

Estimating Fallout Building Protection Attributes from Architectural Features and Global Earthquake Model (GEM) Building Descriptions

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SUMMARY

A nuclear explosion has the potential to injure or kill tens to hundreds of thousands (or more) of people through exposure to fallout (external gamma) radiation. Existing buildings can protect their occupants (reducing fallout radiation exposures) by placing material and distance between fallout particles and individuals indoors. Prior efforts have determined an initial set of building attributes suitable to reasonably assess a given building's protection against fallout radiation. The current work provides methods to determine the quantitative values for these attributes from (a) common architectural features and data and (b) buildings described using the Global Earthquake Model (GEM) taxonomy. These methods will be used to improve estimates of fallout protection for operational US Department of Defense (DoD) and US Department of Energy (DOE) consequence assessment models.

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INTRODUCTION

A nuclear explosion has the potential to injure or kill tens to hundreds of thousands (or more) of people through exposure to fallout (external gamma) radiation. Existing buildings can protect their occupants (reducing fallout radiation exposures) by placing material and distance between fallout particles and indoor individuals. This protection is not well captured in current consequence assessment models and so the US Department of Defense (DoD) and US Department of Energy (DOE) are implementing the Regional Shelter Analysis methodology to improve the ability of the Hazard Prediction and Assessment Capability (HPAC) and National Atmospheric Release Advisory Center (NARAC) models, respectively, to account for building protection. The DoD effort aims to (a) characterize all the types of buildings present in the world, (b) assess their fallout protection, and (c) develop regionally representative estimates of building protection for the world.¹ The DOE effort also aims to improve its fallout building protection capabilities by defining a set of common building types (defined by readily recognizable architectural features) and assessing the range of fallout protection associated with these building types.

To support both of these efforts, we have previously identified the key building attributes that are needed to accurately assess the degree to which an individual building will protect its occupants against external fallout particles. These key building attributes for fallout protection, here termed fallout building attributes, are summarized in the following section and explained in more detail in [1]. However, currently there exists only a limited ability, e.g., [2], to determine the needed quantitative fallout building attribute values from commonly available architectural features and/or structural engineering descriptions. A more complete capability is needed for both DoD and DOE capability improvement efforts.

¹ For the DoD effort, “regionally” refers to 30 arc second grid cells (nominally 1 km x 1 km). In general, “regions” in the Regional Shelter Analysis methodology can refer to a variety of spatial scales ranging from single buildings to entire countries.

This report aims to address this gap, and thereby supports both the ongoing DoD and DOE efforts, by providing a method to derive values for fallout building attributes from (a) common architectural features and (b) the Global Earthquake Model (GEM) building description.² We accomplish this task in four steps. First, we review the building attributes relevant to assessing fallout protection. Second, we provide methods to (a) determine the numerical values for the previously determined set of fallout building attributes from architectural features and (b) provide an extensive set of example fallout building attribute numerical values that correspond to common architectural features. Third, we introduce two simplified building descriptions based on architectural features that are adapted to meet the DoD and DOE project needs. Fourth, we provide a method to derive the quantitative fallout building attribute values from a GEM building description.

This report is focused on providing the information and methods needed to streamline the determination of fallout building attribute values. *Dillon and Homann* [1], and references therein, provides the interested reader a discussion of the substantial, multi-decadal work in this area.

² To support the DoD effort, the Oak Ridge National Laboratory is characterizing the global distribution of building construction using the GEM taxonomy. The GEM taxonomy describes the seismically relevant building features in a comprehensive, uniform manner that is accessible to a wide range of users [3]. However, the GEM building attributes relevant to fallout protection are described in qualitative, architectural terms and so require mapping to quantitative values for use in fallout protection calculations.

STEP 1: FALLOUT BUILDING ATTRIBUTE REVIEW

Previous work has demonstrated that a small set of building attributes is sufficient to reasonably characterize the degree to which buildings protect their occupants from fallout radiation [1]. These attributes are as follows (see **Figure 1**):

General Building Attributes

- Existence of a basement
- Building footprint (length and width)

Story-Specific Attributes (these can vary by story)³

- Story height (room height)
- Height of story floor above ground
- Exterior wall density
- Interior density (includes both room contents and internal walls)
- Ceiling-floor density (includes both ceiling and floor density)
- Roof density
- Apertures (windows and/or doors)
 - o Aperture start height above floor (e.g., window sill height)
 - o Aperture stop height above floor (e.g., top of window)
 - o Aperture fraction of exterior wall area
 - o Aperture density

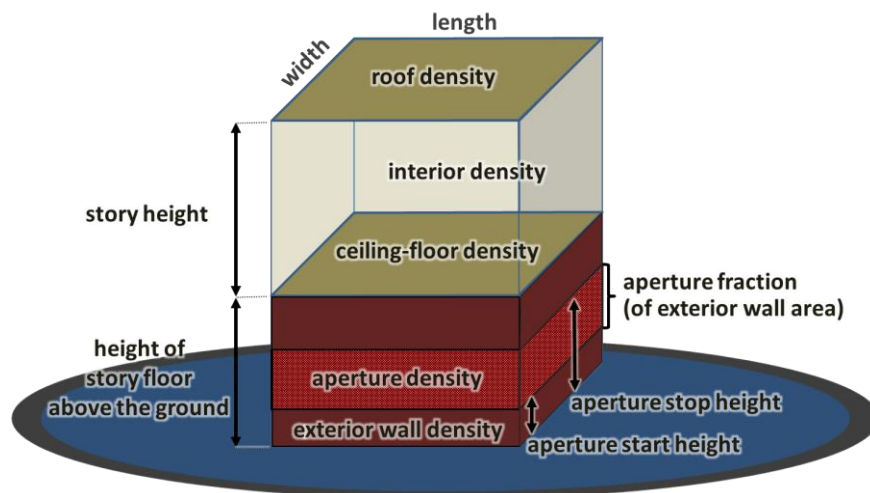


Figure 1. Illustration of key building attributes for fallout building protection. Basements are also important, but are not shown in this figure.

³ The densities used in this report are areal density (mass per unit area) rather than the more commonly encountered volume density (mass per unit volume). See [1] for more detail.

STEP 2: ARCHITECTURAL BUILDING DESCRIPTIONS

DETERMINING FALLOUT BUILDING ATTRIBUTES FROM ARCHITECTURAL FEATURES

While buildings are not typically described in terms of the previously discussed fallout building attributes, values for these attributes can be determined from common architectural features and/or structural engineering building descriptions. **Tables 1a-c**, which reorganizes the attribute list introduced in Step 1, provides a means to determine values for the fallout building attributes. The second column in **Tables 1a-c** provides one or more options to generate numerical values from architectural features.⁴ The simplified building descriptions discussed in the next section are based, in part, on the fallout building attributes shown in **Tables 1a-c**.

The “directly reported” option in these tables indicates cases in which the fallout building attribute value has been provided to the analyst.

The “assumed value” option in these tables indicates cases in which a building-specific determination may not be possible and the analyst must assume a particular value. The following *Simplified Building Descriptions* and *Mapping GEM Strings to a Simplified Building Description* sections assist the analyst in this process.⁵ In addition, **Appendix A** contains a set of common architectural features and example fallout building attribute numerical values. For each type of architectural feature considered in **Tables 1a-c**, the rightmost column labeled *Related Appendices* specifies the corresponding **Appendix A** sub-appendix(ices).

⁴ Each fallout building attribute value can be inferred using a different option number.

⁵ Other options include the use of regional default values based on local construction practices. Such defaults are not provided in this report.

Table 1a. Geometry Related Fallout Building Attributes.

Fallout building attribute	Option(s) to determine fallout building attribute from commonly reported architectural feature(s)	Related appendices
Basement	1) Directly reported, or 2) Assumed value	n/a
Number of Stories Above Ground	1) Directly reported, or 2) Estimated from the building type	A1
Length and Width	1) Directly reported, or 2) Square root of the building footprint area, or 3) Square root of the [total building floor area] / [number of stories]	A2 A3
Story Height (general)	1) Directly reported, or 2) [Reported total building height] / [number of stories], or 3) Assumed value	A4
Story Height (top floor)	1) Directly reported, or 2) [story height, general] + $\frac{1}{2}$ [roof peak height]	A4 A5
Height of Story Floor Above Ground (basement)	1) Directly reported, or 2) Assumed value	A4
Height of Story Floor Above Ground (ground, 1st, story)	1) Directly reported, or 2) Assumed value, or 3) [height of story above ground, basement] + [story height, basement]	A6
Height of Story Floor Above Ground (upper stories)	1) Directly reported, or 2) [height of story above ground, prior story] + [story height, prior story]	n/a

Table 1a provides several options to infer values for geometry related fallout building attributes. These attributes include building dimensions (length, width and height) and related parameters (number of stories; presence of a basement). Each fallout building attribute value can be inferred using a different option number.

Table 1b. Density Related Fallout Building Attributes.

Fallout building attribute	Option(s) to determine fallout building attribute from commonly reported architectural feature(s)	Related appendices
Exterior Wall Density	1) Dead load of the building exterior + Dead load of the building frame in exterior wall + Dead load of the internal wall affixed to the exterior wall	A7
Roof Density	1) Live load of the roof and attic + Dead load of the roof (including rafters) + Dead load of top floor ceiling + Dead load of the building frame in roof (including joists)	A8 A9 A10 A12
Ceiling-Floor Density	1) Dead load of the floor + Dead load of the ceiling attached to the floor + Dead load of the building frame in floor (including joists)	A9 A10 A11
Interior Density	1) Live load of the building contents + Dead load of the interior walls and partitions + Dead load of the building frame associated with interior walls	A12 A13
Window and Door Density (aperture density)	1) Directly reported dead load of the window or door, or 2) 3 psf (lbs per sq ft)	n/a

Table 1b describes how to infer values for density related fallout building attributes. These attributes include interior and exterior wall, ceiling, roof, and aperture densities. Dead load refers to the weight of materials, such as walls, that are intrinsically part of the building. Live load refers to weight of the building contents, such as furniture, that can be readily moved. Each fallout building attribute value can be inferred using a different option number.

Table 1c. Fenestration (Aperture) Dimension-Related Fallout Building Attributes.

Fallout building attribute	Option(s) to determine fallout building attribute from commonly reported architectural feature(s)	Related appendices
Window Percent (of exterior wall area)	1) Directly reported, or 2) Inferred from exterior wall construction and/or building use	A14
Window Sill Height	1) Directly reported, or 2) Inferred from exterior wall construction and/or building use	A16
Top of Window	1) Directly reported, or 2) [story height] *	n/a
Door Percent (of exterior wall area)	1) Directly reported, or 2) Inferred from exterior wall construction and/or building use	A15
Door Sill Height	1) Directly reported, or 2) Level with the floor (0 ft above the floor)	n/a
Top of Door	1) Directly reported, or 2) Min ([story height], 8 ft) *	n/a

* For many buildings, the fallout protection depends only weakly on the height of the aperture.

Table 1c provides several options to infer values for aperture dimension related fallout building attributes based on the building fenestration, the description of openings in the building exterior (also called building envelope). These attributes include the absolute and relative size of the windows and doors. Each fallout building attribute value can be inferred using a different option number.

FALLOUT BUILDING ATTRIBUTE VALUE CATEGORIES

Modeling based on detailed analyses of individual buildings is technically possible, but is often not practical since it is time and labor intensive to acquire and assess the needed input data. Thus we define a set of fallout building attribute value categories, see **Tables 2a-d**, to (a) provide a realistic, yet tractable, set of working values to support later building protection analyses and (b) facilitate the comparison of otherwise disparate architectural features. Each category has a unique name, nominal value, and range. These categories were chosen to (a) span the range of example values presented in **Appendix A** and (b) provide (approximate) order of magnitude and/or mid-point values on both linear and log scales.

Table 2a. Fallout Building Attribute Value Category: Building Height (Number of Stories)

Category name	Nominal value (stories)	Range (stories)
Single Story	1	1
Low Rise	2	1 to 3
Mid Rise	5	4 to 7
High Rise	13	8 to 15
Skyscraper	50	> 15

Table 2b. Fallout Building Attribute Value Category: Building Area

Category name	Nominal value (sq ft)	Range (sq ft)
Small	100	< 500
Medium	1,000	500 to 3,000
Large	10,000	3,000 to 30,000
City Block	100,000	> 30,000

Table 2c. Fallout Building Attribute Value Category: Density

Category name	Nominal value (psf)	Range (psf)
None	0	0 to 0.5
Extremely Light	1.5	0.5 to 2.5
Very Light	5	2.5 to 7.5
Light	10	7.5 to 20
Moderate	30	20 to 40
Heavy	50	40 to 75
Very Heavy	100	75 to 150
Extremely Heavy	300	>150

Table 2d. Fallout Building Attribute Value Category: Apertures

Category name	Nominal Value (%)	Range (%)
None	0	0 to 0.5
Occasional	1.5	0.5 to 2.5
Few	5	2.5 to 7.5
Some	12	7.5 to 15
Moderate	25	15 to 35
Many	50	35 to 75
Predominately	90	75 to 100

STEP 3: SIMPLIFIED BUILDING DESCRIPTIONS

It is not always convenient, or possible, to specify all of the fallout building attributes. In these cases, we are required to make assumptions with respect to building construction. Here we codify two simplified building descriptions based on assumptions appropriate for the DOE and DoD projects: one description for general building analyses and another for GEM based building analyses.

SIMPLIFIED BUILDING DESCRIPTION FOR GENERAL BUILDING ANALYSES

The first simplified building description is intended to streamline the building specification for fallout protection calculations based on architectural features that, in the experience of the authors, are most often, but not always, available. Thus this simplified building description is designed for screening purposes, i.e., generating first order estimates of building protection that (a) maximize the use of available building construction information and (b) use self-consistent default values for commonly unavailable building attributes, e.g., window and door densities. The DOE project is scheduled to use this building description method to specify the common building types. The PFscreen model will then be used to estimate building protection for the common building types [1].

Table 3 specifies the simplified building description attributes used for general building analyses. The numerical values for the **Table 3** simplified building attributes can then be determined from their architectural features, see **Tables 1a-c**. For context, the corresponding example architectural features (i.e., the **Appendix A** sub-appendices) are also listed in **Table 3**.

Tables 4a-e demonstrates how values for the previously discussed fallout building attributes can be estimated from the **Table 3** simplified building description attribute values. In the screening model calculations, the following assumptions are used:

- 1) All buildings are square (building length = building width).
- 2) Interior mass (e.g., interior walls, furniture) is evenly distributed within each story.
- 3) Each above ground story (2nd story and higher), if present, is identical to the 1st story except that no doors are considered.
- 4) The foundation attribute can take one of the following values, which indicates (a) the height of the 1st story (ground) floor above the ground and (b) if the basement parameters are used.
 - a. Basement:
 - i. Basement parameters are used.
 - ii. 1st story floor height = basement height – basement depth.
 - b. Slab:
 - i. Basement parameters are ignored.
 - ii. 1st story floor height = 0 ft (0 m) above the ground.
 - c. Crawlspace:
 - i. Basement parameters are ignored.
 - ii. 1st story floor height = 3.28 ft (1 m) above the ground.⁶
- 5) Apertures:⁷
 - a. The window and door density is 3 psf (lbs per sq ft; 1.5 g cm⁻²).
 - b. Basement story (if present): Windows and doors extend from the ground level (0 ft; 0 m) to the top of the basement story.
 - c. Above ground stories:
 - i. Windows extend from the sill height to the top of the story.
 - ii. Doors extend from the story floor to the top of the story.

⁶ The crawlspace assumed to have the above ground exterior wall density, no windows/doors, and an empty interior.

⁷ The sum of window and door percent values is limited to 100%.

Table 3. Simplified building description attributes used for general building analyses.

Simplified building description attribute name	Common architectural feature appendix
Number of Stories Above Ground	A1
Total Building Floor Area	A3
Joists	A9
Foundation	n/a (basement, slab, or crawlspace values allowed)
Basement Height	A4, A6
Basement Depth	A4
Basement Window Percent	A14
Basement Door Percent	A15
Basement Exterior Wall Density	A7
Basement Interior Wall Density	A13
Basement Live Load	A12
Above Ground Story Height	A4
Above Ground Window Sill Height	A16
Above Ground Window Percent	A14
Above Ground Door Percent	A15
Above Ground Story Exterior Wall Density	A7
Above Ground Interior Wall Density	A13
Above Ground Live Load	A12
Above Ground Floor Density	A11
Above Ground Ceiling Density	A10
Roof Density	A8
Attic/Roof Live Load	A12
Roof Peak Height	A5

Table 4a – General. Determination of fallout building attributes from the simplified building description for general building analyses.

Fallout building attribute name	Calculation using simplified building description attributes
Basement	[Foundation]
Length and Width	$\sqrt{\left(\frac{[\text{Total Building Floor Area}]}{([\text{Number of Stories Above Ground}] + 1 \text{ if } [\text{Foundation}] = \text{Basement})} \right)}$

Table 4b – Basement Story. Determination of fallout building attributes from the simplified building description for general building analyses.

Fallout building attribute name	Calculation using simplified building description attributes
Story Height	[Basement Height]
Height of Story Floor Above Ground	-1 x [Basement Depth]
Exterior Wall Density	[Basement Exterior Wall Density]
Interior Density	[Basement Interior Wall Density] + [Basement Live Load]
Ceiling-Floor Density	[Above Ground Floor Density] + [Joists]
Window Percent	[Basement Window Percent]
Window Sill Height	[Basement Depth]
Top of Window	[Basement Height]
Window Density	3 psf
Door Percent	[Basement Door Percent]
Door Sill Height	[Basement Depth]
Top of Door	[Basement Height]
Door Density	3 psf

Table 4c – Ground Story. Determination of fallout building attributes from the simplified building description for general building analyses.

Fallout building attribute name	Calculation using simplified building description attributes
Story Height	[Above Ground Story Height]
Height of Story Floor Above Ground	[Foundation] = Basement: [Basement Height] - [Basement Depth], [Foundation] = Slab: 0 ft above ground level, [Foundation] = Crawlspace: 3.28 ft above ground level
Exterior Wall Density	[Above Ground Exterior Wall Density]
Interior Density	[Above Ground Interior Wall Density] + [Above Ground Live Load]
Ceiling-Floor Density	[Above Ground Floor Density] + [Joists] + [Above Ground Ceiling Density]
Window Percent	[Above Ground Window Percent]
Window Sill Height	[Above Ground Window Sill Height]
Top of Window	[Above Ground Story Height]
Window Density	3 psf
Door Percent	[Above Ground Door Percent]
Door Sill Height	0 ft
Top of Door	[Above Ground Story Height]
Door Density	3 psf

Table 4d – Upper Stories. Determination of fallout building attributes from the simplified building description for general building analyses.

Fallout building attribute name	Calculation using simplified building description attributes
Story Height	[Above Ground Story Height]
Height of Story Floor Above Ground	[Height of Story Floor Above Ground] for the prior story + [Above Ground Story Height]
Exterior Wall Density	[Above Ground Exterior Wall Density]
Interior Density	[Above Ground Interior Wall Density] + [Above Ground Live Load]
Ceiling-Floor Density	[Above Ground Floor Density] + [Joists] + [Above Ground Ceiling Density]
Window Percent	[Above Ground Window Percent]
Window Sill Height	[Above Ground Window Sill Height]
Top of Window	[Above Ground Story Height]
Window Density	3 psf
Door Percent	0 %
Door Sill Height	n/a
Top of Door	n/a
Door Density	n/a

Table 4e – Top Story. Determination of fallout building attributes from the simplified building description for general building analyses.

Fallout building attribute name	Calculation using simplified building description attributes
Story Height	[Above Ground Story Height] + [Roof Peak Height] / 2
Height of Story Floor Above Ground	[Height of Story Floor Above Ground] for the prior story + [Above Ground Story Height]
Exterior Wall Density	[Above Ground Exterior Wall Density]
Interior Density	[Above Ground Interior Wall Density] + [Above Ground Live Load]
Ceiling-Floor Density	[Roof Density] + [Attic/Roof Live Load] + [Joists] + [Above Ground Ceiling Density]
Window Percent	[Above Ground Window Percent]
Window Sill Height	[Above Ground Window Sill Height]
Top of Window	[Above Ground Story Height]
Window Density	3 psf
Door Percent	0 %
Door Sill Height	n/a
Top of Door	n/a
Door Density	n/a

SIMPLIFIED BUILDING DESCRIPTION FOR GLOBAL EARTHQUAKE MODEL (GEM) BASED ANALYSES

The second simplified building description is motivated by the need (a) to compensate for the limited amount of story-specific information provided by the GEM building taxonomy (see next section) and (b) to reduce the computational burden for the subsequent building protection calculations. This latter issue is especially relevant to the DoD project which aims to model worldwide regional building protection factors and is scheduled to use building protection estimates based on resource intensive Monte Carlo modeling to be performed by Applied Research Associates.

Table 5 specifies the simplified building description attributes used for GEM based analyses. These attribute values can be determined from a GEM building description (string) using the corresponding **Appendix C** look-up table listed in **Table 5**.⁸ The use of these look-up tables is discussed in the *Mapping GEM Strings to a Simplified Building Description* section. Alternately if additional, supplementary information is available; the numerical values for the **Table 5** simplified building attributes can be determined from architectural features in **Tables 1a-c**.

⁸ A look-up table for building footprint area was not available at publication.
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Tables 6a-e demonstrates how values for the previously discussed fallout building attributes can be estimated from the **Table 5** simplified building description attribute values and the following assumptions:

- 1) All buildings are square (building length = building width).
- 2) Interior mass (e.g., interior walls, furniture) is evenly distributed within each story
- 3) All stories are 12 ft (3.7 m) high.
- 4) Basement (if present):
 - a. Basement floor is 9 ft (2.7 m) below ground level.
 - b. Basement exterior wall is 50 psf (24 g cm^{-2}).
 - c. Basement windows are 1.5% of the exterior wall area.
 - d. Basement interior density is 5 psf (2.4 g cm^{-2}).
- 5) The height of the ground (1st) story floor is 3 ft (0.91 m) above the ground level.
- 6) Each above ground (2nd and higher) story, if present, is identical to the ground story except that no doors are considered.
- 7) Apertures:⁹
 - a. Windows extend from waist high (3 ft; 0.91m) to the top of story (12 ft; 3.7m).¹⁰
 - b. Doors extend from the ground level (0 ft; 0 m) to 8.2 ft (2.5 m) above the floor.¹¹
 - c. The window and door densities are 3 psf (1.5 g cm^{-2}).

⁹ The sum of window and door percent values is limited to 100%.

¹⁰ The window sill height should be set to 0 ft (0 m) when the window percent is > 75%.

¹¹ The door top should be set to 12 ft (3.7 m) when the door percent is > 60%.

Table 5. Building attributes included in the simplified building description for GEM based analyses. For context, the corresponding fallout building attribute value category table number and number of categories are provided.

Simplified building description attribute name	Fallout building attribute category table	Number of fallout building attribute value categories	Appendix C look-up table
Basement Present?	n/a (yes or no values allowed)	2	C7
Number of Stories Above Ground	Table 2a	5	C6
Building Footprint Area	Table 2b	4	n/a
Exterior Wall Density	Table 2c	8	C1
Roof Density	Table 2c	8	C2
Ceiling-Floor Density	Table 2c	8	C3
Interior Density	Table 2c	8	C4, C5
Window Percent	Table 2d	7	C8
Door Percent	Table 2d	7	C9

Table 6a – General. Determination of fallout building attributes from the simplified building description for GEM based analyses.

Fallout building attribute name	Calculation using simplified building description attributes
Basement	[Basement Present?]
Length and Width	$\sqrt{[\text{Building Footprint Area}]}$

Table 6b – Basement Story. Determination of fallout building attributes from the simplified building description for GEM based analyses.

Fallout building attribute name	Calculation using simplified building description attributes
Story Height	12 ft
Height of Story Floor Above Ground	-9 ft
Exterior Wall Density	50 psf
Interior Density	5 psf
Ceiling-Floor Density	[Ceiling-Floor Density]
Window Percent	1.5 %
Window Sill Height	7 ft
Top of Window	12 ft
Window Density	3 psf
Door Percent	0 %
Door Sill Height	n/a
Top of Door	n/a
Door Density	n/a

Table 6c – Ground Story. Determination of fallout building attributes from the simplified building description for GEM based analyses.

Fallout building attribute name	Calculation using simplified building description attributes
Story Height	12 ft
Height of Story Floor Above Ground	3 ft
Exterior Wall Density	[Exterior Wall Density]
Interior Density	[Interior Density]
Ceiling-Floor Density	[Ceiling-Floor Density]
Window Percent	[Window Percent]
Window Sill Height	[Window Percent] ≤ 75%: 3 ft, [Window Percent] > 75%: 0 ft
Top of Window	12 ft
Window Density	3 psf
Door Percent	[Door Percent]
Door Sill Height	0 ft
Top of Door	[Door Percent] ≤ 60%: 8.2 ft, [Door Percent] > 60%: 12 ft
Door Density	3 psf

Table 6d – Upper Stories. Determination of fallout building attributes from the simplified building description for GEM based analyses.

Fallout building attribute name	Calculation using simplified building description attributes
Story Height	12 ft
Height of Story Floor Above Ground	[Height of Story Floor Above Ground] for the prior story + 12 ft
Exterior Wall Density	[Exterior Wall Density]
Interior Density	[Interior Density]
Ceiling-Floor Density	[Ceiling-Floor Density]
Window Percent	[Window Percent]
Window Sill Height	[Window Percent] ≤ 75%: 3 ft, [Window Percent] > 75%: 0 ft
Top of Window	12 ft
Window Density	3 psf
Door Percent	0 %
Door Sill Height	n/a
Top of Door	n/a
Door Density	n/a

Table 6e – Top Story. Determination of fallout building attributes from the simplified building description for GEM based analyses.

Fallout building attribute name	Calculation using simplified building description attributes
Story Height	12 ft
Height of Story Floor Above Ground	[Height of Story Floor Above Ground] for the prior story + 12 ft
Exterior Wall Density	[Exterior Wall Density]
Interior Density	[Interior Density]
Ceiling-Floor Density	[Roof Density]
Window Percent	[Window Percent]
Window Sill Height	[Window Percent] ≤ 75%: 3 ft, [Window Percent] > 75%: 0 ft
Top of Window	12 ft
Window Density	3 psf
Door Percent	0 %
Door Sill Height	n/a
Top of Door	n/a
Door Density	n/a

STEP 4: FALLOUT RELEVANT GLOBAL EARTHQUAKE MODEL (GEM) BUILDING ATTRIBUTES

INTRODUCTION TO THE GEM TAXONOMY AND BUILDING STRINGS

The Global Earthquake Model (GEM) taxonomy describes the seismically relevant building features in a uniform manner that is accessible to a wide range of users. In this section, we summarize key features of the GEM building taxonomy relevant to fallout protection. Additional detail is available in the GEM building taxonomy documentation [3].

The GEM taxonomy describes buildings using a set of hierarchical building attributes – allowing for, but not requiring, up to 5 levels of detail to be captured about the building features listed in **Table 7**. A given attribute value (called “ID”) is specified by a combination of letter(s), number(s), and/or a colon (“:”). For a given building, the attribute IDs are assembled into a GEM building (taxonomy) string in the order shown in **Table 7** with a “/” separating GEM building attribute groups (hierarchy level 1) and “+” separating attribute IDs within a building attribute group (hierarchy levels 2 to 5). By convention, there is no “/” before the first attribute group or after the last attribute group. When no attribute ID is specified, the corresponding position can be left blank (this case is also called a “missing” or “unknown” attribute ID). As an example, a single story, single family house with a wooden frame and masonry exterior has the corresponding GEM building string of “/W//HEX:1//RES+RES1////EWMA//”. We note that this example string includes several “blank” GEM building attribute IDs as information was not available to specify some of the GEM building attributes (this situation is common). This example string is used in the next section to illustrate the process of mapping a GEM building string to a simplified building description, including how to handle “blank” attribute IDs.

Table 8 summarizes the subset of the GEM building attributes that are used by our method. For context, the corresponding GEM building attribute group name, hierarchy level and description are provided.

Appendix B lists (a) the individual IDs that the GEM building attributes can take and (b) brief descriptions adapted from the GEM documentation [3].

Table 7. GEM building attribute groups (the GEM building attribute hierarchy level 1 attributes).

GEM building attribute group	Attribute group description (adapted from [3])	ID from example GEM string
Direction	The Direction attribute identifies the position of the two principal horizontal directions of the building plan relative to the street.	(blank)
Material of the Lateral Load-Resisting System	The material of the structural members that resist lateral loads and are the part of the Lateral Load-Resisting System.	W
Lateral Load-Resisting System	The Lateral Load-Resisting System is the structural system that provides resistance against horizontal earthquake forces through vertical and horizontal components.	(blank)
Height	The height of the building measured in stories. The number of stories below ground is also defined as is (a) the height of the ground floor level above grade and (b) the slope of the site.	HEX:1
Date of Construction or Retrofit	The Date of Construction or Retrofit is when the building was completed or upgraded.	(blank)
Occupancy	Occupancy is the type of activity (function) that the building is used for, e.g., residential, commercial. It does not refer directly to the number of occupants.	RES+RES1
Building Position within a Block	The position of the building in relation to other neighboring buildings, in terms of the number of adjoining buildings and their location relative to the building under consideration.	(blank)
Shape of the Building Plan	Shape of the Building Plan (footprint) is the shape of the projection of the exterior edge of the building at grade onto the horizontal plane.	(blank)
Structural Irregularity	Structural Irregularity indicates if the building's structural arrangement produces a known vulnerability during an earthquake, e.g., one story is significantly higher than other stories.	(blank)
Exterior Walls	The material that covers most of the exterior walls of the building.	EWMA
Roof	The structural system that supports the roof covering and environmental loading (such as rain and snow).	(blank)
Floor	The structural system that supports the intermediate floors above the ground level.	(blank)
Foundation System	The Foundation System is the part of the building structure that is in contact with the ground and transfers the loads of the building structure into the ground.	(blank)

Table 8. GEM building attributes used by our method. **Appendix B** provides more detail.

GEM building attribute group	GEM building attribute name (level #)	Attribute description (adapted from [3])
Material of the Lateral Load-Resisting System	Material Type (Level 1)	The material of the structural members that resist lateral loads and are part of the Lateral Load-Resisting System. The lateral load-resisting system is the structural system that provides resistance against horizontal earthquake forces through vertical and horizontal components.
Material of the Lateral Load-Resisting System	Material Technology (Level 2)	A more detailed description of the Lateral Load-Resisting System material type
Height	Height (Level 1)	The height of the building measured in stories. The number of stories below ground is also defined as is (a) the height of the ground floor level above grade ¹² and (b) the slope of the site.
Occupancy	Building Occupancy Class – General (Level 1)	The main overall type of occupancy. Occupancy is the type of activity (function) that the building is used for, e.g., residential, commercial. It does not refer directly to the number of occupants.
Occupancy	Building Occupancy Class – Detail (Level 2)	More detailed occupancy descriptions than provided in the “Building Occupancy Class – General”
Exterior Walls	Exterior Walls (Level 1)	The material that covers most of the exterior walls of the building.
Roof	Roof System Material (Level 3)	The general classification of the material of the roof system. The roof system is the structure that supports roof covering and environmental loading (such as rain and snow). Roof system is often not exposed from the exterior of the building.
Roof	Roof System Type (Level 4)	Detailed classification of the type of roof system.
Floor	Floor System Material (Level 1)	The general classification of the material of the floor system. The floor system is the structure that supports flooring and can be overlaid with different types of flooring.
Floor	Floor System Type (Level 2)	Detailed classification of the type of floor system based on materials and construction methods.

¹² To simplify later computations, the height of ground (1st) story floor above ground is neglected.

MAPPING GEM STRINGS TO A SIMPLIFIED BUILDING DESCRIPTION

GEM building attributes typically indicate qualitative architectural features. Thus a given GEM building attribute ID often corresponds to a wide range of simplified building description attribute values. In contrast, simultaneously considering multiple GEM building attributes can yield a narrower range of simplified building description attribute values compared to the case in which only a single GEM building attribute is used. This latter point, and its advantages in helping to overcome some of the limitations of using qualitative GEM building descriptions to derive simplified building description attribute values, is briefly illustrated here for the example of estimating the exterior wall density.

When only the “Exterior Walls” GEM building attribute is considered, the exterior wall density associated with the example GEM building string can have a wide range of values. Specifically, the density of a masonry exterior wall (GEM “Exterior Walls” building attribute ID of “EWMA”) can range from approximately 20 psf to 300 psf, which corresponds to (a) a thin, lightweight concrete block wall and (b) several foot thick fired brick wall, respectively.

However, when both the “Exterior Walls” and the “Material of the Lateral Load-Resisting System” GEM building attributes are considered together, the exterior wall density associated with the example GEM building string has a narrower range of potential values. Specifically, the density of a masonry exterior wall with a wood frame (GEM “Exterior Walls” building attribute ID of “EWMA”; GEM “Material of the Lateral Load-Resisting System” building attribute ID of “W”) has a 40 psf to 75 psf range, which corresponds to a thin masonry (e.g., brick) veneer over a wood frame.

The next two subsections (a) formalizes this process of using one or more GEM building attributes to determine values for the simplified building description attributes shown in **Table 5** and (b) provides a more extensive, detailed example.

Method

Values for most of the simplified building description attributes shown in **Table 5** can be determined using the method described here and illustrated by the flowchart shown in **Figure 2**. Note however, that the building footprint area is not determined by the current method. This method aims to determine the most precise (narrowest range) of possible values for a given simplified building description attribute by identifying the largest number (up to 3) of relevant GEM building attributes that are also specified by the GEM building string. The number of relevant and specified GEM building attributes is indicated by the “Flowchart Level” number. If the below method is able to identify a GEM Flowchart Level 3 result (3 relevant and specified GEM building attributes), then that result should be used as it has the narrowest range of values. Otherwise, the Flowchart Level 2 result (2 relevant and specified GEM building attributes) should be used, if available. The Flowchart Level 1 result (1 relevant and specified GEM building attribute) should be used only if neither a Flowchart Level 3 result nor a Flowchart Level 2 result is available.

First, we identify the **Appendix C** look-up table (sub-appendix) that corresponds to the simplified building description attribute being determined, see **Table 5**. The look-up table rows are color coded as follows:

Look-up table rows that have black text and a white background are “Flowchart Level 1” rows.

Look-up table rows that have orange text and background are “Flowchart Level 2” rows.

Look-up table rows that have blue text and background are “Flowchart Level 3” rows.

Using an identified look-up table, we identify the Flowchart Level 1 GEM building attribute, i.e., the GEM building attribute name (also called “type”) listed in second column of the Flowchart Level 1 rows. From the GEM building string, we then identify the Flowchart Level 1 GEM building attribute ID. The Flowchart Level 1 GEM building attribute ID is used to look up the simplified building description attribute’s nominal value and range in the look-up table.

Second, in many cases we can determine a more precise simplified building description attribute value and range using two GEM building attributes. These cases are identified by the presence of Flowchart Level 2 rows (orange text and background) immediately following the Flowchart Level 1 row (black text and white background) that contains the Flowchart Level 1 GEM building attribute ID determined in the previous paragraph. For these cases, we identify the Flowchart Level 2 GEM building attribute, i.e., the GEM building attribute listed in the second column of the Flowchart Level 2 rows. From the GEM building string, we then identify the Flowchart Level 2 GEM building attribute ID. The Flowchart Level 2 GEM building attribute ID is used to look up the simplified building description attribute's nominal value and range in the look-up table. If (a) the Flowchart Level 2 GEM building attribute ID is not available (i.e., it is missing or "blank" in the GEM building string) and/or (b) there are no Flowchart Level 2 rows following the previously identified Flowchart Level 1 row, then the Flowchart Level 1 simplified building description attribute's nominal value and range identified in the previous paragraph should be used.

Third, we can sometimes determine a yet more precise simplified building description attribute value and range using three GEM building attributes. These cases are identified by the presence of Flowchart Level 3 rows (blue text and background) immediately following the Flowchart Level 2 row (orange text and background) that contains the Flowchart Level 2 GEM building attribute ID determined in the previous paragraph. For these cases, we identify the Flowchart Level 3 GEM building attribute, i.e., the GEM building attribute listed in the second column of the Flowchart Level 3 rows. From the GEM building string, we then identify the Flowchart Level 3 GEM building attribute ID. The Flowchart Level 3 GEM building attribute ID is used to look up the simplified building description attribute's nominal value and range in the look-up table. If (a) the Flowchart Level 3 GEM building attribute ID is not available (i.e., it is missing or "blank" in the GEM building string) and/or (b) there are no Flowchart Level 3 rows following the previously identified Flowchart Level 2 row, then the Flowchart Level 2 simplified building description attribute's nominal value and range identified in the previous paragraph should be used.

We note that:

- 1) **Appendix C** provides an attribute ID “(blank)” corresponding to missing GEM attributes. The GEM building taxonomy also allows the user to explicitly specify that the attribute ID is unknown. Since “blank” (i.e. missing) attributes are, by definition, unknown, the **Appendix C** tables co-list the “(blank)” IDs with the explicitly specified “unknown” GEM attribute value. For these cases, **Appendix C** provides a typical simplified building description value and range – analogous to the case of an explicitly specified, “known” attribute ID.
- 2) In some cases, a large number of GEM building string IDs have the same simplified building description numerical value and range. For these cases, we create a new table row, with a GEM attribute description of “ALL OTHERS,” to specify the numerical values for these GEM building string IDs. The provided nominal value and range indicate simplified building attribute numerical values for the GEM attributes that are not explicitly specified in other rows. We note that the “ALL OTHERS” case is not intended to refer to a “blank” or “missing” ID.
- 3) Interior density value and range are determined by adding the separately derived live load and interior wall value and range in accordance with **Table 1b**.
- 4) The GEM notation combines the number of stories above and below ground within a single building attribute group and does not always provide a level 1 attribute. From the point of view of this method, the number of above and/or below ground stories (basements) may be indicated by a Flowchart Level 2 ID (or blank) without an explicit corresponding Flowchart Level 1 attribute ID. In this situation (which is shown in the example GEM string), the Flowchart Level 1 attribute ID is assumed to be missing (blank). Furthermore, we note that the provided lookup tables use a subset of valid GEM building attribute height ID values. Conversion of other GEM building attribute height ID values to one (or more) of the “allowed” (from the point of view of this method) ID values may be necessary prior to using the look-up tables.

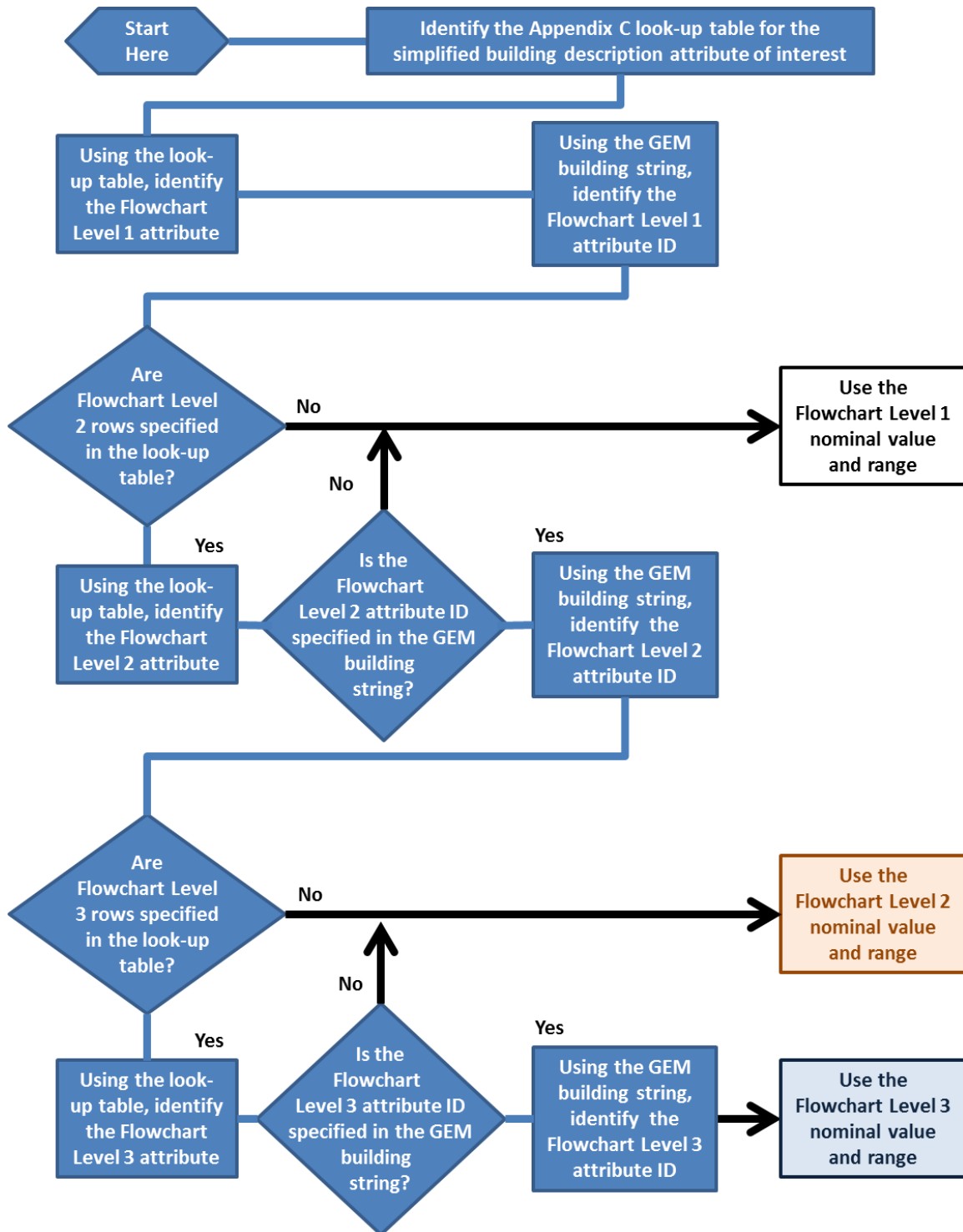


Figure 2. Flowchart of process that determines a single simplified building description attribute value from a GEM building string. This process is followed independently for each building attribute. The Flowchart Level colors shown on the right correspond to the Flowchart Level color coding in the **Appendix C** tables.

EXAMPLE

In this example, consider the previously introduced single story, single family house with a wooden frame and masonry exterior. The corresponding GEM string is “/W//HEX:1//RES+RES1////EWMA//”. We note that this example string, as is common, contains missing (blank) GEM attributes.

The next page provides a step-by-step walk-through of the process used to determine the nominal value and range for the simplified building description exterior wall density.

Exterior Wall Density Example

- 1) **Table 5** indicates that the exterior wall density look-up table is sub-**Appendix C1**. For convenience, we have excerpted the relevant portion of sub-**Appendix C1** into **Table 9**.
- 2) The GEM building attribute corresponding to Flowchart Level 1 (black text and white background) is “Exterior Walls”.
- 3) The example GEM building string “Exterior Walls” attribute has an ID of “EWMA”.
- 4) There are Flowchart Level 2 (orange text and background) rows immediately following the look-up table Flowchart Level 1 row that contains the “EWMA” GEM building attribute ID.
- 5) The GEM building attribute corresponding to Flowchart Level 2 is “Lateral Load-Resisting System Material Type”.
- 6) The example GEM building string “Lateral Load-Resisting System Material Type” attribute has an ID of “W”.
- 7) There are no Flowchart Level 3 (blue text and background) rows immediately following the look-up table Flowchart Level 2 row that contains the “W” GEM building attribute ID.
- 8) Thus the Flowchart Level 2 nominal value of 50 psf (with a range of 40 to 75 psf) is used for the simplified building description exterior wall density.

Table 9. Excerpt from sub-**Appendix C1** that provides the mapping between the example GEM building string and the corresponding exterior wall density. No Flowchart Level 3 is available for this case.

Flowchart Level	GEM attribute name	GEM ID from string	GEM ID description	Nominal value (psf)	Low Value (psf)	High Value (psf)
1	Exterior Walls	EWMA	Masonry exterior walls	100	20	300
2	Lateral Load-Resisting System Material Type	W	Wood	50	40	75

Table 10 summarizes the exterior wall density assignment process detailed on the previous page. **Table 10** also summarizes the assignment process for the other simplified building description attributes.

Table 10. Summary of process used to assign the simplified building description attribute values from the example GEM string: “/W//HEX:1//RES+RES1////EWMA//”.

Simplified building description attribute	Flowchart Level 1		Flowchart Level 2		Flowchart Level 3		Building attribute nominal value (range)
	GEM attribute name	GEM ID from string	GEM attribute name	GEM ID from string	GEM attribute name	GEM ID from string	
Basement Present?	Height	(blank)	Number of storeys below ground	(blank)	n/a	n/a	0 story (0 to 3 story)
Number of above ground stories	Height	(blank)	Exact number of storeys above ground	HEX:1	n/a	n/a	1 story (1 to 1 story)
Exterior wall density	Exterior Walls	EWMA	Lateral Load-Resisting System Material Type	W	n/a	n/a	50 psf (40 to 75 psf)
Roof density	Roof System Material	(blank)	Lateral Load-Resisting System Material Type	W	n/a	n/a	10 psf (1.5 to 75 psf)
Ceiling-floor density	Floor Material	(blank)	Lateral Load-Resisting System Material Type	W	n/a	n/a	10 psf (2.5 to 75 psf)
Interior density	= Live load (5 psf) + Interior wall density (10 psf)					=	15 psf (8 to 60 psf)
Live load	Building Occupancy Class – General	RES	n/a	n/a	n/a	n/a	5 psf (0.5 to 20 psf)
Interior wall density	Exterior Walls	EWMA	Lateral Load-Resisting System Material Type	W	n/a	n/a	10 psf (7.5 to 40 psf)
Window percent	Building Occupancy Class – General	RES	Building Occupancy Class – Detail	RES1	Lateral Load-Resisting System Material Type	W	12 % (2.5 to 35 %)
Door percent	Building Occupancy Class – General	RES	Building Occupancy Class – Detail	RES1	Lateral Load-Resisting System Material Type	W	5 % (0.5 to 35 %)

DISCUSSION AND CONCLUSIONS

A nuclear explosion has the potential to injure or kill tens to hundreds of thousands (or more) of people through exposure to fallout (external gamma) radiation. Existing buildings can protect their occupants (reducing fallout radiation exposures) by placing material and distance between fallout particles and indoor individuals. Prior efforts have determined an initial set of building attributes suitable to reasonably assess a given building's protection [1]. The current work provides methods to determine the quantitative values for these attributes from (a) common architectural features and (b) for buildings described using the GEM taxonomy. While the newly developed methods utilize the current set of fallout building attributes, future work may expand this attribute set to include the effects of the building environment, e.g., local terrain, nearby buildings; more complex building types, e.g., partial basements, courtyards; and/or other considerations, see [1] for more details. If such an expansion occurs, the methods described in this report would also need to be expanded.

While it is beyond the scope of this report to apply the developed methods to specific projects, it is useful to briefly examine the computational challenges involved and explore some potential solutions. In general, the number of possible buildings under consideration can be large. For example, the simplified building description intended for GEM building analyses (**Table 5**) has nine independent parameters which, even when limited to the fallout building attribute value categories, imply that approximately 8 million different buildings (parameter combinations) need to be assessed. This poses a computational challenge for traditional (Monte Carlo) techniques of assessing building protection as they often require days to weeks of processing time for a single building.

One option is to use screening models, such as the PFscreen model discussed in [1], which require a few minutes to determine the protection for a single building. Running 8 million cases would require approximately a week of processing on a 1,000 CPU computational cluster. Further computational savings may be found by first developing a statistical model (also called a surrogate model or response surface model). Broadly speaking, statistical models use various mathematical techniques to determine a relationship between a set of independently determined input/output values. Then for a new set of input values, the outputs can be quickly determined from the statistical relationship. The statistical techniques can range in complexity, but one common example is traditional, least-squares regression analysis (e.g., fitting a set of x/y points to a straight line). Some of the more advanced techniques can be used to determine which input values to sample and so can reduce, often dramatically, the required

number of times the underlying building protection model (e.g., Monte Carlo, PFscreen) would need to be run. This provides a scalability advantage when considering more complex building descriptions. We note that well established software packages exist for the development and use of statistical models, e.g., [4].

A second option is develop a set of common building types – and develop an additional mapping of all possible building parameters to these common building types. In essence, this is the plan being pursued by the DoD and DOE projects. Here, one path is to use subject matter expertise to develop a set of common building types. The advantage of this method is that the developed building types are likely to be recognizable to, hence usable by, a broad audience. The disadvantage is that, without additional work, it is unclear the degree to which these common building types will adequately cover the range of building construction present worldwide. Another path would first determine the frequency of building parameter values present in the world using (a) the method developed in this report and (b) estimates of building frequency (e.g., ORNL is characterizing buildings world-wide based on the GEM taxonomy). Then, common combinations (clusters) of building parameter values would be identified (these clusters would correspond to the common building types).

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APPENDIX A: EXAMPLE FALLOUT BUILDING ATTRIBUTE VALUES CORRESPONDING TO COMMON ARCHITECTURAL FEATURES

This appendix presents a set of common architectural features found in buildings worldwide, with particular attention paid to those features referenced by the GEM building taxonomy [3]. For each architectural feature listed, we provide an example fallout building attribute value based on the structural information provided in the primary reference source (see next paragraph) and supplemented with more detailed sources (for each architectural feature, we cite the specific references used). The architectural features are grouped into sub-appendices by fallout building attribute and, where appropriate, by the fallout building attribute value category (**Tables 2a-d**).

The current architectural feature set was developed using three primary data reference sources. First, we characterized the architectural features specified within the DoD Urban Terrain Building Types (UTBT) report [5]. The UTBT report provides a set of “geotypical” buildings – buildings that, collectively, are intended to describe all major urban building structural types found worldwide. We supplemented this initial set of architectural features with the structural information provided by the World Housing Encyclopedia [6]. At publication, the World Housing Encyclopedia contained 130 reports on the construction used in urban and rural, single and multifamily housing. In many cases, these housing reports provide sufficient detail to allow fallout building attribute value(s) to be determined for one or more architectural features. These cases were used to supplement the initial (UTBT) feature set. The final set of features were added during the development of the mapping of GEM strings to fallout building attribute values when the GEM building taxonomy indicated an architectural feature not previously developed.

Each architectural feature is identified as a separate row in this appendix. The first column provides the feature name. The second column provides a corresponding example fallout building attribute numerical value based on the reference information provided in the third column and the methods specified in the main text (see **Tables 1a-c**). The third column provides a brief summary of the structural characteristics assumed for the example architectural feature and the reference(s) upon which these characteristics are based. The references provided in the third column are unique to this appendix, listed in the last sub-appendix, and were the most authoritative sources identified during the course of this work. These included US government datasets: the Army UTBT (Urban Terrain Building Types) dataset, the FEMA HAZUS Multi-Hazard Loss

Estimation Methodology Earthquake Model, and the Department of Energy population-based Residential Energy Consumption Survey. We also used standard published reference works (World Housing Encyclopedia housing reports); international and professional standards (International Code Council specifications and ASCE 7-10 Standard Minimum Design Loads for Buildings and Other Structures); selected US state building codes; and finally trade association/manufacturer's specifications.

SUB-APPENDIX A1: NUMBER OF STORIES

The number of above ground building stories.

Name	Value (stories)	Notes
Single Story (1 st)	1	
Low Rise (2 st)	2	Ref: HAZUS - Table 3.1
Mid Rise (5 st)	5	Ref: HAZUS - Table 3.1
High Rise (13 st)	13	Ref: HAZUS - Table 3.1
Skyscraper (50 st)	50	Ref: SME judgement

SUB-APPENDIX A2: BUILDING FOOTPRINT AREA

The area enclosed by the exterior building edge touching the ground.

Building Area Category: Small (0 to 500 sq ft)

Name	Value (sq ft)	Notes
<i>no examples defined</i>		

Building Area Category: Medium (500 to 3,000 sq ft)

Name	Value (sq ft)	Notes
Car Wash	800	Ref: HAZUS - Table 3.6
Garage - Service Station	1,400	Ref: HAZUS - Table 3.6
Laundromat	3,000	Ref: HAZUS - Table 3.6

Building Area Category: Large (3,000 to 30,000 sq ft)

Name	Value (sq ft)	Notes
Medical Office	3,500	Ref: HAZUS - Table 3.6
Store - Convenience	4,000	Ref: HAZUS - Table 3.6
Bank	4,100	Ref: HAZUS - Table 3.6
Apt - Medium Low-Rise	5,000	Ref: HAZUS - Table 3.6
Dorm - Small	5,000	Ref: HAZUS - Table 3.6
Restaurant	5,000	Ref: HAZUS - Table 3.6
Fire Station - Medium	5,000	Ref: HAZUS - Table 3.6
Police Station	5,500	Ref: HAZUS - Table 3.6
Country Club	6,000	Ref: HAZUS - Table 3.6
Fire Station - Small	6,000	Ref: HAZUS - Table 3.6

Building Area Category: Large (3,000 to 30,000 sq ft), cont'd

Name	Value (sq ft)	Notes
Town Hall	7,500	Ref: HAZUS - Table 3.6
Hotel - Small Single Story	8,000	Ref: HAZUS - Table 3.6
Store – Small	8,000	Ref: HAZUS - Table 3.6
Apt - Large Mid-Rise	10,000	Ref: HAZUS - Table 3.6
Garage – Repair	10,000	Ref: HAZUS - Table 3.6
Funeral Home	10,000	Ref: HAZUS - Table 3.6
Office - Small Low-Rise	10,000	Ref: HAZUS - Table 3.6
Library	11,000	Ref: HAZUS - Table 3.6
Apt - Large High-Rise	11,154	Ref: HAZUS - Table 3.6
Dorm - Medium Low Rise	12,500	Ref: HAZUS - Table 3.6
Nursing Home - Low Rise	12,500	Ref: HAZUS - Table 3.6
Post Office	13,000	Ref: HAZUS - Table 3.6
Warehouse – Small	15,000	Ref: HAZUS - Table 3.6
Office - Medium Mid-Rise	16,000	Ref: HAZUS - Table 3.6
Dorm - Large Mid Rise	17,000	Ref: HAZUS - Table 3.6
Church	17,000	Ref: HAZUS - Table 3.6
Office - Large High-Rise	20,000	Ref: HAZUS - Table 3.6
Bowling Alley	20,000	Ref: HAZUS - Table 3.6
Auto Sales	21,000	Ref: HAZUS - Table 3.6
Social Club	22,000	Ref: HAZUS - Table 3.6
Hotel - Medium Low Rise	24,500	Ref: HAZUS - Table 3.6
College - Classroom	25,000	Ref: HAZUS - Table 3.6
Hotel - Medium Mid-Rise	27,000	Ref: HAZUS - Table 3.6
Hospital - Medium Low-Rise	27,500	Ref: HAZUS - Table 3.6
Parking Garage - Mid-Rise	29,000	Ref: HAZUS - Table 3.6
Warehouse - Medium	30,000	Ref: HAZUS - Table 3.6
Sports Court	30,000	Ref: HAZUS - Table 3.6
Factory - Small	30,000	Ref: HAZUS - Table 3.6

Building Area Category: Large (3,000 to 30,000 sq ft), cont'd

Name	Value (sq ft)	Notes
Factory - Large	30,000	Ref: HAZUS - Table 3.6
Courthouse - Small	30,000	Ref: HAZUS - Table 3.6
Courthouse - Medium	30,000	Ref: HAZUS - Table 3.6

Building Area Category: City Block (> 30,000 sq ft)

Name	Value (sq ft)	Notes
Hotel - Large High-Rise	34,615	Ref: HAZUS - Table 3.6
Hospital - Large Mid-Rise	40,000	Ref: HAZUS - Table 3.6
Store - Supermarket	44,000	Ref: HAZUS - Table 3.6
College - Laboratory	45,000	Ref: HAZUS - Table 3.6
Store - Department	50,000	Ref: HAZUS - Table 3.6
Warehouse - Large	60,000	Ref: HAZUS - Table 3.6

SUB-APPENDIX A3: TOTAL BUILDING FLOOR AREA

Total amount of floor space (area) available within a building (includes all stories).

Building Area Category: Small (0 to 500 sq ft)

Name	Value (sq ft)	Notes
<i>no examples defined</i>		

Building Area Category: Medium (500 to 3,000 sq ft)

Name	Value (sq ft)	Notes
Petite Structure	500	Ref: SME judgement
Car Wash	800	Ref: HAZUS - Table 3.6
Small Structure	1,000	Ref: SME judgement
US Mobile Home	1,087	Ref: DOE RECS (2009) - Building area corresponding to average total housing unit area for mobile homes in Table HC10.9
Garage - Service Station	1,400	Ref: HAZUS - Table 3.26
US Home - 1 story	1,516	Ref: DOE RECS (2009) - Building area corresponding to average total housing unit area for 1 story, single family homes in Table HC10.9
US Home - Typical Single Family Detached	2,483	Ref: DOE RECS (2009) - Building area corresponding to average total housing unit area for typical detached single family homes in Table HC10.9
Laundromat	3,000	Ref: HAZUS - Table 3.6

Building Area Category: Large (3,000 to 30,000 sq ft)

Name	Value (sq ft)	Notes
Apt - Typical US 3 unit	3,300	Ref: DOE RECS (2009) - Building area corresponding to average total housing unit area per unit for apartments with 2 to 4 units in Table HC10.9
US Home - 3+ Story	3,314	Ref: DOE RECS (2009) - Building area corresponding to average total housing unit area for 3 or more floor, single family homes in Table HC10.9
Store - Convenience	4,000	Ref: HAZUS - Table 3.6

Building Area Category: Large (3,000 to 30,000 sq ft), cont'd

Name	Value (sq ft)	Notes
Bank	4,100	Ref: HAZUS - Table 3.6
Restaurant	5,000	Ref: HAZUS - Table 3.6
Country Club	6,000	Ref: HAZUS - Table 3.6
Fire Station - Small	6,000	Ref: HAZUS - Table 3.6
Medical Office	7,000	Ref: HAZUS - Table 3.6
Hotel - Small Single Story	8,000	Ref: HAZUS - Table 3.6
Store - Small	8,000	Ref: HAZUS - Table 3.6
Apt - Medium Low-Rise	10,000	Ref: HAZUS - Table 3.6
Dorm - Small	10,000	Ref: HAZUS - Table 3.6
Garage - Repair	10,000	Ref: HAZUS - Table 3.6
Funeral Home	10,000	Ref: HAZUS - Table 3.6
Fire Station - Medium	10,000	Ref: HAZUS - Table 3.6
Police Station	11,000	Ref: HAZUS - Table 3.6
Movie Theatre	12,000	Ref: HAZUS - Table 3.6
Post Office	13,000	Ref: HAZUS - Table 3.6
Warehouse - Small	15,000	Ref: HAZUS - Table 3.6
Town Hall	15,000	Ref: HAZUS - Table 3.6
Church	17,000	Ref: HAZUS - Table 3.6
Office - Small Low-Rise	20,000	Ref: HAZUS - Table 3.6
Bowling Alley	20,000	Ref: HAZUS - Table 3.6
Auto Sales	21,000	Ref: HAZUS - Table 3.6
Social Club	22,000	Ref: HAZUS - Table 3.6
Library	22,000	Ref: HAZUS - Table 3.6
Auditorium	24,000	Ref: HAZUS - Table 3.6
Dorm - Medium Low Rise	25,000	Ref: HAZUS - Table 3.6
Nursing Home - Low Rise	25,000	Ref: HAZUS - Table 3.6
Warehouse - Medium	30,000	Ref: HAZUS - Table 3.6
Sports Court	30,000	Ref: HAZUS - Table 3.6
Factory - Small	30,000	Ref: HAZUS - Table 3.6

Building Area Category: Large (3,000 to 30,000 sq ft), cont'd

Name	Value (sq ft)	Notes
Courthouse - Small	30,000	Ref: HAZUS - Table 3.6

Building Area Category: City Block (> 30,000 sq ft)

Name	Value (sq ft)	Notes
Store - Supermarket	44,000	Ref: HAZUS - Table 3.6
School - Elementary	45,000	Ref: HAZUS - Table 3.6
College - Laboratory	45,000	Ref: HAZUS - Table 3.6
Hotel - Medium Low Rise	49,000	Ref: HAZUS - Table 3.6
Apt - Large Mid-Rise	50,000	Ref: HAZUS - Table 3.6
College - Classroom	50,000	Ref: HAZUS - Table 3.6
Hospital - Medium Low-Rise	55,000	Ref: HAZUS - Table 3.6
Warehouse - Large	60,000	Ref: HAZUS - Table 3.6
Courthouse - Medium	60,000	Ref: HAZUS - Table 3.6
Office - Medium Mid-Rise	80,000	Ref: HAZUS - Table 3.6
Dorm - Large Mid Rise	85,000	Ref: HAZUS - Table 3.6
Factory - Large	90,000	Ref: HAZUS - Table 3.6
Store - Department	100,000	Ref: HAZUS - Table 3.6
Parking Garage - Underground	100,000	Ref: HAZUS - Table 3.6
School - Jr. High	110,000	Ref: HAZUS - Table 3.6
School - High	130,000	Ref: HAZUS - Table 3.6
Hotel - Medium Mid-Rise	135,000	Ref: HAZUS - Table 3.6
Apt - Large High-Rise	145,000	Ref: HAZUS - Table 3.6
Parking Garage - Mid-Rise	145,000	Ref: HAZUS - Table 3.6
Hospital - Large Mid-Rise	200,000	Ref: HAZUS - Table 3.6
Office - Large High-Rise	260,000	Ref: HAZUS - Table 3.6
Hotel - Large High-Rise	450,000	Ref: HAZUS - Table 3.6

SUB-APPENDIX A4: STORY HEIGHT

Distance between two adjacent building stories.

Name	Value (ft)	Notes
Basement (7 ft)	7.00	Ref: IRC (2006) - Minimum habitable height
Single (12 ft)	12.00	
1.5 Story (18 ft)	18.00	
Double (24 ft)	24.00	

SUB-APPENDIX A5: ROOF PEAK HEIGHT

Distance between the attic floor and the external peak of the roof.

Name	Value (ft)	Notes
Flat Roof	0.00	
Low Roof Peak	4.70	Ref: (1) UTBT, (2) Schmid (2014) - UTBT Frame 3 one story length from front wall to roof peak = 14 ft; low end of conventional roof pitch range from 4:12 to 9:12 (using 4:12)
High Roof Peak	10.50	Ref: (1) UTBT, (2) Schmid (2014) - UTBT Frame 3 one story length from front wall to roof peak = 14 ft; upper end of conventional roof pitch range from 4:12 to 9:12 (using 9:12)

SUB-APPENDIX A6: 1ST STORY HEIGHT ABOVE GROUND

Distance between the ground and the 1st story floor

Name	Value (ft)	Notes
Ground Level (0 ft)	0.00	
Slight Rise (3 ft)	3.00	

SUB-APPENDIX A7: EXTERIOR WALL DEAD LOAD

External wall construction which is used to determine the average exterior wall density
Specifically the building exterior dead load + building frame in exterior wall + dead load of the internal wall affixed to the exterior wall

Building Density Category: None (0 to 0.5 psf)

Name	Value (psf)	Notes
<i>no examples defined</i>		

Building Density Category: Extremely Light (0.5 to 2.5 psf)

Name	Value (psf)	Notes
Lightweight Vegetation	1.50	Ref: SME judgement based on WHE 147
Wood Frame - Plastic Sheet (Low Income)	1.76	Ref: (1) ASCE 7-10, Table C3-1, (2) 780 CMR, Table G-8 - 2' of 6" thick timbers along 33' of wall length (timber, 35 pcf) + Single-ply waterproof sheet (0.7 psf)

Building Density Category: Very Light (2.5 to 7.5 psf)

Name	Value (psf)	Notes
Wood Frame - Siding (Low Income)	4.06	Ref: (1) ASCE 7-10, Table C3-1, (2) 780 CMR, Table G-8 - 2' of 6" thick timbers along 33' of wall length (timber, 35 pcf) + Wood Shingles (3 psf)
Wood Frame - Cemesto	6.46	Ref: (1) 780 CMR, Table G-8, (2) Kelly, (3) Cemesto - Cemesto walls in wood frame, 4" square posts spaced 3.3 m on center (timber, 35 pcf) + 2" Cemesto structural insulating panel (5.4 psf)

Building Density Category: Light (7.5 to 20 psf)

Name	Value (psf)	Notes
Steel Frame - Light Clad Sheet Metal	8.00	Ref: ASCE 7-10, Table C3-1 - 150 plf w 30 ft spacing (5 psf) + 18 gage deck metal (3 psf)
Wood Frame - Cemesto + Wood Siding	9.46	Ref: (1) ASCE 7-10, Table C3-1, (2) 780 CMR, Table G-8, (3) Kelly, (4) Cemesto - Cemesto walls in wood frame, 4" square posts spaced 3.3 m on center (timber, 35 pcf) + Cemesto board (5.4 psf) + wood shingles (3 psf)
Concrete Frame - No Exterior Cladding	9.62	Ref: (1) ASCE 7-10, Table C3-1, (2) BC – 30 cm square solid 125 pcf concrete spaced 4 m apart
Steel Frame - No Exterior Cladding	10.00	Ref: FEMA 451 (6-story steel frame building) - 200 plf w 20 ft spacing (10 psf)
Wood Frame - Siding	11.00	Ref: ASCE 7-10, Table C3-1 - 2"x4" @ 16", 5/8" gypsum insulated, 3/8" siding (11 psf)
Steel Frame - Light Clad - CEX Metal Siding	14.00	Ref: CEX-59.7B Part II - Butler building (Steel frame, 14 psf) - additional steel members added for blast resistance
Concrete Frame - Light Clad Metal	16.65	Ref: (1) ASCE 7-10, Table C3-1, (2) MCA – 40 cm square solid 125 pcf concrete spaced 8 m apart + metal faced foam panels (3 psf) + 2"x4" wood studs (4 psf) + gypsum board (1.1 psf per 1/2")
Solid Wood - 6" Log Walls	17.50	Ref: (1) 780 CMR, Table G-8, (2) WHE 56 – 15 cm solid logs (timber, 35 pcf)
Steel Frame - Light Clad Glass	18.00	Ref: (1) FEMA 451 (6-story steel frame building), (2) ASCE 7-10, Table C3-1 - 200 plf w 20 ft spacing (10 psf) + window incl. glass, frame, and sash (8 psf)
Steel Frame - Light Clad Metal Composite Panel	18.60	Ref: (1) FEMA 451 (6-story steel frame building), (2) ASCE 7-10, Table C3-1 - 200 plf w 20 ft spacing (10 psf) + metal faced foam panels (3.5 psf) + 2"x4" wood studs (4 psf) + gypsum board (1.1 psf per 1/2")

Building Density Category: Moderate (20 to 40 psf)

Name	Value (psf)	Notes
Wood Frame - Stucco	21.00	Ref: (1) ASCE 7-10, Table C3-1 and (2) BC - 2"x4" @ 16", 5/8" gypsum insulated, 3/8" siding (11 psf) + Stucco (10 psf)
Concrete Frame - Light Clad Glass	21.65	Ref: ASCE 7-10, Table C3-1 – 40 cm square solid 125 pcf concrete spaced 8m apart + window incl. glass, frame, and sash (8 psf) + 2"x4" wood studs (4 psf) + gypsum board (1.1 psf per 1/2")
Concrete Frame - Light Clad Concrete	27.40	Ref: ASCE 7-10, Table C3-1 – 40 cm square solid 125 pcf concrete spaced 8m apart + 3.5 cm solid 105 pcf lightweight concrete cladding + 2"x4" wood studs (4 psf) + gypsum board (1.1 psf per 1/2") + 1" rigid insulation (0.75 psf per 1/2")
Steel Frame - Light Clad Concrete	28.85	Ref: (1) FEMA 451 (6-story steel frame building), (2) ASCE 7-10, Table C3-1 - 200 plf w 20 ft spacing (10 psf) + 3.5 cm solid 105 pcf lightweight concrete cladding + 2"x4" wood studs (4 psf) + gypsum board (1.1 psf per 1/2") + 1" rigid insulation (0.75 psf per 1/2")
Masonry - Adobe - 10cm (Thin Wall)	33.33	Ref: (1) Ninaquispe-Romero (2016), (2) WHE 136 - adobe brick at 100 pcf; 10 cm depth
Solid Wood - 12" Log Walls	35.00	Ref: (1) 780 CMR, Table G-8 - 1' solid logs (timber, 35 pcf)
Masonry - Concrete - 8" Blocks, Unreinforced	36.00	Ref: ASCE 7-10, Table C3-1 - 8" 125 pcf concrete blocks, no grout (36 psf)
Concrete Frame - Light Clad Thin Stone	36.15	Ref: (1) ASCE 7-10, Table C3-1, (2) 780 CMR, Table G-8 – 40 cm square solid 125 pcf concrete spaced 8 m apart + 1.5" stone veneer (granite 168 pcf) + 1" rigid insulation (0.75 psf per 1/2") + 2"x4" wood studs (4 psf) + gypsum board (1.1 psf per 1/2")
Steel Frame - Light Clad Thin Stone	37.60	Ref: (1) FEMA 451 (6-story steel frame building), (2) ASCE 7-10, Table C3-1, (3) 780 CMR, Table G-8 - 200 plf w 20 ft spacing (10 psf) + 1.5" stone veneer (granite 168 pcf) + 1" rigid insulation (0.75 psf per 1/2") + 2"x4" wood studs (4 psf) + gypsum board (1.1 psf per 1/2")

Building Density Category: Heavy (40 to 75 psf)

Name	Value (psf)	Notes
Wood Frame - Half-Timber, Thin Wall (Wattle and Daub)	40.38	Ref: (1) ASCE 7-10, Table C3-1, (2) 780 CMR, Table G-8 - 6" walls, ~10% of area is timber posts/lintels, 90% wattle and daub w 1" wattle (timber), 5" mud (timber, 35 pcf; dry earth, 96 pcf)
Masonry - Concrete - 8" Blocks + Drywall, Unreinforced	41.10	Ref: ASCE 7-10, Table C3-1 - 8" 125 pcf concrete blocks, no grout (36 psf) + 2"x4" wood studs (4 psf) + gypsum board (1.1 psf per 1/2")
Concrete Frame - Thin Unreinforced 8" Concrete Block Infill	42.02	Ref: (1) ASCE 7-10, Table C3-1, (2) BC – 30 cm square solid 125 pcf concrete spaced 4 m apart + 90% of 8" 125 pcf concrete blocks, no grout (36 pcf)
Masonry - Fired Brick - 5" (Thin Wall)	47.92	Ref: (1) ASCE 7-10, Table C3-1, (2) WHE 91 - 5" bricks clay bricks (115 psf per 12")
Wood Frame - Brick Veneer	48.00	Ref: ASCE 7-10, Table C3-1 - Exterior stud walls with brick veneer (48 psf)
Concrete Frame - Light Clad Brick Veneer	54.15	Ref: ASCE 7-10, Table C3-1 – 40 cm square solid 125 pcf concrete spaced 8 m apart + 4" brick veneer (39 psf) + 2"x4" wood studs (4 psf) + gypsum board (1.1 psf per 1/2") + 1" rigid insulation (0.75 psf per 1/2")
Steel Frame - Light Clad Brick Veneer	55.60	Ref: (1) FEMA 451 (6-story steel frame building), (2) ASCE 7-10, Table C3-1 - 200 plf w 20 ft spacing (10 psf) + 4" brick veneer (39 psf) + 2"x4" wood studs (4 psf) + gypsum board (1.1 psf per 1/2") + 1" rigid insulation (0.75 psf per 1/2")
Concrete Frame - Unreinforced 8" Concrete Block Infill + Stucco	58.76	Ref: (1) ASCE 7-10, Table C3-1, (2) BC - 30cm square solid 125 pcf concrete spaced 3.3 m apart + 90% of 8" 125 pcf concrete blocks, no grout (36 pcf) + plaster over tile/concrete (5 psf) + Stucco (10 psf)
Masonry - Concrete - 8" Blocks, Reinforced w 16" Grout Spacing	59.00	Ref: ASCE 7-10, Table C3-1 - 8" 125 pcf blocks, rebar/grout 16" on center spacing (59 psf)
Concrete Frame - Thin Terra Cotta Infill	59.11	Ref: (1) ASCE 7-10, Table C3-1, (2) BC, (3) 780 CMR, Table G-8 – 40 cm x 25 cm solid 125 pcf concrete spaced 4 m apart + 90% of 23 cm terra cotta (unfilled voids 72 pcf)
Concrete Frame - Thin Reinforced, 16" oc 8" Concrete Block Infill	62.72	Ref: (1) ASCE 7-10, Table C3-1, (2) BC – 30 cm square solid 125 pcf concrete spaced 4 m apart + 90% of 8" 125 pcf concrete blocks, 16" on center grout (59 psf)
Masonry - Concrete - 8" Blocks + Drywall, Reinforced w 16" Grout Spacing	64.10	Ref: ASCE 7-10, Table C3-1 - 8" 125 pcf blocks, rebar/grout 16" on center spacing (59 psf) + 2"x4" wood studs (4 psf) + gypsum board (1.1 psf per 1/2")
Concrete - 6" + Drywall	67.60	Ref: ASCE 7-10, Table C3-1 - 6" solid 125 pcf concrete + 2"x4" wood studs (4 psf) + gypsum board (1.1 psf per 1/2")

Building Density Category: Heavy (40 to 75 psf), cont'd

Name	Value (psf)	Notes
Masonry - Concrete - 8" Blocks + Drywall + Stucco, Reinforced w 16" Grout Spacing	74.10	Ref: (1) ASCE 7-10, Table C3-1 and (2) BC - 8" 125 pcf blocks, rebar/grout 16" on center spacing (59 psf) + Stucco (10 psf) + 2"x4" wood studs (4 psf) + gypsum board (1.1 psf per 1/2")

Building Density Category: Very Heavy (75 to 150 psf)

Name	Value (psf)	Notes
Concrete Frame - Reinforced, 16" oc Grout, 8" Concrete Block Infill + Stucco	79.46	Ref: (1) ASCE 7-10, Table C3-1, (2) BC – 30 cm square solid 125 pcf concrete spaced 3.3 m apart + 90% of 8" 125 pcf concrete blocks, 16" on center grout (59 psf) + plaster over tile/concrete (5 psf) + Stucco (10 psf)
Earthen - 10" Rammed Earth (Low Income)	80.00	Ref: (1) 780 CMR, Table G-8, (2) WHE 45, rammed earth wall 200 mm to 300 mm wide (dry earth 96 pcf)
Wood Frame - Half-Timber, Thick Wall (Wattle and Daub)	80.75	Ref: (1) ASCE 7-10, Table C3-1, (2) 780 CMR, Table G-8 - 12" walls, ~10% of area is timber posts/lintels, 90% wattle and daub w 1" wattle (timber), 5" mud (timber, 35 pcf; dry earth, 96 pcf)
Concrete - 8"	83.33	Ref: ASCE 7-10, Table C3-1 - 8" solid 125 pcf concrete
Masonry - Concrete - 8" Lightweight Solid Blocks + Drywall + Stucco	84.10	Ref: (1) ASCE 7-10, Table C3-1 and (2) BC - 8" 105 pcf blocks, solid (69 psf) + Stucco (10 psf) + 2"x4" wood studs (4 psf) + gypsum board (1.1 psf per 1/2")
Masonry - Concrete - 8" Blocks + Drywall, Reinforced w Full Grout	86.10	Ref: ASCE 7-10, Table C3-1 - 8" 125 pcf blocks, full grout (81 psf) + 2"x4" wood studs (4 psf) + gypsum board (1.1 psf per 1/2")
Masonry - Concrete - 12" Blocks, Reinforced w 16" Grout Spacing	87.00	Ref: ASCE 7-10, Table C3-1 - 12" 125 pcf blocks, rebar/grout 16" on center spacing (87 psf)
Concrete - 8" + Drywall	88.43	Ref: ASCE 7-10, Table C3-1 - 8" solid 125 pcf concrete + 2"x4" wood studs (4 psf) + gypsum board (1.1 psf per 1/2")
Concrete Frame - Brick Infill	91.29	Ref: (1) ASCE 7-10, Table C3-1, (2) BC – 40 cm x 25 cm solid 125 pcf concrete spaced 3 m apart + 90% of 23 cm fired brick infill (115 pcf)
Masonry - Concrete - 8" Blocks + Drywall + Stucco, Reinforced w Full Grout	96.10	Ref: (1) ASCE 7-10, Table C3-1 and (2) BC - 8" 125 pcf blocks, full grout (81 psf) + stucco (10 psf) + 2"x4" wood studs (4 psf) + gypsum board (1.1 psf per 1/2")

Building Density Category: Very Heavy (75 to 150 psf), cont'd

Name	Value (psf)	Notes
Concrete Frame - Reinforced, Full Grout 8" Concrete Block Infill + Stucco	99.26	Ref: (1) ASCE 7-10, Table C3-1, (2) BC – 30 cm square solid 125 pcf concrete spaced 3.3 m apart + 90% of 8" 125 pcf concrete blocks, full grout (81 pcf) + plaster over tile/concrete (5 psf) + stucco (10 psf)
Masonry - Adobe - 30cm	100.00	Ref: (1) Ninaquispe-Romero (2016), (2) WHE 134 - adobe brick at 100 pcf; 30 cm depth
Concrete Frame - Brick Infill + Stucco	106.29	Ref: (1) ASCE 7-10, Table C3-1, (2) BC – 40 cm x 25 cm solid 125 pcf concrete spaced 3 m apart + 90% of 23 cm fired brick infill (115 pcf) + plaster over tile/concrete (5 psf) + stucco (10 psf)
Wood Frame - Half-Timber, Thick Wall (Masonry)	107.00	Ref: (1) ASCE 7-10, Table C3-1, (2) 780 CMR, Table G-8, (3) WHE 116 - 12" walls, ~10% of area is timber posts/lintels, 90% clay bricks (timber, 35 pcf; 115 psf per 12" brick)
Concrete Frame - Reinforced, 16" oc Grout, 8" Concrete Block Infill + Brick Veneer	108.46	Ref: (1) ASCE 7-10, Table C3-1, (2) BC – 30 cm square solid 125 pcf concrete spaced 3.3 m apart + 90% of 8" 125 pcf concrete blocks, 16" on center grout (59 psf) + plaster over tile/concrete (5 psf) + 4" fired brick (39 psf)
Masonry - Concrete - 8" Blocks + Drywall + Brick Veneer, Reinforced w 16" Grout Spacing	109.10	Ref: ASCE 7-10, Table C3-1 - 8" 125 pcf blocks, rebar/grout 16" on center spacing (59 psf) + 4" brick (39 psf) + 0.5" mortar (12 psf per in) + 2"x4" wood studs (4 psf) + gypsum board (1.1 psf per 1/2")
Concrete - 10" + Drywall	109.27	Ref: ASCE 7-10, Table C3-1 - 10" solid 125 pcf concrete + 2"x4" wood studs (4 psf) + gypsum board (1.1 psf per 1/2")
Concrete Frame - Terra Cotta Infill + Stucco	115.07	Ref: (1) ASCE 7-10, Table C3-1, (2) BC, (3) 780 CMR, Table G-8 – 40 cm x 25 cm solid 125 pcf concrete spaced 3 m apart + 90% of 40 cm terra cotta (unfilled voids 72 pcf) + plaster over tile/concrete (5 psf) + Stucco (10 psf)
Masonry - Concrete - 8" Lightweight Solid Blocks + Drywall + Brick Veneer	119.10	Ref: (1) ASCE 7-10, Table C3-1 and (2) BC - 8" 105 pcf blocks, solid (69 psf) + 4" brick (39 psf) + 0.5" mortar (12 psf per in) + 2"x4" wood studs (4 psf) + gypsum board (1.1 psf per 1/2")
Concrete - 12"	125.00	Ref: ASCE 7-10, Table C3-1 - 12" solid 125 pcf concrete
Concrete Frame - Reinforced, Full Grout 8" Concrete Block Infill + Brick Veneer	128.26	Ref: (1) ASCE 7-10, Table C3-1, (2) BC – 30 cm square solid 125 pcf concrete spaced 3.3 m apart + 90% of 8" 125 pcf concrete blocks, full grout (81 psf) + plaster over tile/concrete (5 psf) + 4" fired brick (39 psf)

Building Density Category: Very Heavy (75 to 150 psf), cont'd

Name	Value (psf)	Notes
Steel Frame - Heavy Clad	129.75	Ref: (1) FEMA 451 (6-story steel frame building), (2) ASCE 7-10, Table C3-1 - 200 plf w 20 ft spacing (10 psf) + 1" fiberboard insulation (0.75 psf per 1/2") + 9" fired brick (115 pcf) + 4" Hollow Terra Cotta Tile (2x2" book tile, 12 psf ea) + plaster on wood lath (8 psf)
Concrete - 12" + Drywall	130.10	Ref: ASCE 7-10, Table C3-1 - 12" solid 125 pcf concrete + 2"x4" wood studs (4 psf) + gypsum board (1.1 psf per 1/2")
Masonry - Fired Brick - 35cm + Plaster (Moderate Wall)	137.05	Ref: ASCE 7-10, Table C3-1 – 35 cm of clay bricks (115 psf per 12") + plaster on tile or concrete (5 psf)
Masonry - Fired Brick - 35cm + Plaster + Stucco (Moderate Wall)	147.05	Ref: (1) ASCE 7-10, Table C3-1, (2) BC – 35 cm of clay bricks (115 psf per 12") + plaster on tile or concrete (5 psf) + stucco (10 psf)

Building Density Category: Extremely Heavy (>150 psf)

Name	Value (psf)	Notes
Earthen - 1.6' Rammed Earth (Low Income)	153.60	Ref: (1) 780 CMR, Table G-8, (2) WHE 143, (3) WHE 171 - rammed earth wall 0.5m wide (dry earth 96 pcf)
Concrete Frame - Triple Brick Infill + Stucco	154.41	Ref: (1) ASCE 7-10, Table C3-1, (2) BC – 30 cm x 30cm solid 125 pcf concrete spaced 2 m apart + 90% of 36 cm fired brick infill (115 pcf) + plaster over tile/concrete (5 psf) + Stucco (10 psf)
Masonry - Adobe - 45cm (Thick Wall)	164.16	Ref: (1) Ninaquispe-Romero (2016), (2) BC - adobe brick at 100 pcf; 45 cm depth + 3 cm mortar (12 psf per in)
Masonry - Fired Brick - 48cm + Plaster	186.10	Ref: ASCE 7-10, Table C3-1 – 48 cm of clay bricks (115 psf per 12") + plaster on tile or concrete (5 psf)
Concrete - 12" + 6" Stone Covering + Drywall	200.10	Ref: (1) ASCE 7-10, Table C3-1, (2) 780 CMR - 12" solid 125 psf concrete + 6" stone, limestone (140 pcf) + 2"x4" wood studs (4 psf) + gypsum board (1.1 psf per 1/2")
Masonry - Stone - 1.3' + Plaster	223.40	Ref: (1) 780 CMR, Table G-8, (2) ASCE 7-10, Table C3-1 - 1.3' masonry granite stone (168 pcf) + plaster on tile or concrete (5 psf)

Building Density Category: Extremely Heavy (>150 psf), cont'd

Name	Value (psf)	Notes
Masonry - Fired Brick - 60cm + Plaster (Thick Wall)	231.38	Ref: ASCE 7-10, Table C3-1 – 60 cm of clay bricks (115 psf per 12") + plaster on tile or concrete (5 psf)
Masonry - Adobe - 80cm (Very Thick Wall)	262.00	Ref: Ninaquispe-Romero (2016) - adobe brick at 100 pcf; 80 cm depth
Masonry - Fired Brick - 60cm + Tile	272.38	Ref: ASCE 7-10, Table C3-1 – 60 cm of clay bricks (115 psf per 12") + 2x 3/4" ceramic tile on 1" mortar (23 psf ea)
Masonry - Fired Brick - 72cm + Plaster	276.65	Ref: ASCE 7-10, Table C3-1 – 72 cm of clay bricks (115 psf per 12") + plaster on tile or concrete (5 psf)
Earthen - 3' Rammed Earth (Low Income)	288.00	Ref: (1) 780 CMR, Table G-8, (2) WHE 14 - rammed earth wall 3' wide (dry earth 96 pcf)
Masonry - Fired Brick - 84cm + Plaster	321.93	Ref: ASCE 7-10, Table C3-1 – 84 cm of clay bricks (115 psf per 12") + plaster on tile or concrete (5 psf)
Masonry - Fired Brick - 96cm + Plaster (Very Thick Wall)	367.20	Ref: ASCE 7-10, Table C3-1 – 96 cm of clay bricks (115 psf per 12") + plaster on tile or concrete (5 psf)
Masonry - Stone - 3'	504.00	Ref: 780 CMR, Table G-8 - 3' masonry granite stone (168 pcf)

SUB-APPENDIX A8: ROOF DEAD LOAD

Roof and attic construction which is used to determine the roof density
Specifically the roof dead load excluding floor joists and roof/attic live load

Building Density Category: None (0 to 0.5 psf)

Name	Value (psf)	Notes
<i>no examples defined</i>		

Building Density Category: Extremely Light (0.5 to 2.5 psf)

Name	Value (psf)	Notes
Fabric - Lightweight	0.50	Ref: SME judgement for tents/awnings
Vegetative - 1" Thatch	1.90	Ref: (1) BC, (2) WHE 43, (3) 780 CMR, Table G-8 - 2.5 cm thatch (straw, 8 pcf) + 9 cm diameter logs spaced 60 cm on center (timber, 35 pcf)

Building Density Category: Very Light (2.5 to 7.5 psf)

Name	Value (psf)	Notes
Vegetative - 4" Thatch	3.90	Ref: (1) BC, (2) WHE 143, (3) 780 CMR, Table G-8 - 4" thatch (straw = 8 pcf) + 9 cm diameter logs spaced 60 cm on center (timber, 35 pcf)
Wood - Wood Shingles (Low Income)	4.24	Ref: (1) ASCE 7-10, Table C3-1, (2) 780 CMR, Table G-8 - wood shingles (3 psf) + 9 cm diameter logs spaced 60 cm on center (timber, 35 pcf)
Wood - Metal Sheets (Low Income)	4.24	Ref: (1) ASCE 7-10, Table C3-1, (2) 780 CMR, Table G-8 - 18 gage deck (3 psf) + 9 cm diameter logs spaced 60 cm on center (timber, 35 pcf)
Concrete - 0.5" Solid	5.21	Ref: ASCE 7-10, Table C3-1 - 0.5" solid 125 pcf concrete
Lightweight - Metal	5.50	Ref: (1) ASCE 7-10, Table C3-1, (2) INSDAG - 18 gage deck (3 psf) + steel trusses (2.5 psf)
Lightweight - Elastomeric (rubber)	7.00	Ref: (1) ASCE 7-10, Table C3-1, (2) INSDAG - 18 gage deck (3 psf) + smooth bituminous liquid waterproofing (1.5 psf) + steel trusses (2.5 psf)

Building Density Category: Light (7.5 to 20 psf)

Name	Value (psf)	Notes
Wood - Asphalt Shingles	8.75	Ref: ASCE 7-10, Table C3-1 - 2"x8" @ 16" spacing wood (6 psf), asphalt shingles (2 psf), 1/2" fiberboard (0.75 psf)
Wood - Wood Shingles	9.75	Ref: ASCE 7-10, Table C3-1 - 2"x8" @ 16" spacing wood (6 psf), wood shingles (3 psf), 1/2" fiberboard (0.75 psf)
Wood - Metal Sheets	9.75	Ref: ASCE 7-10, Table C3-1 - 2"x8" @ 16" spacing wood (6 psf), 18 gage deck (3 psf), 1/2" fiberboard (0.75 psf)
Wood - Elastomeric (rubber)	10.50	Ref: (1) ASCE 7-10, Table C3-1 - 2"x8" @ 16" spacing wood (6 psf) + 18 gage deck (3 psf) + smooth bituminous liquid waterproofing (1.5 psf)
Lightweight - Elastomeric (rubber) + Gravel	11.00	Ref: (1) ASCE 7-10, Table C3-1, (2) INSDAG - 18 gauge deck (3 psf) + bituminous w gravel (5.5 psf) + steel trusses (2.5 psf)
Wood - Elastomeric (rubber) + Gravel	14.50	Ref: (1) ASCE 7-10, Table C3-1 - 2"x8" @ 16" spacing wood (6 psf) + 18 gauge deck (3 psf per in) + bituminous w gravel (5.5 psf)
Wood - Mud (Thin)	14.90	Ref: (1) 780 CMR, Table G-8, (2) WHE 89 - 4cm mud plaster (dry earth, 96 pcf) + 9cm diameter logs spaced 60 cm on center (timber, 35 pcf) + 0.5" wood sheathing (3 psf per in)
Masonry - Slate Tile	17.50	Ref: ASCE 7-10, Table C3-1 - 2"x8" @ 16" spacing wood (6 psf) + 0.5" wood sheathing (3 psf per in) + 1/4" slate tile (10 psf)
Fabric	20.00	Ref: Cremers (2015) - Table 10.2 lists stadium fabric roofs ranging from 82 to 200 kg m ⁻² (includes support structures)

Building Density Category: Moderate (20 to 40 psf)

Name	Value (psf)	Notes
Concrete - 2" Solid	22.33	Ref: ASCE 7-10, Table C3-1 - 2" solid 125 pcf concrete + smooth bituminous liquid waterproofing (1.5 psf)
Masonry - Cement Tile	23.50	Ref: ASCE 7-10, Table C3-1 - 2"x8" @ 16" spacing wood (6 psf) + 0.5" wood sheathing (3 psf per in) + cement tile (16 psf)
Masonry - Clay Tile	27.50	Ref: ASCE 7-10, Table C3-1 - 2"x8" @ 16" spacing wood (6 psf) + 0.5" wood sheathing (3 psf per in) + clay tile (3" tile, 20 psf)
Masonry - Slate Tile w Mortar	27.50	Ref: ASCE 7-10, Table C3-1 - 2"x8" @ 16" spacing wood (6 psf) + 0.5" wood sheathing (3 psf per in) + 1/4" slate tile (10 psf) + mortar (10 psf)
Masonry - Cement Tile w Mortar	33.50	Ref: ASCE 7-10, Table C3-1 - 2"x8" @ 16" spacing wood (6 psf) + 0.5" wood sheathing (3 psf per in) + cement tile (16 psf) + mortar (10 psf)
Earthen - Wattle and Daub	35.11	Ref: (1) ASCE 7-10, Table C3-1, (2) 780 CMR, Table G-8 – 2"x6" 24" spacing (5 psf) + 0.5" wood planks (3 psf per in) + 10 cm wattle and daub w 1:5 wattle (timber) to mud (timber, 35 pcf; dry earth, 96 pcf)
Masonry - Clay Tile w Mortar	37.50	Ref: ASCE 7-10, Table C3-1 - 2"x8" @ 16" spacing wood (6 psf) + 0.5" wood sheathing (3 psf per in) + clay tile (3" tile = 20 psf) + mortar (10 psf)

Building Density Category: Heavy (40 to 75 psf)

Name	Value (psf)	Notes
Masonry - 10cm Fired Brick	42.73	Ref: ASCE 7-10, Table C3-1 - 10cm of clay bricks (115 psf per 12") + plaster on tile or concrete (5 psf)
Concrete - 4" Solid	43.17	Ref: ASCE 7-10, Table C3-1 - 4" solid 125 pcf concrete + smooth bituminous liquid waterproofing (1.5 psf)
Concrete - 6" Hollowcore	45.00	Ref: (1) FEMA 451, (2) Oldcastle - 6" E type Hollowcore, grouted (45 psf)
Masonry - Fired Brick Shallow Vault	47.00	Ref: Krah (1966), Figure 18 - Shallow brick vault w/ lightweight concrete fill and paving brick
Wood - Mud (Thick)	47.25	Ref: (1) 780 CMR, Table G-8, (2) WHE 89 - 5" mud (dry earth 96 pcf) + 2x 2"x6" @ 24" spacing wood (5 psf) + 0.75" wood planks (3 psf per in)
Concrete - 8" Hollowcore	54.00	Ref: (1) FEMA 451, (2) Oldcastle - 8" E type Hollowcore, grouted (54 psf)
Concrete Frame - Thin Terra Cotta Infill	59.11	Ref: (1) ASCE 7-10, Table C3-1, (2) BC, (3) 780 CMR, Table G-8, (4) WHE 11 – 40cm x 25 cm solid 125 pcf concrete spaced 4 m apart + 90% of 23 cm terra cotta (unfilled voids 72 pcf)
Concrete - Waffle Slab - 19" @ 24oc, 6" Rib Depth, 2.5" Slab	66.00	Ref: 780 CMR
Concrete - 6" Hollowcore + 2" topping	70.00	Ref: (1) FEMA 451, (2) Oldcastle - 6" E type Hollowcore, grouted (45 psf) + 2" topping (25 psf)
Concrete - Waffle Slab - 30" @ 36oc, 8" Rib Depth, 3" Slab	73.00	Ref: 780 CMR

Building Density Category: Very Heavy (75 to 150 psf)

Name	Value (psf)	Notes
Concrete - 8" Solid	83.33	Ref: ASCE 7-10, Table C3-1, (2) PCI - 8" solid 125 pcf concrete
Concrete - 8" Hollowcore + 2" topping	85.00	Ref: (1) FEMA 451, (2) Oldcastle - 8" H type Hollowcore, grouted (60 psf) + 2" topping (25 psf)
Concrete Frame - Brick Infill	91.29	Ref: (1) ASCE 7-10, Table C3-1, (2) BC, (3) WHE 11 – 40cm x 25 cm solid 125 pcf concrete spaced 3 m apart + 90% of 23 cm fired brick infill (115 pcf)
Concrete - 12" Hollowcore	95.00	Ref: (1) FEMA 451, (2) Oldcastle - 8" E type Hollowcore, grouted (95 psf)
Concrete - Waffle Slab - 19" @ 24oc, 12" Rib Depth, 2.5" Slab	101.00	Ref: 780 CMR
Concrete - 16" Hollowcore + 2" topping	120.00	Ref: (1) FEMA 451, (2) Oldcastle - 16" E type Hollowcore, grouted (95 psf) + 2" topping (25 psf)
Masonry - Fired Brick Barrel Vault - 8" thick	120.43	Ref: SME judgement - Assumes barrel dome with 8" length bricks clay bricks (115 pcf)
Masonry - Adobe Vault/Dome	123.00	Ref: WHE 177 - Roof weight typically ranges from 460 to 750 kg m ⁻² (using 600 kg m ⁻²)
Concrete - 12" Solid	125.00	Ref: (1) ASCE 7-10, Table C3-1, (2) PCI - 12" solid 125 pcf concrete
Concrete - Waffle Slab - 30" @ 36oc, 20" Rib Depth, 3" Slab	135.00	Ref: 780 CMR

Building Density Category: Extremely Heavy (>150 psf)

Name	Value (psf)	Notes
Masonry - Fired Brick Barrel Vault - 12" thick	180.64	Ref: SME judgement - assumes barrel dome with 1' length bricks clay bricks (115 pcf)

SUB-APPENDIX A9: JOIST DEAD LOAD

Floor-ceiling joist construction which is used to determine the joist density

Building Density Category: None (0 to 0.5 psf)

Name	Value (psf)	Notes
No Joists	0.00	

Building Density Category: Extremely Light (0.5 to 2.5 psf)

Name	Value (psf)	Notes
Wood - Lightweight	1.24	Ref: (1) 780 CMR, Table G-8, (2) WHE 89 – 9 cm diameter logs spaced 60 cm on center (timber, 35 pcf)
Metal - Steel Trusses	2.50	Ref: INSDAG - steel trusses (2.5 psf)

Building Density Category: Very Light (2.5 to 7.5 psf)

Name	Value (psf)	Notes
Wood - 6" cross beams, 2m oc	2.92	Ref: 780 CMR, Table G-8 - 2x 15 cm square solid wood beams spaced 2 m apart (timber, 35 pcf)
Wood - 2x6, 16"oc	5.00	Ref: ASCE 7-10, Table C3-1 - 2"x6" double wood joist @ 16" spacing (5 psf)
Wood - 12" cross beams, 4m oc	5.38	Ref: 780 CMR, Table G-8 - 2x 30 cm square solid wood beams spaced 4 m apart (timber, 35 pcf)
Wood - 2x10, 16"oc	6.00	Ref: ASCE 7-10, Table C3-1 - 2"x10" double wood joist @ 16" spacing (6 psf)
Metal - Steel Joists	6.00	Ref: FEMA 451 - 2x 90 plf steel beams spaced 30' apart (see Six-Story Steel Building in ref; avg value [girders range from 84 to 94 plf])
Wood - 2x12, 16"oc	7.00	Ref: ASCE 7-10, Table C3-1 - 2"x12" double joist @ 16" spacing wood (7 psf)

Building Density Category: Light (7.5 to 20 psf)

Name	Value (psf)	Notes
Wood - 3x10, 16"oc	8.00	Ref: 780 CMR, Table G-7 - 3"x10" double joist @ 16" spacing wood (8 psf)
Concrete - 12" Cross Beams 8m oc	9.62	Ref: 780 CMR, Table G-8 - 2x 30 cm square solid 125 pcf concrete spaced 8 m apart

Building Density Category: Moderate (20 to 40 psf)

Name	Value (psf)	Notes
Concrete - 12" Cross Beams 3m oc	25.00	Ref: 780 CMR, Table G-8 - 2x 30 cm square solid 125 pcf concrete spaced 3 m apart

Building Density Category: Heavy (40 to 75 psf)

Name	Value (psf)	Notes
Concrete - 12" Cross Beams 2m oc	41.67	Ref: 780 CMR, Table G-8 - 2x 30 cm square solid 125 pcf concrete spaced 2 m apart

Building Density Category: Very Heavy (75 to 150 psf)

Name	Value (psf)	Notes
<i>no examples defined</i>		

Building Density Category: Extremely Heavy (>150 psf)

Name	Value (psf)	Notes
<i>no examples defined</i>		

SUB-APPENDIX A10: CEILING DEAD LOAD

Ceiling construction which is used to determine the average ceiling density
Specifically the dead load of ceiling materials excluding the joists

Building Density Category: None (0 to 0.5 psf)

Name	Value (psf)	Notes
No Ceiling	0.00	Upper joists are exposed

Building Density Category: Extremely Light (0.5 to 2.5 psf)

Name	Value (psf)	Notes
Wood - Drywall (gypsum)	2.20	Ref: ASCE 7-10, Table C3-1 - gypsum board (2.2 psf per 1/2")

Building Density Category: Very Light (2.5 to 7.5 psf)

Name	Value (psf)	Notes
Masonry - Plaster	5.00	Ref: ASCE 7-10, Table C3-1 - plaster on tile or cement (5 psf)
Mechanical Ducts and Insulation	5.10	Ref: (1) ASCE 7-10, Table C3-1, (2) INSDAG - fiberglass insulation (1.1 psf) + mechanical ducts (4 psf)
Metal - Acoustical Panels + Ducts	7.00	Ref: ASCE 7-10, Table C3-1 - steel channel system (2 psf) + mechanical ducts (4 psf) + acoustical fiberboard (1 psf)

Building Density Category: Light (7.5 to 20 psf)

Name	Value (psf)	Notes
Wood - Plaster (wood lath)	8.00	Ref: ASCE 7-10, Table C3-1 - plaster on wood lath (8 psf)
Wood - Drywall Over Plaster (wood lath)	10.20	Ref: ASCE 7-10, Table C3-1 - plaster on wood lath (8 psf), gypsum board (2.2 psf per 1/2")
Metal - Cement Plaster (metal lath)	15.00	Ref: ASCE 7-10, Table C3-1 - plaster on metal lath (15 psf)

Building Density Category: Moderate (20 to 40 psf)

Name	Value (psf)	Notes
<i>no examples defined</i>		

Building Density Category: Heavy (40 to 75 psf)

Name	Value (psf)	Notes
<i>no examples defined</i>		

Building Density Category: Very Heavy (75 to 150 psf)

Name	Value (psf)	Notes
<i>no examples defined</i>		

Building Density Category: Extremely Heavy (>150 psf)

Name	Value (psf)	Notes
<i>no examples defined</i>		

SUB-APPENDIX A11: FLOOR DEAD LOAD

Floor construction which is used to determine the average floor density
Specifically the dead load of floor materials excluding the joists

Building Density Category: None (0 to 0.5 psf)

Name	Value (psf)	Notes
<i>no examples defined</i>		

Building Density Category: Extremely Light (0.5 to 2.5 psf)

Name	Value (psf)	Notes
Wood - Thin Planks	1.46	Ref: 780 CMR, Table G-8 - 1/2" wood (timber, 35 pcf)
Lightweight - Composite Panel	2.00	Ref: SME judgement

Building Density Category: Very Light (2.5 to 7.5 psf)

Name	Value (psf)	Notes
Wood – Resilient	4.00	Ref: ASCE 7-10, Table C3-1 - 3/4" sub-flooring (3 psf), 1/4" linoleum floor (1 psf)
Wood – Carpet	5.00	Ref: (1) ASCE 7-10, Table C3-1 and (2) BC - 3/4" sub-flooring (3 psf), carpet and pad (2 psf)
Wood – Hardwood	6.00	Ref: ASCE 7-10, Table C3-1 - 3/4" sub-flooring (3 psf), 3/4" hardwood floor (3 psf)

Building Density Category: Light (7.5 to 20 psf)

Name	Value (psf)	Notes
Earthen - 4cm Mud	12.80	Ref: (1) 780 CMR, Table G-8, (2) WHE 89 – 4 cm mud plaster (dry earth 96 pcf)
Masonry - 3/4" Ceramic or Quarry Tile	16.00	Ref: ASCE 7-10, Table C3-1 - ceramic or quarry tile on 1/2" mortar bed (16 psf)
Wood - Ceramic/Slate Tile	19.00	Ref: ASCE 7-10, Table C3-1 - 3/4" sub-flooring (3 psf), 3/4" ceramic tile on 1/2" mortar (16 psf)

Building Density Category: Moderate (20 to 40 psf)

Name	Value (psf)	Notes
Concrete - 2" Solid	20.83	Ref: ASCE 7-10, Table C3-1 - 2" solid 125 pcf concrete
Concrete - 2" w Carpet	22.83	Ref: ASCE 7-10, Table C3-1 and (2) BC - 2" solid 125 pcf concrete, carpet and pad (2 psf)
Earthen - 2" mud + wood planks	27.67	Ref: (1) 780 CMR, Table G-8, (2) WHE 116 - 4" wood planks (timber, 35 pcf) + 2" mud (dry earth, 96 pcf)
Earthen - Wattle and Daub	30.11	Ref: (1) ASCE 7-10, Table C3-1, (2) 780 CMR, Table G-8 - 0.5" wood planks (3 psf per in) + 10 cm wattle and daub w 1:5 wattle (timber) to mud (timber, 35 pcf; dry earth, 96 pcf)
Concrete - 2" w 1" Terrazzo	32.00	Ref: ASCE 7-10, Table C3-1 - terrazzo (1") on 2" stone concrete (32 psf)
Masonry - Stone	33.00	Ref: ASCE 7-10, Table C3-1 - marble and mortar of stone-concrete fill (33 psf)

Building Density Category: Heavy (40 to 75 psf)

Name	Value (psf)	Notes
Concrete - 4" Solid	41.67	Ref: ASCE 7-10, Table C3-1 - 4" solid 125 pcf concrete
Concrete - 4" w Carpet	43.67	Ref: ASCE 7-10, Table C3-1 and (2) BC - 4" solid 125 pcf concrete, carpet and pad (2 psf)
Concrete - 6" Hollowcore	45.00	Ref: (1) FEMA 451, (2) Oldcastle - 6" E type Hollowcore, grouted (45 psf)
Masonry - Fired Brick Shallow Vault	47.00	Ref: Krael (1966), Figure 18 - shallow brick vault w/ lightweight concrete fill and paving brick
Concrete - 8" Hollowcore	54.00	Ref: (1) FEMA 451, (2) Oldcastle - 8" E type Hollowcore, grouted (54 psf)
Concrete Frame - Thin Terra Cotta Infill	59.11	Ref: (1) ASCE 7-10, Table C3-1, (2) BC, (3) 780 CMR, Table G-8, (4) WHE 11 – 40 cm x 25 cm solid 125 pcf concrete spaced 4 m apart + 90% of 23 cm terra cotta (unfilled voids 72 pcf)
Concrete - 6" Solid	62.50	Ref: ASCE 7-10, Table C3-1 - 6" solid 125 pcf concrete
Concrete - Waffle Slab - 19" @ 24oc, 6" Rib Depth, 2.5" Slab	66.00	Ref: 780 CMR
Concrete - 6" Hollowcore + 2" topping	70.00	Ref: (1) FEMA 451, (2) Oldcastle - 6" E type Hollowcore, grouted (45 psf) + 2" topping (25 psf)

Building Density Category: Heavy (40 to 75 psf), cont'd

Name	Value (psf)	Notes
Concrete - Waffle Slab - 30" @ 36oc, 8" Rib Depth, 3" Slab	73.00	Ref: 780 CMR

Building Density Category: Very Heavy (75 to 150 psf)

Name	Value (psf)	Notes
Concrete - 8" Solid	83.33	Ref: (1) ASCE 7-10, Table C3-1, (2) PCI - 8" solid 125 pcf concrete
Concrete - 8" Hollowcore + 2" topping	85.00	Ref: (1) FEMA 451, (2) Oldcastle, 8" H type Hollowcore, grouted (60 psf) + 2" topping (25 psf)
Concrete Frame - Brick Infill	91.29	Ref: (1) ASCE 7-10, Table C3-1, (2) BC, (3) WHE 11 – 40 cm x 25 cm solid 125 pcf concrete spaced 3 m apart + 90% of 23 cm fired brick infill (115 pcf)
Concrete - 12" Hollowcore	95.00	Ref: (1) FEMA 451, (2) Oldcastle, 8" E type Hollowcore, grouted (95 psf)
Concrete - Waffle Slab - 19" @ 24oc, 12" Rib Depth, 2.5" Slab	101.00	Ref: 780 CMR
Concrete - 16" Hollowcore + 2" topping	120.00	Ref: (1) FEMA 451, (2) Oldcastle, 16" E type Hollowcore, grouted (95 psf) + 2" topping (25 psf)
Concrete - 12" Solid	125.00	Ref: (1) ASCE 7-10, Table C3-1, (2) PCI - 12" solid 125 pcf concrete
Concrete - Waffle Slab - 30" @ 36oc, 20" Rib Depth, 3" Slab	135.00	Ref: 780 CMR
Concrete - 8" Solid	83.33	Ref: ASCE 7-10, Table C3-1, (2) PCI - 8" solid 125 pcf concrete
Concrete - 8" Hollowcore + 2" topping	85.00	Ref: (1) FEMA 451, (2) Oldcastle, 8" H type Hollowcore, grouted (60 psf) + 2" topping (25 psf)
Concrete Frame - Brick Infill	91.29	Ref: (1) ASCE 7-10, Table C3-1, (2) BC, (3) WHE 11 – 40 cm x 25 cm solid 125 pcf concrete spaced 3 m apart + 90% of 23 cm fired brick infill (115 pcf)
Concrete - 12" Hollowcore	95.00	Ref: (1) FEMA 451, (2) Oldcastle, 8" E type Hollowcore, grouted (95 psf)
Concrete - Waffle Slab - 19" @ 24oc, 12" Rib Depth, 2.5" Slab	101.00	Ref: 780 CMR
Concrete - 16" Hollowcore + 2" topping	120.00	Ref: (1) FEMA 451, (2) Oldcastle, 16" E type Hollowcore, grouted (95 psf) + 2" topping (25 psf)

Building Density Category: Very Heavy (75 to 150 psf), cont'd

Name	Value (psf)	Notes
Concrete - 12" Solid	125.00	Ref: (1) ASCE 7-10, Table C3-1, (2) PCI - 12" solid 125 pcf concrete
Concrete - Waffle Slab - 30" @ 36oc, 20" Rib Depth, 3" Slab	135.00	Ref: 780 CMR

Building Density Category: Extremely Heavy (>150 psf)

Name	Value (psf)	Notes
<i>no examples defined</i>		

SUB-APPENDIX A12: LIVE LOAD

Building contents that contribute to the overall interior density
Specifically the live load for a basement, above ground story, or attic

Building Density Category: None (0 to 0.5 psf)

Name	Value (psf)	Notes
Empty	0.00	
Office - Light	0.00	Ref: ASCE 7-10 Tables 4-1 and C4-2 - live load: office (50 psf) * typical (20%) - 2*sigma (2*5.9). Value is rounded to zero.

Building Density Category: Extremely Light (0.5 to 2.5 psf)

Name	Value (psf)	Notes
Residential - Light	0.80	Ref: ASCE 7-10 Tables 4-1 and C4-2 and Section 12.7.2 - live load: (a) residential, all other areas and (b) penal cell blocks (40 psf) * typical (15%) - 2 sigma (2* 2.6 psf)
Insulated Attic/Roof	1.50	Ref: ASCE 7-10, Table C3-1 - 1" rigid insulation (0.75 psf per 1/2")

Building Density Category: Very Light (2.5 to 7.5 psf)

Name	Value (psf)	Notes
Residential - Typical	6.00	Ref: ASCE 7-10 Tables 4-1 and C4-2 and Section 12.7.2 - live load: (a) residential, all other areas and (b) penal cell blocks (40 psf) * 15%
Agriculture - Poultry - Quarter Max	6.25	Ref: (1) H-20 and (2) ASCE 7-10 Section 12.7.2 - live load: (a) chickens (floor houses) and (b) turkeys (25 psf) * 25%
School - Light	6.60	Ref: ASCE 7-10 Tables 4-1 and C4-2 - live load: school classrooms (40 psf) * typical (30%) - 2*sigma (2 * 2.7psf)

Building Density Category: Light (7.5 to 20 psf)

Name	Value (psf)	Notes
Parking Garage - Quarter Max	10.00	Ref: ASCE 7-10 Table 4-1 - live load: garages - passenger vehicles (40 psf) * 25%
Residential - Heavy	11.20	Ref: ASCE 7-10 Tables 4-1 and C4-2 and Section 12.7.2 - live Load: (a) residential, all other areas and (b) penal cell blocks (40 psf) * typical (15%) + 2 sigma (2* 2.6 psf)
School - Typical	12.00	Ref: ASCE 7-10 Tables 4-1 and C4-2 - live load: school classrooms (40 psf) * 30%
Hospital - Quarter Max	12.50	Ref: ASCE 7-10 Tables 4-1 and C4-2 - live load: hospital operating and patient rooms (40 to 60 psf) * 25%
Agriculture - Swine/Sheep - Quarter Max	12.50	Ref: (1) H-20 and (2) ASCE 7-10 Section 12.7.2 - live load: (a) swine (200 lbs), (b) sheep (ewes, rams) (50 psf) * 25%
Agriculture - Poultry - Half Max	12.50	Ref: (1) H-20 and (2) ASCE 7-10 Section 12.7.2 - live load: (a) chickens (floor houses) and (b) turkeys (25 psf) * 50%
School - Heavy	17.40	Ref: ASCE 7-10 Tables 4-1 and C4-2 - live load: school classrooms (40 psf) * typical (30%) + 2*sigma (2 * 2.7psf)

Building Density Category: Moderate (20 to 40 psf)

Name	Value (psf)	Notes
Residential Storage	20.00	Ref: ASCE 7-10 Table 4-1 - live load: storage area above ceilings (20 psf)
Parking Garage - Half Max	20.00	Ref: ASCE 7-10 Table 4-1 - live load: garages - passenger vehicles (40 psf) * 50%
Office - Heavy	21.80	Ref: ASCE 7-10 Tables 4-1 and C4-2 - live load: office (50 psf) * typical (20%) + 2*sigma (2*5.9).
Hospital - Half Max	25.00	Ref: ASCE 7-10 Tables 4-1 and C4-2 - live load: hospital operating and patient rooms (40 to 60 psf) * 50%
Laboratory - Quarter Max	25.00	Ref: ASCE 7-10 Tables 4-1, C4-1, and C4-2 - live load: scientific laboratories (100 psf) * 25%
Agriculture - Cattle/Horses - Quarter Max	25.00	Ref: (1) H-20 and (2) ASCE 7-10 Section 12.7.2 - live load: (a) beef cattle (feeders/breeders), (b) dairy cattle (mature), (c) horses (100 psf) * 25%
Agriculture - Swine/Sheep - Half Max	25.00	Ref: (1) H-20 and (2) ASCE 7-10 Section 12.7.2 - live load: (a) swine (200 lbs), (b) sheep (ewes, rams) (50 psf) * 50%

Building Density Category: Moderate (20 to 40 psf), con'd

Name	Value (psf)	Notes
Restaurant - Quarter Max	25.00	Ref: ASCE 7-10 Tables 4-1, C4-1, and C4-2 - live load: dining rooms and restaurants (100 psf)*25%
Recreational/Assembly - Quarter Max	25.00	Ref: ASCE 7-10 Tables 4-1, C4-1, and C4-2 - live load: assembly areas/theaters - movable seats (100 psf)*25%
Store - Quarter Max	25.00	Ref: ASCE 7-10 Tables 4-1, C4-1, and C4-2 - live load: store - first floor (100 psf)*25%
Library - Quarter Max	25.00	Ref: ASCE 7-10 Table 4-1 and Section 12.7.2 - live load: library - midrange of stacks, corridors, and reading rooms (100 psf)*25%
Light Manuf/Warehouse - Quarter Max	31.25	Ref: ASCE 7-10 Table 4-1 and Section 12.7.2 - live load: light (a) manuf and (b) warehouses (125 psf) * 25%
Agriculture - Greenhouses - Quarter Max	37.50	Ref: ASCE 7-10 Table C4-1 - live load: greenhouses (150 psf) * 25%
Parking Garage - Max	40.00	Ref: ASCE 7-10 Table 4-1 - live load: garages - passenger vehicles (40 psf)

Building Density Category: Heavy (40 to 75 psf)

Name	Value (psf)	Notes
Laboratory - Half Max	50.00	Ref: ASCE 7-10 Tables 4-1, C4-1, and C4-2 - live load: scientific laboratories (100 psf)*50%
Agriculture - Cattle/Horses - Half Max	50.00	Ref: (1) H-20 and (2) ASCE 7-10 Section 12.7.2 - live load: (a) beef cattle (feeders/breeders), (b) dairy cattle (mature), (c) horses (100 psf) * 50%
Restaurant - Half Max	50.00	Ref: ASCE 7-10 Tables 4-1, C4-1, and C4-2 - live load: dining rooms and restaurants (100 psf)*50%
Recreational/Assembly - Half Max	50.00	Ref: ASCE 7-10 Tables 4-1, C4-1, and C4-2 - live load: assembly areas/theaters - movable seats (100 psf)*50%
Store - Half Max	50.00	Ref: ASCE 7-10 Tables 4-1, C4-1, and C4-2 - live load: store - first floor (100 psf)*50%
Library - Half Max	50.00	Ref: ASCE 7-10 Table 4-1 - live load: library - midrange of stacks, corridors, and reading rooms (100 psf)*50%
Light Manuf/Warehouse - Half Max	62.50	Ref: ASCE 7-10 Table 4-1 and Section 12.7.2 - live load: light (a) manuf and (b) warehouses (125 psf) * 50%

Building Density Category: Heavy (40 to 75 psf), cont'd

Name	Value (psf)	Notes
Heavy Manuf/Warehouse - Quarter Max	62.50	Ref: ASCE 7-10 Table 4-1 and Section 12.7.2 - live load: heavy (a) manuf and (b) warehouses (250 psf) * 25%
Agriculture - Greenhouses - Half Max	75.00	Ref: ASCE 7-10 Table C4-1 - live load: greenhouses (150 psf) * 50%

Building Density Category: Very Heavy (75 to 150 psf)

Name	Value (psf)	Notes
Restaurant - Max	100.00	Ref: ASCE 7-10 Tables 4-1, C4-1, and C4-2 - live load: dining rooms and restaurants (100 psf)
Recreational/Assembly - Max	100.00	Ref: ASCE 7-10 Tables 4-1, C4-1, and C4-2 - live load: assembly areas/theaters - movable seats (100 psf)
Store - Max	100.00	Ref: ASCE 7-10 Tables 4-1, C4-1, and C4-2 - live load: store - first floor (100 psf)
Library - Max	100.00	Ref: ASCE 7-10 Table 4-1 - live load: library - midrange of stacks, corridors, and reading rooms (100 psf)
Bus station	100.00	Ref: PA - NY/NJ Port Authority Bus Terminal, Section 3.2.1.6 (100 psf typ when bus in station and pedestrian areas)
Light Manuf/Warehouse - Max	125.00	Ref: ASCE 7-10 Table 4-1 and Section 12.7.2 - live load: light (a) manuf and (b) warehouses (125 psf)
Heavy Manuf/Warehouse - Half Max	125.00	Ref: ASCE 7-10 Table 4-1 and Section 12.7.2 - live load: heavy (a) manuf and (b) warehouses (250 psf)

Building Density Category: Extremely Heavy (>150 psf)

Name	Value (psf)	Notes
Heavy Manuf/Warehouse - Max	250.00	Ref: ASCE 7-10 Table 4-1 and Section 12.7.2 - live load: heavy (a) manuf and (b) warehouses (250 psf)

SUB-APPENDIX A13: INTERIOR WALLS AND COLUMNS DEAD LOAD

Interior and partition wall construction that contributes to the overall interior density

Building Density Category: None (0 to 0.5 psf)

Name	Value (psf)	Notes
No Interior Walls or Columns	0.00	
Columns - 6" Square Timbers	0.41	Ref: 780 CMR, Table G-8 – 15 cm square solid wood beams (timber, 35 pcf), 16 ft on center spacing, 12' height

Building Density Category: Extremely Light (0.5 to 2.5 psf)

Name	Value (psf)	Notes
Columns - 12" Square Timbers	1.64	Ref: 780 CMR, Table G-8 – 30 cm square solid wood beams (timber, 35 pcf), 16 ft on center spacing, 12' height
Columns - Steel	2.45	Ref: FEMA 451 - 160 plf steel, 28 ft on center spacing, 12' height (6-story steel frame building, range of 123-200 plf steel column)

Building Density Category: Very Light (2.5 to 7.5 psf)

Name	Value (psf)	Notes
Columns - Concrete Column	5.86	Ref: ASCE 7-10, Table C3-1 – 30 cm square solid 125 pcf concrete, 16 ft on center spacing, 12' height

Building Density Category: Light (7.5 to 20 psf)

Name	Value (psf)	Notes
Interior Walls - Cemesto walls	9.69	Ref: (1) 780 CMR, Table G-8, (2) Kelly, (3) Cemesto - Cemesto walls in wood frame, 4" square posts spaced 3.3 m on center (timber, 35 pcf) + 2" Cemesto structural insulating panel (5.4 psf), 16x16x12 ft rooms
Interior Walls - Drywall	12.00	Ref: ASCE 7-10, Table C3-1 - wood or steel studs, 1/2" gypsum board on both sides (8 psf), 16x16x12 ft rooms
Interior Walls and Column - Lightweight partitions + 6" Square Timbers	12.41	Ref: (1) ASCE 7-10, Table C3-1, (2) 780 CMR, Table G-8 - wood or steel studs, 1/2" gypsum board on both sides (8 psf) + 15 cm square solid wood beams (timber, 35 pcf), 16 ft on center spacing, 12' height
Interior Walls and Columns - Lightweight partitions + Well Spaced Concrete Column	12.48	Ref: ASCE 7-10, Table C3-1 - wood or steel studs, 1/2" gypsum board on both sides (8 psf), 22x22x12 ft rooms + 30 cm square solid 125 pcf concrete, 20 ft on center spacing, 12' height
Interior Walls and Column - Lightweight partitions + 12" Square Timbers	13.64	Ref: (1) ASCE 7-10, Table C3-1, (2) 780 CMR, Table G-8 - wood or steel studs, 1/2" gypsum board on both sides (8 psf) + 30 cm square solid wood beams (timber, 35 pcf), 16 ft on center spacing, 12' height
Interior Walls and Columns - Lightweight Partition + Steel Column, Large Rooms	14.09	Ref: ASCE 7-10, Table C3-1 - wood or steel studs, 1/2" gypsum board on both sides (8 psf), 65x65x26 ft rooms + 200 plf Steel Column w 26' on center spacing
Interior Walls and Columns - Lightweight Partition + Steel Column	15.55	Ref: ASCE 7-10, Table C3-1 - wood or steel studs, 1/2" gypsum board on both sides (8 psf), 16x16x12 ft rooms + 200 plf Steel Column w 26' on center spacing

Building Density Category: Moderate (20 to 40 psf)

Name	Value (psf)	Notes
Interior Walls and Column - Lightweight partitions + 40cm Square Concrete Columns	21.90	Ref: (1) ASCE 7-10, Table C3-1, (2) 780 CMR, Table G-8 - wood or steel studs, 1/2" gypsum board on both sides (8 psf) + 40 cm square solid 125 pcf concrete, 16 ft on center spacing, 12' height
Interior Walls - Masonry, 4.2cm Fired Brick	23.77	Ref: (1) ASCE 7-10, Table C3-1, (2) WHE 24 - 4.2 cm of clay bricks (115 psf per 12"), 16x16x12 ft rooms
Interior Walls - 6" Log Walls	26.25	Ref: (1) 780 CMR, Table G-8, (2) WHE 56 – 15 cm solid logs (timber, 35 pcf), 16x16x12 ft rooms
Central Concrete Pylon + Lightweight Partition	26.56	Ref: (1) ASCE 7-10, Table C3-1, (2) 780 CMR, Table G-8 - wood or steel studs, 1/2" gypsum board on both sides (8 psf), 16x16x12 ft rooms + 10 m x 10 m 30 cm solid concrete (125 pcf) over 1,225 m ² area
Interior Walls - Plaster	30.00	Ref: ASCE 7-10, Table C3-1 - 2"x4" wood studs, plaster on two sides (20 psf), 16x16x12 ft rooms
Interior Walls and Columns - Lightweight partitions + Heavy Concrete Column	32.16	Ref: (1) ASCE 7-10, Table C3-1, (2) FEMA 451 - wood or steel studs, 1/2" gypsum board on both sides (8 psf), 22x22x12 ft rooms + 30" square solid 125 pcf concrete, 20 ft on center spacing, 12' height, see. Fig 6-24 in FEMA 451
Interior Walls - Drywall Over Plaster	36.60	Ref: ASCE 7-10, Table C3-1 - 2"x4" wood studs, plaster on two sides (20 psf) + 2x 1/2" gypsum board (2.2 psf ea), 16x16x12 ft rooms
Interior Walls - Masonry, 4.2cm Fired Brick + Plaster	38.77	Ref: (1) ASCE 7-10, Table C3-1, (2) WHE 24 - 4.2 cm of clay bricks (115 psf per 12") + 2x plaster on tile or concrete (5 psf) , 16x16x12 ft rooms
Interior Walls - Masonry, 4" Concrete Block, Unreinforced	39.00	Ref: ASCE 7-10, Table C3-1 - 4" 125 pcf concrete blocks, no grout (26 psf), 16x16x12 ft rooms

Building Density Category: Heavy (40 to 75 psf)

Name	Value (psf)	Notes
Interior Walls and Columns - Masonry, 4" Concrete Block, Unreinforced + Concrete Column	44.86	Ref: ASCE 7-10, Table C3-1 - 4" 125 pcf concrete blocks, no grout (26 psf) , 16x16x12 ft rooms + 30 cm square solid 125 pcf concrete, 16 ft on center spacing, 12' height
Interior Walls - Masonry, 35cm Fired Brick - Large Room	51.12	Ref: ASCE 7-10, Table C3-1 – 35 cm of clay bricks (115 psf per 12") , 62x62x12 ft rooms
Interior Walls - 12" Log Walls	52.50	Ref: (1) 780 CMR, Table G-8, (2) WHE 56 – 1 ft solid logs (timber, 35 pcf), 16x16x12 ft rooms
Interior Walls and Columns - Lightweight partitions + Tightly Spaced Concrete Column	53.67	Ref: ASCE 7-10, Table C3-1 - wood or steel studs, 1/2" gypsum board on both sides (8 psf), 16x16x12 ft rooms + 30 cm square solid 125 pcf concrete, 6 ft on center spacing, 12' height
Interior Walls - Masonry, 4" Concrete Block, Unreinforced + Plaster	54.00	Ref: ASCE 7-10, Table C3-1 - 4" 125 pcf concrete blocks, no grout (26 psf) + 2x plaster on tile or concrete (5 psf), 16x16x12 ft rooms
Interior Walls - Masonry, 8" Concrete Block, Unreinforced	54.00	Ref: ASCE 7-10, Table C3-1 - 8" 125 pcf concrete blocks, no grout (36 psf) , 16x16x12 ft rooms
Interior Walls and Columns - Masonry, 4" Concrete Block w Plaster, Unreinforced + Concrete Column	59.86	Ref: ASCE 7-10, Table C3-1 - 4" 125 pcf concrete blocks, no grout (26 psf) + 2x plaster on tile or concrete (5 psf), 16x16x12 ft rooms + 30 cm square solid 125 pcf concrete, 16 ft on center spacing, 12' height
Interior Walls - Half-Timber, Thin Wall (Wattle and Daub)	60.56	Ref: (1) 780 CMR, Table G-8 - 6" walls, ~10% of area is timber posts/lintels, 90% wattle and daub w 1" wattle (timber), 5" mud (timber, 35 pcf; dry earth, 96 pcf), 16x16x12 ft rooms
Interior Walls - Concrete 4"	62.50	Ref: ASCE 7-10, Table C3-1 - 4" solid 125 pcf concrete, 16x16x12 ft rooms
Interior Walls and Column - Brick Walls + Concrete Columns	63.75	Ref: (1) ASCE 7-10, Table C3-1, (2) 780 CMR, Table G-8 - 4" clay brick (115 psf per 12") + 40 cm x 25 cm solid 125 pcf concrete, 16 ft on center spacing, 12' height
Interior Walls and Columns - Masonry, 4" Concrete Block, Unreinforced + Steel Column	72.31	Ref: ASCE 7-10, Table C3-1 - 4" 125 pcf concrete blocks, no grout (26 psf) , 26x26x26 ft rooms + 200 plf Steel Column w 16' on center spacing

Building Density Category: Very Heavy (75 to 150 psf)

Name	Value (psf)	Notes
Columns - 3' Diameter Fired Brick	76.21	Ref: ASCE 7-10, Table C3-1 - fired clay bricks (115 pcf), 16 ft on center spacing, 24' height
Interior Walls and Column - Brick Walls w Plaster + Concrete Columns	78.75	Ref: (1) ASCE 7-10, Table C3-1, (2) 780 CMR, Table G-8 - 4" clay brick (115 psf per 12") + 2x plaster on tile or concrete (5 psf) + 40 cm x 25 cm solid 125 pcf concrete, 16 ft on center spacing, 12' height
Interior Walls - Masonry, 6" Adobe Brick + Plaster	90.00	Ref: Ninaquispe-Romero (2016) - adobe brick at 100 pcf; 15 cm depth + 2x plaster on tile or concrete (5 psf), 16x16x12 ft rooms
Interior Walls - Concrete 6"	93.75	Ref: ASCE 7-10, Table C3-1 - 6" solid 125 pcf concrete, 16x16x12 ft rooms
Interior Walls - Masonry, 8" Concrete Block, 16" oc + Plaster	103.50	Ref: ASCE 7-10, Table C3-1 - 8" 125 pcf concrete blocks, 16" on center (59 psf) + 2x plaster on tile or concrete (5 psf), 16x16x12 ft rooms
Columns - 3' Diameter Stone	111.33	Ref: 780 CMR - 3' masonry granite stone (168 pcf), 16 ft on center spacing, 24' height
Interior Walls - Masonry, 8" Concrete Block, full grout	121.50	Ref: ASCE 7-10, Table C3-1 - 8" 125 pcf concrete blocks, full grout (81 psf), 16x16x12 ft rooms
Interior Walls - Masonry, 9" Fired Brick + Plaster	145.17	Ref: ASCE 7-10, Table C3-1 – 23 cm of clay bricks (115 psf per 12") + 2x plaster on tile or concrete (5 psf) , 16x16x12 ft rooms
Interior Walls and Column - Terracotta Infill + Concrete Columns	146.65	Ref: (1) ASCE 7-10, Table C3-1, (2) 780 CMR, Table G-8 – 40 cm terra cotta (unfilled voids 72 pcf) + 40 cm x 25 cm solid 125 pcf concrete, 16 ft on center spacing, 12' height

Building Density Category: Extremely Heavy (>150 psf)

Name	Value (psf)	Notes
Interior Walls and Column - Terracotta Infill w Plaster + Concrete Columns	161.65	Ref: (1) ASCE 7-10, Table C3-1, (2) 780 CMR, Table G-8 – 40 cm terra cotta (unfilled voids 72 pcf) + 2x plaster on tile or concrete (5 psf) + 40 cm x 25 cm solid 125 pcf concrete, 16 ft on center spacing, 12' height
Interior Walls - Masonry - 8" Stone	168.00	Ref: 780 CMR – 20 cm masonry granite stone (168 pcf), 16x16x12 ft rooms
Interior Walls - Masonry, 35cm Fired Brick + Plaster	213.08	Ref: ASCE 7-10, Table C3-1 – 35 cm of clay bricks (115 psf per 12") + 2x plaster on tile or concrete (5 psf), 16x16x12 ft rooms
Interior Walls - 1.5' Earthen	216.00	Ref: (1) 780 CMR, Table G-8, (2) WHE 171 - rammed earth wall 0.5 m wide (dry earth 96 pcf), 16x16x12 ft rooms
Interior Walls - Masonry - 80cm Adobe Brick + Plaster	408.00	Ref: Ninaquispe-Romero (2016) - adobe brick at 100 pcf; 80 cm depth + 2x plaster on tile or concrete (5 psf), 16x16x12 ft rooms

SUB-APPENDIX A14: WINDOW PERCENT

Percent of floor to ceiling external wall area that contains a window

Aperture Category: None (0 to 0.5 % of exterior wall area)

Name	Value (%)	Notes
Large Mall	0.50	Ref: SME judgment - Large, covered shopping mall

Aperture Category: Occasional (0.5 to 2.5 % of exterior wall area)

Name	Value (%)	Notes
Large, Masonry Industrial - Low	1.60	Ref: UTBT Table 12 - percentage of front wall for mass construction building types (assumes all walls have similar amounts of windows)
Light Clad Industrial - Low	2.10	Ref: UTBT Table 13 - percentage of front wall for framed construction building types (assumes all walls have similar amounts of windows)

Aperture Category: Few (2.5 to 7.5 % of exterior wall area)

Name	Value (%)	Notes
CMU House - Low	3.90	Ref: UTBT Table 12 - percentage of front wall for mass construction building types (assumes all walls have similar amounts of windows)
Light Clad Industrial - Average	4.40	Ref: UTBT Table 13 - percentage of front wall for framed construction building types (assumes all walls have similar amounts of windows)
Stone House - Low	4.60	Ref: UTBT Table 12 - percentage of front wall for mass construction building types (assumes all walls have similar amounts of windows)
Parking - Closed Sides	5.00	Ref: SME judgment - Parking structure shielding from surroundings through use of tall berms or barrier walls
Brick House - Low	5.30	Ref: UTBT Table 12 - percentage of front wall for mass construction building types (assumes all walls have similar amounts of windows)
Brick Row House - Low	5.40	Ref: UTBT Table 12 - percentage of front wall for mass construction building types (assumes all walls have similar amounts of windows)

Aperture Category: Few (2.5 to 7.5 % of exterior wall area), cont'd

Name	Value (%)	Notes
Brick Industrial - Low	6.40	Ref: UTBT Table 12 - percentage of front wall for mass construction building types (assumes all walls have similar amounts of windows)
Adobe House	6.50	Ref: UTBT Table 12 - percentage of front wall for mass construction building types (assumes all walls have similar amounts of windows)
Light Clad Industrial - High	7.20	Ref: UTBT Table 13 - percentage of front wall for framed construction building types (assumes all walls have similar amounts of windows)

Aperture Category: Some (7.5 to 15 % of exterior wall area)

Name	Value (%)	Notes
Stone House - Average	7.80	Ref: UTBT Table 12 - percentage of front wall for mass construction building types (assumes all walls have similar amounts of windows)
Wood Frame House - Low	7.80	Ref: UTBT Table 13 - percentage of front wall for framed construction building types (assumes all walls have similar amounts of windows)
Large, Masonry Industrial - Average	8.50	Ref: UTBT Table 12 - percentage of front wall for mass construction building types (assumes all walls have similar amounts of windows)
Stone House - Average	7.80	Ref: UTBT Table 12 - percentage of front wall for mass construction building types (assumes all walls have similar amounts of windows)
Wood Frame House - Low	7.80	Ref: UTBT Table 13 - percentage of front wall for framed construction building types (assumes all walls have similar amounts of windows)
Large, Masonry Industrial - Average	8.50	Ref: UTBT Table 12 - percentage of front wall for mass construction building types (assumes all walls have similar amounts of windows)
Wood Frame House - Average	9.10	Ref: UTBT Table 13 - percentage of front wall for framed construction building types (assumes all walls have similar amounts of windows)
Light Clad Infill Wall Apartment - Low	9.30	Ref: UTBT Table 13 - percentage of front wall for framed construction building types (assumes all walls have similar amounts of windows)
Brick Office - Low	9.90	Ref: UTBT Table 12 - percentage of front wall for mass construction building types (assumes all walls have similar amounts of windows)
CMU House - Average	10.10	Ref: UTBT Table 12 - percentage of front wall for mass construction building types (assumes all walls have similar amounts of windows)

Aperture Category: Some (7.5 to 15 % of exterior wall area), cont'd

Name	Value (%)	Notes
Brick Apartment - Low	10.40	Ref: UTBT Table 12 - percentage of front wall for mass construction building types (assumes all walls have similar amounts of windows)
Light Clad Curtain Wall Hotel - Low	10.70	Ref: UTBT Table 13 - percentage of front wall for framed construction building types (assumes all walls have similar amounts of windows)
Wood Frame House - High	11.20	Ref: UTBT Table 13 - percentage of front wall for framed construction building types (assumes all walls have similar amounts of windows)
Light Clad Infill Wall Office - Low	11.30	Ref: UTBT Table 13 - percentage of front wall for framed construction building types (assumes all walls have similar amounts of windows)
Brick Row House - Average	12.10	Ref: UTBT Table 12 - percentage of front wall for mass construction building types (assumes all walls have similar amounts of windows)
Heavy Clad Hotel - Low	12.10	Ref: UTBT Table 13 - percentage of front wall for framed construction building types (assumes all walls have similar amounts of windows)
Brick Hotel - Low	12.40	Ref: UTBT Table 12 - percentage of front wall for mass construction building types (assumes all walls have similar amounts of windows)
Stone House - High	12.50	Ref: UTBT Table 12 - percentage of front wall for mass construction building types (assumes all walls have similar amounts of windows)
Brick Apartment - Average	13.10	Ref: UTBT Table 12 - percentage of front wall for mass construction building types (assumes all walls have similar amounts of windows)
Light Clad Curtain Wall Apartment - Low	13.30	Ref: UTBT Table 13 - percentage of front wall for framed construction building types (assumes all walls have similar amounts of windows)
Box-Wall Apartment - Low	13.70	Ref: UTBT Table 12 - percentage of front wall for mass construction building types (assumes all walls have similar amounts of windows)
Brick House - Average	13.90	Ref: UTBT Table 12 - percentage of front wall for mass construction building types (assumes all walls have similar amounts of windows)

Aperture Category: Moderate (15 to 35 % of exterior wall area)

Name	Value (%)	Notes
Brick Office - Average	15.00	Ref: UTBT Table 12 - percentage of front wall for mass construction building types (assumes all walls have similar amounts of windows)
CMU House - High	15.30	Ref: UTBT Table 12 - percentage of front wall for mass construction building types (assumes all walls have similar amounts of windows)
Light Clad Infill Wall Apartment - Average	15.70	Ref: UTBT Table 13 - percentage of front wall for framed construction building types (assumes all walls have similar amounts of windows)
Light Clad Infill Wall Hotel - Low	15.90	Ref: UTBT Table 13 - percentage of front wall for framed construction building types (assumes all walls have similar amounts of windows)
Light Clad Curtain Wall Office - Low	16.30	Ref: UTBT Table 13 - percentage of front wall for framed construction building types (assumes all walls have similar amounts of windows)
Brick Row House - High	16.50	Ref: UTBT Table 12 - percentage of front wall for mass construction building types (assumes all walls have similar amounts of windows)
Brick Apartment - High	16.90	Ref: UTBT Table 12 - percentage of front wall for mass construction building types (assumes all walls have similar amounts of windows)
Brick Hotel - Average	16.90	Ref: UTBT Table 12 - percentage of front wall for mass construction building types (assumes all walls have similar amounts of windows)
Brick Industrial - Average	18.10	Ref: UTBT Table 12 - percentage of front wall for mass construction building types (assumes all walls have similar amounts of windows)
Heavy Clad Hotel - Average	18.30	Ref: UTBT Table 13 - percentage of front wall for framed construction building types (assumes all walls have similar amounts of windows)
Large, Masonry Industrial - High	19.10	Ref: UTBT Table 12 - percentage of front wall for mass construction building types (assumes all walls have similar amounts of windows)
Brick Office - High	20.50	Ref: UTBT Table 12 - percentage of front wall for mass construction building types (assumes all walls have similar amounts of windows)
Light Clad Infill Wall Apartment - High	21.30	Ref: UTBT Table 13 - percentage of front wall for framed construction building types (assumes all walls have similar amounts of windows)
Light Clad Curtain Wall Hotel - Average	21.80	Ref: UTBT Table 13 - percentage of front wall for framed construction building types (assumes all walls have similar amounts of windows)
Brick Hotel - High	22.10	Ref: UTBT Table 12 - percentage of front wall for mass construction building types (assumes all walls have similar amounts of windows)

Aperture Category: Moderate (15 to 35 % of exterior wall area), cont'd

Name	Value (%)	Notes
Brick House - High	22.30	Ref: UTBT Table 12 - percentage of front wall for mass construction building types (assumes all walls have similar amounts of windows)
Light Clad Infill Wall Office - Average	22.60	Ref: UTBT Table 13 - percentage of front wall for framed construction building types (assumes all walls have similar amounts of windows)
Box-Wall Apartment - Average	24.20	Ref: UTBT Table 12 - percentage of front wall for mass construction building types (assumes all walls have similar amounts of windows)
Square Store with Full Front Window	25.00	Ref: SME judgment - Square building with floor to ceiling window on front wall
Light Clad Curtain Wall Apartment - Average	27.20	Ref: UTBT Table 13 - percentage of front wall for framed construction building types (assumes all walls have similar amounts of windows)
Brick Industrial - High	27.40	Ref: UTBT Table 12 - percentage of front wall for mass construction building types (assumes all walls have similar amounts of windows)
Light Clad Infill Wall Hotel - Average	28.10	Ref: UTBT Table 13 - percentage of front wall for framed construction building types (assumes all walls have similar amounts of windows)
Heavy Clad Hotel - High	30.90	Ref: UTBT Table 13 - percentage of front wall for framed construction building types (assumes all walls have similar amounts of windows)
Box-Wall Apartment - High	34.30	Ref: UTBT Table 12 - percentage of front wall for mass construction building types (assumes all walls have similar amounts of windows)
Light Clad Infill Wall Office - High	34.90	Ref: UTBT Table 13 - percentage of front wall for framed construction building types (assumes all walls have similar amounts of windows)

Aperture Category: Many (35 to 75 % of exterior wall area)

Name	Value (%)	Notes
Light Clad Infill Wall Hotel - High	35.30	Ref: UTBT Table 13 - percentage of front wall for framed construction building types (assumes all walls have similar amounts of windows)
Light Clad Curtain Wall Apartment - High	39.40	Ref: UTBT Table 13 - percentage of front wall for framed construction building types (assumes all walls have similar amounts of windows)
Light Clad Curtain Wall Office - Average	41.10	Ref: UTBT Table 13 - percentage of front wall for framed construction building types (assumes all walls have similar amounts of windows)
Light Clad Curtain Wall Hotel - High	44.20	Ref: UTBT Table 13 - percentage of front wall for framed construction building types (assumes all walls have similar amounts of windows)
Parking - Half-Open Sides	50.00	Ref: SME judgment - Parking structure consisting of half-height exterior walls
Light Clad Curtain Wall Office - High	58.80	Ref: UTBT Table 13 - percentage of front wall for framed construction building types (assumes all walls have similar amounts of windows)

Aperture Category: Predominately (75 to 100 % of exterior wall area)

Name	Value (%)	Notes
Parking - Open Sides	90.00	Ref: SME judgment - Parking structure consisting of roof/floors with minimal sides

SUB-APPENDIX A15: DOOR PERCENT

Percent of floor to ceiling external wall area that contains a door or other opening
Most entries are for the ground floor of a building

Aperture Category: None (0 to 0.5 % of exterior wall area)

Name	Value (%)	Notes
Mobile Home	0.04	Ref: SME judgement - assumes single 3' wide door on 26 ft x 9 ft footprint trailer

Aperture Category: Occasional (0.5 to 2.5 % of exterior wall area)

Name	Value (%)	Notes
Brick Infill School - Ground Story	0.56	Ref: UTBT Table 6 - 0.7% doors on front wall; 2 stories; doors on front wall
Brick Industrial - Ground Story	0.58	Ref: UTBT Table 6 - 2.6% doors on front wall; 1 story; doors on front wall
Light Clad Office - Ground Story	1.00	Ref: UTBT Table 6 - 0.6% doors on front wall; 5 stories; doors on front wall
Double Light Frame Industrial - Ground Story	1.02	Ref: UTBT Table 6 - 5.7% doors on front wall; 1 story; doors on front wall
Adobe Store - Ground Story	1.37	Ref: UTBT Table 6 - 6.2% doors on front wall; 1 story; doors on front wall
Brick Infill Store - Ground Story	1.44	Ref: UTBT Table 6 - 1.8% doors on front wall; 2 stories; doors on front and back walls
Middle Eastern House - Ground Story	1.45	Ref: UTBT Table 6 - 6.2% doors on front wall; 1 story; doors on front wall
Mobile Home	0.04	Ref: SME judgement - assumes single 3' wide door on 26ft x 9ft footprint trailer
Brick Infill School - Ground Story	0.56	Ref: UTBT Table 6 - 0.7% doors on front wall; 2 stories; doors on front wall
Brick Industrial - Ground Story	0.58	Ref: UTBT Table 6 - 2.6% doors on front wall; 1 story; doors on front wall
Concrete Apt - Upper Stories	1.61	Ref: SME judgement - see UTBT discussion pages on this building
Light Frame Industrial - Ground Story	1.69	Ref: UTBT Table 6 - 7.4% doors on front wall; 1 story; doors on front wall
Light Clad Hotel - Ground Story	2.16	Ref: UTBT Table 6 - 1.3% doors on front wall; 5 stories; doors on front wall
Heavy Clad Office - Ground Story	2.40	Ref: UTBT Table 6 - 0.8% doors on front wall; 11 stories; doors on front wall
CMU Infill Store/Apt - Ground Story	2.41	Ref: UTBT Table 6 - 3% doors on front wall; 2 stories; doors on front and back walls

Aperture Category: Few (2.5 to 7.5 % of exterior wall area)

Name	Value (%)	Notes
German Brick/Block House - Ground Story	2.80	Ref: UTBT Table 6 - 5.6% doors on front wall; 1 story (2nd story is half story); doors on front and back walls
Terra Cotta Infill House - Ground Story	3.06	Ref: UTBT Table 6 - 2.9% doors on front wall; 2 stories; doors on front and back walls
Brick Infill House - Ground Story	3.07	Ref: UTBT Table 6 - 2.9% doors on front wall; 2 stories; doors on front and back walls
Brick Office - Ground Story	3.17	Ref: UTBT Table 6 - 2.6% doors on front wall; 5 stories; doors on front wall
Half-Timbered House - Ground Story	3.20	Ref: UTBT Table 6 - 2.4% doors on front wall; 2 stories; doors on front and back walls
Triple Brick House - Ground Story	3.45	Ref: UTBT Table 6 - 6.9% doors on front wall; 1 story (2nd story is half-story); doors on front and back walls
Adobe House - Ground Story	3.50	Ref: UTBT Table 6 - 5.9% doors on front wall; 1 story; doors on front and back walls
Brick/Block House - Ground Story	3.66	Ref: UTBT Table 6 - 6.4% doors on front wall; 1 story; doors on front and back walls
Concrete Store - Ground Story	4.09	Ref: UTBT Table 6 - 7.5% doors on front wall; 1 story; doors on front and back walls
CMU Infill Industrial - Ground Story	4.37	Ref: UTBT Table 6 - 9.1% doors on front wall; 1 story; doors on front and back walls
Terracotta Infill Industrial - Ground Story	4.37	Ref: UTBT Table 6 - 9.1% doors on front wall; 1 story; doors on front and back walls
Brick Infill Industrial - Ground Story	4.37	Ref: UTBT Table 6 - 9.1% doors on front wall; 1 story; doors on front and back walls
Box Wall Apt - Ground Story	4.48	Ref: UTBT Table 6 - 2.4% doors on front wall; 5 stories; doors on front wall
CMU House - Ground Story	4.55	Ref: UTBT Table 6 - 7.5% doors on front wall; 1 story (2nd story is half-story); doors on front and back walls
Box Wall Hotel - Ground Story	4.59	Ref: UTBT Table 6 - 1.1% doors on front wall; 11 stories; doors on front, back, and side walls
CMU Store - Ground Story	4.86	Ref: UTBT Table 6 - 25.5% doors on front wall; 1 story; doors on front (vehicle) and back (personal) walls

Aperture Category: Few (2.5 to 7.5 % of exterior wall area), cont'd

Name	Value (%)	Notes
Stone House - Ground Story	5.35	Ref: UTBT Table 6 - 4.1% doors on front wall; 2 stories; doors on front and back walls
Tilt-up Industrial - Ground Story	5.91	Ref: UTBT Table 6 - 13% doors on front wall; 1 story; doors on front and back walls
Brick Veneer House - Ground Story	5.97	Ref: UTBT Table 6 - 10.5% doors on front wall; 1 story; doors on front and back walls
Wood Framed House - Ground Story	6.04	Ref: UTBT Table 6 - 10.5% doors on front wall; 1 story; doors on front and back walls
CMU Industrial - Ground Story	6.63	Ref: UTBT Table 6 - 2.6% doors on front wall; 1 story; doors on front (personal) and back (vehicle) walls
Central Pylon Office - Ground Story	7.20	Ref: UTBT Table 6 - 0.8% doors on front wall; 9 stories; doors on all walls

Aperture Category: Some (7.5 to 15 % of exterior wall area)

Name	Value (%)	Notes
Brick Store - Ground Story	9.48	Ref: UTBT Table 6 - 20.8% doors on front wall; 1 story; doors on front wall
Row House - Ground Story	10.27	Ref: UTBT Table 6 - 6.9% doors on front wall; 2 stories; doors on front and back walls
Wood Store - Ground Story	13.17	Ref: UTBT Table 6 - 70% doors on front wall; 1 story; doors on front and back walls
Brick Apt Building - Ground Story	13.62	Ref: UTBT Table 6 - 10.5% doors on front wall; 5 stories; doors on front wall
Half-Timbered Store - Ground Story	14.19	Ref: UTBT Table 6 - 5.1% doors on front wall; 4 stories; doors on front and back walls
Brick Hotel - Ground Story	14.42	Ref: UTBT Table 6 - 11.8% doors on front wall; 5 stories; doors on front wall

Aperture Category: Moderate (15 to 35 % of exterior wall area)

Name	Value (%)	Notes
Steel Framed Hotel - Ground Story	19.60	Ref: UTBT Table 6 - 2.8% doors on front wall; 14 stories; doors on front and side walls
Concrete Apt - Ground Story (Parking)	24.18	Ref: SME judgement - see UTBT discussion pages on this building
Animal Shelter - Open on Single Side	25.00	Ref: SME judgement - assumes square building
Light Clad Apt - Ground Story (Some Parking)	25.06	Ref: SME judgement - see UTBT discussion pages on this building (assumes parking openings on one side of the building)

Aperture Category: Many (35 to 75 % of exterior wall area)

Name	Value (%)	Notes
<i>no examples defined</i>		

Aperture Category: Predominately (75 to 100 % of exterior wall area)

Name	Value (%)	Notes
Light Clad Apt - Ground Story (All Parking)	90.00	Ref: SME judgement - see UTBT discussion pages on this building (assumes only parking and pillars are on the ground floor)

SUB-APPENDIX A16: SILL HEIGHT

Height of the window or door above the floor

Name	Value (ft)	Notes
Floor (0 ft)	0.00	
Building Code Requirement (2 ft)	2.00	Ref: IBC 1405.1.2.2 R613.2 - Window Sills (for windows >72 in. above grade)
Waist high (3 ft)	3.00	
Factory Wall Illumination Windows (12 ft)	12.00	

SUB-APPENDIX A17: APPENDIX A REFERENCES

References used to develop **Appendix A** building attribute values.

Reference	Citation
780 CMR	Massachusetts State Board of Building Regulations and Standards (1997) The Massachusetts State Building Code, 1997 (available at: http://www.mass.gov/eopss/docs/dps/buildingcode/7800ag.pdf)
ASCE 7-10	ASCE (2010) Minimum Design Loads for Buildings and Other Structures, American Society of Civil Engineers / Structural Engineering Institute Standard 7-10, Reston, Virginia, ISBN 978-0-7844-1085-1 note Errata No. 2, March 31, 2013 is available at: http://ascelibrary.org/doi/pdf/10.1061/9780784410851.err
BC	Boise Cascade (2016) Weights of Building Materials, Tech Note GE-1 (available at: https://www.bc.com/content/uploads/bc-resources/GE-1_Weights_Building_Materials.pdf)
Cemesto	Cemesto Panel Spec Sheet (available at: http://www.asbestosbooks.com/images/654i2.jpg)
CEX-59.7B Part II	Burson, Z.G. (1963) Experimental Radiation Measurements in Conventional Structures Part II: Comparison of Measurements in Above-Ground and Below-Ground Structures from Simulated and Actual Fallout Radiation. U.S. Atomic Energy Commission Report CEX-59.7B.
Cremers (2015)	Cremers, J.M. (2015) "Chapter 10: Environmental Impact of Architectural Fabric Structures" in "Fabric Structures in Architecture" (Llorens Ed.), Woodhead Publishing (Elsevier), San Francisco, CA (http://dx.doi.org/10.1016/B978-1-78242-233-4.00010-3)
DOE RECS (2009)	U.S. Department of Energy (2013) 2009 Residential Energy Consumption Survey, April 2013 Final Release (available at: http://www.eia.gov/emeu/recs/contents.html).
FEMA 451	FEMA (2006) NEHRP Recommended Provisions: Design Examples, Washington DC (available at: https://www.wbdg.org/ccb/DHS/fema451.pdf)
H-20	Carson J. (1989) Weights Of Building Materials, Agricultural Commodities, and Floor Loads For Buildings. (available at: http://extension.psu.edu/publications/h-20)
HAZUS	U.S. Department of Homeland Security, Federal Emergency Management Agency. (2014) Multi-hazard Loss Estimation Methodology Earthquake Model HAZUS®MH MR4 Technical Manual. Washington DC (available at: http://www.fema.gov/library/viewRecord.do?id=3731).

Reference	Citation
IBC 1405 (2005)	International Code Council, IBC 1405.1.2.2 Window Sills (2005) (available at: http://www.iccsafe.org/cs/CTC/Documents/window/resource/2002-2005_code_change_history.pdf)
INSDAG	Institute for Steel Development & Growth, Teaching Materials Chapter 27 Trusses, Calcutta, India (available at: http://www.steel-insdag.org/TM_Contents.asp)
IRC (2006)	International Residential Code (2006) (Available at: https://law.resource.org/pub/us/code/ibr/icc.irc.2006.pdf)
Kelly (1951)	The Prefabrication of Houses (available at: http://www.survivorlibrary.com/library/the_prefabrication_of_houses_1951.pdf)
Krahl (1966)	Krahl, N.W. and H.S. Ransom (1966) Vaulted Brick Construction in Guadalajara. Series: Architecture at Rice University (Number 18). Houston TX (available at: https://archive.org/details/vaultedbrickcons18krah)
MCA	Metal Construction Association (2013) Selection Guide for Insulated Metal Panels, Version 1, Chicago, IL (available at: http://www.metalconstruction.org/download.php/education/downloads/user_file_5)
Ninaquispe-Romero (2012)	Ninaquispe-Romero, L., Weeks S., & Huelman, P. (2012) Totorá: A Sustainable Insulation Material for the Andean Parts of Peru. PLEA2012 - 28th Conference, Opportunities, Limits & Needs Towards an environmentally responsible architecture Lima, Perú 7-9 November 2012. (available at: http://plea-arch.org/ARCHIVE/2012/files/T02-20120130-0067.pdf)
Oldcastle	Oldcastle Precast Building Systems (2010) Technical Guide For Precast, Prestressed Concrete Hollowcore Plank (available at: https://oldcastleprecast.com/wp-content/uploads/hollowcore-guide-2010.pdf)
PA	The Port Authority of NY & NJ Engineering Dept (2014) Design Guidelines Structural (available at: https://www.panynj.gov/business-opportunities/pdf/discipline-guidelines/structural.pdf)
PCI	Precast/Prestressed Concrete Institute (accessed 2017) Precast Floor and Roof Systems (available at: http://www.pci.org/design_resources/about_precast/floors_and_roofs/)
Schade (2008)	Schade, R.S. (2008) Philadelphia Rowhouse Manual, Philadelphia, PA (available at: http://www.phila.gov/CityPlanning/Initiatives/pdf/rowhousemanual.pdf)
Schmid (2014)	Schmid, Karl F. (2014) <i>Concise encyclopedia of construction terms and phrases</i> . New York: Momentum. ISBN 978-1606506189.
SME judgement	Best estimate of specified property

Reference	Citation
UTBT	Ellefsen, R. and D. Fordyce (2012) Urban Terrain Building Types, Second Edition, Public Releasable Version. Army Research Laboratory Report ARL-TR-4395 (http://www.arl.army.mil/arlreports/2012/ARL-TR-4395a.pdf)
WHE	World Housing Encyclopedia, Various Housing Reports (report number provided in citation), reports available at: download at http://www.world-housing.net/)

APPENDIX B: GEM BUILDING TAXONOMY

This appendix provides more detail on the specific GEM taxonomy building attributes used in our method to map a GEM building string to a set of fallout building attribute values. Specifically, this appendix lists the individual values (IDs) that the GEM attribute can take and, for context, provides a brief description of these attribute IDs by adapting the text provided in the main GEM documentation [3]. This information is organized into sub-appendices – with each sub-appendix corresponding to an individual GEM building attribute listed in **Table 8**.

SUB-APPENDIX B1: GEM BUILDING ATTRIBUTE – MATERIAL TYPE

This attribute specifies the material of the structural members that resist lateral loads and are part of the Lateral Load-Resisting System. The Lateral Load-Resisting System is the structural system that provides resistance against horizontal earthquake forces through vertical and horizontal components.

For clarity, this table is spread across several pages.

GEM Building Attribute Name	GEM Building Attribute ID	Attribute Description
Unknown material	MAT99 (or blank)	The lateral load-resisting system material is unknown due to it being unclear which material is used. The material may be hidden, or information about it is unavailable.
Concrete, unknown reinforcement	C99	The structural material is concrete, but it is not known if the concrete is reinforced or unreinforced.
Concrete, unreinforced	CU	Concrete does not contain steel reinforcing or reinforcing of any kind.
Concrete, reinforced	CR	Concrete that is reinforced by metal, usually steel rods or bars cast into the concrete, or by other reinforcement such as glass or metal fibers or natural materials that are strong in tension. Includes pre-stressed concrete, and can be pre-cast or cast-in-place.
Concrete, composite with steel section	SRC	Members of the lateral load-resisting system consist of large metal or steel sections filled with or encased in concrete to increase their strength rather than for fire-protection only.
Steel	S	Includes all grades and alloys of steel.
Metal (except steel)	ME	Metal (except steel) is a material like aluminum or iron used as a structural element.
Masonry, unknown reinforcement	M99	The structural material is masonry, but the type of reinforcement is unknown.
Masonry, unreinforced	MUR	Masonry without any form of reinforcement.
Masonry, confined	MCF	Masonry construction where masonry walls are first laid and then horizontal and vertical reinforced concrete confining elements are cast.
Masonry, reinforced	MR	Masonry wall construction in which reinforcement is embedded in such a manner that two materials act together in resisting forces.

GEM Building Attribute Name	GEM Building Attribute ID	Attribute Description
Earth, unknown reinforcement	E99	It is clear that the structural material is earth, but whether or not it is reinforced is unknown. Note that adobe is not considered to be earthen construction technology (it is a masonry construction).
Earth, unreinforced	EU	Earthen construction, without any reinforcement.
Earth, reinforced	ER	Earthen construction that is reinforced by horizontal and or vertical bands or posts from wood or other materials capable of resisting bending and or tension.
Wood	W	Wood construction may consist of posts or columns and beams as in post and beam construction, as light wood framing consisting of closely-spaced posts as in light wood-framed walls, or as in solid wood construction where thick planks or logs are laid horizontally to create load-bearing walls.
Other Material	MATO	Any known material that does not fit into the other definitions in this table. Examples include reeds, plastics and fabrics.

SUB-APPENDIX B2 GEM BUILDING ATTRIBUTE – MATERIAL TECHNOLOGY

This attribute provides more detail on the material on the Lateral Load-Resisting System material type. Only the subset of attributes that are explicitly referenced in our process is listed here.

GEM Building Attribute Name	GEM Building Attribute ID	Attribute Description
Adobe blocks	ADO	Sun-dried (or air-dried), unfired mud (clay) masonry, where the clay is cast into blocks (and sometimes into bricks).
Stone, unknown technology	ST99	It is clear that the structural material is stone, but the type of stone masonry is unknown.
Rubble (field stone) or semi-dressed stone	STRUB	Rubble/field stone masonry is composed of uncoursed, rounded field stones or roughly-cut stones used for construction with or without mortar. There are two wall wythes and a core, usually filled with stone rubble and mud. Semi-dressed stone masonry is characterized by one wall wythe (usually exterior) built using shaped stones; usually only the exposed stone surface is shaped.
Dressed stone	STDRE	Square or rectangular-shaped prismatic stone blocks in bonded courses with narrow joints, with or without mortar.
Unknown earth technology	ET99	It is clear that the structural material is earth construction, but the type of construction is unknown.
Rammed earth	ETR	Wall construction of earth which is compacted by hand or mechanically into formwork that is then removed and the wall allowed to dry.
Cob or wet construction	ETC	Stacked earthen construction that uses clay-based soil in the form of a cohesive paste. A layer is left to dry before adding the next layer to build up walls.
Earth technology, other	ETO	Any earthen construction type that is known but does not fit the descriptions of the other earth construction types in this table.
Solid Wood	WS	Walls are made from solid wood. Includes hewn or unhewn log construction.
Wattle and daub	WWD	A wooden frame around a lattice consisting of woven twigs (wattles that are filled or plastered with mud), reeds, grass, or bamboo.
Bamboo	WBB	Hollow-stemmed plant. It is commonly used as split and woven construction, in the form of trusses and frames.

SUB-APPENDIX B3: GEM BUILDING ATTRIBUTE – HEIGHT

The height of the building measured in stories.
Only the subset of attributes explicitly referenced in our process is listed here.

GEM Building Attribute Name	GEM Building Attribute ID	Attribute Description
Range of number of stories above ground	HBET	Recording the number of stories above ground as a range can be used to reflect either the surveyor's lack of certainty for a single building, or when height ranges are used in regional surveys. The number of the floors above ground includes the ground floor and floors above. It also includes storage and mechanical plant levels only if these cover over 50% of the plan area, but does not include basements below ground. If the building is stepped in height, then record the highest part.
Exact number of storeys above ground	HEX	The exact number of stories above ground is clear from survey or drawings.
Approximate number of storeys above ground	HAPP	An approximate number of stories above ground can be determined by the surveyor where the exact number of stories above ground is not clear from survey or drawing.
Number of storeys below ground unknown	HB99	The number of stories of the building below ground is unknown. It is impossible to determine the number of stories within an estimated range, or to an approximate number.
Range of number of storeys below ground	HBBET	Recording the number of stories below ground as a range can be used where there is a lack of certainty about the exact number of stories below ground but the surveyor is able to determine a range. This does not include the ground floor. It includes storage and mechanical plant levels only if these cover over 50% of the plan area.
Exact number of storeys below ground	HBEX	The exact number of stories below ground is clear from survey or drawings. This does not include the ground floor.
Approximate number of storeys below ground	HBAPP	An approximate number of stories below ground can be determined by the surveyor where the exact number of stories above ground is not clear from survey or drawing.

SUB-APPENDIX B4: GEM BUILDING ATTRIBUTE – BUILDING OCCUPANCY CLASS - GENERAL

This attribute describes the main occupancy type. Occupancy is the type of activity (function) that the building is used for (e.g., residential, commercial). It does not refer directly to the number of occupants.

GEM Building Attribute Name	GEM Building Attribute ID	Attribute Description
Unknown occupancy type	OC99 (or blank)	The use of the building is unknown.
Residential	RES	The building is mainly used as housing.
Commercial and public	COM	The building is mainly used for commercial and public purposes, including retail, storage, sports facilities, hospitals, libraries and museums.
Mixed Use	MIX	The building is used for commercial or retail at the ground floor with residential or office accommodation above.
Industrial	IND	The building is used for industrial processes and manufacturing.
Agricultural	AGR	The building is used for farming and produce growing purposes.
Assembly	ASS	The building is a place of worship or a membership organization such as a club or society.
Government	GOV	The building is used by national or local government and includes office buildings and facilities involved in emergency management. Medical and educational facilities are not included in this category.
Education	EDU	The building is mainly used for education, including schools and universities.
Other occupancy type	OCO	Use that is known, but is not adequately described by any of the uses listed in this table.

SUB-APPENDIX B5: GEM BUILDING ATTRIBUTE – BUILDING OCCUPANCY CLASS - DETAIL

This attribute provides more detailed occupancy descriptions than provided in the “Building Occupancy Class – General”. For clarity, this table is spread across several pages.

GEM Building Attribute Name	GEM Building Attribute ID	Attribute Description
Residential, unknown type	RES99	It is clear that the building is a residential building, but the format of the dwellings and number of dwellings in the building is unknown.
Single dwelling	RES1	A single residential unit which would typically house one family. It is stand-alone and is not structurally joined to other residential units.
Multi-unit, unknown type	RES2	It is clear that the building is a multi-unit residential building with structurally connected neighboring units or apartments stacked vertically, but the number of dwellings in the building is unknown.
2 Units (duplex)	RES2A	Two residential units joined together. Can be stacked vertically or joined horizontally as two semi-detached houses.
3-4 Units	RES2B	Apartments, condominiums, townhouses of 3 to 4 units. Residential units are structurally connected.
5-9 Units	RES2C	Apartments, condominiums, townhouses of 5 to 9 units. Residential units are structurally connected.
10-19 Units	RES2D	Apartments, condominiums, townhouses of 10 to 19 units. Residential units are structurally connected.
20-49 Units	RES2E	Apartments, condominiums, townhouses of 20 to 49 units. Residential units are structurally connected.
50+ Units	RES2F	Apartments, condominiums, townhouses of 50+ units. Residential units are structurally connected.
Temporary housing	RES3	Guest accommodation including hotels, motels, guest lodges, cabins, and holiday accommodation.
Institutional housing	RES4	Group housing including military, college, prisons, and nursing homes.
Mobile home	RES5	A lightweight wheeled trailer home that can be towed and that provides temporary or permanent accommodation. This does not include motorized trucks or camper vans.
Informal housing	RES6	Any form of shelter or settlement which is illegal, falls outside of government control or regulation, or is not afforded protection by the state.

GEM Building Attribute Name	GEM Building Attribute ID	Attribute Description
Commercial and public, unknown type	COM99	It is clear that the building is a commercial building, but the exact type of commercial use is unknown.
Retail trade	COM1	All retail uses including retail shops, supermarkets, shopping malls.
Wholesale trade and storage (warehouse)	COM2	All warehouses and storage facilities.
Offices, professional/technical services	COM3	All office buildings, including banks, but excluding national and local government office buildings.
Hospital/medical clinic	COM4	All medical facilities, including hospitals and clinics.
Entertainment	COM5	Restaurants, bars, cafes
Public building	COM6	Examples: gallery, museum, monument building, library
Covered parking garage	COM7	Car parking facilities, covered and multi-story. Does not include flat open lots.
Bus station	COM8	A building or group of buildings where buses stop for the loading and unloading of passengers.
Railway station	COM9	A building or group of buildings where trains stop for the loading and unloading of passengers, and buildings used for the loading and unloading of freight trains. This does not include covered sheds for storage and maintenance of trains.
Airport	COM10	A building or group of buildings that accompany a landing strip for aircraft for loading and unloading of passengers.
Recreation and leisure	COM11	All sports and recreational facilities with seating for fewer than 1,000 spectators.

GEM Building Attribute Name	GEM Building Attribute ID	Attribute Description
Mixed, unknown type	MIX99	The building is clearly mixed use, but the types of use are unknown.
Mostly residential and commercial	MIX1	The building is mixed use, a mixture of residential and commercial. The majority of the floor area is for residential use.
Mostly commercial and residential	MIX2	The building is mixed use, a mixture of commercial and residential. The majority of the floor area is for commercial use.
Mostly commercial and industrial	MIX3	The building is mixed use, a mixture of commercial and industrial. The majority of the floor area is for commercial use.
Mostly residential and industrial	MIX4	The building is mixed use, a mixture of residential and industrial. The majority of the floor area is for residential use.
Mostly industrial and commercial	MIX5	The building is mixed use, a mixture of industrial and commercial. The majority of the floor area is for industrial use.
Mostly industrial and residential	MIX6	The building is mixed use, a mixture of industrial and residential. The majority of the floor area is for industrial use.
Industrial, unknown type	IND99	It is clear that the building is an industrial building, but the exact type of industrial use is unknown.
Heavy industrial	IND1	Factories and facilities considered as heavy industry. E.g. Oil and petrochemical, power generation and distribution, pulp and paper.
Light industrial	IND2	Factories and facilities considered as light industry. E.g. Factories, telecommunications, textiles, transportation services, utilities.
Agriculture, unknown type	AGR99	The building is used for agriculture, but it is not known what type of agricultural use.
Produce storage	AGR1	A building used for the storage of agricultural produce. It includes grain storage, hay, silage, fruit, and vegetables.
Animal shelter	AGR2	A building in which animals are reared or where they take shelter.
Agricultural processing	AGR3	A building used for any agricultural process. This includes sorting of produce, milking of cows, abattoirs.

GEM Building Attribute Name	GEM Building Attribute ID	Attribute Description
Assembly, unknown type	ASS99	It is clear that the building is used for religion or non-profit organizations, but the exact type of this use is unknown.
Religious gathering	ASS1	Place for religious gathering such as church, mosque, temple, synagogue, or monastery.
Arena	ASS2	A large sporting venue with seating for more than 1,000 spectators. Seating can be indoors or outdoors.
Cinema or concert hall	ASS3	A venue for performance and viewing of films, including music and dance performances.
Other gatherings	ASS4	A building used for social gatherings such as clubs (other than sports clubs), societies, political parties, function centers and conference centers, community halls, town halls.
Government, unknown type	GOV99	It is clear that the building is used by national or local government, but the exact type of government use is unknown.
Government, general services	GOV1	Office buildings used for national government or local government purposes.
Government, emergency response	GOV2	Any local or national government-owned building that has an essential post-disaster function. E.g. Police, fire station, emergency operations center. For hospitals see COM5 Hospital / Medical clinic.
Education, unknown type	EDU99	It is clear that the building is used for education, but the exact type of educational use is unknown.
Pre-school facility	EDU1	Any pre-school educational center. E.g. Child care center, crèche.
School	EDU2	Any school-age educational center. Includes government-owned and private schools.
College/university offices and/or classrooms	EDU3	Buildings used for higher education and vocational training. Group housing, e.g. college residences, is not included in this category.
College/university research facilities and/or labs	EDU4	A building used for research, or laboratory buildings, within a university or college.

SUB-APPENDIX B6: GEM BUILDING ATTRIBUTE – EXTERIOR WALL

This attribute describes the material that covers most of the exterior walls of the building.

GEM Building Attribute Name	GEM Building Attribute ID	Attribute Description
Unknown material of exterior walls	EW99 (or blank)	The material covering the exterior walls is unknown. There is insufficient information available or it is not possible to determine the material from a visual survey.
Concrete exterior walls	EW C	All types of concrete construction and cladding, reinforced or unreinforced, including where there is a plaster finish directly applied to the concrete. Includes cast-in-place or precast concrete panels, but not thin panels such as glass reinforced concrete (GRC) panels or fiber cement board.
Glass exterior walls	EW G	Glass curtain walls, storefront glass systems, or any other exterior walls where glass windows cover more of the walls by area than any other material. Also includes solar paneled exterior walls, where photovoltaics modules are integrated directly into a building envelope by replacing curtain walls (Building Integrated Photovoltaics).
Earthen exterior walls	EW E	All types of earthen construction, including cob, rammed earth, bajareque, quincha, sod, banco, wattle and daub.
Masonry exterior walls	EW MA	All types of masonry units used as cladding, infill, or exposed wall structure. Includes a variety of masonry units, including adobe bricks and blocks, burnt clay bricks and blocks, stone, ceramic tile.
Metal exterior walls	EW ME	All types of metal cladding and wall materials. Includes aluminum planks, corrugated steel sheets (CGI) or aluminum sheets, aluminum composite sheets, copper sheets, wire mesh and perforated sheet metal.
Vegetative exterior walls	EW V	All types of plant-based wall materials. Includes matting, palm, thatch, straw.
Wooden exterior walls	EW W	All types of wood cladding including wood planks, wood shingles, and plywood sheets. Also includes wood construction where it also forms the exterior wall surface, such as solid wood or log construction.
Stucco finish on light framing for exterior walls	EW SL	Plaster finish over sheet material, such as fiber cement board or expanded polystyrene, fixed to metal or wood studs.
Plastic/Vinyl exterior walls, various	EW PL	All types of plastic cladding. Includes plastic siding, and corrugated plastic sheet.
Cement-based boards for exterior walls	EW CB	Fiber cement or asbestos boards and fiber-reinforced concrete (FCR) and glass reinforced concrete (GRC) panels.
Material of exterior walls, other	EW O	The material covering the exterior walls is known, but it does not fit any of the definitions found in this table.

SUB-APPENDIX B7: GEM BUILDING ATTRIBUTE – ROOF SYSTEM MATERIAL

This attribute describes the material of the roof system. The roof system is the structure that supports the roof covering and environmental loading (such as rain and snow). The roof system is often not exposed from the exterior of the building.

GEM Building Attribute Name	GEM Building Attribute ID	Attribute Description
Roof material unknown	R99 (or blank)	The material of the roof is unknown. It has not been inspected sufficiently to determine the material or information is unavailable.
Masonry roof	RM	The roof structure is constructed of masonry.
Earthen roof	RE	The roof structure is of earthen construction.
Concrete roof	RC	The roof structure is constructed of concrete.
Metal roof	RME	The roof structure is constructed of metal. Note that this refers to the structure, and not any lightweight sheet metal roof covering that might be present.
Wooden roof	RWO	The roof structure is constructed of wood.
Fabric roof	RFA	The building has a fabric roof. Fabric is defined in this case as a textile material, woven or otherwise bonded into a thin flexible sheet.
Roof material, other	RO	The roof structure material is known, but does not fit within any of the definitions in this table.

SUB-APPENDIX B8: GEM BUILDING ATTRIBUTE – ROOF SYSTEM TYPE

This attribute provides a more detailed classification of the type of roof system (the structure that supports the roof covering). For clarity, this table is spread across several pages.

GEM Building Attribute Name	GEM Building Attribute ID	Attribute Description
Masonry roof, unknown	RM99	It is clear that the roof structure is made from masonry, but the type of masonry system is unknown.
Vaulted masonry roof	RM1	Masonry spans between bearing walls and is overlaid with fill. A flat roof surface is provided and is often overlaid with roofing. Includes two-way vaults and masonry domes.
Shallow-arched masonry roof	RM2	Shallow-arched masonry roof spans between metal, timber, or concrete joists, with ballast fill and overlaid with roofing.
Composite masonry and concrete roof system	RM3	Cast-in-place concrete joists with hollow clay tiles and cast-in-place reinforced concrete topping, sometimes overlaid with roofing.
Earthen roof, unknown	RE99	It is clear that the roof structure is made from earthen construction, but the type of earthen construction system is unknown.
Vaulted earthen roof	RE1	These systems include earthen domes and vaults.
Concrete roof, unknown	RC99	It is clear that the roof structure is made from concrete, but the type of concrete system is unknown.
Cast-in-place beamless reinforced concrete roof	RC1	Reinforced concrete slabs are supported by columns or load-bearing walls.
Cast-in-place beam-supported reinforced concrete roof	RC2	Reinforced concrete slabs are supported by beams.
Precast concrete roof with reinforced concrete topping	RC3	Precast concrete units with reinforced concrete topping.
Precast concrete roof without reinforced concrete topping	RC4	Precast concrete units without reinforced concrete topping.

GEM Building Attribute Name	GEM Building Attribute ID	Attribute Description
Metal roof, unknown	RME99	It is clear that the roof structure is made from metal, but the type of metal structural system is unknown.
Metal beams or trusses supporting light roofing	RME1	Metal beams or trusses supporting light-weight roofing system, e.g. corrugated metal or plywood sheets over steel rafters or purlins.
Metal roof beams supporting precast concrete slabs	RME2	Precast concrete slabs (e.g. hollow-core slabs) supported by steel beams.
Composite steel roof deck and concrete slab	RME3	Reinforced concrete cast onto steel decking supported by beams or load bearing walls.
Wooden roof, unknown	RWO99	It is clear that the roof structure is made from wood, but the type of wooden structural system is unknown.
Wooden structure with light roof covering	RWO1	Wooden beams or trusses and joists, supporting light roof covering, e.g. corrugated sheets. Also includes curved roof structures, e.g. vaulted roofs.
Wooden beams or trusses with heavy roof covering	RWO2	Wooden beams or trusses and joists supporting heavy roof covering. Examples include (a) a sloped wooden roof with a layer of earth covered by clay roof tiles, (b) stone tiles, and (c) flat roofs with heavy roof covering made from a mixture of clay, straw and tamped earth.
Wood-based sheets on rafters or purlins	RWO3	Plywood, particle board, or other sheet material fixed over wooden members.
Plywood panels or other light-weight panels for roof	RWO4	Panels are supported on beams or bearing walls (possibly stressed-skin).
Bamboo, straw or thatch roof	RWO5	The surface of the roof is made from reed materials, such as bamboo, straw or thatch; laid onto wood battens, with a primary structure of wood members. No sheet material is used for the roofing.
Inflatable or tensile membrane roof	RFA1	An inflatable roof uses fabric chambers pressurized with air to form a self-supporting structure.
Fabric roof, other	RFAO	The type of fabric roof is known, but it is not adequately described by the other attributes in this table. This includes any other type of fabric not inflatable or stretched like a tensile membrane, such as plastic sheet, tarpaulin, or canvas sheeting.

SUB-APPENDIX B9: GEM BUILDING ATTRIBUTE – FLOOR SYSTEM MATERIAL

This attribute describes the material of the floor system. The floor system is the structure that supports flooring and can be overlaid with different types of flooring.

GEM Building Attribute Name	GEM Building Attribute ID	Attribute Description
No elevated or suspended floor	FN	The building is a single story building with no floors above the ground floor level, and the ground floor level is not elevated above grade.
Floor material unknown	F99 (or blank)	The material of the floor is unknown. It has not been inspected sufficiently to determine the material, or information is unavailable.
Masonry floor	FM	The floor structure is constructed of masonry.
Earthen floor	FE	The floor structure is of earthen construction.
Concrete floor	FC	The floor structure is constructed of concrete.
Metal floor	FME	The floor structure is constructed of metal. Note that this refers to the structure, and not any lightweight sheet flooring (such as plywood) that might be present.
Wooden floor	FW	The floor structure is constructed of wood. Note that this refers to the structure, and not wood overlay flooring or plywood sheet laid over a different structural material.
Floor material, other	RO	The floor structure material is known, but they do not fit within any of the definitions in this table.

SUB-APPENDIX B10: GEM BUILDING ATTRIBUTE – FLOOR SYSTEM TYPE

This attribute describes the type of floor system based on materials and construction methods.

For clarity, this table is spread across several pages.

GEM Building Attribute Name	GEM Building Attribute ID	Attribute Description
Masonry floor, unknown	FM99	It is clear that the floor structure is made from masonry, but the type of masonry system is unknown.
Vaulted masonry floor	FM1	Masonry spans between bearing walls and is overlaid with fill. A flat floor surface is provided and is often overlaid with roofing. Includes two-way vaults and masonry domes.
Shallow-arched masonry floor	FM2	Shallow-arched masonry roof spans between metal, timber or concrete joists, with ballast fill and overlaid with flooring.
Composite cast-in-place reinforced concrete and masonry floor system	FM3	Cast-in-place concrete joists with hollow clay tiles and cast-in-place reinforced concrete topping, sometimes overlaid with flooring.
Earthen floor, unknown	FE99	It is clear that the floor structure is made from earthen construction, but the type of earthen construction system is unknown.
Concrete floor, unknown	FC99	It is clear that the floor structure is made from concrete, but the type of concrete system is unknown.
Cast-in-place beamless reinforced concrete floor	FC1	Reinforced concrete slabs are supported by columns or load-bearing walls.
Cast-in-place beam-supported reinforced concrete floor	FC2	Reinforced concrete slabs are supported by beams.
Precast concrete floor with reinforced concrete topping	FC3	Precast concrete units with reinforced concrete topping.
Precast concrete floor without reinforced concrete topping	FC4	Precast concrete units without reinforced concrete topping.

GEM Building Attribute Name	GEM Building Attribute ID	Attribute Description
Metal floor, unknown	FME99	It is clear that the floor structure is made from metal, but the type of metal structural system is unknown.
Metal beams or trusses supporting light flooring	FME1	Metal beams or trusses supporting light-weight flooring system e.g. plywood sheets over steel rafters or purlins.
Metal floor beams supporting precast concrete slabs	FME2	Precast concrete slabs (e.g. hollow-core slabs) supported by steel beams.
Composite steel deck and concrete slab	FME3	Reinforced concrete cast onto steel decking, supported by beams or load bearing walls.
Wooden floor, unknown	FW99	It is clear that the floor structure is made from wood, but the type of wooden structural system is unknown.
Wooden beams or trusses and joists supporting light flooring	FW1	Wooden beams or trusses and joists, supporting light flooring, e.g. wooden planks.
Wooden beams or trusses and joists supporting heavy flooring	FW2	Examples include (a) wooden floor with a ballast fill (earth or other material) covered by clay tiles and (b) stone tiles.
Wood-based sheets on joists or beams	FW3	Plywood, particle board, or other sheet material fixed over wooden members.
Plywood panels or other light-weight panels for floor	FW4	Panels are supported on beams or bearing walls (possibly stressed-skin).

APPENDIX C: LOOK-UP TABLES NEEDED TO MAP A GEM BUILDING STRING TO A SIMPLIFIED BUILDING DESCRIPTION

This appendix provides the supplemental look-up tables needed to determine the simplified building description attribute values from a given GEM building string (the method is described in the main text). This appendix is organized into sub-appendices – with each sub-appendix corresponding to a different simplified building description attribute listed in **Table 5** (the building footprint area attribute is not included).

These look-up tables were developed by using the following steps:

- 1) Identifying the example architectural features listed in **Appendix A** that are consistent with a given combination of GEM attributes. For building attributes that require multiple architectural features, see **Tables 1a-c**, reasonable combinations of the architectural features were considered.
- 2) Identifying the fallout building attribute value category (see **Tables 2a-d**) corresponding to each example architectural feature. For example, the “Steel Frame – Heavy Clad” exterior wall example has a density of 130 psf and so corresponds to the “Very Heavy” fallout building attribute value category – with a nominal value of 100 psf and a range of 75 to 150 psf.
- 3) Reporting the range of fallout building attribute category values corresponding to the architectural features identified in step 1.
- 4) Choosing a nominal value to reflect either (a) the most likely architectural feature or, if many features were judged likely, (b) the nominal value of the central fallout building attribute value category.
- 5) Providing, for context, example architectural features corresponding to the low, nominal, and high values identified in steps 3 and 4.

SUB-APPENDIX C1: EXTERIOR WALL DENSITY

External wall construction which is used to determine the average exterior wall density
Specifically the building exterior dead load + building frame in exterior wall + dead load of the internal wall affixed to the exterior wall.
For clarity, this table is spread across several pages.

Flowchart Level	GEM Attribute Type	GEM Attribute ID	GEM Attribute Description	Nominal Value (psf)	(example)	Low Range (psf)	(example)	High Range (psf)	(example)
1	Exterior Walls	EW99 (or blank)	Unknown material of exterior walls	100	Concrete - 8" + Drywall	0.5	Lightweight Vegetation	300	Earthen - 3' Rammed Earth (Low Income)
1	Exterior Walls	EWC	Concrete exterior walls	100	Concrete - 8" + Drywall	20	Steel Frame - Light Clad Concrete	150 ¹³	Concrete - 12" + Drywall
1	Exterior Walls	EWG	Glass exterior walls	10	Steel Frame - Light Clad Glass	7.5	Steel Frame - Light Clad Glass	20	Steel Frame - Light Clad Glass
1	Exterior Walls	EWE	Earthen exterior walls	100	Earthen - 10" Rammed Earth (Low Income)	40	Wood Frame - Half-Timber, Thin Wall (Wattle and Daub)	300	Earthen - 3' Rammed Earth (Low Income)
2	Lateral Load-Resisting System Material Technology	WWD	Wattle and daub	50	Wood Frame - Half-Timber, Thin Wall (Wattle and Daub)	40	Wood Frame - Half-Timber, Thin Wall (Wattle and Daub)	150	Wood Frame - Half-Timber, Thick Wall (Wattle and Daub)

¹³ Neglects stone veneer over thick concrete walls

Flowchart Level	GEM Attribute Type	GEM Attribute ID	GEM Attribute Description	Nominal Value (psf)	(example)	Low Range (psf)	(example)	High Range (psf)	(example)
2	Lateral Load-Resisting System Material Technology	n/a	ALL OTHERS	100	Earthen - 10" Rammed Earth (Low Income)	75	Earthen - 10" Rammed Earth (Low Income)	300	Earthen - 3' Rammed Earth (Low Income)
1	Exterior Walls	EWMA	Masonry exterior walls	100	Masonry - Fired Brick - 35cm + Plaster (Moderate Wall)	20	Steel Frame - Light Clad Thin Stone	300	Masonry - Stone - 3'
2	Lateral Load-Resisting System Material Type	C99	Concrete, unknown reinforcement	100	Masonry - Concrete - 8" Lightweight Solid Blocks + Drywall + Brick Veneer	20	Concrete Frame - Light Clad Thin Stone	150	Masonry - Concrete - 8" Lightweight Solid Blocks + Drywall + Brick Veneer
2	Lateral Load-Resisting System Material Type	CU	Concrete, unreinforced	100	Masonry - Concrete - 8" Lightweight Solid Blocks + Drywall + Brick Veneer	20	Concrete Frame - Light Clad Thin Stone	150	Masonry - Concrete - 8" Lightweight Solid Blocks + Drywall + Brick Veneer

Flowchart Level	GEM Attribute Type	GEM Attribute ID	GEM Attribute Description	Nominal Value (psf)	(example)	Low Range (psf)	(example)	High Range (psf)	(example)
2	Lateral Load-Resisting System Material Type	CR	Concrete, reinforced	100	Concrete Frame - Reinforced, 16" oc Grout, 8" Concrete Block Infill + Brick Veneer	20	Concrete Frame - Light Clad Thin Stone	150	Concrete Frame - Reinforced, Full Grout 8" Concrete Block Infill + Brick Veneer
2	Lateral Load-Resisting System Material Type	SRC	Concrete, composite with steel section	100	Concrete Frame - Reinforced, 16" oc Grout, 8" Concrete Block Infill + Brick Veneer	20	Concrete Frame - Light Clad Thin Stone	150	Concrete Frame - Reinforced, Full Grout 8" Concrete Block Infill + Brick Veneer
2	Lateral Load-Resisting System Material Type	S	Steel	100	Steel Frame - Heavy Clad	20	Steel Frame - Light Clad Thin Stone	150	Steel Frame - Heavy Clad
2	Lateral Load-Resisting System Material Type	ME	Metal (except steel)	100	Steel Frame - Heavy Clad	20	Steel Frame - Light Clad Thin Stone	150	Steel Frame - Heavy Clad

Flowchart Level	GEM Attribute Type	GEM Attribute ID	GEM Attribute Description	Nominal Value (psf)	(example)	Low Range (psf)	(example)	High Range (psf)	(example)
2	Lateral Load-Resisting System Material Type	MCF	Masonry, confined	100	Concrete Frame - Brick Infill	40	Concrete Frame - Thin Unreinforced 8" Concrete Block Infill	150	Concrete Frame - Reinforced, 16" oc Grout, 8" Concrete Block Infill + Brick Veneer
2	Lateral Load-Resisting System Material Type	MR	Masonry, reinforced	100	Masonry - Concrete - 8" Blocks + Drywall, Reinforced w Full Grout	40	Masonry - Concrete - 8" Blocks, Reinforced w 16" Grout Spacing	150	Masonry - Concrete - 8" Blocks + Drywall + Brick Veneer, Reinforced w 16" Grout Spacing
2	Lateral Load-Resisting System Material Type	W	Wood	50	Wood Frame - Brick Veneer	40	Wood Frame - Brick Veneer	75	Wood Frame - Brick Veneer
2	Lateral Load-Resisting System Material Type	n/a	ALL OTHERS	100	Masonry - Fired Brick - 35cm + Plaster (Moderate Wall)	20	Masonry - Concrete - 8" Blocks, Unreinforced	300	Masonry - Stone - 3'

Flowchart Level	GEM Attribute Type	GEM Attribute ID	GEM Attribute Description	Nominal Value (psf)	(example)	Low Range (psf)	(example)	High Range (psf)	(example)
1	Exterior Walls	EWME	Metal exterior walls	10	Steel Frame - Light Clad Sheet Metal	2.5	Wood Frame - Siding (Low Income)	20	Steel Frame - Light Clad Metal Composite Panel
2	Lateral Load-Resisting System Material Technology	WBB	Bamboo	5	Wood Frame - Siding (Low Income)	2.5	Wood Frame - Siding (Low Income)	7.5	Wood Frame - Siding (Low Income)
2	Lateral Load-Resisting System Material Technology	n/a	ALL OTHERS	10	Steel Frame - Light Clad Sheet Metal	7.5	Steel Frame - Light Clad Sheet Metal	20	Steel Frame - Light Clad Metal Composite Panel
1	Exterior Walls	EWV	Vegetative exterior walls	1.5	Lightweight Vegetation	0.5	Lightweight Vegetation	2.5	Lightweight Vegetation
1	Exterior Walls	EWV	Wooden exterior walls	10	Wood Frame - Siding	2.5	Wood Frame - Siding (Low Income)	300	Masonry - Fired Brick - 72cm + Plaster
2	Lateral Load-Resisting System Material Type	MAT99 (or blank)	Unknown material	10	Wood Frame - Siding	2.5	Wood Frame - Siding (Low Income)	300	Masonry - Fired Brick - 72cm + Plaster

Flowchart Level	GEM Attribute Type	GEM Attribute ID	GEM Attribute Description	Nominal Value (psf)	(example)	Low Range (psf)	(example)	High Range (psf)	(example)
2	Lateral Load-Resisting System Material Type	C99	Concrete, unknown reinforcement	100	Concrete - 8" + Drywall	40	Concrete - 6" + Drywall	150	Concrete - 12" + Drywall
2	Lateral Load-Resisting System Material Type	CU	Concrete, unreinforced	100	Concrete - 8" + Drywall	40	Concrete - 6" + Drywall	150	Concrete - 12" + Drywall
2	Lateral Load-Resisting System Material Type	CR	Concrete, reinforced	100	Concrete - 8" + Drywall	40	Concrete - 6" + Drywall	150	Concrete - 12" + Drywall
2	Lateral Load-Resisting System Material Type	SRC	Concrete, composite with steel section	100	Concrete - 8" + Drywall	40	Concrete - 6" + Drywall	150	Concrete - 12" + Drywall
2	Lateral Load-Resisting System Material Type	S	Steel	10	Wood Frame - Siding	7.5	Wood Frame - Siding	20	Wood Frame - Siding

Flowchart Level	GEM Attribute Type	GEM Attribute ID	GEM Attribute Description	Nominal Value (psf)	(example)	Low Range (psf)	(example)	High Range (psf)	(example)
2	Lateral Load-Resisting System Material Type	ME	Metal (except steel)	10	Wood Frame - Siding	7.5	Wood Frame - Siding	20	Wood Frame - Siding
2	Lateral Load-Resisting System Material Type	M99	Masonry, unknown reinforcement	100	Masonry - Fired Brick - 35cm + Plaster (Moderate Wall)	20	Masonry - Concrete - 8" Blocks, Unreinforced	300	Masonry - Fired Brick - 72cm + Plaster
2	Lateral Load-Resisting System Material Type	MUR	Masonry, unreinforced	100	Masonry - Fired Brick - 35cm + Plaster (Moderate Wall)	20	Masonry - Concrete - 8" Blocks, Unreinforced	300	Masonry - Fired Brick - 72cm + Plaster
2	Lateral Load-Resisting System Material Type	MCF	Masonry, confined	100	Concrete Frame - Brick Infill	40	Concrete Frame - Thin Unreinforced 8" Concrete Block Infill	150	Concrete Frame - Reinforced, 16" oc Grout, 8" Concrete Block Infill + Brick Veneer

Flowchart Level	GEM Attribute Type	GEM Attribute ID	GEM Attribute Description	Nominal Value (psf)	(example)	Low Range (psf)	(example)	High Range (psf)	(example)
2	Lateral Load-Resisting System Material Type	MR	Masonry, reinforced	100	Masonry - Concrete - 8" Blocks + Drywall, Reinforced w Full Grout	40	Masonry - Concrete - 8" Blocks, Reinforced w 16" Grout Spacing	150	Masonry - Concrete - 8" Blocks + Drywall + Brick Veneer, Reinforced w 16" Grout Spacing
2	Lateral Load-Resisting System Material Type	E99	Earth, unknown reinforcement	100	Earthen - 10" Rammed Earth (Low Income)	75	Earthen - 10" Rammed Earth (Low Income)	300	Earthen - 3' Rammed Earth (Low Income)
2	Lateral Load-Resisting System Material Type	EU	Earth, unreinforced	100	Earthen - 10" Rammed Earth (Low Income)	75	Earthen - 10" Rammed Earth (Low Income)	300	Earthen - 3' Rammed Earth (Low Income)
2	Lateral Load-Resisting System Material Type	ER	Earth, reinforced	100	Earthen - 10" Rammed Earth (Low Income)	75	Earthen - 10" Rammed Earth (Low Income)	300	Earthen - 3' Rammed Earth (Low Income)

Flowchart Level	GEM Attribute Type	GEM Attribute ID	GEM Attribute Description	Nominal Value (psf)	(example)	Low Range (psf)	(example)	High Range (psf)	(example)
2	Lateral Load-Resisting System Material Type	W	Wood	10	Wood Frame - Siding	2.5	Wood Frame - Siding (Low Income)	40	Solid Wood - 12" Log Walls
3	Lateral Load-Resisting System Material Technology	WS	Solid Wood	30	Solid Wood - 12" Log Walls	7.5	Solid Wood - 6" Log Walls	40	Solid Wood - 12" Log Walls
3	Lateral Load-Resisting System Material Technology	WBB	Bamboo	5	Wood Frame - Siding (Low Income)	2.5	Wood Frame - Siding (Low Income)	7.5	Wood Frame - Siding (Low Income)
3	Lateral Load-Resisting System Material Technology	n/a	ALL OTHERS	10	Wood Frame - Siding	2.5	Wood Frame - Siding (Low Income)	20	Wood Frame - Siding
2	Lateral Load-Resisting System Material Type	MATO	Other Material	10	n/a	7.5	n/a	20	n/a

Flowchart Level	GEM Attribute Type	GEM Attribute ID	GEM Attribute Description	Nominal Value (psf)	(example)	Low Range (psf)	(example)	High Range (psf)	(example)
1	Exterior Walls	EWSL	Stucco finish on light framing for exterior walls	30	Wood Frame - Stucco	20	Wood Frame - Stucco	40	Steel Frame - Light Clad Concrete
1	Exterior Walls	EWPL	Plastic/Vinyl exterior walls, various	10	Wood Frame - Siding	0.5	Wood Frame - Plastic Sheet (Low Income)	300	Masonry - Fired Brick - 72cm + Plaster
2	Lateral Load-Resisting System Material Type	MAT99 (or blank)	Unknown material	10	Wood Frame - Siding	0.5	Wood Frame - Plastic Sheet (Low Income)	300	Masonry - Fired Brick - 72cm + Plaster
2	Lateral Load-Resisting System Material Type	C99	Concrete, unknown reinforcement	100	Concrete - 8" + Drywall	7.5	Concrete Frame - Light Clad Metal	150	Concrete - 12" + Drywall
2	Lateral Load-Resisting System Material Type	CU	Concrete, unreinforced	100	Concrete - 8" + Drywall	7.5	Concrete Frame - Light Clad Metal	150	Concrete - 12" + Drywall

Flowchart Level	GEM Attribute Type	GEM Attribute ID	GEM Attribute Description	Nominal Value (psf)	(example)	Low Range (psf)	(example)	High Range (psf)	(example)
2	Lateral Load-Resisting System Material Type	CR	Concrete, reinforced	100	Concrete - 8" + Drywall	7.5	Concrete Frame - Light Clad Metal	150	Concrete - 12" + Drywall
2	Lateral Load-Resisting System Material Type	SRC	Concrete, composite with steel section	100	Concrete - 8" + Drywall	7.5	Concrete Frame - Light Clad Metal	150	Concrete - 12" + Drywall
2	Lateral Load-Resisting System Material Type	S	Steel	10	Wood Frame - Siding	2.5	Wood Frame - Siding (Low Income)	20	Wood Frame - Siding
2	Lateral Load-Resisting System Material Type	ME	Metal (except steel)	10	Wood Frame - Siding	2.5	Wood Frame - Siding (Low Income)	20	Wood Frame - Siding
2	Lateral Load-Resisting System Material Type	M99	Masonry, unknown reinforcement	100	Masonry - Fired Brick - 35cm + Plaster (Moderate Wall)	20	Masonry - Concrete - 8" Blocks, Unreinforced	300	Masonry - Fired Brick - 72cm + Plaster

Flowchart Level	GEM Attribute Type	GEM Attribute ID	GEM Attribute Description	Nominal Value (psf)	(example)	Low Range (psf)	(example)	High Range (psf)	(example)
2	Lateral Load-Resisting System Material Type	MUR	Masonry, unreinforced	100	Masonry - Fired Brick - 35cm + Plaster (Moderate Wall)	20	Masonry - Concrete - 8" Blocks, Unreinforced	300	Masonry - Fired Brick - 72cm + Plaster
2	Lateral Load-Resisting System Material Type	MCF	Masonry, confined	100	Concrete Frame - Brick Infill	40	Concrete Frame - Thin Unreinforced 8" Concrete Block Infill	150	Concrete Frame - Reinforced, 16" oc Grout, 8" Concrete Block Infill + Brick Veneer
2	Lateral Load-Resisting System Material Type	MR	Masonry, reinforced	100	Masonry - Concrete - 8" Blocks + Drywall, Reinforced w Full Grout	40	Masonry - Concrete - 8" Blocks, Reinforced w 16" Grout Spacing	150	Masonry - Concrete - 8" Blocks + Drywall + Brick Veneer, Reinforced w 16" Grout Spacing
2	Lateral Load-Resisting System Material Type	E99	Earth, unknown reinforcement	100	Earthen - 10" Rammed Earth (Low Income)	75	Earthen - 10" Rammed Earth (Low Income)	300	Earthen - 3' Rammed Earth (Low Income)

Flowchart Level	GEM Attribute Type	GEM Attribute ID	GEM Attribute Description	Nominal Value (psf)	(example)	Low Range (psf)	(example)	High Range (psf)	(example)
2	Lateral Load-Resisting System Material Type	EU	Earth, unreinforced	100	Earthen - 10" Rammed Earth (Low Income)	75	Earthen - 10" Rammed Earth (Low Income)	300	Earthen - 3' Rammed Earth (Low Income)
2	Lateral Load-Resisting System Material Type	ER	Earth, reinforced	100	Earthen - 10" Rammed Earth (Low Income)	75	Earthen - 10" Rammed Earth (Low Income)	300	Earthen - 3' Rammed Earth (Low Income)
2	Lateral Load-Resisting System Material Type	W	Wood	10	Wood Frame - Siding	0.5	Wood Frame - Plastic Sheet (Low Income)	20	Wood Frame - Siding
3	Lateral Load-Resisting System Material Technology	WBB	Bamboo	1.5	Wood Frame - Plastic Sheet (Low Income)	0.5	Wood Frame - Plastic Sheet (Low Income)	7.5	Wood Frame - Siding (Low Income)
3	Lateral Load-Resisting System Material Technology	n/a	ALL OTHERS	10	Wood Frame - Siding	2.5	Wood Frame - Siding (Low Income)	20	Wood Frame - Siding

Flowchart Level	GEM Attribute Type	GEM Attribute ID	GEM Attribute Description	Nominal Value (psf)	(example)	Low Range (psf)	(example)	High Range (psf)	(example)
2	Lateral Load-Resisting System Material Type	MATO	Other Material	10	n/a	0.5	n/a	300	n/a
1	Exterior Walls	EWCB	Cement-based boards for exterior walls	10	Wood Frame - Cemesto + Wood Siding	2.5	Wood Frame - Cemesto	20	Wood Frame - Cemesto + Wood Siding
1	Exterior Walls	EWO	Material of exterior walls, other	100	n/a	0.5	n/a	300	n/a

SUB-APPENDIX C2: ROOF DENSITY

Roof and attic construction which is used to determine the roof density.
Specifically the roof dead load + floor joists + roof/attic live load.
For clarity, this table is spread across several pages.

Flowchart Level	GEM Attribute Type	GEM Attribute ID	GEM Attribute Description	Nominal Value (psf)	(example)	Low Range (psf)	(example)	High Range (psf)	(example)
1	Roof System Material	R99 (or blank)	Roof material unknown	30	Concrete - 2" Solid	1.5	[Roof: Vegetative - 1" Thatch]	300	[Roof: Masonry - Fired Brick Barrel Vault = 12" thick]
2	Lateral Load-Resisting System Material Type	W	Wood	10	[Roof: Wood - Asphalt Shingles] + [Joists: Wood - 2x6, 16"oc] + [Ceiling: Wood - Drywall (gypsum)]	1.5	[Roof: Vegetative - 1" Thatch]	75	[Roof: Masonry - Clay Tile w Mortar] + [Joists: Wood - 2x6, 16"oc] + [Ceiling: Wood - Plaster (wood lath)]
2	Lateral Load-Resisting System Material Type	n/a	ALL OTHERS	30	Concrete - 2" Solid	1.5	[Roof: Vegetative - 1" Thatch]	300	[Roof: Masonry - Fired Brick Barrel Vault = 12" thick]

Flowchart Level	GEM Attribute Type	GEM Attribute ID	GEM Attribute Description	Nominal Value (psf)	(example)	Low Range (psf)	(example)	High Range (psf)	(example)
1	Roof System Material	RM	Masonry roof	100	[Roof: Masonry - Fired Brick Barrel Vault - 8" thick]	40	[Roof: Masonry - Fired Brick Shallow Vault]	300	[Roof: Masonry - Fired Brick Barrel Vault = 12" thick]
2	Roof System Type	RM99	Masonry roof, unknown	100	[Roof: Masonry - Fired Brick Barrel Vault - 8" thick]	40	[Roof: Masonry - Fired Brick Shallow Vault]	300	[Roof: Masonry - Fired Brick Barrel Vault = 12" thick]
2	Roof System Type	RM1	Vaulted masonry roof	100	[Roof: Masonry - Fired Brick Barrel Vault - 8" thick]	75	[Roof: Masonry - Fired Brick Barrel Vault - 8" thick]	300	[Roof: Masonry - Fired Brick Barrel Vault = 12" thick]
2	Roof System Type	RM2	Shallow-arched masonry roof	50	[Roof: Masonry - Fired Brick Shallow Vault]	40	[Roof: Masonry - Fired Brick Shallow Vault]	75	[Roof: Masonry - Fired Brick Shallow Vault]
2	Roof System Type	RM3	Composite masonry and concrete roof system	100	[Roof: Concrete - 8" Hollowcore + 2" topping] ¹⁴	40	[Roof: Concrete Frame - Thin Terra Cotta Infill]	150	[Roof: Concrete Frame - Brick Infill]

¹⁴ Assumes hollowcore concrete slabs are similar in weight to composite concrete and hollow masonry.

Flowchart Level	GEM Attribute Type	GEM Attribute ID	GEM Attribute Description	Nominal Value (psf)	(example)	Low Range (psf)	(example)	High Range (psf)	(example)
1	Roof System Material	RE	Earthen roof	100	[Roof: Masonry - Adobe Vault/Dome]	75	[Roof: Masonry - Adobe Vault/Dome]	150	[Roof: Masonry - Adobe Vault/Dome]
1	Roof System Material	RC	Concrete roof	30	Concrete - 2" Solid	20	Concrete - 2" Solid	150	Concrete - 8" Hollowcore + 2" topping
2	Roof System Type	RC99	Concrete roof, unknown	30	Concrete - 2" Solid	20	Concrete - 2" Solid	150	Concrete - 8" Hollowcore + 2" topping
2	Roof System Type	RC1	Cast-in-place beamless reinforced concrete roof	30	[Roof: Concrete - 2" Solid]	20	[Roof: Concrete - 2" Solid]	75	[Roof: Concrete - 6" Solid]
2	Roof System Type	RC2	Cast-in-place beam-supported reinforced concrete roof	30	[Roof: Concrete - 2" Solid] + [Joists: Concrete - 12" Cross Beams 8m oc]	20	[Roof: Concrete - 2" Solid] + [Joists: Concrete - 12" Cross Beams 8m oc]	75	[Roof: Concrete - 6" Solid] + [Joists: Concrete - 12" Cross Beams 8m oc]

Flowchart Level	GEM Attribute Type	GEM Attribute ID	GEM Attribute Description	Nominal Value (psf)	(example)	Low Range (psf)	(example)	High Range (psf)	(example)
2	Roof System Type	RC3	Precast concrete roof with reinforced concrete topping	50	[Roof: Concrete - 4" Solid]	40	[Roof: Concrete - 4" Solid]	150	[Roof: Concrete - 8" Hollowcore + 2" topping]
2	Roof System Type	RC4	Precast concrete roof without reinforced concrete topping	30	[Roof: Concrete - 2" Solid]	20	[Roof: Concrete - 2" Solid]	75	[Roof: Concrete - 6" Solid]
1	Roof System Material	RME	Metal roof	30	[Roof: Concrete - 2" Solid] + [Joists: Metal Joists]	2.5	[Roof: Lightweight - Metal]	75	[Roof: Concrete - 4" Solid] + [Joists: Metal Joists]
2	Roof System Type	RME99	Metal roof, unknown	30	[Roof: Concrete - 2" Solid] + [Joists: Metal Joists]	2.5	[Roof: Lightweight - Metal]	75	[Roof: Concrete - 4" Solid] + [Joists: Metal Joists]
2	Roof System Type	RME1	Metal beams or trusses supporting light roofing	5	[Roof: Lightweight - Metal]	2.5	[Roof: Lightweight - Metal]	20	[Roof: Lightweight - Elastomeric (rubber) + Gravel]

Flowchart Level	GEM Attribute Type	GEM Attribute ID	GEM Attribute Description	Nominal Value (psf)	(example)	Low Range (psf)	(example)	High Range (psf)	(example)
2	Roof System Type	RME2	Metal roof beams supporting precast concrete slabs	30	[Roof: Concrete - 2" Solid] + [Joists: Metal Joists]	20	[Roof: Concrete - 2" Solid] + [Joists: Metal Joists]	75	[Roof: Concrete - 4" Solid] + [Joists: Metal Joists]
2	Roof System Type	RME3	Composite steel roof deck and concrete slab	30	[Roof: Concrete - 2" Solid] + [Joists: Metal Joists]	20	[Roof: Concrete - 2" Solid] + [Joists: Metal Joists]	75	[Roof: Concrete - 4" Solid] + [Joists: Metal Joists]
1	Roof System Material	RWO	Wooden roof	10	[Roof: Wood - Asphalt Shingles] + [Joists: Wood - 2x6, 16"oc] + [Ceiling: Wood - Drywall (gypsum)]	1.5	[Roof: Vegetative - 1" Thatch]	75	[Roof: Masonry - Clay Tile w Mortar] + [Joists: Wood - 2x6, 16"oc] + [Ceiling: Wood - Plaster (wood lath)]

Flowchart Level	GEM Attribute Type	GEM Attribute ID	GEM Attribute Description	Nominal Value (psf)	(example)	Low Range (psf)	(example)	High Range (psf)	(example)
2	Roof System Type	RWO99	Wooden roof, unknown	10	[Roof: Wood - Asphalt Shingles] + [Joists: Wood - 2x6, 16"oc] + [Ceiling: Wood - Drywall (gypsum)]	1.5	[Roof: Vegetative - 1" Thatch]	75	[Roof: Masonry - Clay Tile w Mortar] + [Joists: Wood - 2x6, 16"oc] + [Ceiling: Wood - Plaster (wood lath)]
2	Roof System Type	RWO1	Wooden structure with light roof covering	10	[Roof: Wood - Elastomeric (rubber)]	2.5	[Roof: Wood - Wood Shingles (Low Income)]	40	[Roof: Wood - Metal Sheets] + [Joists: Wood - 2x6, 16"oc] + [Ceiling: Wood - Plaster (wood lath)]
2	Roof System Type	RWO2	Wooden beams or trusses with heavy roof covering	30	[Roof: Earthen - Wattle and Daub]	7.5	[Roof: Wood - Mud (Thin)]	75	[Roof: Wood - Mud (Thick)]

Flowchart Level	GEM Attribute Type	GEM Attribute ID	GEM Attribute Description	Nominal Value (psf)	(example)	Low Range (psf)	(example)	High Range (psf)	(example)
2	Roof System Type	RWO3	Wood-based sheets on rafters or purlins	10	[Roof: Wood - Asphalt Shingles] + [Joists: Wood - 2x6, 16"oc] + [Ceiling: Wood - Drywall (gypsum)]	7.5	[Roof: Wood - Asphalt Shingles]	75	[Roof: Masonry - Clay Tile w Mortar] + [Joists: Wood - 2x6, 16"oc] + [Ceiling: Wood - Plaster (wood lath)]
2	Roof System Type	RWO4	Plywood panels or other light-weight panels for roof	10	[Roof: Wood - Elastomeric (rubber)]	2.5	[Roof: Wood - Metal Sheets (Low Income)]	20	[Roof: Wood - Elastomeric (rubber)] + [Joists: Wood - 2x6, 16"oc] + [Ceiling: Wood - Drywall (gypsum)]
2	Roof System Type	RWO5	Bamboo, straw or thatch roof	5	[Roof: Vegetative - 4" Thatch]	1.5	[Roof: Vegetative - 1" Thatch]	20	[Roof: Vegetative - 4" Thatch] + [Joists: Wood - 2x6, 16"oc] + [Ceiling: Wood - Drywall (gypsum)]

Flowchart Level	GEM Attribute Type	GEM Attribute ID	GEM Attribute Description	Nominal Value (psf)	(example)	Low Range (psf)	(example)	High Range (psf)	(example)
1	Roof System Material	RFA	Fabric roof	10	[Roof: Fabric]	0.5	[Roof: Fabric - Lightweight]	20	[Roof: Fabric]
2	Roof System Type	RFA1	Inflatable or tensile membrane roof	10	[Roof: Fabric]	7.5	[Roof: Fabric]	20	[Roof: Fabric]
2	Roof System Type	RFAO	Fabric roof, other	10	[Roof: Fabric]	0.5	[Roof: Fabric - Lightweight]	20	[Roof: Fabric]
1	Roof System Material	RO	Roof material, other	30	n/a	1.5	n/a	300	n/a

SUB-APPENDIX C3: CEILING-FLOOR DENSITY

Construction which is used to determine the floor density.
Specifically the ceiling dead load + floor joists + floor dead load.
For clarity, this table is spread across several pages.

Flowchart Level	GEM Attribute Type	GEM Attribute ID	GEM Attribute Description	Nominal Value (psf)	(example)	Low Range (psf)	(example)	High Range (psf)	(example)
1	Floor Material	FN	No elevated or suspended floor	30	[Floor: Earthen - Wattle and Daub]	2.5	[Floor: Wood - Thin Planks] + [Joists: Wood - 6" cross beams, 2m oc]	150	[Floor: Concrete - 12"]
1	Floor Material	F99 (or blank)	Floor material, unknown	30	[Floor: Earthen - Wattle and Daub]	2.5	[Floor: Wood - Thin Planks] + [Joists: Wood - 6" cross beams, 2m oc]	150	[Floor: Concrete - 12"]
2	Lateral Load-Resisting System Material Type	W	Wood	10	[Floor: Wood - Hardwood] + [Joists: Wood - 2x6, 16"oc] + [Ceiling: Wood - Drywall (gypsum)]	2.5	[Floor: Wood - Thin Planks] + [Joists: Wood - 6" cross beams, 2m oc]	75	[Floor: Earthen - Wattle and Daub] + [Joists: Wood - 12" cross beams, 4m oc] + [Ceiling: Wood - Plaster (wood lath)]

Flowchart Level	GEM Attribute Type	GEM Attribute ID	GEM Attribute Description	Nominal Value (psf)	(example)	Low Range (psf)	(example)	High Range (psf)	(example)
2	Lateral Load-Resisting System Material Type		ALL OTHERS	30	[Floor: Earthen - Wattle and Daub]	2.5	[Floor: Wood - Thin Planks] + [Joists: Wood - 6" cross beams, 2m oc]	150	[Floor: Concrete - 12"]
1	Floor Material	FM	Masonry floor	100	[Floor: Concrete - 8" Hollowcore + 2" topping]	40	[Floor: Masonry - Fired Brick Shallow Vault]	150	[Floor: Concrete Frame - Brick Infill]
2	Floor System Type	FM99	Masonry floor, unknown	100	[Floor: Concrete - 8" Hollowcore + 2" topping]	40	[Floor: Masonry - Fired Brick Shallow Vault]	150	[Floor: Concrete Frame - Brick Infill]
2	Floor System Type	FM1	Vaulted masonry floor	50	[Floor: Masonry - Fired Brick Shallow Vault]	40	[Floor: Masonry - Fired Brick Shallow Vault]	75	[Floor: Masonry - Fired Brick Shallow Vault]
2	Floor System Type	FM2	Shallow-arched masonry floor	50	[Floor: Masonry - Fired Brick Shallow Vault]	40	[Floor: Masonry - Fired Brick Shallow Vault]	75	[Floor: Masonry - Fired Brick Shallow Vault]

Flowchart Level	GEM Attribute Type	GEM Attribute ID	GEM Attribute Description	Nominal Value (psf)	(example)	Low Range (psf)	(example)	High Range (psf)	(example)
2	Floor System Type	FM3	Composite cast-in-place reinforced concrete and masonry floor system	100	[Floor: Concrete - 8" Hollowcore + 2" topping] ¹⁵	40	[Floor: Concrete Frame - Thin Terra Cotta Infill]	150	[Floor: Concrete Frame - Brick Infill]
1	Floor Material	FE	Earthen floor	30	[Floor: Earthen - Wattle and Daub]	7.5	[Floor: Earthen - 4cm Mud] + [Joists: Wood - Lightweight]	75	[Floor: Wood - Mud (Thick)]
1	Floor Material	FC	Concrete floor	50	[Floor: Concrete - 4" Solid]	20	[Floor: Concrete - 2" Solid]	150	[Floor: Concrete - 16" Hollowcore + 2" topping]
2	Floor System Type	FC99	Concrete floor, unknown	50	[Floor: Concrete - 4" Solid]	20	[Floor: Concrete - 2" Solid]	150	[Floor: Concrete - 16" Hollowcore + 2" topping]
2	Floor System Type	FC1	Cast-in-place beamless reinforced concrete floor	50	[Floor: Concrete - 4" Solid]	20	[Floor: Concrete - 2" Solid]	75	[Floor: Concrete - 6" Solid]

¹⁵ Assumes hollowcore concrete slabs are similar in weight to composite concrete and hollow masonry.

Flowchart Level	GEM Attribute Type	GEM Attribute ID	GEM Attribute Description	Nominal Value (psf)	(example)	Low Range (psf)	(example)	High Range (psf)	(example)
2	Floor System Type	FC2	Cast-in-place beam-supported reinforced concrete floor	50	[Floor: Concrete - 4" Solid] + [Joists: Concrete - 12" Cross Beams 8m oc]	20	[Floor: Concrete - 2" Solid] + [Joists: Concrete - 12" Cross Beams 8m oc]	75	[Floor: Concrete - 6" Solid] + [Joists: Concrete - 12" Cross Beams 8m oc]
2	Floor System Type	FC3	Precast concrete floor with reinforced concrete topping	50	[Floor: Concrete - 6" Hollowcore + 2" topping]	40	[Floor: Concrete - 4" Solid]	150	[Floor: Concrete - 16" Hollowcore + 2" topping]
2	Floor System Type	FC4	Precast concrete floor without reinforced concrete topping	50	[Floor: Concrete - 4" Solid]	20	[Floor: Concrete - 2" Solid]	150	[Floor: Concrete - 12"]
1	Floor Material	FME	Metal floor	50	[Floor: Concrete - 4" Solid] + [Joists: Metal Joists]	2.5	[Floor: Wood - Resilient] + [Joists: Metal - Steel Trusses]	150	[Floor: Concrete - 8" Hollowcore + 2" topping]

Flowchart Level	GEM Attribute Type	GEM Attribute ID	GEM Attribute Description	Nominal Value (psf)	(example)	Low Range (psf)	(example)	High Range (psf)	(example)
2	Floor System Type	FME99	Metal floor, unknown	50	[Floor: Concrete - 4" Solid] + [Joists: Metal Joists]	2.5	[Floor: Wood - Resilient] + [Joists: Metal - Steel Trusses]	150	[Floor: Concrete - 8" Hollowcore + 2" topping]
2	Floor System Type	FME1	Metal beams or trusses supporting light flooring	10	[Floor: Wood - Resilient] + [Joists: Metal - Steel Joists] + [Ceiling: Metal - Acoustical Panels + Ducts]	2.5	[Floor: Wood - Resilient] + [Joists: Metal - Steel Trusses]	20	[Floor: Wood - Resilient] + [Joists: Metal - Steel Joists] + [Ceiling: Metal - Acoustical Panels + Ducts]
2	Floor System Type	FME2	Metal floor beams supporting precast concrete slabs	50	[Floor: Concrete - 4" Solid] + [Joists: Metal Joists]	20	[Floor: Concrete - 2" Solid] + [Joists: Metal Joists]	150	[Floor: Concrete - 8" Hollowcore + 2" topping] + [Joists: Metal Joists]
2	Floor System Type	FME3	Composite steel deck and concrete slab	50	[Floor: Concrete - 4" Solid]	20	[Floor: Concrete - 2" Solid]	150	[Floor: Concrete - 8" Hollowcore + 2" topping]

Flowchart Level	GEM Attribute Type	GEM Attribute ID	GEM Attribute Description	Nominal Value (psf)	(example)	Low Range (psf)	(example)	High Range (psf)	(example)
1	Floor Material	FW	Wooden floor	10	[Floor: Wood - Hardwood] + [Joists: Wood - 2x6, 16"oc] + [Ceiling: Wood - Drywall (gypsum)]	2.5	[Floor: Wood - Thin Planks] + [Joists: Wood - 6" cross beams, 2m oc]	75	[Floor: Earthen - Wattle and Daub] + [Joists: Wood - 12" cross beams, 4m oc] + [Ceiling: Wood - Plaster (wood lath)]
2	Floor System Type	FW99	Wooden floor, unknown	10	[Floor: Wood - Hardwood] + [Joists: Wood - 2x6, 16"oc] + [Ceiling: Wood - Drywall (gypsum)]	2.5	[Floor: Wood - Thin Planks] + [Joists: Wood - 6" cross beams, 2m oc]	75	[Floor: Earthen - Wattle and Daub] + [Joists: Wood - 12" cross beams, 4m oc] + [Ceiling: Wood - Plaster (wood lath)]
2	Floor System Type	FW1	Wooden beams or trusses and joists supporting light flooring	5	[Floor: Wood - Thin Planks] + [Joists: Wood - 6" cross beams, 2m oc]	2.5	[Floor: Wood - Thin Planks] + [Joists: Wood - 6" cross beams, 2m oc]	20	[Floor: Wood - Hardwood] + [Joists: Wood - 12" cross beams, 4m oc]

Flowchart Level	GEM Attribute Type	GEM Attribute ID	GEM Attribute Description	Nominal Value (psf)	(example)	Low Range (psf)	(example)	High Range (psf)	(example)
2	Floor System Type	FW2	Wooden beams or trusses and joists supporting heavy flooring	30	[Floor: Earthen - Wattle and Daub] + [Joists: Wood - 12" cross beams, 4m oc]	7.5	[Floor: Earthen - 4cm Mud] + [Joists: Wood - 6" cross beams, 2m oc]	75	[Floor: Earthen - Wattle and Daub] + [Joists: Wood - 12" cross beams, 4m oc] + [Ceiling: Wood - Plaster (wood lath)]
2	Floor System Type	FW3	Wood-based sheets on joists or beams	10	[Floor: Wood - Hardwood] + [Joists: Wood - 2x6, 16"oc] + [Ceiling: Wood - Drywall (gypsum)]	7.5	[Floor: Wood - Resilient] + [Joists: Wood - 2x6, 16"oc]	40	[Floor: Wood - Ceramic/Slate Tile] + [Joists: Wood - 12" cross beams, 4m oc] + [Ceiling: Wood - Plaster (wood lath)]

Flowchart Level	GEM Attribute Type	GEM Attribute ID	GEM Attribute Description	Nominal Value (psf)	(example)	Low Range (psf)	(example)	High Range (psf)	(example)
2	Floor System Type	FW4	Plywood panels or other light-weight panels for floor	10	[Floor: Lightweight - Composite Panel] + [Joists: Wood - 2x10, 16"oc] + [Ceiling: Wood - Drywall (gypsum)]	2.5	[Floor: Lightweight - Composite Panel] + [Joists: Wood - 2x10, 16"oc]	20	[Floor: Lightweight - Composite Panel] + [Joists: Wood - 2x10, 16"oc] + [Ceiling: Metal - Acoustical Panels + Ducts]
1	Floor Material	FO	Floor material, other	30	n/a	2.5	n/a	150	n/a

SUB-APPENDIX C4: LIVE LOAD

Building contents that contribute to the overall interior density.
Specifically the live load for a basement or above ground story.
For clarity, this table is spread across several pages.

Flowchart Level	GEM Attribute Type	GEM Attribute ID	GEM Attribute Description	Nominal Value (psf)	(example)	Low Range (psf)	(example)	High Range (psf)	(example)
1	Building Occupancy Class – General	OC99 (or blank)	Unknown occupancy type	10	Office - Typical	0	Office - Light	300	Heavy Manuf/Warehouse - Max
1	Building Occupancy Class – General	RES	Residential	5	Residential - Typical	0.5	Residential - Light	20	Residential - Heavy
1	Building Occupancy Class – General	COM	Commercial and public	30	Store - Quarter Max	0	Office - Light	300	Heavy Manuf/Warehouse - Max
2	Building Occupancy Class – Detail	COM99	Commercial and public, unknown type	30	Store - Quarter Max	0.5	Office - Light	300	Heavy Manuf/Warehouse - Max
2	Building Occupancy Class – Detail	COM1	Retail trade	30	Store - Quarter Max	20	Store - Quarter Max	150	Store - Max
2	Building Occupancy Class – Detail	COM2	Wholesale trade and storage (warehouse)	50	Light Manuf/Warehouse - Half Max	20	Light Manuf/Warehouse - Quarter Max	300	Heavy Manuf/Warehouse - Max

Flowchart Level	GEM Attribute Type	GEM Attribute ID	GEM Attribute Description	Nominal Value (psf)	(example)	Low Range (psf)	(example)	High Range (psf)	(example)
2	Building Occupancy Class – Detail	COM3	Offices, professional/technical services	10	Office - Typical	0	Office - Light	40	Office - Heavy
2	Building Occupancy Class – Detail	COM4	Hospital/medical clinic	10	Hospital - Quarter Max	7.5	Hospital - Quarter Max	40	Hospital - Half Max
2	Building Occupancy Class – Detail	COM5	Entertainment	50	Restaurant - Half Max	20	Restaurant - Quarter Max	150	Restaurant - Max
2	Building Occupancy Class – Detail	COM6	Public building	50	Recreational /Assembly - Half Max	20	Library - Quarter Max	150	Library - Max
2	Building Occupancy Class – Detail	COM7	Covered parking garage	10	Parking Garage - Quarter Max	7.5	Parking Garage - Quarter Max	40	Parking Garage - Max
2	Building Occupancy Class – Detail	COM8	Bus station	100	Bus station	75	Bus station	150	Bus station

Flowchart Level	GEM Attribute Type	GEM Attribute ID	GEM Attribute Description	Nominal Value (psf)	(example)	Low Range (psf)	(example)	High Range (psf)	(example)
2	Building Occupancy Class – Detail	COM9	Railway station	100	Bus station	75	Bus station	150	Bus station
2	Building Occupancy Class – Detail	COM10	Airport	100	Bus station	75	Bus station	150	Bus station
2	Building Occupancy Class – Detail	COM11	Recreation and leisure	50	Recreational /Assembly - Half Max	20	Recreational /Assembly - Quarter Max	150	Recreational /Assembly - Max
1	Building Occupancy Class – General	MIX	Mixed Use	30	Store - Quarter Max	0	Office - Light	300	Heavy Manuf/Warehouse - Max
2	Building Occupancy Class – Detail	MIX99	Mixed, unknown type	30	Store - Quarter Max	0	Office - Light	300	Heavy Manuf/Warehouse - Max
2	Building Occupancy Class – Detail	MIX1	Mostly residential and commercial	5	Residential - Typical	0	Office - Light	150	Store - Max
2	Building Occupancy Class – Detail	MIX2	Mostly commercial and residential	10	Office - Typical	0	Office - Light	150	Store - Max

Flowchart Level	GEM Attribute Type	GEM Attribute ID	GEM Attribute Description	Nominal Value (psf)	(example)	Low Range (psf)	(example)	High Range (psf)	(example)
2	Building Occupancy Class – Detail	MIX3	Mostly commercial and industrial	10	Office - Typical	0	Office - Light	300	Heavy Manuf/Warehouse - Max
2	Building Occupancy Class – Detail	MIX4	Mostly residential and industrial	5	Residential - Typical	0.5	Residential - Light	300	Heavy Manuf/Warehouse - Max
2	Building Occupancy Class – Detail	MIX5	Mostly industrial and commercial	50	Light Manuf/Warehouse - Half Max	0	Office - Light	300	Heavy Manuf/Warehouse - Max
2	Building Occupancy Class – Detail	MIX6	Mostly industrial and residential	50	Light Manuf/Warehouse - Half Max	0.5	Residential - Light	300	Heavy Manuf/Warehouse - Max
1	Building Occupancy Class – General	IND	Industrial	50	Light Manuf/Warehouse - Half Max	20	Light Manuf/Warehouse - Quarter Max	300	Heavy Manuf/Warehouse - Max
2	Building Occupancy Class – Detail	IND99	Industrial, unknown type	50	Light Manuf/Warehouse - Half Max	20	Light Manuf/Warehouse - Quarter Max	300	Heavy Manuf/Warehouse - Max
2	Building Occupancy Class – Detail	IND1	Heavy industrial	100	Heavy Manuf/Warehouse - Half Max	40	Heavy Manuf/Warehouse - Quarter Max	300	Heavy Manuf/Warehouse - Max

Flowchart Level	GEM Attribute Type	GEM Attribute ID	GEM Attribute Description	Nominal Value (psf)	(example)	Low Range (psf)	(example)	High Range (psf)	(example)
2	Building Occupancy Class – Detail	IND2	Light industrial	50	Light Manuf/Warehouse - Half Max	20	Light Manuf/Warehouse - Quarter Max	150	Light Manuf/Warehouse - Max
1	Building Occupancy Class – General	AGR	Agricultural	50	Light Manuf/Warehouse - Half Max	2.5	Agriculture - Poultry - Quarter Max	300	Heavy Manuf/Warehouse - Max
2	Building Occupancy Class – Detail	AGR99	Agriculture, unknown type	50	Light Manuf/Warehouse - Half Max	2.5	Agriculture - Poultry - Quarter Max	300	Heavy Manuf/Warehouse - Max
2	Building Occupancy Class – Detail	AGR1	Produce storage	50	Light Manuf/Warehouse - Half Max	20	Light Manuf/Warehouse - Quarter Max	300	Heavy Manuf/Warehouse - Max
2	Building Occupancy Class – Detail	AGR2	Animal shelter	30	Agriculture - Swine/Sheep - Half Max	2.5	Agriculture - Poultry - Quarter Max	75	Agriculture - Cattle/Horses - Half Max
2	Building Occupancy Class – Detail	AGR3	Agricultural processing	50	Light Manuf/Warehouse - Half Max	20	Light Manuf/Warehouse - Quarter Max	300	Heavy Manuf/Warehouse - Max
1	Building Occupancy Class – General	ASS	Assembly	50	Recreational /Assembly - Half Max	20	Recreational /Assembly - Quarter Max	150	Recreational /Assembly - Max

Flowchart Level	GEM Attribute Type	GEM Attribute ID	GEM Attribute Description	Nominal Value (psf)	(example)	Low Range (psf)	(example)	High Range (psf)	(example)
1	Building Occupancy Class – General	GOV	Government	10	Office - Typical	0	Office - Light	40	Office - Heavy
2	Building Occupancy Class – Detail	GOV99	Government, unknown type	10	Office - Typical	0	Office - Light	40	Office - Heavy
2	Building Occupancy Class – Detail	GOV1	Government, general services	10	Office - Typical	0	Office - Light	40	Office - Heavy
2	Building Occupancy Class – Detail	GOV2	Government, emergency response	10	Office - Typical	7.5	Office - Typical	40	Parking Garage - Max
1	Building Occupancy Class – General	EDU	Education	10	School - Typical	2.5	School - Light	75	Laboratory - Half Max
2	Building Occupancy Class – Detail	EDU99	Education, unknown type	10	School - Typical	2.5	School - Light	75	Laboratory - Half Max
2	Building Occupancy Class – Detail	EDU1	Pre-school facility	10	School - Typical	2.5	School - Light	20	School - Heavy

Flowchart Level	GEM Attribute Type	GEM Attribute ID	GEM Attribute Description	Nominal Value (psf)	(example)	Low Range (psf)	(example)	High Range (psf)	(example)
2	Building Occupancy Class – Detail	EDU2	School	10	School - Typical	2.5	School - Light	20	School - Heavy
2	Building Occupancy Class – Detail	EDU3	College/university offices and/or classrooms	10	School - Typical	2.5	School - Light	20	School - Heavy
2	Building Occupancy Class – Detail	EDU4	College/university research facilities and/or labs	30	Laboratory - Quarter Max	20	Laboratory - Quarter Max	75	Laboratory - Half Max
1	Building Occupancy Class – General	OCO	Other occupancy type	10	n/a	0	n/a	300	n/a

SUB-APPENDIX C5: INTERIOR WALL DENSITY

Interior and partition wall construction that contributes to the overall interior density.
Specifically the dead load for interior walls, columns, and/or partitions.
For clarity, this table is spread across several pages.

Flowchart Level	GEM Attribute Type	GEM Attribute ID	GEM Attribute Description	Nominal Value (psf)	(example)	Low Range (psf)	(example)	High Range (psf)	(example)
1	Exterior Walls	EW99 (or blank)	Unknown material of exterior walls	30	Interior Walls and Column - Lightweight partitions + 40cm Square Concrete Columns	0	No Interior Walls or Columns	300	Interior Walls - 1.5' Earthen
1	Exterior Walls	EWC	Concrete exterior walls	50	Interior Walls - Concrete 4"	0	No Interior Walls or Columns	150	Interior Walls - Concrete 6"
1	Exterior Walls	EWG	Glass exterior walls	10	Interior Walls and Columns - Lightweight partitions + Well Spaced Concrete Column	0	No Interior Walls or Columns	75	Interior Walls and Columns - Lightweight partitions + Tightly Spaced Concrete Column

Flowchart Level	GEM Attribute Type	GEM Attribute ID	GEM Attribute Description	Nominal Value (psf)	(example)	Low Range (psf)	(example)	High Range (psf)	(example)
1	Exterior Walls	EWE	Earthen exterior walls	100	Interior Walls - Masonry, 6" Adobe Brick + Plaster ¹⁶	0	No Interior Walls or Columns	300	Interior Walls - 1.5' Earthen
2	Lateral Load-Resisting System Material Technology	WWD	Wattle and daub	10	Interior Walls and Column - Lightweight partitions + 6" Square Timbers	0	No Interior Walls or Columns	75	Interior Walls - Half-Timber, Thin Wall (Wattle and Daub)
2	Lateral Load-Resisting System Material Technology	n/a	ALL OTHERS	100	Interior Walls - Masonry, 6" Adobe Brick + Plaster	0	No Interior Walls or Columns	300	Interior Walls - 1.5' Earthen
1	Exterior Walls	EWMA	Masonry exterior walls	50	Interior Walls - Masonry, 4" Concrete Block, Unreinforced + Plaster	0	No Interior Walls or Columns	300	Interior Walls - Masonry, 35cm Fired Brick + Plaster

¹⁶ Assumes adobe brick and earthen walls are similar in weight.

Flowchart Level	GEM Attribute Type	GEM Attribute ID	GEM Attribute Description	Nominal Value (psf)	(example)	Low Range (psf)	(example)	High Range (psf)	(example)
2	Lateral Load-Resisting System Material Type	MAT99 (or blank)	Unknown material	50	Interior Walls - Masonry, 4" Concrete Block, Unreinforced + Plaster	0	No Interior Walls or Columns	300	Interior Walls - Masonry, 35cm Fired Brick + Plaster
2	Lateral Load-Resisting System Material Type	C99	Concrete, unknown reinforcement	50	Interior Walls - Masonry, 4" Concrete Block, Unreinforced + Plaster	0	No Interior Walls or Columns	150	Interior Walls - Concrete 6"
2	Lateral Load-Resisting System Material Type	CU	Concrete, unreinforced	50	Interior Walls - Masonry, 4" Concrete Block, Unreinforced + Plaster	0	No Interior Walls or Columns	150	Interior Walls - Concrete 6"
2	Lateral Load-Resisting System Material Type	CR	Concrete, reinforced	30	Interior Walls and Column - Lightweight partitions + 40cm Square Concrete Columns	0	No Interior Walls or Columns	150	Interior Walls and Column - Terracotta Infill + Concrete Columns

Flowchart Level	GEM Attribute Type	GEM Attribute ID	GEM Attribute Description	Nominal Value (psf)	(example)	Low Range (psf)	(example)	High Range (psf)	(example)
2	Lateral Load-Resisting System Material Type	SRC	Concrete, composite with steel section	50	Interior Walls - Concrete 4"	0	No Interior Walls or Columns	150	Interior Walls - Concrete 6"
2	Lateral Load-Resisting System Material Type	S	Steel	10	Interior Walls and Columns - Lightweight Partition + Steel Column, Large Rooms	0	No Interior Walls or Columns	40	Interior Walls - Drywall Over Plaster
2	Lateral Load-Resisting System Material Type	ME	Metal (except steel)	10	Interior Walls and Columns - Lightweight Partition + Steel Column, Large Rooms	0	No Interior Walls or Columns	40	Interior Walls - Drywall Over Plaster
2	Lateral Load-Resisting System Material Type	M99	Masonry, unknown reinforcement	100	Interior Walls - Masonry, 9" Fired Brick + Plaster	0	No Interior Walls or Columns	300	Interior Walls - Masonry, 35cm Fired Brick + Plaster

Flowchart Level	GEM Attribute Type	GEM Attribute ID	GEM Attribute Description	Nominal Value (psf)	(example)	Low Range (psf)	(example)	High Range (psf)	(example)
2	Lateral Load-Resisting System Material Type	MUR	Masonry, unreinforced	100	Interior Walls - Masonry, 9" Fired Brick + Plaster	1.5	Columns - 12" Square Timbers	300	Interior Walls - Masonry, 35cm Fired Brick + Plaster
2	Lateral Load-Resisting System Material Type	MCF	Masonry, confined	50	Interior Walls and Columns - Masonry, 4" Concrete Block w Plaster, Unreinforced + Concrete Column	0	No Interior Walls or Columns	150	Interior Walls and Column - Terracotta Infill + Concrete Columns
2	Lateral Load-Resisting System Material Type	MR	Masonry, reinforced	100	Interior Walls - Masonry, 8" Concrete Block, 16" oc + Plaster	0	No Interior Walls or Columns	150	Interior Walls - Masonry, 8" Concrete Block, full grout
2	Lateral Load-Resisting System Material Type	E99	Earth, unknown reinforcement	100	Interior Walls - Masonry, 6" Adobe Brick + Plaster ¹⁷	0	No Interior Walls or Columns	300	Interior Walls - 1.5' Earthen

¹⁷ Assumes adobe brick and earthen walls are similar in weight.

Flowchart Level	GEM Attribute Type	GEM Attribute ID	GEM Attribute Description	Nominal Value (psf)	(example)	Low Range (psf)	(example)	High Range (psf)	(example)
2	Lateral Load-Resisting System Material Type	EU	Earth, unreinforced	100	Interior Walls - Masonry, 6" Adobe Brick + Plaster ¹⁸	0	No Interior Walls or Columns	300	Interior Walls - 1.5' Earthen
2	Lateral Load-Resisting System Material Type	ER	Earth, reinforced	100	Interior Walls - Masonry, 6" Adobe Brick + Plaster ¹⁹	0	No Interior Walls or Columns	300	Interior Walls - 1.5' Earthen
2	Lateral Load-Resisting System Material Type	W	Wood	10	Interior Walls - Drywall	7.5	Interior Walls - Drywall	40	Interior Walls - Drywall Over Plaster
2	Lateral Load-Resisting System Material Type	MATO	Other Material	100	n/a	0	n/a	300	n/a

¹⁸ Assumes adobe brick and earthen walls are similar in weight.

¹⁹ Assumes adobe brick and earthen walls are similar in weight.

Flowchart Level	GEM Attribute Type	GEM Attribute ID	GEM Attribute Description	Nominal Value (psf)	(example)	Low Range (psf)	(example)	High Range (psf)	(example)
1	Exterior Walls	EWME	Metal exterior walls	30	Central Concrete Pylon + Lightweight Partition	0	No Interior Walls or Columns	75	Interior Walls and Columns - Lightweight partitions + Tightly Spaced Concrete Column
2	Lateral Load-Resisting System Material Technology	WBB	Bamboo	1.5	Columns - 6" Square Timbers	0	No Interior Walls or Columns	2.5	Columns - 12" Square Timbers
2	Lateral Load-Resisting System Material Technology	n/a	ALL OTHERS	30	Central Concrete Pylon + Lightweight Partition	0	No Interior Walls or Columns	75	Interior Walls and Columns - Lightweight partitions + Tightly Spaced Concrete Column
1	Exterior Walls	EWV	Vegetative exterior walls	1.5	Columns - 6" Square Timbers	0	No Interior Walls or Columns	2.5	Columns - 12" Square Timbers

Flowchart Level	GEM Attribute Type	GEM Attribute ID	GEM Attribute Description	Nominal Value (psf)	(example)	Low Range (psf)	(example)	High Range (psf)	(example)
1	Exterior Walls	EWV	Wooden exterior walls	10	Interior Walls - Drywall	7.5	Interior Walls - Drywall	40	Interior Walls - Drywall Over Plaster
1	Exterior Walls	EWSL	Stucco finish on light framing for exterior walls	10	Interior Walls - Drywall	0	No Interior Walls or Columns	40	Interior Walls - Drywall Over Plaster
1	Exterior Walls	EWPL	Plastic/Vinyl exterior walls, various	10	Interior Walls - Drywall	0	No Interior Walls or Columns	300	Interior Walls - 1.5' Earthen
2	Lateral Load-Resisting System Material Type	MAT99 (or blank)	Unknown material	10	Interior Walls - Drywall	0	No Interior Walls or Columns	300	Interior Walls - 1.5' Earthen
2	Lateral Load-Resisting System Material Type	C99	Concrete, unknown reinforcement	50	Interior Walls - Masonry, 4" Concrete Block, Unreinforced + Plaster	0	No Interior Walls or Columns	150	Interior Walls - Concrete 6"

Flowchart Level	GEM Attribute Type	GEM Attribute ID	GEM Attribute Description	Nominal Value (psf)	(example)	Low Range (psf)	(example)	High Range (psf)	(example)
2	Lateral Load-Resisting System Material Type	CU	Concrete, unreinforced	50	Interior Walls and Columns - Masonry, 4" Concrete Block w Plaster, Unreinforced + Concrete Column	0	No Interior Walls or Columns	150	Interior Walls and Column - Brick Walls w Plaster + Concrete Columns
2	Lateral Load-Resisting System Material Type	CR	Concrete, reinforced	30	Interior Walls and Column - Lightweight partitions + 40cm Square Concrete Columns	0	No Interior Walls or Columns	150	Interior Walls and Column - Brick Walls w Plaster + Concrete Columns
2	Lateral Load-Resisting System Material Type	SRC	Concrete, composite with steel section	50	Interior Walls - Concrete 4"	0	No Interior Walls or Columns	150	Interior Walls - Concrete 6"

Flowchart Level	GEM Attribute Type	GEM Attribute ID	GEM Attribute Description	Nominal Value (psf)	(example)	Low Range (psf)	(example)	High Range (psf)	(example)
2	Lateral Load-Resisting System Material Type	S	Steel	10	Interior Walls and Columns - Lightweight Partition + Steel Column, Large Rooms	0	No Interior Walls or Columns	40	Interior Walls - Drywall Over Plaster
2	Lateral Load-Resisting System Material Type	ME	Metal (except steel)	10	Interior Walls and Columns - Lightweight Partition + Steel Column, Large Rooms	0	No Interior Walls or Columns	40	Interior Walls - Drywall Over Plaster
2	Lateral Load-Resisting System Material Type	M99	Masonry, unknown reinforcement	100	Interior Walls - Masonry, 9" Fired Brick + Plaster	0	No Interior Walls or Columns	300	Interior Walls - Masonry, 35cm Fired Brick + Plaster
2	Lateral Load-Resisting System Material Type	MUR	Masonry, unreinforced	100	Interior Walls - Masonry, 9" Fired Brick + Plaster	1.5	Columns - 12" Square Timbers	300	Interior Walls - Masonry, 35cm Fired Brick + Plaster

Flowchart Level	GEM Attribute Type	GEM Attribute ID	GEM Attribute Description	Nominal Value (psf)	(example)	Low Range (psf)	(example)	High Range (psf)	(example)
2	Lateral Load-Resisting System Material Type	MCF	Masonry, confined	50	Interior Walls and Columns - Masonry, 4" Concrete Block w Plaster, Unreinforced + Concrete Column	0	No Interior Walls or Columns	150	Interior Walls and Column - Brick Walls w Plaster + Concrete Columns
2	Lateral Load-Resisting System Material Type	MR	Masonry, reinforced	100	Interior Walls - Masonry, 8" Concrete Block, 16" oc + Plaster	0	No Interior Walls or Columns	150	Interior Walls - Masonry, 8" Concrete Block, full grout
2	Lateral Load-Resisting System Material Type	E99	Earth, unknown reinforcement	100	Interior Walls - Masonry, 6" Adobe Brick + Plaster ²⁰	0	No Interior Walls or Columns	300	Interior Walls - 1.5' Earthen
2	Lateral Load-Resisting System Material Type	EU	Earth, unreinforced	100	Interior Walls - Masonry, 6" Adobe Brick + Plaster ²¹	0	No Interior Walls or Columns	300	Interior Walls - 1.5' Earthen

²⁰ Assumes adobe brick and earthen walls are similar in weight.

²¹ Assumes adobe brick and earthen walls are similar in weight.

Flowchart Level	GEM Attribute Type	GEM Attribute ID	GEM Attribute Description	Nominal Value (psf)	(example)	Low Range (psf)	(example)	High Range (psf)	(example)
2	Lateral Load-Resisting System Material Type	ER	Earth, reinforced	100	Interior Walls - Masonry, 6" Adobe Brick + Plaster ²²	0	No Interior Walls or Columns	300	Interior Walls - 1.5' Earthen
2	Lateral Load-Resisting System Material Type	W	Wood	10	Interior Walls - Drywall	0	No Interior Walls or Columns	40	Interior Walls - Drywall Over Plaster
3	Lateral Load-Resisting System Material Technology	WBB	Bamboo	0	No Interior Walls or Columns	0	No Interior Walls or Columns	2.5	Columns - 6" Square Timbers
3	Lateral Load-Resisting System Material Technology	n/a	ALL OTHERS	10	Interior Walls - Drywall	7.5	Interior Walls - Drywall	40	Interior Walls - Drywall Over Plaster

²² Assumes adobe brick and earthen walls are similar in weight.

Flowchart Level	GEM Attribute Type	GEM Attribute ID	GEM Attribute Description	Nominal Value (psf)	(example)	Low Range (psf)	(example)	High Range (psf)	(example)
2	Lateral Load-Resisting System Material Type	MATO	Other Material	10	Interior Walls - Drywall	0	No Interior Walls or Columns	300	Interior Walls - 1.5' Earthen
1	Exterior Walls	EWCB	Cement-based boards for exterior walls	10	Interior Walls - Drywall	7.5	Interior Walls - Drywall	40	Interior Walls - Drywall Over Plaster
1	Exterior Walls	EWO	Material of exterior walls, other	30	n/a	0	n/a	300	n/a

SUB-APPENDIX C6: NUMBER OF ABOVE GROUND STORIES

The number of above ground building stories.

This lookup table expects the GEM height attribute values to be one of a limited set of “allowed” values.

Conversion of other GEM height attribute values to one (or more) of the “allowed” attribute values may be necessary.

For clarity, this table is spread across several pages.

Flowchart Level	GEM Attribute Type	GEM Attribute ID	GEM Attribute Description	Nominal Value (stories)	(example)	Low Range (stories)	(example)	High Range (stories)	(example)
1	Height	H99 (or blank)	Number of stories unknown	2	n/a	1	n/a	100	n/a
2	Number of storeys above ground	(blank)	Number of stories unknown	2	n/a	1	n/a	100	n/a
2	Exact number of storeys above ground	HEX:1	n/a	1	n/a	1	n/a	1	n/a
2	Range of number of storeys above ground	HBET:3,1	n/a	2	n/a	1	n/a	3	n/a
2	Range of number of storeys above ground	HBET:7,4	n/a	5	n/a	4	n/a	7	n/a

Flowchart Level	GEM Attribute Type	GEM Attribute ID	GEM Attribute Description	Nominal Value (stories)	(example)	Low Range (stories)	(example)	High Range (stories)	(example)
2	Range of number of storeys above ground	HBET:15,8	n/a	13	n/a	8	n/a	15	n/a
2	Range of number of storeys above ground	HBET:100,16	n/a	50	n/a	16	n/a	100	n/a
2	Range of number of storeys above ground	n/a	ALL OTHERS	50	n/a	16	n/a	100	n/a
1	Height	H	Number of stories above ground	2	n/a	1	n/a	100	n/a
2	Number of storeys above ground	(blank)	Number of stories unknown	2	n/a	1	n/a	100	n/a
2	Exact number of storeys above ground	HEX:1	n/a	1	n/a	1	n/a	1	n/a

Flowchart Level	GEM Attribute Type	GEM Attribute ID	GEM Attribute Description	Nominal Value (stories)	(example)	Low Range (stories)	(example)	High Range (stories)	(example)
2	Range of number of storeys above ground	HBET:3,1	n/a	2	n/a	1	n/a	3	n/a
2	Range of number of storeys above ground	HBET:7,4	n/a	5	n/a	4	n/a	7	n/a
2	Range of number of storeys above ground	HBET:15,8	n/a	13	n/a	8	n/a	15	n/a
2	Range of number of storeys above ground	HBET:100,16	n/a	50	n/a	16	n/a	100	n/a
2	Range of number of storeys above ground	n/a	ALL OTHERS	50	n/a	16	n/a	100	n/a

SUB-APPENDIX C7: BASEMENT PRESENT?

The number of below ground building stories.

This lookup table expects the GEM height attribute values to be one of a limited set of “allowed” values. Conversion of other GEM height attribute values to one (or more) of the “allowed” attribute values may be necessary. For clarity, this table is spread across several pages.

Flowchart Level	GEM Attribute Type	GEM Attribute ID	GEM Attribute Description	Nominal Value (stories)	(example)	Low Range (stories)	(example)	High Range (stories)	(example)
1	Height	H99 (or blank)	Number of stories unknown	0	n/a	0	n/a	3	n/a
2	Number of storeys below ground	(blank)	Number of stories unknown	0	n/a	0	n/a	3	n/a
2	Exact number of storeys below ground	HBBEX:0	n/a	0	n/a	0	n/a	0	n/a
2	Exact number of storeys below ground	HBBEX:1	n/a	1	n/a	1	n/a	1	n/a
2	Range of number of storeys below ground	n/a	ALL OTHERS	3	n/a	n/a	n/a	n/a	n/a

Flowchart Level	GEM Attribute Type	GEM Attribute ID	GEM Attribute Description	Nominal Value (stories)	(example)	Low Range (stories)	(example)	High Range (stories)	(example)
1	Height	HB	Number of stories below ground	0	n/a	0	n/a	3	n/a
2	Number of storeys below ground	(blank)	Number of stories unknown	0	n/a	0	n/a	3	n/a
2	Exact number of storeys below ground	HBBEX:0	n/a	0	n/a	0	n/a	0	n/a
2	Exact number of storeys below ground	HBBEX:1	n/a	1	n/a	1	n/a	1	n/a
2	Range of number of storeys below ground	n/a	ALL OTHERS	3	n/a	n/a	n/a	n/a	n/a

SUB-APPENDIX C8: WINDOW PERCENT

Percent of a single story's floor to ceiling external wall area that contains a window.
For clarity, this table is spread across several pages.

Flowchart Level	GEM Attribute Type	GEM Attribute ID	GEM Attribute Description	Nominal Value (%)	(example)	Low Range (%)	(example)	High Range (%)	(example)
1	Building Occupancy Class – General	OC99 (or blank)	Unknown occupancy type	12	CMU House - Average	0.5	Light Clad Industrial - Low	75	Light Clad Curtain Wall Office - High
1	Building Occupancy Class – General	RES	Residential	12	CMU House - Average	2.5	CMU House - Low	75	Light Clad Curtain Wall Hotel - High
2	Building Occupancy Class – Detail	RES99	Residential, unknown type	12	CMU House - Average	2.5	CMU House - Low	75	Light Clad Curtain Wall Hotel - High
2	Building Occupancy Class – Detail	RES1	Single dwelling	12	CMU House - Average	2.5	CMU House - Low	35	Brick House - High
3	Lateral Load-Resisting System Material Technology	ADO	Adobe blocks	5	Adobe House	2.5	Adobe House	15	Stone House - High

Flowchart Level	GEM Attribute Type	GEM Attribute ID	GEM Attribute Description	Nominal Value (%)	(example)	Low Range (%)	(example)	High Range (%)	(example)
3	Lateral Load-Resisting System Material Technology	ST99	Stone, unknown technology	5	Stone House - Low	2.5	Stone House - Low	15	Stone House - High
3	Lateral Load-Resisting System Material Technology	STRUB	Rubble (field stone) or semi-dressed stone	5	Stone House - Low	2.5	Stone House - Low	15	Stone House - High
3	Lateral Load-Resisting System Material Technology	STDRE	Dressed stone	5	Stone House - Low	2.5	Stone House - Low	15	Stone House - High
3	Lateral Load-Resisting System Material Technology	ET99	Unknown earth technology	5	Adobe House	2.5	Adobe House	15	Stone House - High
3	Lateral Load-Resisting System Material Technology	ETR	Rammed earth	5	Adobe House	2.5	Adobe House	15	Stone House - High

Flowchart Level	GEM Attribute Type	GEM Attribute ID	GEM Attribute Description	Nominal Value (%)	(example)	Low Range (%)	(example)	High Range (%)	(example)
3	Lateral Load-Resisting System Material Technology	ETC	Cob or wet construction	5	Adobe House	2.5	Adobe House	15	Stone House - High
3	Lateral Load-Resisting System Material Technology	ETO	Earth technology, other	5	Adobe House	2.5	Adobe House	15	Stone House - High
3	Lateral Load-Resisting System Material Technology	n/a	ALL OTHERS	12	CMU House - Average	2.5	CMU House - Low	35	Brick House - High
2	Building Occupancy Class – Detail	RES2A	2 Units (duplex)	12	CMU House - Average	2.5	CMU House - Low	35	Brick House - High
3	Lateral Load-Resisting System Material Technology	ADO	Adobe blocks	5	Adobe House	2.5	Adobe House	15	Stone House - High

Flowchart Level	GEM Attribute Type	GEM Attribute ID	GEM Attribute Description	Nominal Value (%)	(example)	Low Range (%)	(example)	High Range (%)	(example)
3	Lateral Load-Resisting System Material Technology	ST99	Stone, unknown technology	5	Stone House - Low	2.5	Stone House - Low	15	Stone House - High
3	Lateral Load-Resisting System Material Technology	STRUB	Rubble (field stone) or semi-dressed stone	5	Stone House - Low	2.5	Stone House - Low	15	Stone House - High
3	Lateral Load-Resisting System Material Technology	STDRE	Dressed stone	5	Stone House - Low	2.5	Stone House - Low	15	Stone House - High
3	Lateral Load-Resisting System Material Technology	ET99	Unknown earth technology	5	Adobe House	2.5	Adobe House	15	Stone House - High
3	Lateral Load-Resisting System Material Technology	ETR	Rammed earth	5	Adobe House	2.5	Adobe House	15	Stone House - High

Flowchart Level	GEM Attribute Type	GEM Attribute ID	GEM Attribute Description	Nominal Value (%)	(example)	Low Range (%)	(example)	High Range (%)	(example)
3	Lateral Load-Resisting System Material Technology	ETC	Cob or wet construction	5	Adobe House	2.5	Adobe House	15	Stone House - High
3	Lateral Load-Resisting System Material Technology	ETO	Earth technology, other	5	Adobe House	2.5	Adobe House	15	Stone House - High
3	Lateral Load-Resisting System Material Technology	n/a	ALL OTHERS	12	CMU House - Average	2.5	CMU House - Low	35	Brick House - High
2	Building Occupancy Class – Detail	RES3	Temporary housing	25	Brick Hotel - High	7.5	Light Clad Curtain Wall Hotel - Low	75	Light Clad Curtain Wall Hotel - High
3	Exterior Walls	EWG	Glass exterior walls	50	Light Clad Curtain Wall Hotel - High	35	Light Clad Curtain Wall Hotel - High	75	Light Clad Curtain Wall Hotel - High
3	Exterior Walls	n/a	ALL OTHERS	25	Brick Hotel - High	7.5	Light Clad Curtain Wall Hotel - Low	35	Heavy Clad Hotel – High

Flowchart Level	GEM Attribute Type	GEM Attribute ID	GEM Attribute Description	Nominal Value (%)	(example)	Low Range (%)	(example)	High Range (%)	(example)
2	Building Occupancy Class – Detail	RES5	Mobile Home	12	CMU House - Average	2.5	CMU House - Low	35	Brick House – High
2	Building Occupancy Class – Detail	n/a	ALL OTHERS	25	Box-Wall Apartment - Average	7.5	Light Clad Infill Wall Apartment - Low	75	Light Clad Curtain Wall Apartment - High
3	Exterior Walls	EWG	Glass exterior walls	50	Light Clad Curtain Wall Apartment - High	35	Light Clad Curtain Wall Apartment - High	75	Light Clad Curtain Wall Apartment - High
3	Exterior Walls	n/a	ALL OTHERS	25	Box-Wall Apartment - Average	7.5	Light Clad Infill Wall Apartment - Low	35	Box-Wall Apartment - High
1	Building Occupancy Class – General	COM	Commercial/Public	25	Light Clad Infill Wall Office - Average	0.5	Light Clad Industrial - Low	75	Light Clad Curtain Wall Office - High
2	Building Occupancy Class – Detail	COM99	Commercial and public, unknown type	25	Light Clad Infill Wall Office - Average	0.5	Light Clad Industrial - Low	75	Light Clad Curtain Wall Office - High
2	Building Occupancy Class – Detail	COM1	Retail trade	12	Brick Office - Average	0.5	Large Mall	35	Square Store with Full Front Window

Flowchart Level	GEM Attribute Type	GEM Attribute ID	GEM Attribute Description	Nominal Value (%)	(example)	Low Range (%)	(example)	High Range (%)	(example)
2	Building Occupancy Class – Detail	COM2	Wholesale trade and storage (warehouse)	12	Large, Masonry Industrial - Average	0.5	Light Clad Industrial - Low	35	Brick Industrial - High
3	Exterior Walls	EW99 (or blank)	Unknown material of exterior walls	12	Large, Masonry Industrial - Average	0.5	Large, Masonry Industrial - Low	35	Brick Industrial - High
3	Exterior Walls	EWC	Concrete exterior walls	12	Large, Masonry Industrial - Average	0.5	Large, Masonry Industrial - Low	35	Brick Industrial - High
3	Exterior Walls	EWG	Glass exterior walls	50	Light Clad Curtain Wall Office - High	35	Light Clad Curtain Wall Office - High	75	Light Clad Curtain Wall Office - High
3	Exterior Walls	EWE	Earthen exterior walls	12	Large, Masonry Industrial - Average	0.5	Large, Masonry Industrial - Low	35	Brick Industrial - High
3	Exterior Walls	EWMA	Masonry exterior walls	12	Large, Masonry Industrial - Average	0.5	Large, Masonry Industrial - Low	35	Brick Industrial - High
3	Exterior Walls	EWO	Material of exterior walls, other	12	n/a	0.5	n/a	35	n/a
3	Exterior Walls	n/a	ALL OTHERS	5	Light Clad Industrial - Average	0.5	Light Clad Industrial - Low	7.5	Light Clad Industrial - High

Flowchart Level	GEM Attribute Type	GEM Attribute ID	GEM Attribute Description	Nominal Value (%)	(example)	Low Range (%)	(example)	High Range (%)	(example)
2	Building Occupancy Class – Detail	COM3	Offices, professional/technical services	25	Light Clad Infill Wall Office - Average	7.5	Brick Office - Low	75	Light Clad Curtain Wall Office - High
3	Exterior Walls	EWG	Glass exterior walls	50	Light Clad Curtain Wall Office - High	35	Light Clad Curtain Wall Office - High	75	Light Clad Curtain Wall Office - High
3	Exterior Walls	n/a	ALL OTHERS	25	Light Clad Infill Wall Office - Average	7.5	Brick Office - Low	35	Light Clad Infill Wall Office - High
2	Building Occupancy Class – Detail	COM4	Hospital/medical clinic	25	Light Clad Infill Wall Office - Average	7.5	Brick Office - Low	75	Light Clad Curtain Wall Office - High
3	Exterior Walls	EWG	Glass exterior walls	50	Light Clad Curtain Wall Office - High	35	Light Clad Curtain Wall Office - High	75	Light Clad Curtain Wall Office - High
3	Exterior Walls	n/a	ALL OTHERS	25	Light Clad Infill Wall Office - Average	7.5	Brick Office - Low	35	Light Clad Infill Wall Office - High
2	Building Occupancy Class – Detail	COM5	Entertainment	50	Light Clad Curtain Wall Office - High	7.5	Brick Office - Low	75	Light Clad Curtain Wall Office - High

Flowchart Level	GEM Attribute Type	GEM Attribute ID	GEM Attribute Description	Nominal Value (%)	(example)	Low Range (%)	(example)	High Range (%)	(example)
3	Exterior Walls	EWG	Glass exterior walls	50	Light Clad Curtain Wall Office - High	35	Light Clad Curtain Wall Office - High	75	Light Clad Curtain Wall Office - High
3	Exterior Walls	n/a	ALL OTHERS	25	Light Clad Infill Wall Office - Average	7.5	Brick Office - Low	35	Light Clad Infill Wall Office - High
2	Building Occupancy Class – Detail	COM6	Public building	25	Light Clad Infill Wall Office - Average	7.5	Brick Office - Low	75	Light Clad Curtain Wall Office - High
3	Exterior Walls	EWG	Glass exterior walls	50	Light Clad Curtain Wall Office - High	35	Light Clad Curtain Wall Office - High	75	Light Clad Curtain Wall Office - High
3	Exterior Walls	n/a	ALL OTHERS	25	Light Clad Infill Wall Office - Average	7.5	Brick Office - Low	35	Light Clad Infill Wall Office - High
2	Building Occupancy Class – Detail	COM7	Covered parking garage	50	Parking - Half-Open Sides	5	Parking - Closed Sides	90	Parking - Open Sides
2	Building Occupancy Class – Detail	COM8	Bus station	25	Light Clad Infill Wall Office - Average	7.5	Brick Office - Low	75	Light Clad Curtain Wall Office - High

Flowchart Level	GEM Attribute Type	GEM Attribute ID	GEM Attribute Description	Nominal Value (%)	(example)	Low Range (%)	(example)	High Range (%)	(example)
3	Exterior Walls	EWG	Glass exterior walls	50	Light Clad Curtain Wall Office - High	35	Light Clad Curtain Wall Office - High	75	Light Clad Curtain Wall Office - High
3	Exterior Walls	n/a	ALL OTHERS	25	Light Clad Infill Wall Office - Average	7.5	Brick Office - Low	35	Light Clad Infill Wall Office - High
2	Building Occupancy Class – Detail	COM9	Railway station	25	Light Clad Infill Wall Office - Average	7.5	Brick Office - Low	75	Light Clad Curtain Wall Office - High
3	Exterior Walls	EWG	Glass exterior walls	50	Light Clad Curtain Wall Office - High	35	Light Clad Curtain Wall Office - High	75	Light Clad Curtain Wall Office - High
3	Exterior Walls	n/a	ALL OTHERS	25	Light Clad Infill Wall Office - Average	7.5	Brick Office - Low	35	Light Clad Infill Wall Office - High
2	Building Occupancy Class – Detail	COM10	Airport	50	Light Clad Curtain Wall Office - High	35	Light Clad Curtain Wall Office - High	75	Light Clad Curtain Wall Office - High
3	Exterior Walls	EWG	Glass exterior walls	50	Light Clad Curtain Wall Office - High	35	Light Clad Curtain Wall Office - High	75	Light Clad Curtain Wall Office - High

Flowchart Level	GEM Attribute Type	GEM Attribute ID	GEM Attribute Description	Nominal Value (%)	(example)	Low Range (%)	(example)	High Range (%)	(example)
3	Exterior Walls	n/a	ALL OTHERS	25	Light Clad Infill Wall Office - Average	7.5	Brick Office - Low	35	Light Clad Infill Wall Office - High
2	Building Occupancy Class – Detail	COM11	Recreation and leisure	25	Light Clad Infill Wall Office - Average	7.5	Brick Office - Low	75	Light Clad Curtain Wall Office - High
3	Exterior Walls	EWG	Glass exterior walls	50	Light Clad Curtain Wall Office - High	35	Light Clad Curtain Wall Office - High	75	Light Clad Curtain Wall Office - High
3	Exterior Walls	n/a	ALL OTHERS	25	Light Clad Infill Wall Office - Average	7.5	Brick Office - Low	35	Light Clad Infill Wall Office - High
1	Building Occupancy Class – General	MIX	Mixed Use	12	Large, Masonry Industrial - Average	0.5	Large, Masonry Industrial - Low	75	Light Clad Curtain Wall Office - High
2	Building Occupancy Class – Detail	MIX99	Mixed, unknown type	12	Large, Masonry Industrial - Average	0.5	Large, Masonry Industrial - Low	75	Light Clad Curtain Wall Office - High
2	Building Occupancy Class – Detail	MIX1	Mostly residential and commercial	12	Large, Masonry Industrial - Average	2.5	CMU House - Low	75	Light Clad Curtain Wall Hotel - High

Flowchart Level	GEM Attribute Type	GEM Attribute ID	GEM Attribute Description	Nominal Value (%)	(example)	Low Range (%)	(example)	High Range (%)	(example)
2	Building Occupancy Class – Detail	MIX2	Mostly commercial and residential	25	Light Clad Infill Wall Office - Average	0.5	Large, Masonry Industrial - Low	75	Light Clad Curtain Wall Office - High
2	Building Occupancy Class – Detail	MIX3	Mostly commercial and industrial	25	Brick Industrial - Average	0.5	Large, Masonry Industrial - Low	75	Light Clad Curtain Wall Office - High
2	Building Occupancy Class – Detail	MIX4	Mostly residential and industrial	12	Large, Masonry Industrial - Average	0.5	Large, Masonry Industrial - Low	75	Light Clad Curtain Wall Hotel - High
2	Building Occupancy Class – Detail	MIX5	Mostly industrial and commercial	12	Large, Masonry Industrial - Average	0.5	Light Clad Industrial - Low	35	Light Clad Infill Wall Office - High
2	Building Occupancy Class – Detail	MIX6	Mostly industrial and residential	12	Large, Masonry Industrial - Average	0.5	Light Clad Industrial - Low	35	Box-Wall Apartment - High
1	Building Occupancy Class – General	IND	Industrial	12	Large, Masonry Industrial - Average	0.5	Light Clad Industrial - Low	35	Brick Industrial - High
2	Exterior Walls	EW99 (or blank)	Unknown material of exterior walls	12	Large, Masonry Industrial - Average	0.5	Light Clad Industrial - Low	35	Brick Industrial - High

Flowchart Level	GEM Attribute Type	GEM Attribute ID	GEM Attribute Description	Nominal Value (%)	(example)	Low Range (%)	(example)	High Range (%)	(example)
2	Exterior Walls	EWC	Concrete exterior walls	12	Large, Masonry Industrial - Average	0.5	Large, Masonry Industrial - Low	35	Brick Industrial - High
2	Exterior Walls	EWG	Glass exterior walls	50	Light Clad Curtain Wall Office - High	35	Light Clad Curtain Wall Office - High	75	Light Clad Curtain Wall Office - High
2	Exterior Walls	EWE	Earthen exterior walls	12	Large, Masonry Industrial - Average	0.5	Large, Masonry Industrial - Low	35	Brick Industrial - High
2	Exterior Walls	EWMA	Masonry exterior walls	12	Large, Masonry Industrial - Average	0.5	Large, Masonry Industrial - Low	35	Brick Industrial - High
2	Exterior Walls	EWO	Material of exterior walls, other	12	n/a	0.5	n/a	35	n/a
2	Exterior Walls	n/a	ALL OTHERS	5	Light Clad Industrial - Average	0.5	Light Clad Industrial - Low	7.5	Light Clad Industrial - High
1	Building Occupancy Class – General	AGR	Agricultural	12	Large, Masonry Industrial - Average	0.5	Light Clad Industrial - Low	35	Brick Industrial - High

Flowchart Level	GEM Attribute Type	GEM Attribute ID	GEM Attribute Description	Nominal Value (%)	(example)	Low Range (%)	(example)	High Range (%)	(example)
2	Exterior Walls	EW99 (or blank)	Unknown material of exterior walls	12	Large, Masonry Industrial - Average	0.5	Light Clad Industrial - Low	35	Brick Industrial - High
2	Exterior Walls	EWC	Concrete exterior walls	12	Large, Masonry Industrial - Average	0.5	Large, Masonry Industrial - Low	35	Brick Industrial - High
2	Exterior Walls	EWG	Glass exterior walls	50	Light Clad Curtain Wall Office - High	35	Light Clad Curtain Wall Office - High	75	Light Clad Curtain Wall Office - High
2	Exterior Walls	EWE	Earthen exterior walls	12	Large, Masonry Industrial - Average	0.5	Large, Masonry Industrial - Low	35	Brick Industrial - High
2	Exterior Walls	EWMA	Masonry exterior walls	12	Large, Masonry Industrial - Average	0.5	Large, Masonry Industrial - Low	35	Brick Industrial - High
2	Exterior Walls	EWO	Material of exterior walls, other	12	n/a	0.5	n/a	35	n/a
2	Exterior Walls	n/a	ALL OTHERS	5	Light Clad Industrial - Average	0.5	Light Clad Industrial - Low	7.5	Light Clad Industrial - High
1	Building Occupancy Class – General	ASS	Assembly	25	Light Clad Infill Wall Office - Average	0.5	Large, Masonry Industrial - Low	75	Light Clad Curtain Wall Office - High

Flowchart Level	GEM Attribute Type	GEM Attribute ID	GEM Attribute Description	Nominal Value (%)	(example)	Low Range (%)	(example)	High Range (%)	(example)
2	Building Occupancy Class – Detail	ASS99	Assembly, unknown type	25	Light Clad Infill Wall Office - Average	0.5	Large, Masonry Industrial - Low	75	Light Clad Curtain Wall Office - High
2	Building Occupancy Class – Detail	ASS1	Religious gathering	12	n/a	7.5	n/a	35	n/a
2	Building Occupancy Class – Detail	ASS2	Arena	50	n/a	0.5	n/a	75	n/a
2	Building Occupancy Class – Detail	ASS3	Cinema or concert hall	25	n/a	0.5	n/a	75	n/a
2	Building Occupancy Class – Detail	ASS4	Other gatherings	25	Light Clad Infill Wall Office - Average	7.5	Brick Office - Low	75	Light Clad Curtain Wall Office - High
3	Exterior Walls	EWG	Glass Exterior Walls	50	Light Clad Curtain Wall Office - High	35	Light Clad Curtain Wall Office - High	75	Light Clad Curtain Wall Office - High
3	Exterior Walls	n/a	ALL OTHERS	25	Light Clad Infill Wall Office - Average	7.5	Brick Office - Low	35	Light Clad Infill Wall Office - High

Flowchart Level	GEM Attribute Type	GEM Attribute ID	GEM Attribute Description	Nominal Value (%)	(example)	Low Range (%)	(example)	High Range (%)	(example)
1	Building Occupancy Class – General	GOV	Government	25	Light Clad Infill Wall Office - Average	0.5	Light Clad Industrial - Low	75	Light Clad Curtain Wall Office - High
2	Building Occupancy Class – Detail	GOV99	Government, unknown type	25	Light Clad Infill Wall Office - Average	0.5	Light Clad Industrial - Low	75	Light Clad Curtain Wall Office - High
2	Building Occupancy Class – Detail	GOV1	Government, general services	25	Light Clad Infill Wall Office - Average	7.5	Brick Office - Low	75	Light Clad Curtain Wall Office - High
3	Exterior Walls	EWG	Glass exterior walls	50	Light Clad Curtain Wall Office - High	35	Light Clad Curtain Wall Office - High	75	Light Clad Curtain Wall Office - High
3	Exterior Walls	n/a	ALL OTHERS	25	Light Clad Infill Wall Office - Average	7.5	Brick Office - Low	35	Light Clad Infill Wall Office - High
2	Building Occupancy Class – Detail	GOV2	Government, emergency response	12	Large, Masonry Industrial - Average	0.5	Light Clad Industrial - Low	35	Brick Industrial - High
3	Exterior Walls	EW99 (or blank)	Unknown material of exterior walls	12	Large, Masonry Industrial - Average	0.5	Light Clad Industrial - Low	35	Brick Industrial - High

Flowchart Level	GEM Attribute Type	GEM Attribute ID	GEM Attribute Description	Nominal Value (%)	(example)	Low Range (%)	(example)	High Range (%)	(example)
3	Exterior Walls	EWC	Concrete exterior walls	12	Large, Masonry Industrial - Average	0.5	Large, Masonry Industrial - Low	35	Brick Industrial - High
3	Exterior Walls	EWG	Glass exterior walls	50	Light Clad Curtain Wall Office - High	35	Light Clad Curtain Wall Office - High	75	Light Clad Curtain Wall Office - High
3	Exterior Walls	EWE	Earthen exterior walls	12	Large, Masonry Industrial - Average	0.5	Large, Masonry Industrial - Low	35	Brick Industrial - High
3	Exterior Walls	EWMA	Masonry exterior walls	12	Large, Masonry Industrial - Average	0.5	Large, Masonry Industrial - Low	35	Brick Industrial - High
3	Exterior Walls	EWO	Material of exterior walls, other	12	n/a	0.5	n/a	35	n/a
3	Exterior Walls	n/a	ALL OTHERS	5	Light Clad Industrial - Average	0.5	Light Clad Industrial - Low	7.5	Light Clad Industrial - High
1	Building Occupancy Class – General	EDU	Education	25	Light Clad Infill Wall Office - Average	0.5	Light Clad Industrial - Low	75	Light Clad Curtain Wall Office - High
2	Building Occupancy Class – Detail	EDU4	College/university research facilities and/or labs	12	Large, Masonry Industrial - Average	0.5	Light Clad Industrial - Low	75	Light Clad Curtain Wall Office - High

Flowchart Level	GEM Attribute Type	GEM Attribute ID	GEM Attribute Description	Nominal Value (%)	(example)	Low Range (%)	(example)	High Range (%)	(example)
3	Exterior Walls	EW99 (or blank)	Unknown material of exterior walls	12	Large, Masonry Industrial - Average	0.5	Light Clad Industrial - Low	75	Light Clad Curtain Wall Office - High
3	Exterior Walls	EWC	Concrete exterior walls	12	Large, Masonry Industrial - Average	0.5	Large, Masonry Industrial - Low	35	Brick Industrial - High
3	Exterior Walls	EWG	Glass exterior walls	50	Light Clad Curtain Wall Office - High	35	Light Clad Curtain Wall Office - High	75	Light Clad Curtain Wall Office - High
3	Exterior Walls	EWE	Earthen exterior walls	12	Large, Masonry Industrial - Average	0.5	Large, Masonry Industrial - Low	35	Brick Industrial - High
3	Exterior Walls	EWMA	Masonry exterior walls	12	Large, Masonry Industrial - Average	0.5	Large, Masonry Industrial - Low	35	Brick Industrial - High
3	Exterior Walls	EWO	Material of exterior walls, other	12	n/a	0.5	n/a	35	n/a
3	Exterior Walls	n/a	ALL OTHERS	5	Light Clad Industrial - Average	0.5	Light Clad Industrial - Low	35	Light Clad Infill Wall Office - Average

Flowchart Level	GEM Attribute Type	GEM Attribute ID	GEM Attribute Description	Nominal Value (%)	(example)	Low Range (%)	(example)	High Range (%)	(example)
2	Building Occupancy Class – Detail	n/a	ALL OTHERS	25	Light Clad Infill Wall Office - Average	7.5	Brick Office - Low	75	Light Clad Curtain Wall Office - High
3	Exterior Walls	EWG	Glass exterior walls	50	Light Clad Curtain Wall Office - High	35	Light Clad Curtain Wall Office - High	75	Light Clad Curtain Wall Office - High
3	Exterior Walls	n/a	ALL OTHERS	25	Light Clad Infill Wall Office - Average	7.5	Brick Office - Low	35	Light Clad Infill Wall Office - High
1	Building Occupancy Class – General	OCO	Other occupancy type	12	n/a	0.5	n/a	75	n/a

SUB-APPENDIX C9: DOOR PERCENT

Percent of a single story's floor to ceiling external wall area that contains a door.
For clarity, this table is spread across several pages.

Flowchart Level	GEM Attribute Type	GEM Attribute ID	GEM Attribute Description	Nominal Value (%)	(example)	Low Range (%)	(example)	High Range (%)	(example)
1	Building Occupancy Class – General	OC99 (or blank)	Unknown occupancy type	5	Wood Framed House - Ground Story	0.5	Light Clad Hotel - Ground Story	90	Light Clad Apt - Ground Story (All Parking)
1	Building Occupancy Class – General	RES	Residential	5	Wood Framed House - Ground Story	0.5	Middle Eastern House - Ground Story	35	Light Clad Apt - Ground Story (Some Parking)
2	Building Occupancy Class – Detail	RES5	Mobile Home	0	Mobile Home	0	Mobile Home	0.5	Mobile Home
2	Building Occupancy Class – Detail	n/a	ALL OTHERS	5	Box Wall Apt - Ground Story	0.5	Light Clad Hotel - Ground Story	90	Light Clad Apt - Ground Story (All Parking)
3	Lateral Load-Resisting System Material Type	C99	Concrete, unknown reinforcement	5	Box Wall Apt - Ground Story	0.5	Light Clad Hotel - Ground Story	90	Light Clad Apt - Ground Story (All Parking)

Flowchart Level	GEM Attribute Type	GEM Attribute ID	GEM Attribute Description	Nominal Value (%)	(example)	Low Range (%)	(example)	High Range (%)	(example)
3	Lateral Load-Resisting System Material Type	CU	Concrete, unreinforced	5	Box Wall Apt - Ground Story	0.5	Light Clad Hotel - Ground Story	90	Light Clad Apt - Ground Story (All Parking)
3	Lateral Load-Resisting System Material Type	CR	Concrete, reinforced	5	Box Wall Apt - Ground Story	0.5	Light Clad Hotel - Ground Story	90	Light Clad Apt - Ground Story (All Parking)
3	Lateral Load-Resisting System Material Type	SRC	Concrete, composite with steel section	5	Box Wall Apt - Ground Story	0.5	Light Clad Hotel - Ground Story	90	Light Clad Apt - Ground Story (All Parking)
3	Lateral Load-Resisting System Material Type	S	Steel	5	Box Wall Apt - Ground Story	0.5	Light Clad Hotel - Ground Story	90	Light Clad Apt - Ground Story (All Parking)
3	Lateral Load-Resisting System Material Type	ME	Metal (except steel)	5	Box Wall Apt - Ground Story	0.5	Light Clad Hotel - Ground Story	90	Light Clad Apt - Ground Story (All Parking)

Flowchart Level	GEM Attribute Type	GEM Attribute ID	GEM Attribute Description	Nominal Value (%)	(example)	Low Range (%)	(example)	High Range (%)	(example)
3	Lateral Load-Resisting System Material Type	n/a	ALL OTHERS	5	Wood Framed House - Ground Story	0.5	Middle Eastern House - Ground Story	35	Light Clad Apt - Ground Story (Some Parking)
1	Building Occupancy Class – General	COM	Commercial/Public	5	CMU Store - Ground Story	0.5	Light Clad Office - Ground Story	90	Light Clad Apt - Ground Story (All Parking)
2	Building Occupancy Class – Detail	COM1	Retail trade	5	CMU Store - Ground Story	0.5	Light Clad Office - Ground Story	35	Steel Framed Hotel - Ground Story
2	Building Occupancy Class – Detail	COM2	Wholesale trade and storage (warehouse)	5	CMU Infill Industrial - Ground Story	0.5	Brick Industrial - Ground Story	7.5	CMU Industrial - Ground Story
2	Building Occupancy Class – Detail	COM5	Entertainment	5	CMU Store - Ground Story	0.5	Light Clad Office - Ground Story	35	Steel Framed Hotel - Ground Story
2	Building Occupancy Class – Detail	COM10	Airport	5	CMU Infill Industrial - Ground Story	0.5	Brick Industrial - Ground Story	7.5	CMU Industrial - Ground Story

Flowchart Level	GEM Attribute Type	GEM Attribute ID	GEM Attribute Description	Nominal Value (%)	(example)	Low Range (%)	(example)	High Range (%)	(example)
2	Building Occupancy Class – Detail	COM11	Recreation and leisure	5	CMU Infill Industrial - Ground Story	0.5	Brick Industrial - Ground Story	7.5	CMU Industrial - Ground Story
2	Building Occupancy Class – Detail	n/a	ALL OTHERS	5	CMU Store - Ground Story	0.5	Light Clad Office - Ground Story	90	Light Clad Apt - Ground Story (All Parking)
1	Building Occupancy Class – General	MIX	Mixed Use	5	CMU Store - Ground Story	0.5	Light Clad Office - Ground Story	90	Light Clad Apt - Ground Story (All Parking)
1	Building Occupancy Class – General	IND	Industrial	5	CMU Infill Industrial - Ground Story	0.5	Brick Industrial - Ground Story	7.5	CMU Industrial - Ground Story
1	Building Occupancy Class – General	AGR	Agricultural	5	CMU Infill Industrial - Ground Story	0.5	Brick Industrial - Ground Story	35	Animal Shelter - Open on Single Side
2	Building Occupancy Class – Detail	AGR99	Agriculture, unknown type	5	CMU Infill Industrial - Ground Story	0.5	Brick Industrial - Ground Story	35	Animal Shelter - Open on Single Side
2	Building Occupancy Class – Detail	AGR2	Animal shelter	5	CMU Infill Industrial - Ground Story	0.5	Brick Industrial - Ground Story	35	Animal Shelter - Open on Single Side

Flowchart Level	GEM Attribute Type	GEM Attribute ID	GEM Attribute Description	Nominal Value (%)	(example)	Low Range (%)	(example)	High Range (%)	(example)
2	Building Occupancy Class – Detail	n/a	ALL OTHERS	5	CMU Infill Industrial - Ground Story	0.5	Brick Industrial - Ground Story	7.5	CMU Industrial - Ground Story
1	Building Occupancy Class – General	ASS	Assembly	5	CMU Infill Industrial - Ground Story	0.5	Brick Industrial - Ground Story	7.5	CMU Industrial - Ground Story
1	Building Occupancy Class – General	GOV	Government	5	Brick Office - Ground Story	0.5	Light Clad Office - Ground Story	90	Light Clad Apt - Ground Story (All Parking)
1	Building Occupancy Class – General	EDU	Education	5	Brick Office - Ground Story	0.5	Light Clad Office - Ground Story	90	Light Clad Apt - Ground Story (All Parking)
1	Building Occupancy Class – General	OCO	Other occupancy type	5	n/a	0.5	n/a	90	n/a