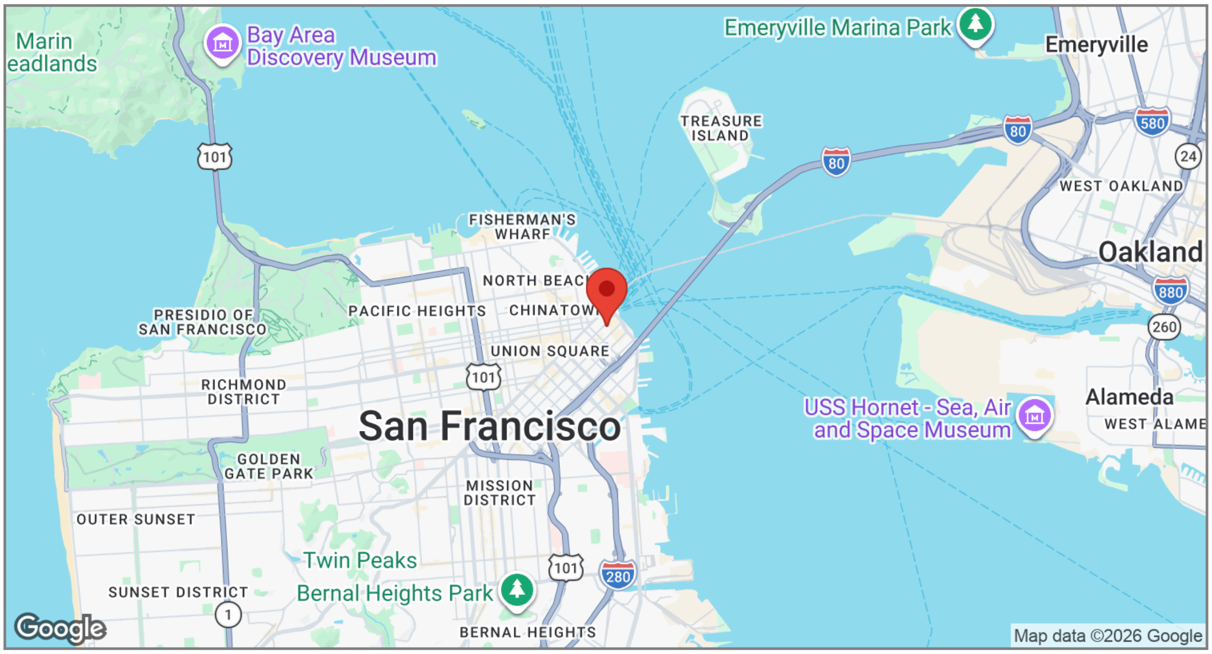
SEISMIC RISK ASSESSMENT REPORT

Created with the SP3-RiskModel *Advanced + Recovery*

Risk Analysis Report



Report Generated for:

123 Main Street, San Francisco, CA

Latitude: 37.79166°

Longitude: -122.39442°

Report Generated by:

v14.7.1 of the SP3-RiskModel

May 22, 2026

SP3 | Where Research Meets Practice

CONTENTS

1 SUMMARY OF INPUTS AND RISK RESULTS

Risk Model Inputs

Primary

Project Name:	Website
Model Name:	123 Main Street
Building Type:	Steel: BRBF CoreBrace with Back-up Frame
Design Code Year:	2010
Number of Stories:	8
Address:	
	123 Main Street San Francisco, CA
Latitude:	37.79166°
Longitude:	-122.39442°
Occupancy:	Commercial Office

Building Design Info

Level of Detailing (Dir. 1, 2):	Special, Special
Drift Limit (Dir. 1, 2):	1%, 1%
Risk Category:	(Cat. III)
Seismic Importance Factor, I_e:	–
Component Importance Factor, I_p:	–
Design Spectral Acceleration	
Mapped Short Period, S_s	–
Mapped 1 Second, S_1	–
Design Short Period, S_{Ds}	–
Design 1 Second, S_{D1}	–

Analysis Options

Include Collapse in Analysis:	Yes
Consider Residual Drift:	Yes
Simulation Options	
Number of EQ Simulations:	2,500
Collapse Distribution Truncation?	Yes
Truncation Level:	–
Component Distribution Truncation?	No
Truncation Level:	–
Cost Multipliers	
Region Cost Multiplier:	–
Date Cost Multiplier:	–
Occupancy Cost Multiplier:	–
Component Soft Cost Modifier:	–

Structural Properties

Mode Shapes Specified?	No	
Directional Properties	*Dir. 1*	*Dir. 2*
Base Shear Strength (g):	–	–
Yield Drift (%):	–	–
Design Model Period (T_1) (s):	–	–
1^{st} Mode Period (T_1) (s):	–	–
2^{nd} Mode Period (T_2) (s):	–	–
3^{rd} Mode Period (T_3) (s):	–	–

Component Information

Selection Method	Automatic

Building Layout Information

Cost per Square Foot:	–
Scale component repair costs with building value?	Yes
Total Square Feet:	–
Aspect Ratio:	–
First Story Height (ft):	–
Upper Story Heights (ft):	–

Building Stability

Collapse Definition Method:	FEMA P-154
Score Calc Method:	Rapid Visual Screening Checklist
FEMA P-154 Score:	–
Beta (Dispersion):	–

Ground Motion and Soil Information

Site Class:	–
Site Hazard:	U.S. Geological Survey
Edition:	–

Recovery Time Options

Recovery Time Method	ATC-138 (Beta)
Building Replacement Time	–
Statistical Damage Correlation Model: Original FEMA P-58 Correlation Model (2012/2018)	
Factors Delaying Start of Repairs	
Inspection	Yes
Financing	Yes
Permitting	Yes
Engineering Mobilization	Yes
Contractor Mobilization	Yes
Long Lead Time	No
Mitigation Factors	
Inspector on Retainer	Yes
Engineer on Retainer	Yes
Contractor Relationship	Retainer
Funding Source	–
Cash on Hand	15.0%

Responses

Response	EDP	Method	Use as Default for Comps?	Derived From
Peak Story Drift Ratio	IDR	SP3 SRPE	Yes	–
Peak Floor Acceleration	PFA	SP3 SRPE	Yes	–
Residual Story Drift Ratio	RIDR	SP3 SRPE	Yes	Peak Story Drift Ratio
Direction 1				
Residual Drift Model:		–		
Record-to-Record Dispersion:		–		
Direction 2				
Residual Drift Model:		–		
Record-to-Record Dispersion:		–		

Structural Response Dispersion Options

Record-to-Record Dispersion Model:	FEMA P-58
Modeling dispersion:	–
Residual Drift Simulation Method:	–

Recovery Time Options Specific to ATC-138 (Beta)

HVAC

Need Ventilation for Reoccupancy?	–	Need Ventilation for Function?	Yes
Need Heating for Reoccupancy?	–	Need Heating for Function?	Yes
Need Cooling for Reoccupancy?	–	Need Cooling for Function?	Yes
Need Exhaust for Reoccupancy?	–	Need Exhaust for Function?	Yes

Elevator

Need Elevator for Function?	Yes	Max. Walkable Story	3
Use updated elevator components?	No		

Surge

Include Surge Demand?	No

Temporary Repair

Allow Temporary Repairs?	Yes	Allow Temporary Shoring?	–

Fire

Allow Fire Watch for Occupancy?	No

Plumbing

Is Potable Water Required for Occupancy?	–	Is Potable Water Required for Function?	–
Is Sanitary Piping Required for Occupancy?	–	Is Sanitary Piping Required for Function?	–

Electrical

Is Electricity Required for Function?	–

Egress

Percentage of the Exits Required for Occupancy?	–	Minimum Number of Exits Required for Occupancy?	–
Door racking affects egress?	–		

Flooding

Include flooding consequences?	Yes

“Smart” Components

Use “smart” piping components?	No
Use “smart” equipment components?	No

Component Checklist

Exterior

- Percent of Building Surface Glazed
  > *80.0%*
- Does the building have glazing?
  > *Yes*
  - What type of glazing does the building have?
    > *Insulating Glass Unit (Untested)*
- Does the building have cladding?
  > *Yes*
  - What kind of cladding does the building have?
    > *Precast Concrete Panels*

Interior Finishes

- Are there partition walls in the building?
  > *Yes*
  - What kind of partition walls does the building have?
    > *Metal Studs*

Continued on next page

Component Checklist (*Continued*))

- What finish do the partition walls have?
  > *Gypsum + Wallpaper*
  - How are the partitions constructed?
    > *Full Height: Slip Tracks with Returns*
- Does the building have raised access floors?
  > *No*
- Does the building have suspended ceilings?
  > *Yes*
  - Are the ceilings laterally supported?
    > *Yes (SDC D/E/F or equivalent)*
    - What is the Ip factor used to design the ceilings?
      > *1.5*
- Does the building contain pendant (non-recessed) lighting?
  > *No*

Stairs and Elevators

- Does the building have stairs?
  > *Yes*
  - What type of stairs are in the building?
    > *Prefabricated steel*
    - Do the stairs have seismic joints?
      > *Yes*
- Are there elevators in the building?
  > *Yes*
  - What type of elevators are in the building?
    > *Traction*
    - From which era are the building's elevators?
      > *Post-2000 Seismic Zone 3*

Fire Supression

- Does the building contain a fire sprinkler system?
  > *Yes*
  - Does the fire sprinkler system have braced horizontal mains?
    > *Yes*
    - Are the horizontal mains OSHPD certified (or equivalent)?
      > *Yes*
  - Are the fire sprinkler drops OSHPD certified (or equivalent)?
    > *Yes*
    - What type of ceiling do the fire drops enter into?
      > *Soft Braced*

Piping

- Does the building contain potable water piping?
  > *Yes*
  - Is the building's water piping OSHPD certified or equivalent?
    > *Yes*
- Does the building contain sanitary piping?
  > *Yes*
  - Is the building's sanitary piping OSHPD certified or equivalent?
    > *Yes*
    - What type of couplings do the pipes have?
      > *Flexible*

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Component Checklist (*Continued*))

HVAC

- Does the building have an HVAC system?
  > *Yes*
  - Is the HVAC cooling/heating equipment seismically anchored?
    > *Yes*
    - How is the cooling/heating system configured?
      > *Roof Top Units*
      - Are the RTUs used for medical purposes (or equivalent)?
        > *No*
        - Are the RTUs small or large?
          > *Large*
      - Does the building have a control panel?
        > *Yes*
  - Is there an HVAC exhaust system in the building?
    > *Yes*
    - Is the HVAC exhaust system seismically anchored?
      > *Yes*
  - Does the HVAC distribution system meet OSHPD standards (or similar)?
    > *Yes*
    - Is there any large diameter ducting (6 SqFt+) in the HVAC system?
      > *Yes*

Electrical

- Does the building have a backup battery/generator system?
  > *Yes*
  - Is the battery backup system equipment seismically anchored?
    > *Yes*
- Which best describes the building's electrical system?
  > *Full Commercial-grade Electrical System*
  - Is the electrical equipment seismically anchored?
    > *Yes*
  - What best describes the buildings motor control centers?
    > *Anchored*

Building Modifiers Checklist

Vertical Irregularities	
Soft Story	
Soft or Weak Story Vertical Irregularity?	–
Sloping Site	
Full story grade change? (FEMA Type non-W1 buildings)	–
Setback	
Outboard vertical elements of the lateral system at an upper story?	–
Inboard vertical elements of the lateral system at upper stories?	–
In-plane offset of the lateral elements greater their length?	–
Split Level	
Split level at one of the floor levels or at the roof?	–
Other	
Other observable vertical irregularity?	–
Plan Irregularities	
Torsion Irregularity?	–
Non-parallel system?	–
Re-entrant corner projection 25% of plan dimension?	–
Diaphragm opening over 50% of the total diaphragm width?	–
Other observable plan irregularity?	–
Redundancy	
At least two bays of lateral elements?	–
Pounding	
Floors Unaligned?	–
Different building heights?	–
End of block?	–
Steel Braced Frames (S1)	
K bracing geometry is visible?	–
Construction Quality	
Structural Construction Quality	–
Non-structural Construction Quality	–
Structural Material Deterioration	–

Notes

No notes were provided.

Expected Loss

Expected loss in percent of total building value

Shaking Intensity	Return Period	SEL (%)	SUL (%)
90% in 50 years	22 Years	0.0	0.1
50% in 30 years	43 Years	0.1	0.2
50% in 50 years	72 Years	0.3	0.6
50% in 75 years	108 Years	0.5	1.2
50% in 100 years	144 Years	0.8	1.7
20% in 50 years	224 Years	1.6	3.0
10% in 50 years	475 Years	4.4	6.6
DE	920 Years	21	40
5% in 50 years	975 Years	23	43
2% in 50 years	2475 Years	56	90
MCE_R	2880 Years	60	96

Recovery Time

Reported recovery times are the time required for the entire building to reach a recovery state (re-occupancy, functional recovery, or full recovery).

Median recovery time summary

Intensity	ATC-138 Functional Recovery (Beta)†			FEMA P-58‡	
	Re-Occupancy	Functional	Full	Full (Parallel)	Full (Series)
90% in 50 years	0 days	0 days	6 days	0.19 days	0.58 days
50% in 30 years	0 days	0 days	8 days	0.27 days	1.2 days
50% in 50 years	0 days	3 days	10 days	0.55 days	2.4 days
50% in 75 years	2 days	4 days	13 days	1.2 days	4.2 days
50% in 100 years	3 days	5 days	2.3 weeks	2.1 days	6.8 days
20% in 50 years	4 days	6 days	4.9 weeks	5 days	12 days
10% in 50 years	7 days	5.6 weeks	2.7 months	11 days	3.8 weeks
DE	2.3 months	3.4 months	4.1 months	3.1 weeks	7.7 weeks
5% in 50 years	2.6 months	3.6 months	4.3 months	3.2 weeks	1.9 months
2% in 50 years	38 months	38 months	38 months	38 months	38 months
MCE_R	38 months	38 months	38 months	38 months	38 months

† Does include factors delaying start of repairs
‡ Does ***not*** include factors delaying start of repairs

2 BASIS OF ANALYSIS

This analysis is based on the SP3-RiskModel of the Seismic Performance Prediction Program (SP3) software platform. The underlying analysis methods are based on the FEMA P-58 analytical method, which is a transparent and well documented method developed through a 15 year project (Applied Technology Council, 2018). This project leveraged the previous decades of academic research, funded by a $16 million investment by the Federal Emergency Management Agency (FEMA). In contrast to many risk assessment methods based on judgment and past earthquake experience, the FEMA P-58 and SP3 analysis are based on engineering-oriented risk evaluation methods.

3 DOCUMENTATION OF SITE AND BUILDING INPUT DATA

Project Name: Website
Model Name: 123 Main Street

3.1 Site Information

Address: 123 Main Street, San Francisco, CA
Latitude: 37.79166°
Longitude: -122.39442°

3.2 Building Information

Material Type:	Steel
Number of Stories:	8
Total Building Square Footage:	80,000
Total Expected Building Replacement Value:	$58,600,692

4 SITE HAZARD INFORMATION

This section presents the site's seismic hazard information. The V_{S30} value is the shear wave velocity in the soil at a depth of 30 meters. This value and the associated site class are presented in Table 4.1.

Table 4.1. Site soil information

V_{S30} (m/s):	314.0
Site Class:	C/D
Closest V_{S30} for USGS Hazard Lookup (m/s):	365

Table 4.2 and Figure 4.1 present the spectral acceleration information for this site. The spectral acceleration is a measure of how much force the building will attract in an earthquake. This amount of force is dependent on the intensity of the ground shaking (e.g. 10% in 50 years), as well as a dynamic property of the building known as the "fundamental period". Shorter buildings tend to have smaller fundamental periods and taller buildings tend to have larger fundamental periods. As indicated by Figure 4.1, smaller fundamental periods (with the exception of very short fundamental periods) will attract more force in an earthquake.

The Design Earthquake (DE) and Maximum Considered Earthquake (MCE) are based on the modern code maximum direction spectra and are converted to geometric mean for comparison.

Table 4.2. Geometric mean spectral acceleration values (in g)

Intensity	Return Period (yrs)	PGA	$S_a(0.2s)$	$S_a(1.0s)$	$S_a(1.4s)$	$S_a(T_1)/v_{ult}$ † Dir 1	$S_a(T_1)/v_{ult}$ † Dir 2
90% in 50 years	22	0.09	0.21	0.08	0.05	0.42	0.42
50% in 30 years	43	0.15	0.36	0.14	0.10	0.74	0.74
50% in 50 years	72	0.21	0.50	0.20	0.14	1.11	1.11
50% in 75 years	108	0.26	0.64	0.27	0.19	1.48	1.48
50% in 100 years	144	0.31	0.73	0.32	0.23	1.79	1.79
20% in 50 years	224	0.37	0.90	0.41	0.30	2.32	2.32
10% in 50 years	475	0.50	1.20	0.60	0.44	3.41	3.41
DE	920	0.63	1.51	0.80	0.59	4.57	4.57
5% in 50 years	975	0.64	1.54	0.82	0.61	4.67	4.67
2% in 50 years	2475	0.83	2.01	1.15	0.86	6.60	6.60
MCE_R	2880	0.87	2.10	1.20	0.90	6.92	6.92

† $S_a(T_1)/v_{ult}$ is the ratio of shaking intensity to building strength where in direction 1 $v_{ult} = 0.130$ and $T_1 = 1.40$s and in direction 2 $v_{ult} = 0.130$ and $T_1 = 1.40$s (see Table 5.3 for more detailed structural properties)

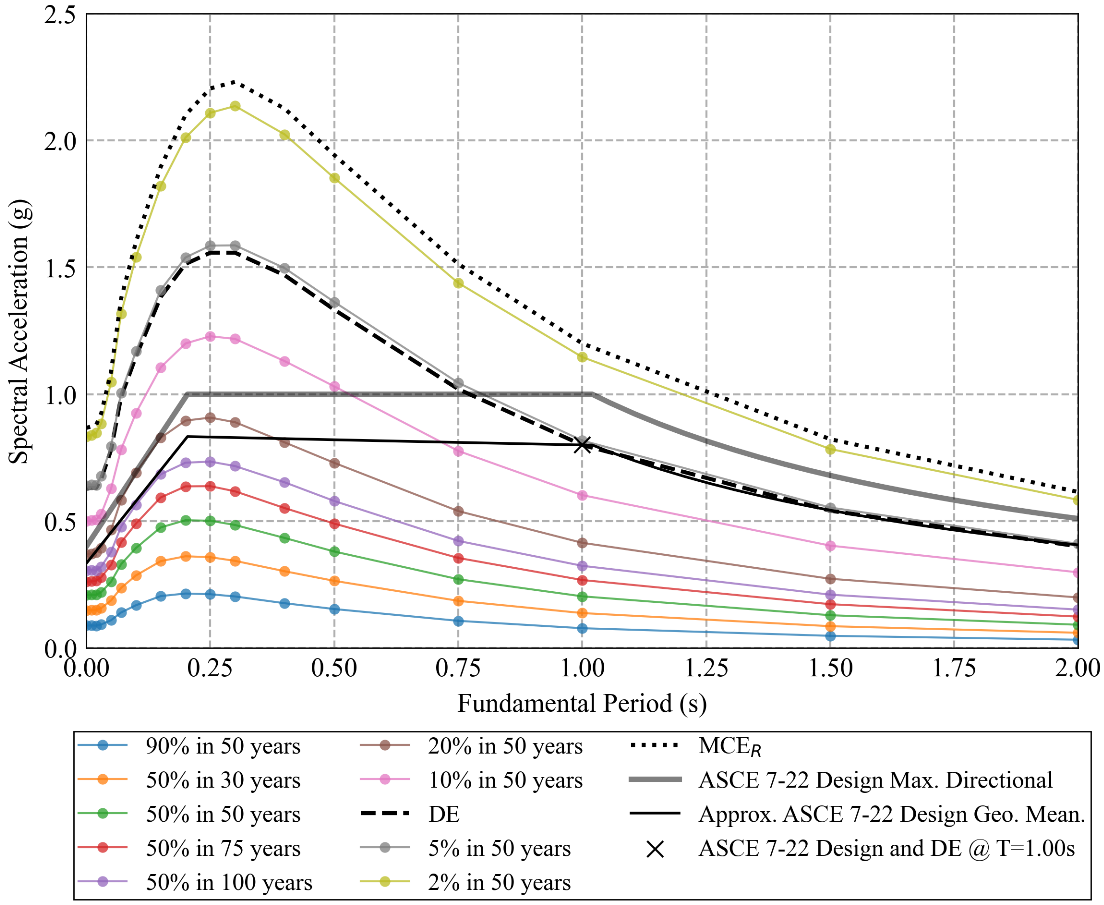

Figure 4.1. Hazard curves for this site from the USGS Conterminous US 2018 hazard edition using a V_{S30} of 365 m/s (site class C/D Boundary). All curves are geometric mean unless otherwise stated.

5 BUILDING DESIGN SUMMARY FROM THE *SP3 BUILDING CODE DESIGN DATABASE*

5.1 Building Code Design Parameters

The seismic design parameters used to compute the seismic base shear coefficients for this building are presented in Table 5.1. These parameters are specific to ASCE/SEI 7-2010 (American Society of Civil Engineers, 2010).

Table 5.1. Code design parameters

(a) ASCE 7-10 structural system parameters

Parameter	Dir. 1	Dir. 2
C_t	0.03	0.03
C_d	5	5
x	0.75	0.75
R	8	8
Ω_0	2.5	2.5

(b) ASCE 7-10 site specific parameters

Parameter	Value
S_s	1.5
S_1	0.6
S_{ds}	1
S_{d1}	0.6
SDC	D
C_u	1.4

(c) ASCE 7-10 site specific parameters based on the period of the building (T=1.4s)

Parameter	Value
$\mathrm{MCE}_{R,max}(g)$	0.643
$\mathrm{MCE}_{R,geomean}(g)$	0.514
$\mathrm{DE}_{max}(g)$	0.429
$\mathrm{DE}_{geomean}(g)$	0.343

5.2 Modern Building Code Design Parameters (for comparison purposes)

For comparison to modern code, the modern code parameters are presented in Table 5.2.

Note that only the non-structural parts of ASCE 7-22 (chapter 13) have currently been implemented, so the structural parameters shown as ASCE 7-22 are actually from ASCE 7-16 (American Society of Civil Engineers, 2016).

Table 5.2. Modern code design parameters (ASCE 7-22 applies to non-structural only, the structural properties are from ASCE 7-16)

(a) ASCE 7-22 structural system parameters

Parameter	Dir. 1	Dir. 2
C_t	0.03	0.03
C_d	5	5
x	0.75	0.75
R	8	8
Ω_0	2.5	2.5

(b) ASCE 7-22 site specific parameters

Parameter	Value
S_s	1.5
S_1	0.6
S_{ds}	1
S_{d1}	1.02
SDC	D
C_u	1.4

(c) ASCE 7-22 site specific parameters based on the period of the building (T=1.4s)

Parameter	Value
$\mathrm{MCE}_{R,max}(g)$	1.094
$\mathrm{MCE}_{R,geomean}(g)$	0.873
$\mathrm{DE}_{max}(g)$	0.729
$\mathrm{DE}_{geomean}(g)$	0.582

5.3 Structural Properties

This section summarizes the main structural properties of the building in each direction. These structural properties are used as inputs to the SP3 Structural Response Prediction Engine.

Table 5.3. Structural properties table

Parameter	Direction 1	Direction 2
General		
Structural System	Steel: BRBF CoreBrace with Back-up Frame	Steel: BRBF CoreBrace with Back-up Frame
Building Edge Length (ft)	100	100
Detailing Level	Special	Special
Seismic Strength		
Seismic Design Base Shear Ratio, C_s †	0.064	0.064
C_s with Structural Overstrength	0.082	0.082
Wind Strength		
Wind Design Base Shear Ratio, v_{wind} †	0.046	0.046
v_{wind} with Structural Overstrength	0.069	0.069
Total Strength		
Strength Governed by	seismic	seismic
Governing Seismic/Wind with Structural Overstrength	0.082	0.082
With Gravity System Strength	0.101	0.101
With Non-structural Strength	0.130	0.130
Ultimate Base Shear Ratio, v_{ult}	0.130	0.130
Stiffness		
Design Drift (%)	0.90	0.90
$T_{1,design}$ (s)	1.70	1.70
T_1 with structural overstiffness (s)	1.62	1.62
T_1 with gravity system (s)	1.54	1.54
T_1 with non-structural components (s)	1.40	1.40
T_1 empirical lower bound (s)	0.70	0.70
T_1 empirical upper bound (s)	1.79	1.79
T_1 Final (s)	1.40	1.40

† Design base shear values reported as LRFD

5.4 Mode Shapes

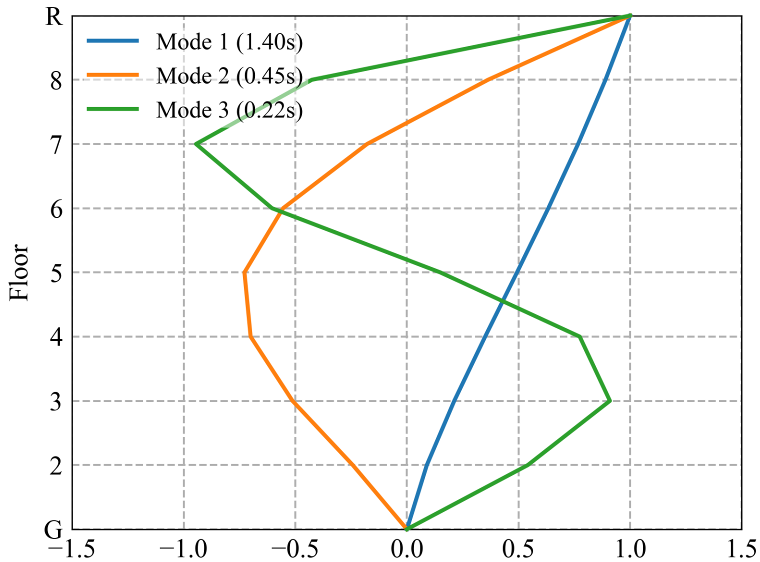

Figure 5.1. Mode shapes

Table 5.4. Mode shape values

	Dir. 1			Dir. 2		
	Mode 1	Mode 2	Mode 3	Mode 1	Mode 2	Mode 3
R	1.00	1.00	1.00	1.00	1.00	1.00
8	0.890	0.363	-0.426	0.890	0.363	-0.426
7	0.767	-0.178	-0.945	0.767	-0.178	-0.945
6	0.634	-0.555	-0.604	0.634	-0.555	-0.604
5	0.493	-0.728	0.150	0.493	-0.728	0.150
4	0.351	-0.700	0.774	0.351	-0.700	0.774
3	0.212	-0.513	0.910	0.212	-0.513	0.910
2	0.0893	-0.243	0.542	0.0893	-0.243	0.542
G	0.00	0.00	0.00	0.00	0.00	0.00

6 SP3 PERFORMANCE FACTORS

Table 6.1 compares the seismic design base shear, C_s, to the 475-year shaking (reduced by the modern response modification coefficient, R). Generally speaking, the modern building code design requirements are based on the 475-year event with the exception of extremely high seismic (near-fault) areas that are designed for a lesser deterministic ground motion or the transition region between deterministic and probabilistic portions of the ground motion maps.

The shaking intensity is then reduced by the response modification coefficient, R, based on the ductility level of the system (in anticipation of controlled damage of specially designed elements).

When the ratio of design base shear to the reduced spectra ($C_s/\left[S_a(T_1)_{475}/R\right]$) is 1.0, then the building was designed consistent with 10% in 50 year hazard. When the ratio is above 1.0, it was designed higher, so expect better performance (all other things equal), and for ratios below 1.0, expect worse performance.

Table 6.1. Design base shear vs. 475-year shaking intensity

	Dir. 1	Dir. 2
Seismic Design Base Shear, C_s	0.064	0.064
475-year Shaking Intensity, $S_a(T_1)_{475}$ †	0.444g	0.444g
Reduced Spectral Acceleration, $S_a(T_1)_{475}/R$ ‡	0.055g	0.055g
Ratio of Design Base Shear to 475-year Shaking Demand, $C_s/\left[S_a(T_1)_{475}/R\right]$	**1.16**	**1.16**

† T_1 includes all sources of overstiffness ($T_{1,dir1} = 1.40$s and $T_{1,dir2} = 1.40$s, see Table 5.3).
‡ Response Modification Coefficient, R, is from the modern code ($R_{dir1} = 8$ and $R_{dir2} = 8$).

Table 6.2 shows a comparison of the properties of the building to the properties of the building if it were constructed using the modern code guidelines. This table only compares the difference in building strength and period, and does not present differences in component damageability. The full SP3-RiskModel analysis does include effects of component damageability differences, so while the metrics in this table are informative, they are not all-encompassing of differences between new and old code design.

Table 6.2. Comparison of structural properties from ASCE 7-10 and ASCE 7-22

	Dir. 1	Dir. 2
Seismic Design Base Shear, C_s		
ASCE 7-10	0.064	0.064
ASCE 7-22†	0.109	0.109
Ratio $\frac{C_{s,ASCE7-10}}{C_{s,ASCE7-22}}$	**0.588**	**0.588**
Ultimate Base Shear (C_s with Overstrength), v_{ult}		
ASCE 7-10	0.130	0.130
ASCE 7-22	0.212	0.212
Ratio $\frac{v_{ult,ASCE7-10}}{v_{ult,ASCE7-22}}$	**0.613**	**0.613**
Period Considering All Sources of Stiffness, T_1 (s)		
ASCE 7-10	1.40	1.40
ASCE 7-22	1.08	1.08

† $R_{dir1} = 8$ and $R_{dir2} = 8$

7 BUILDING STABILITY

The FEMA P-154 collapse capacity score was calculated as follows using the "very high" seismicity level. The terminology used in this section is consistent with the FEMA P-154 methodology (Applied Technology Council, 2015a):

- P$[COL|MCE_R]_{P-154}$: the probability that the building will be in the HAZUS complete structural damage state when subjected to MCER shaking, times the collapse factor
- P$[COL|MCE_R]_{P-58}$: the probability that the building will be in the HAZUS complete structural damage state when subjected to MCER shaking
- Collapse Factor: expected ratio of collapsed area to total area given that the building is in the HAZUS Complete structural damage state
- MCE_R: For ASCE 7 era buildings, SP3 anchors the collapse capacity to an MCE level that corresponds to the S_{DS} and S_{D1} coefficients that govern the building design.

For a more in-depth explanation of "collapse," refer to Section 4.4.1.5 of FEMA P-155 Third Edition available here (Applied Technology Council, 2015b).

Table 7.1. Breakdown of FEMA P-154 score assignment (Seismicity level: very high)

	FEMA ID: S2
Level 1	
Basic Score	1.4
Soil	0
Year	1.1
Plan Irregularity (P_{L1})	0
Vertical Irregularity (V_{L1})	0
Risk Category (Cat. III)[†]	0.4
S_{L1}	2.9
$S' = S_{L1} - V_{L1} - P_{L1}$	2.9
Level 2	
No Level 2 information provided ($V_{L2} = P_{L2} = M = 0$).	
$S_{L2} = S' + V_{L2} + P_{L2} +$ Other Modifiers(M)	0
Sum:	2.9
Minimum Allowed:	0.5
Final Score:	**2.9**
Dispersion (β):	0.6

[†] Non-standard property implemented by SP3

The FEMA P-154 probability of collapse at the MCE_R level event is then calculated as:

$$\begin{aligned} \mathrm{P}[COL|MCE_R]_{P-154} &= 10^{-\text{score}} \\ &= 10^{-2.9} \qquad \text{(FEMA P-155 eqn. 4-1)} \\ &= 0.126\% \end{aligned}$$

Taking into account the fraction of floor area collapsed (0.5 in this case), the probability of collapse is:

$$\begin{aligned}\text{P}[COL|MCE_R]_{P-58} &= \text{P}[COL|MCE_R]_{P-154} \text{ / Collapse Factor}\\ &= 0.126\% \text{ / } 0.5\\ &= 0.252\%\end{aligned}$$

The median collapse capacity is calculated as:

$$\begin{aligned}S_{a,\ collapse\ median,\ P-58} &= \exp\left(\ln(S_{a,MCE_R}) - \text{norminv}\left(P[COL|MCE_R]_{P-58}\right)\cdot\beta\right)\\ &= \exp\left(\ln(0.514g) - \text{norminv}\left(0.252\%\right)\cdot 0.6\right)\\ &= 2.76g\end{aligned}$$

where `norminv` is the inverse of the standard normal cumulative distribution function (CDF).
The value of S_{a,MCE_R} can be found in Table 5.1c.
Figure 7.1 shows the collapse capacity cumulative distribution function used in the analysis.

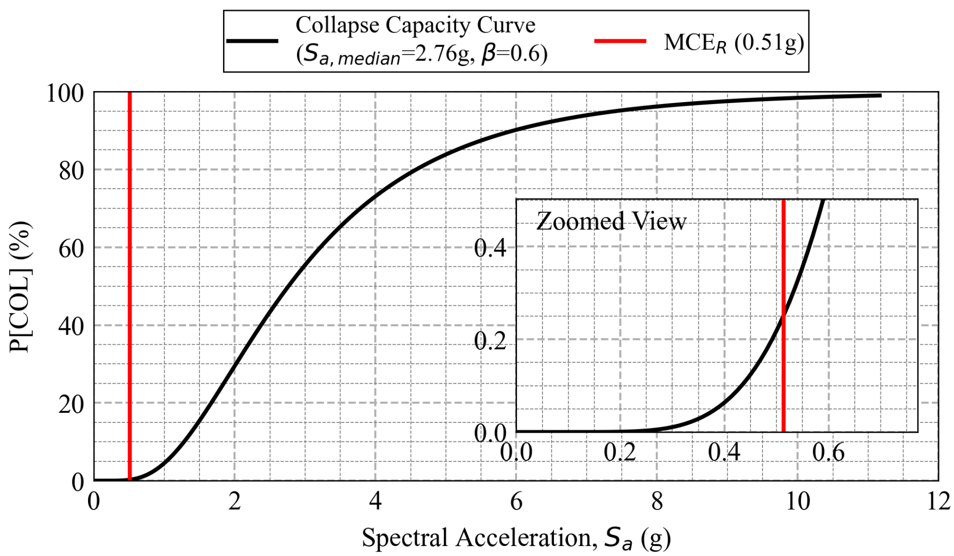

Figure 7.1. Cumulative distribution function for collapse capacity

8 STRUCTURAL RESPONSE PREDICTIONS FROM THE SP3 STRUCTURAL RESPONSE PREDICTION ENGINE

The SP3 Response Prediction Engine predicts the structural responses (typically providing 100 ground motions per intensity level); this is done by using a combination of three-mode elastic modal analysis, coupled with both elastic and inelastic response modifiers mined from the large SP3 Structural Responses Database (with over 4,000,000 response simulations, and growing). These response predictions track all of the important statistical information in the responses (mean, variability, and correlations); this enables a statistically robust vulnerability curve at the end of the risk assessment process.

8.1 Peak Story Drift Ratio

Peak interstory drift ratio is an important metric for both structural and non-structural components in the building. It measures how much the ceiling of a given story moves relative to the floor, normalized to the height of the story. The greater the interstory drift ratio, the greater the damage to the components on that level. Typical components that are damaged from interstory drift ratio are structural components (beams and columns), gypsum partition walls, and exterior cladding and glazing.

Table 8.1. Median Peak Story Drift Ratio demands are the same in both directions

Story	90% in 50 years	50% in 30 years	50% in 50 years	50% in 75 years	50% in 100 years	20% in 50 years	10% in 50 years	DE	5% in 50 years	2% in 50 years	MCE_R
8	0.13	0.23	0.31	0.33	0.35	0.39	0.49	0.55	0.56	0.56	0.55
7	0.13	0.24	0.32	0.37	0.40	0.46	0.61	0.74	0.75	0.88	0.90
6	0.14	0.24	0.33	0.40	0.45	0.54	0.73	0.91	0.93	1.19	1.22
5	0.14	0.24	0.34	0.42	0.49	0.61	0.84	1.08	1.11	1.49	1.55
4	0.14	0.25	0.35	0.45	0.53	0.67	0.95	1.25	1.28	1.78	1.87
3	0.14	0.24	0.35	0.46	0.56	0.72	1.04	1.38	1.41	2.03	2.13
2	0.12	0.22	0.32	0.45	0.55	0.72	1.05	1.43	1.46	2.14	2.26
1	0.09	0.15	0.31	0.43	0.56	0.75	1.15	1.63	1.68	2.62	2.80
$\frac{S_a(T_1)}{v_{ult}} =$	0.42	0.74	1.11	1.48	1.79	2.32	3.41	4.57	4.67	6.60	6.92

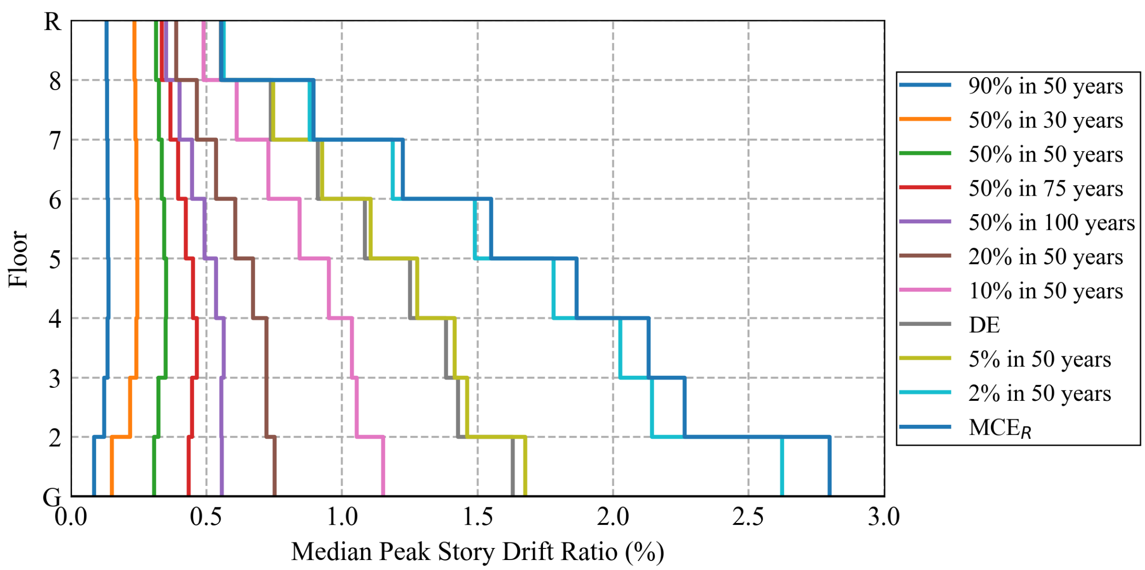

Figure 8.1. Median Peak Story Drift Ratio demands are the same in both directions

8.2 Peak Floor Acceleration

Peak floor acceleration is an an important metric for non-structural components in the building. Components such as piping, HVAC, and electrical switchgear are sensitive to the floor accelerations. High accelerations will typically damage a component itself or cause the component's anchorage to fail, both of which may require repair or replacement of the component.

Table 8.2. Median Peak Floor Acceleration demands are the same in both directions

Floor	90% in 50 years	50% in 30 years	50% in 50 years	50% in 75 years	50% in 100 years	20% in 50 years	10% in 50 years	DE	5% in 50 years	2% in 50 years	MCE_R
R	0.21	0.35	0.48	0.54	0.57	0.61	0.66	0.74	0.75	0.88	0.90
8	0.15	0.25	0.35	0.40	0.43	0.48	0.57	0.65	0.66	0.77	0.80
7	0.14	0.23	0.32	0.38	0.41	0.45	0.55	0.64	0.64	0.76	0.79
6	0.14	0.23	0.33	0.39	0.42	0.47	0.58	0.68	0.69	0.82	0.85
5	0.13	0.22	0.31	0.36	0.39	0.45	0.56	0.66	0.67	0.81	0.84
4	0.12	0.21	0.29	0.35	0.39	0.44	0.56	0.67	0.68	0.83	0.86
3	0.10	0.17	0.25	0.29	0.33	0.38	0.49	0.59	0.60	0.75	0.77
2	0.10	0.16	0.23	0.28	0.31	0.37	0.48	0.59	0.60	0.75	0.78
G	0.09	0.15	0.21	0.26	0.31	0.37	0.50	0.63	0.64	0.83	0.87
$\frac{S_a(T_1)}{v_{ult}} =$	0.42	0.74	1.11	1.48	1.79	2.32	3.41	4.57	4.67	6.60	6.92

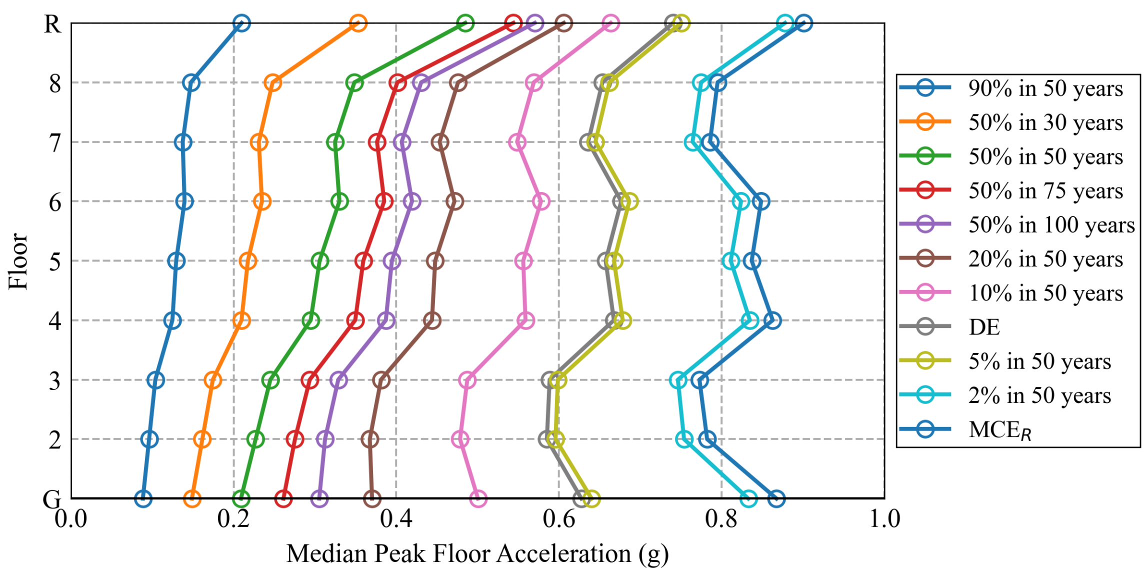

Figure 8.2. Median Peak Floor Acceleration demands are the same in both directions

8.3 Residual Story Drift Ratio

Residual drift is a metric that informs the need for structural repairs or building demolition (where excessive drifts are present). Residual drift ratio is a measure of how much the building is "leaning over" after the seismic event has ceased. A residual drift of 2% would indicate that the story is laterally displaced 2% of it's height, which equates to about 3.6 inches for a 15 foot tall story.

Table 8.3. Median Residual Story Drift Ratio demands are the same in both directions

Story	90% in 50 years	50% in 30 years	50% in 50 years	50% in 75 years	50% in 100 years	20% in 50 years	10% in 50 years	DE	5% in 50 years	2% in 50 years	MCE$_R$
8	0.00	0.01	0.01	0.02	0.02	0.02	0.03	0.04	0.04	0.04	0.04
7	0.00	0.01	0.02	0.02	0.02	0.03	0.04	0.06	0.06	0.07	0.07
6	0.00	0.01	0.02	0.02	0.03	0.04	0.06	0.07	0.08	0.13	0.14
5	0.00	0.01	0.02	0.03	0.03	0.04	0.07	0.09	0.10	0.25	0.27
4	0.00	0.01	0.02	0.03	0.04	0.05	0.08	0.15	0.16	0.37	0.40
3	0.00	0.01	0.02	0.03	0.04	0.06	0.09	0.21	0.22	0.46	0.51
2	0.00	0.01	0.02	0.03	0.04	0.06	0.09	0.22	0.24	0.51	0.56
1	0.00	0.00	0.01	0.03	0.04	0.06	0.11	0.31	0.32	0.70	0.77
$\frac{S_a(T_1)}{v_{ult}} =$	0.42	0.74	1.11	1.48	1.79	2.32	3.41	4.57	4.67	6.60	6.92

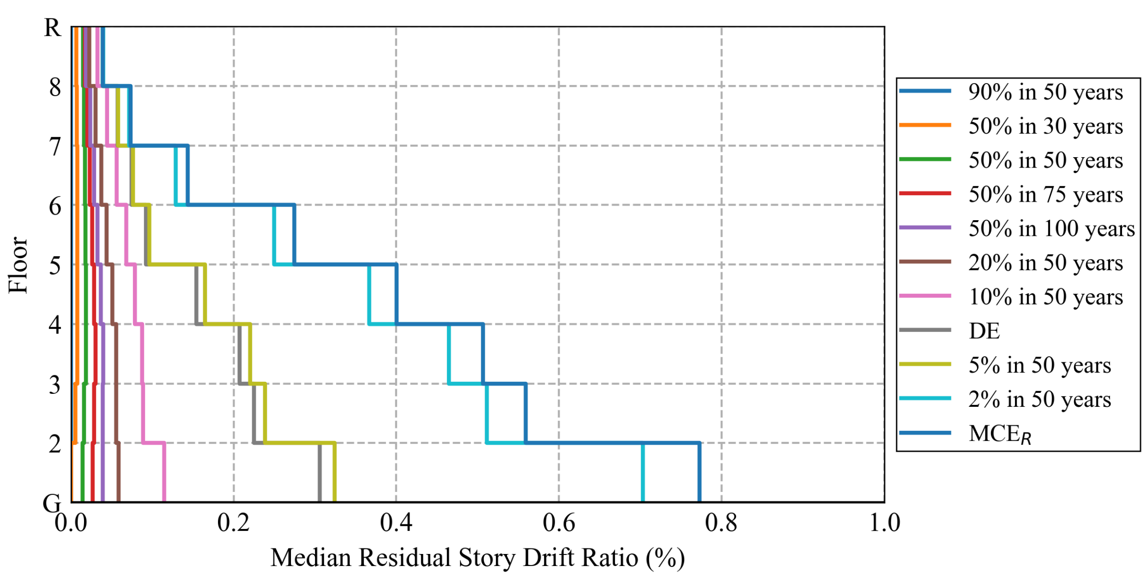

Figure 8.3. Median Residual Story Drift Ratio demands are the same in both directions

8.4 Max. Residual Interstory Drift

Table 8.4. Median Max. Residual Interstory Drift demands are the same in both directions

	90% in 50 years	50% in 30 years	50% in 50 years	50% in 75 years	50% in 100 years	20% in 50 years	10% in 50 years	DE	5% in 50 years	2% in 50 years	MCE_R
–	0.00	0.01	0.02	0.03	0.04	0.06	0.11	0.31	0.32	0.70	0.77
$\frac{S_a(T_1)}{v_{ult}}$ =	0.42	0.74	1.11	1.48	1.79	2.32	3.41	4.57	4.67	6.60	6.92

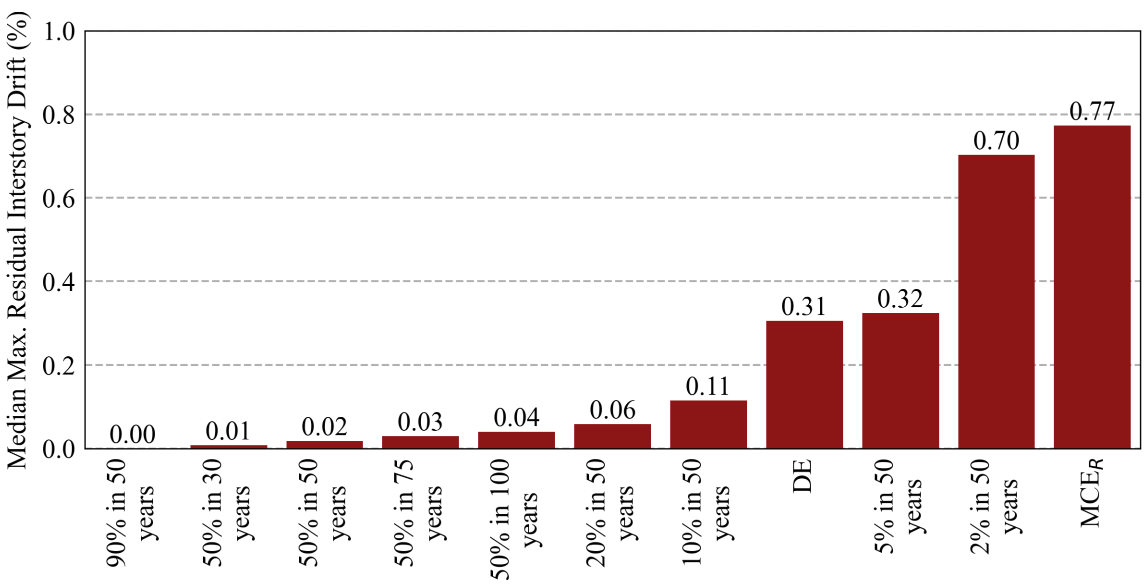

Figure 8.4. Median Max. Residual Interstory Drift demands are the same in both directions

9 REPAIR COSTS - BY LEVEL OF GROUND MOTION

9.1 Mean and 90th Percentile Repair Costs (SEL and SUL)

The different metrics for repair cost are as follows:

- **Mean (SEL)**: ("Scenario Expected Loss") the average repair cost of the building repair/replacement.
- **Median**: there is a 50% probability that the repair cost will not exceed this value.
- **Fitted SUL**: Fitted value of "Scenario Upper Loss".
- **Counted 90th Percentile**: there is a 90% probability that the repair cost will not exceed this value.

Table 9.1. Loss metrics normalized by building cost

Intensity	PGA (g)	Mean (SEL) (%)	Fitted SUL (%)	Median (%)	Counted 90th Percentile (%)	$S_a(T_1)/v_{ult}$ † Dir 1	Dir 2
90% in 50 years	0.09	0.0	0.1	0.0	0.1	0.42	0.42
50% in 30 years	0.15	0.1	0.2	0.1	0.2	0.74	0.74
50% in 50 years	0.21	0.3	0.6	0.2	0.6	1.11	1.11
50% in 75 years	0.26	0.5	1.2	0.3	1.2	1.48	1.48
50% in 100 years	0.31	0.8	1.7	0.5	1.7	1.79	1.79
20% in 50 years	0.37	1.6	3.0	1.0	3.0	2.32	2.32
10% in 50 years	0.50	4.4	6.6	2.2	5.9	3.41	3.41
DE	0.63	21	40	4.6	100	4.57	4.57
5% in 50 years	0.64	23	43	4.9	100	4.67	4.67
2% in 50 years	0.83	56	90	100	100	6.60	6.60
MCE$_R$	0.87	60	96	100	100	6.92	6.92

† $S_a(T_1)/v_{ult}$ is the ratio of shaking intensity to building strength where in direction 1 $v_{ult} = 0.130$ and $T_1 = 1.40$s and in direction 2 $v_{ult} = 0.130$ and $T_1 = 1.40$s (see Table 5.3 for more detailed structural properties)

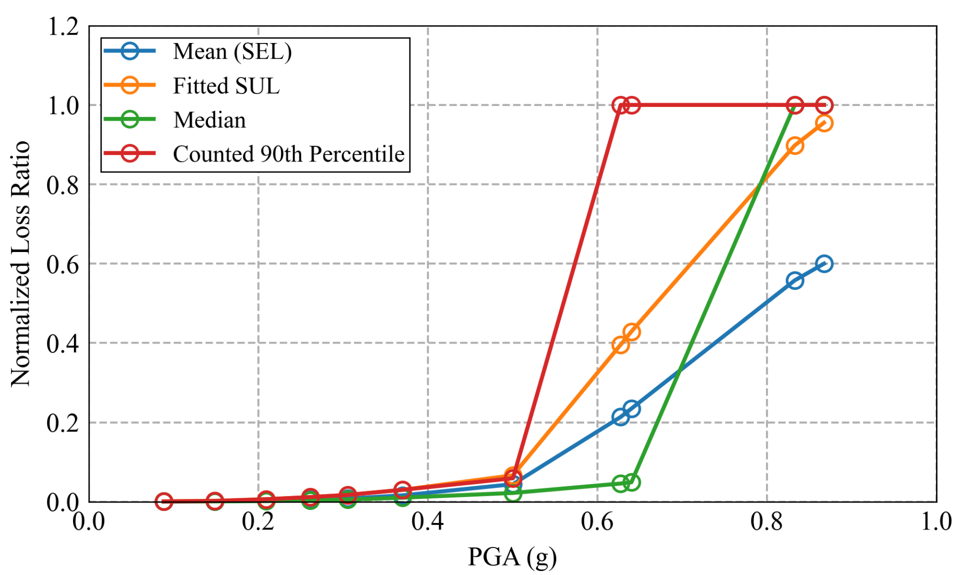

Figure 9.1. Loss metrics across all intensity levels analyzed

10 REPAIR COST BREAKDOWN BY BUILDING COMPONENTS

10.1 Categories for Repair Cost Breakdowns

Repair costs are binned into eight categories as follows:

- **Collapse**: building demolition and replacement following a collapse.
- **Residual**: building demolition and replacement following unacceptable residual drifts.
- **Structural**: components of the lateral force resisting system or gravity system (e.g. beam column connections, link beams, shear wall, shear tabs, etc.).
- **Partitions**: partition wall components (e.g. wood or metal stud gypsum full height partitions).
- **Exterior**: components placed on the exterior of the building (e.g. cladding, glazing, etc.).
- **Interior**: non-structural components on the interior of the building (e.g. raised access floors, ceilings, lighting).
- **HVAC**: HVAC and plumbing components (e.g. water piping and bracing, sanitary piping, ducting, boilers etc.).
- **Other**: components not included in the categories above (e.g. elevators, user defined components, fire protection components).

10.2 Repair Cost Breakdown for Various Ground Motion Levels

Table 10.1. Expected mean loss per component group (in percent)

Intensity	Total	Residual	Collapse	Exterior	Structural	Other	Interior	Partitions	HVAC
90% in 50 years	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
50% in 30 years	0.1	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0
50% in 50 years	0.3	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.0
50% in 75 years	0.5	0.0	0.0	0.1	0.0	0.2	0.1	0.1	0.0
50% in 100 years	0.8	0.0	0.0	0.2	0.0	0.3	0.1	0.1	0.0
20% in 50 years	1.6	0.2	0.0	0.6	0.1	0.4	0.2	0.2	0.0
10% in 50 years	4.4	1.7	0.0	1.3	0.3	0.6	0.3	0.3	0.0
DE	21	18	0.0	1.7	0.6	0.7	0.4	0.3	0.0
5% in 50 years	23	20	0.0	1.7	0.6	0.7	0.4	0.3	0.0
2% in 50 years	56	51	1.5	1.6	0.8	0.6	0.4	0.2	0.0
MCE_R	60	54	2.1	1.5	0.8	0.5	0.4	0.2	0.0

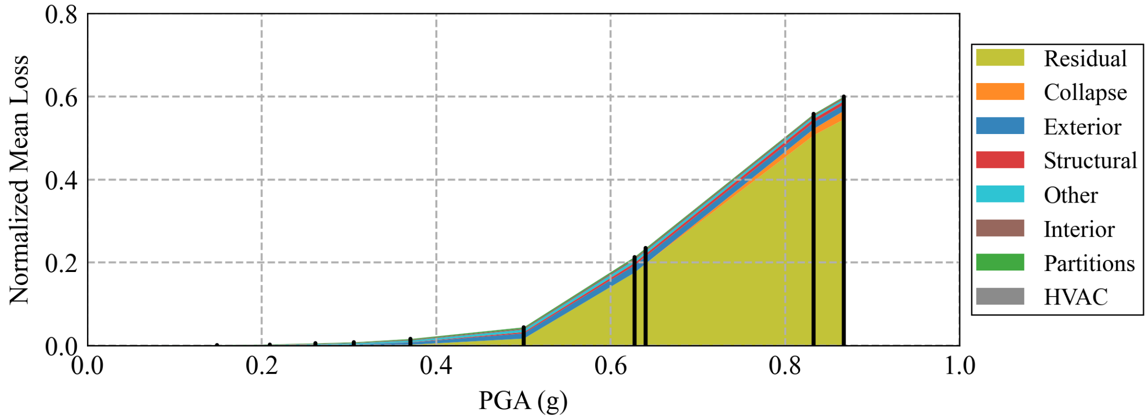

Figure 10.1. Contribution of building components to mean loss ratio

10.3 Repair Cost Breakdown for Expected Annual Loss

The expected annual loss for this building is \$41,128.

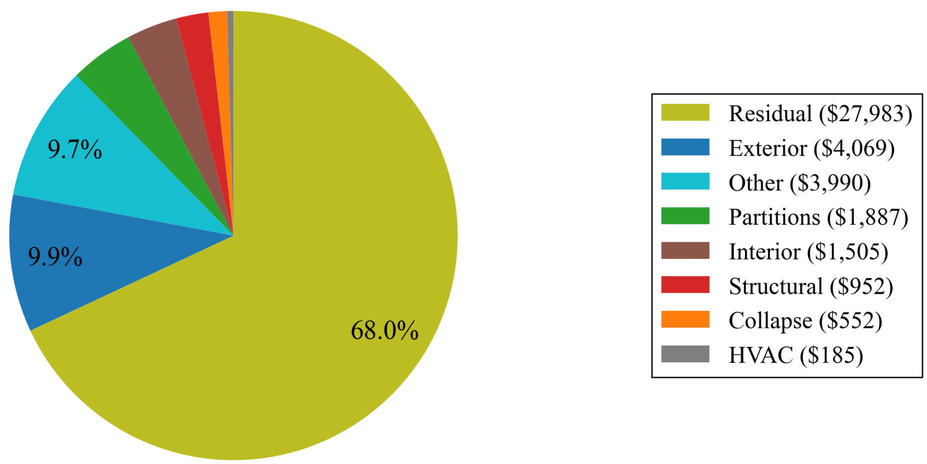

Figure 10.2. Annualized loss breakdown

11 RECOVERY TIME

These recovery times were calculated using the ATC-138 Functional Recovery (Beta) Methodology. This includes all sources of impedance specified by the user; possible sources of impedance considered are listed below.

- Post-earthquake Inspection
- Engineering Mobilization and Review/Re-design
- Financing
- Contractor Mobilization and Bid Process
- Permitting

These capture the time required to start the repairs, since beginning repairs immediately after an earthquake may not be realistic.

Reported recovery times are the time required for the entire building to reach a recovery state: (re-occupancy, functional recovery, or full recovery).

Table 11.1. Median repair time summary

	ATC-138 Functional Recovery (Beta)†			FEMA P-58‡	
Intensity	Re-Occupancy	Functional	Full	Full (Parallel)	Full (Series)
90% in 50 years	0 days	0 days	6 days	0.19 days	0.58 days
50% in 30 years	0 days	0 days	8 days	0.27 days	1.2 days
50% in 50 years	0 days	3 days	10 days	0.55 days	2.4 days
50% in 75 years	2 days	4 days	13 days	1.2 days	4.2 days
50% in 100 years	3 days	5 days	2.3 weeks	2.1 days	6.8 days
20% in 50 years	4 days	6 days	4.9 weeks	5 days	12 days
10% in 50 years	7 days	5.6 weeks	2.7 months	11 days	3.8 weeks
DE	2.3 months	3.4 months	4.1 months	3.1 weeks	7.7 weeks
5% in 50 years	2.6 months	3.6 months	4.3 months	3.2 weeks	1.9 months
2% in 50 years	38 months	38 months	38 months	38 months	38 months
MCE_R	38 months	38 months	38 months	38 months	38 months

† Does include factors delaying start of repairs
‡ Does ***not*** include factors delaying start of repairs

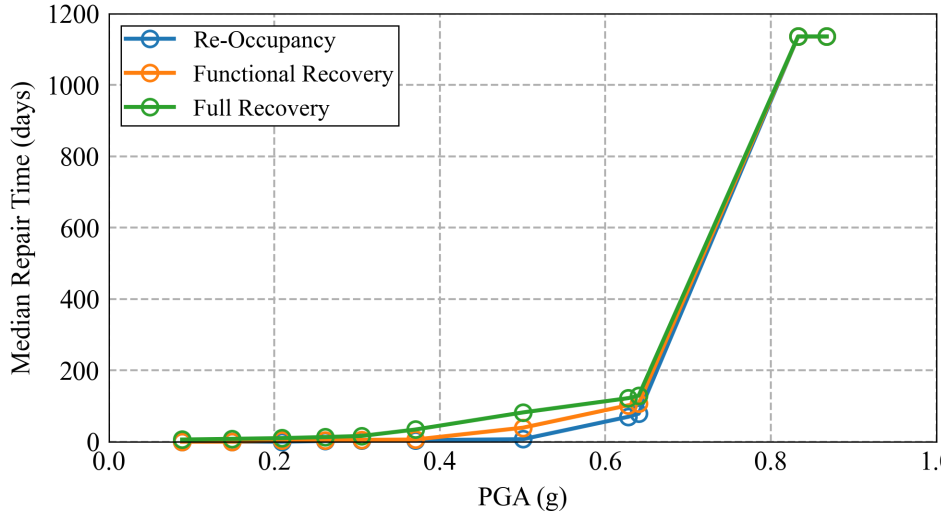

Figure 11.1. Median recovery time from the ATC-138 Functional Recovery (Beta) Methodology, includes specified impeding factors

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