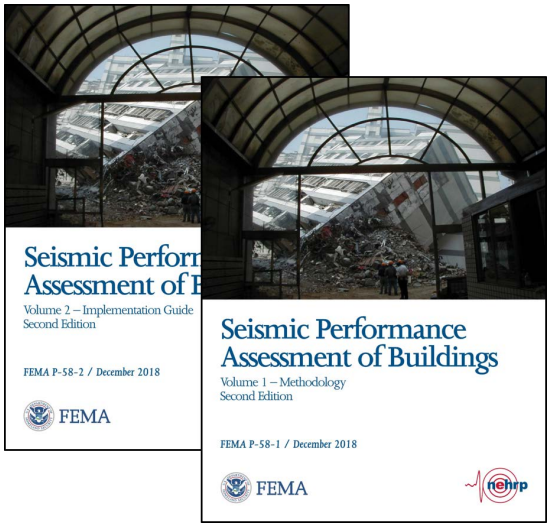

Background Document

FEMA P-58/BD-3.7.19

Updates to Fragilities

Submitted to

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FEMA

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Background Documentation

FEMA P-58 Background Documents are a series of reports documenting the technical background and source information for key aspects of the FEMA P-58 methodology and its implementation. This report was developed over the course of the 5-year ATC-58-2 Project funded under FEMA Contract HSFE60-12-C-0243.

Background Documents were developed by consultants, serving at various levels within the project hierarchy, reporting the results of: (1) decisions on technical development protocols; (2) focused studies on the development of key aspects of the methodology; (3) documentation of recommended procedures; and (4) collection of available data for the development of structural and nonstructural fragilities. They were initially intended to serve as a record of the technical state-of-knowledge at the time they were produced, and as resources for the development of the eventual project reports. As such, they represent a snapshot in time, and may, or may not, match the technical content, recommended procedures, or data incorporated into the final methodology and its implementation.

This Background Document is intended for the purpose of providing supplemental knowledge to users of the FEMA P-58 methodology. Information contained herein has not been independently verified for accuracy as a stand-alone document, and may have been superseded in its final implementation within the methodology. Specifically in the case of certain nonstructural component fragilities, the NISTIR fragility classification numbering scheme was modified over the course of the project, and the fragility classification number assigned in this document might be different from numbers assigned in the final fragility database. Users of information in this document assume all liability arising from such use.

Notice

Cover photograph – Primary resource documents for the FEMA P-58 *Seismic Performance Assessment of Buildings, Methodology and Implementation* series of products: FEMA P-58-1, *Volume 1 – Methodology, Second Edition*, and FEMA P-58-2, *Volume 2 – Implementation Guide, Second Edition*.

Updates to Fragilities
March 2018

Notes:

- The following fragility updates were made in response to review team observations of PACT findings.
- Trivial grammatical changes are not listed.
- *FEMAP-58_LinebyLineComparisonofFragilityDB.xls*, an Excel Workbook within FEMA P-58- Volume 3, Folder 3.2, Provided Fragility Data, presents a line-by-line comparison of current fragility database versus versions published prior to September 2016.
- The revisions are included in the March 2018 version of the *Fragility Database*. This database also includes environmental consequences for all of the provided fragilities.

1. Updates to damage states and repair consequences.

Fragility	Component Description	Notable Changes
B1031.001 B1031.011a B1031.011b B1031.011c B1031.021a B1031.021b B1031.021c	Gravity beam shear tab, steel base plate, and steel column splice	• The DS1 damage state was found to generate disproportionately high repair cost. • In response, it was decided to duplicate the DS1 state and introduce a mutually exclusive DS1/DS2 condition. DS1 results in zero repair and zero cost consequence and represents 95% of events DS1/DS2 mutual exclusive events triggered. DS2 retains the former repair and cost consequence in the remaining 5% of events. • The former DS2 and above remain as renamed subsequent sequential damage states. • DS1 "beta" values are set to 0.25 in order to prevent computational error within PACT.
B1033.011a B1033.011b B1033.011c B1033.012a B1033.012b B1033.012c B1033.013a B1033.013b B1033.013c		• DS1 unsafe placard value was changed from "Yes" to "No" to be consistent with minimal damage at DS1.
B1033.031a B1033.031b B1033.031c B1033.032a B1033.032b B1033.032c		• Repair descriptions have been revised.

B2011.201a	Precast concrete cladding panel – in plane response	• The DS1 damage state was found to generate disproportionately high repair cost. • In response, it was decided to duplicate the DS1 state and introduce a mutually exclusive DS1/DS2 condition where a new DS1 calls for repair equal to 20% of the former DS1 consequence. The new DS2 is equal to the former DS1. The resulting DS1/DS2 mutual exclusive damage states are given 50%/50% event probability respectively. • The former DS2 and above remain as sequential states.
B2022	Curtain Walls	• Excessive injuries were observed. In response, damage state injury medians were revised from 25% to 2% with a dispersion of 0.50. • The unsafe placard for glass falling was revised from 50% median and 0.50 dispersion to 90% median and 0.50 dispersion.
B2023.031 B2023.032 B2023.033 B2023.034 B2023.051 B2023.052 B2023.053 B2023.054 B2023.055 B2023.056 B2023.057 B2023.058	Curtain Walls	• Revisions to demand and consequence data.
C2011 (all)	Stairs	• Excessive unsafe placarding was observed. In response DS2 was revised not to cause unsafe placard. Similarly, the DS3 unsafe placard probability was increased to 75%.
D4011 (all)	Fire sprinkler pipes and mains	• It was observed that excessive unsafe placards resulted from damage to this component.

2. Updates to repair costs

For the following fragilities, file quantity max and quantity min ($min & $max) were edited so that the consequence data are in agreement with the cost unit of the source data. For example, if the source cost data are provided on a per square foot basis, then the economy of scale quantities must also be in square foot units – not in the PACT UNIT which have varying bundled quantities for ceilings, walls, glazing, and distributed mechanical components.

Fragility	**Component Description**	**Notable Changes**

C1011.001a through C1011.011a	Wall Partitions	• Revised $max and $min to 1300 square feet and 13,000 square feet to generate 1 to 10 PACT UNITS
B3041.001	Masonry Parapets	• Revised $max and $min to 100 feet and 500 feet to generate 1 to 5 PACT UNITS
C3032.001a through C3032.004d	Ceilings	• Revised $max and $min to 100 feet and 500 feet to generate 1 to 10 PACT UNITS. Specific multipliers applied vary due to ceilings having variable quantiles ranging between 250 square feet and 2500 square feet.
D3041.001a through D3041.002d	Fan Units	• Revised $max and $min to 10 and 50 to generate 1 to 5 PACT UNITS.
D3041.031a through D3041.041b	HVAC drops	• Revised $max and $min to 10 and 50 to generate 1 to 5 PACT UNITS.
D4011.031a through D4011.074a	Sprinkler drops	• Revised $max and $min to 200 and 500 to generate 2 to 5 PACT UNITS.

3. Miscellaneous changes

The following fragilities were revised in response to review comments offered by various groups.

Fragility	**Component Description**	**Notable Changes**
B1031.021a B1031.021b B1031.021c	Welded column splices, various column sizes.	• Damage State 3 removed. • Minor DS1 and DS2 description and repair description edits. • Revision of DS1 and DS2 median demand. • Addition of toughness note to commentary. • Revision history added linking edits to FEMA P-58 literature.
B1033.001a through B1033.073c	Concentrically Braced Frames (CBF)	• Removed reference to HSS in DS2 description.
B1041.021a B1041.021b B1041.022a B1041.022b B1041.023a B1041.023b	ACI 318 Intermediate Moment Frame (IMF)	• Included value for axial load ratio under component description
B1042.001a B1042.001b B1042.002a B1042.002b B1042.011a	Diagonally or conventionally reinforced concrete link beams	• Median demand of DS1, DS2, and DS3 corrected to be in numeric drift, not percent drift. (e.g. 1.79 revised to 0.0179)

B1042.011b B1042.012a B1042.012b B1042.021a B1042.021b B1042.022a B1042.022b		
B1044.091 B1044.092 B1044.093 B1044.101 B1044.102 B1044.103 B1044.111 B1044.112 B1044.113	Slender concrete walls.	• DS1, DS2, and DS3 median demand, dispersion, and total dispersion (beta) values revised slightly. • Demand parameter revised from "Story drift ratio" to "Effective Drift".
B1061.001a B1061.001b B1061.011a B1061.011b B1061.021a B1061.021b	Various cold formed steel walls.	• Revised DS1, DS2, and DS3 (where it occurs) to be numeric drift, not percent drift. (e.g. 0.40 revised to 0.004)
B2011.001a B2011.001b B2011.011a B2011.011b B2011.021a B2011.021b	Various exterior wall cold formed steel walls.	• Revised DS1, DS2, and DS3 (where it occurs) to be numeric drift, not percent drift. (e.g. 0.40 revised to 0.004)
C1011.001a C1011.001b C1011.001c C1011.001d C1011.001e C1011.001f C1011.011a	Various gypsum interior wall partition types.	• Reduced from five damage states to three damage states by removal of mutually exclusive DS2 and DS3 to be sequential DS1 through DS3. • Edit to DS1, DS2, and DS3 damage and repair descriptions. • Changes to DS1, DS2, and DS3 median demand and total dispersion (beta) values. • Revision of DS1, DS2, and DS3 cost and time consequences with corresponding changes to reported statistical parameters (mean, CV, p10, p50, p90, and normal / lognormal fit type).
C3021.001a through C3021.001p	Various generic floor covering types- flooding of floor caused by pipe breakage.	• Fragilities redefined to be the flooding of the floor caused by breaking of pipes. • Costs based upon repair of one square foot of flooring. • Seismic design category now by user. • Damage state DS2 (drop joint piping breaks) removed.

		• Data quality, relevance, and documentation changed to "none" • Changes to DS1 damage and repair text descriptions. • Note added requiring user to supply median demand and total dispersion (beta).
C3032.001a C3032.001b C3032.001c C3032.001d C3032.003a C3032.003b C3032.003c C3032.003d C3032.004a C3032.004b C3032.004c C3032.004d	Various suspended ceilings	• Editing of DS1, DS2, and DS3 median demand and total dispersion (beta) values. • Minor grammatical edit to DS1, DS2, and DS3 repair description. • Change DS3 to have more specific damage extent description. • Extend to include SDC A, B, and C (SDC C formerly not included) Note: C3032.002a C3032.002b, and C3032.002c do not exist. Omission is intentional.
D2021 (all)	Cold or hot potable water	• Corrected consequence description
D2022 (all)	Heating hot water piping	• Corrected consequence description
D2031 (all)	Sanitary waste piping	• Corrected consequence description
D2051 (all)	Chilled water piping	• Corrected consequence description
D2061 (all)	Steam piping	• Corrected consequence description
D2061.023a D2061.023b	Steam piping – large diameter welded steel	• Corrected consequence description
D3031.011a through D3031.13l	Chiller	• Revised repair description.
D3032.021a through D3032.023l	Cooling tower	• Revised repair description
D3052.011a through D3052.013l	Air handling unit	• Revised repair description
D4011.021a through D4011.074a	Fire sprinkler drops	• Clarified damage state descriptions
D5011.011a through D5011.013l	Transformer/ Primary service	• Revised repair description

4. Editorial Changes

A line-by-line comparison of the fragility database issued in September 2016 versus previous versions is documented in *FEMAP-58_LinebyLineComparisonofFragilityDB.xls* within FEMA P-58-3 Folder 3.2. The following table summarizes the notable changes.

NISTIR No.	**Component Description**	**Notable Changes**
B1071	Light-framed wood walls	• Reorganized subcategory numbering
C1011	Modified consequences	• Deleted. This was used as a placeholder for internal project work.
C3033	Recessed lighting in suspended ceiling	• Deleted. Damage to this type of component is covered in ceilings.
D3067	Control panel	• Reorganized subcategory numbering
D2021	Colt or hot potable water	• Clarified component definition