GLOBAL EARTHQUAKE MODEL
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Development of the Earthquake Risk Model for Myanmar

Version 1.02 – September 2019

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This report has been produced as part of a collaboration between the GEM Foundation and the Myanmar Earthquake Committee

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1 Development of the Exposure Model

An open exposure model describing the residential, industrial, and commercial buildings in Myanmar has been developed by GEM as part of a collaboration with the Myanmar Earthquake Committee and with the support of the Asian Development Bank (ADB). Only publicly available sources of information were considered in development of this exposure model. The primary data sources were the 2014 Myanmar Population and Housing Census databases (DoP, 2014a) for the residential exposure model, and the 2017 Myanmar Micro, Small and Medium Enterprise Survey (CSO and UNU-WIDER, 2018) and 2015 Myanmar Business Survey (CSO and UNDP Myanmar, 2015) for the industrial and commercial exposure models.

For the purposes of administration of the country, Myanmar is divided into 15 top-level divisions including seven states, seven regions, and the union territory of Nay Pyi Taw. At the time of the 2014 census, these were divided into 74 districts and 5 self-administering zones. These are further sub-divided into 330 townships. The current exposure model has been constructed at the third administrative level of the urban and rural townships. **Figure 1.1** shows the hierarchy of administrative divisions of Myanmar, updated in December 2018.

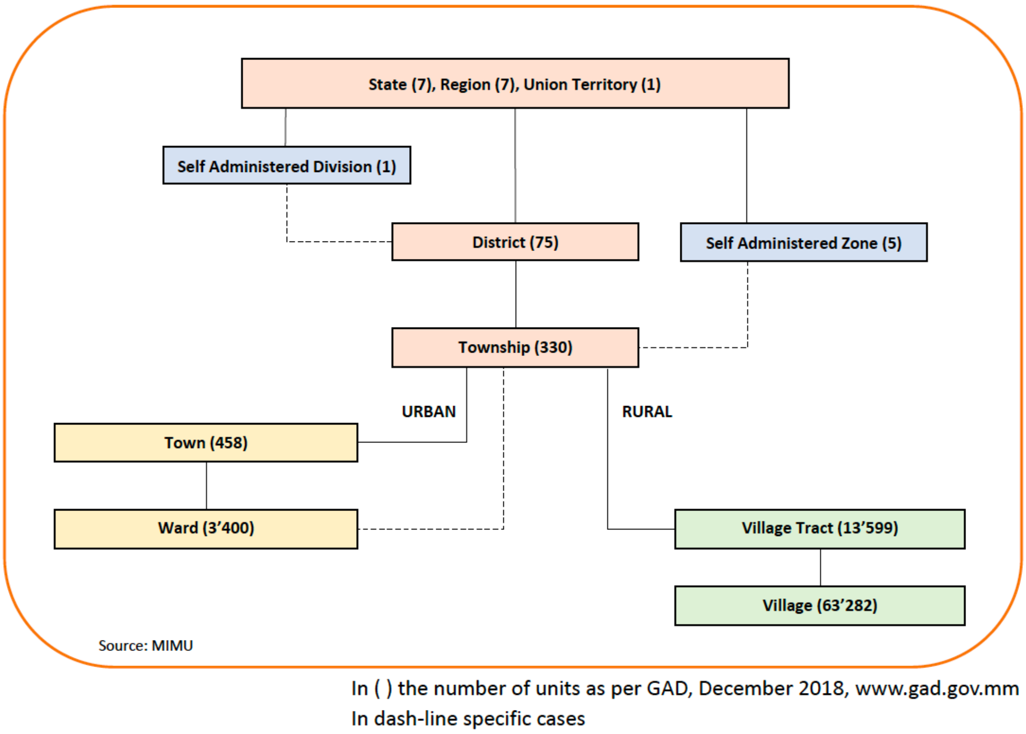


Figure 1.1. Administrative divisions of Myanmar. Figure source: Myanmar Information Management Unit (MIMU).

The 2014 population and housing census data shows that nearly half of the Myanmar's population is concentrated within a corridor that runs along the central part of the country, connecting the urban regions of Mandalay, Nay Pyi Taw, and Yangon (see **Figure 1.2**a). The remaining population is thinly distributed in the remaining parts of the country. Myanmar is a highly rural country, with just under 30% of the total population of the country living in urban areas (see **Figure 1.2**b). In fact, about half of the total urban population in Myanmar live in either Mandalay, Nay Pyi Taw, or Yangon.

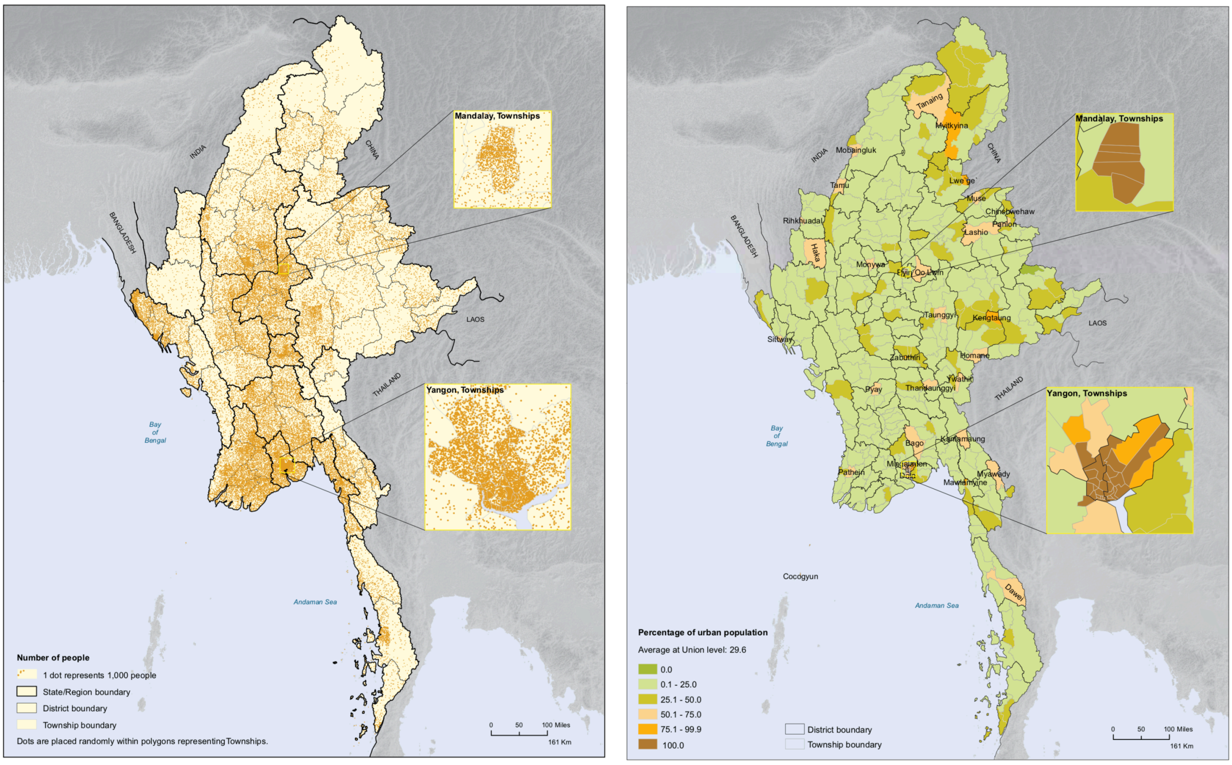


Figure 1.2. Population distribution across Myanmar (left), and proportion of urban population by township (right).

Source for figures: 2014 Myanmar Census Atlas (DoP, 2014b).

The development of the exposure model followed four main steps:

1. Definition of building classes.
2. Mapping census data to building classes.
3. Mapping housing units or establishments to buildings.
4. Estimation of built up areas and replacement costs.

1.1 Definition of Building Classes

The building stock of Myanmar has been classified into a set of building classes that indicate the structural characteristics and expected performance under seismic loads. In order to identify the main building classes, a review of existing classifications was conducted. Sources consulted to create a shortlist of the set of building classes included previous seismic risk assessment studies (Towashiraporn, 2012; MES, 2015), a study of traditional houses (Oo et al., 2003), guidelines for retrofitting existing houses (UN-HABITAT, 2015), and building damage surveys conducted after recent earthquakes (Aung et al., 2019; New et al., 2018; Zaw et al., 2019).

The definition of the building classes was then undertaken using the GEM Building Taxonomy (Brezv et al., 2013), a uniform and comprehensive classification system developed to characterize buildings according to a number of attributes. Users can explore the GEM building taxonomy through an interactive web-tool available at https://platform.openquake.org/taxtweb/. For the current exposure model, only the construction material, the structural type of the lateral load resisting system, the ductility level, and the range of number of stories were used to classify the building stock. The list of building classes shortlisted for developing the exposure model are listed below in **Table 1.1**.

Table 1.1. List of building classes shortlisted for the exposure model for Myanmar.

No.	Description	GEM Taxonomy	Typical Number of Storeys	Ductility Level
1	Earthen Houses	EU/LWAL+DNO/H:1	1	Non-ductile
2	Traditional Bamboo Houses	W+WBB/LPB+DNO/H:1	1	Non-ductile
3	Traditional Timber Houses, Non Ductile	W+WO/LN/H:1	1	Non-ductile
4	Light Wood Frame Structures	W/LFM+DUL/HBET:1-2	1–2	Low ductility
5	Brick Nogging Structures	MIX(M-W)/LWAL+DNO/HBET:1-2	1–2	Non-ductile
6	Unreinforced Masonry Structures	MUR/LWAL+DNO/H:1 MUR/LWAL+DNO/H:2 MUR/LWAL+DNO/H:3	1–3	Non-ductile
7	Reinforced Concrete Momemt Frame Structures with Masonry Infill	CR/LFINF+DUL/H:1 CR/LFINF+DUL/H:2 CR/LFINF+DUL/HBET:3-5	1–5	Low ductility
8	Reinforced Concrete Shear Wall Structures	CR/LDUAL+DUL/HBET:6-12	6–12	Low ductility
9		CR/LDUAL+DUM/HBET:13-	13–34	Moderate ductility
10	Reinforced Concrete Momemt Frame Structures without Masonry Infill	CR/LFM+DUL/HBET:1-2	1–2	Low ductility
11	Steel Frame Structures	S/LFM+DUL/HBET:1-2	1–2	Low ductility
12	Unknown Construction	UNK/H:1	1	Non-ductile

1.2 Mapping Census Data to Building Classes

From the census data, a large variation of construction materials can be observed across the country. The 2017 Myanmar living conditions survey (CSO and UNDP Myanmar, 2018) provides the following highly useful summary of the housing data from the 2014 census:

> *"By the coast, households are more likely to use dhani, theke or bamboo for their walls or roof. For example, 40 percent of households in Ayeyarwady use dhani for their walls while 58 percent of households in Tanintharyi use it for their roofs. Overall the use of corrugated sheet for walls is low in Myanmar (2 percent) but in Chin this rises to 9 percent. This is explained by the cold weather in Chin, situated in a mountainous area. The use of bamboo for walls is high overall in Myanmar (43 percent), this is particularly the case in the hot and relatively dry regions of Sagaing, Magway, Mandalay and Nay Pyi Taw where more than 60 percent of households have bamboo walls."*

The population and housing statistics provides information regarding the number of housing units (or households) and its attributes, and not the number of buildings or building classes directly. Thus, the attributes provided in the census datasets must be related with the set of building classes presented previously. For the residential exposure, the following variables from the 2014 population and housing census were considered as input data:

1. Type of housing unit (e.g. condominium, bungalow, semi-pucca house, wooden house, bamboo house, hut, etc.).
2. Predominant material of construction of the walls (e.g. dhani/theke, bamboo, earth, wood, brick/concrete etc.).
3. Predominant material of construction of the floor (e.g. bamboo, earth, wood, tile/brick/concrete etc.).
4. Type of settlement (urban or rural).

Table 1.2 shows a snippet of the raw census data for Insein, an urban township in the North District of Yangon.

After analysing the information available in the census datasets, it became clear that certain categories could be associated to more than one of the building classes. For example, housing units whose predominant structural material for the walls was defined as tile/brick/concrete could be assigned to either reinforced concrete moment-frame with masonry infill walls, brick-nogging, or unreinforced brick masonry structures. Moreover, these classes could be further divided based on the number of storeys and expected level of ductility. Thus, it was necessary to establish a relationship between the attributes provided in the census data, and the set of building classes shortlisted in the previous step. This relationship is herein named as a mapping scheme.

Table 1.2. Raw census data for Insein township in North Yangon district, Yangon.

AREA # 120101 **Insein**

Type residence	Floor	Walls							
Condominium/Apartment/Flat		Dhani/Theke/In leaf	Bamboo	Earth	Wood	Corrugated sheet	Tile/Brick/Concrete	Other	Total
	Wood	-	-	-	46	2	181	9	238
	Tile/Brick/Concrete	-	-	-	22	20	5865	5	5912
	Other	-	-	-	-	2	15	7	24
	Total	-	-	-	68	24	6061	21	6174
Bungalow/Brick house		Dhani/Theke/In leaf	Bamboo	Earth	Wood	Corrugated sheet	Tile/Brick/Concrete	Other	Total
	Bamboo	-	1	-	-	-	-	-	1
	Earth	-	1	-	-	-	3	-	4
	Wood	-	10	-	69	20	756	1	856
	Tile/Brick/Concrete	-	7	-	37	21	5824	1	5890
	Other	-	-	-	-	-	24	10	34
	Total	-	19	-	106	41	6607	12	6785
Semi-pacca house		Dhani/Theke/In leaf	Bamboo	Earth	Wood	Corrugated sheet	Tile/Brick/Concrete	Other	Total
	Bamboo	2	6	-	3	-	4	-	15
	Earth	-	2	-	4	2	12	-	20
	Wood	11	179	1	931	65	2095	10	3292
	Tile/Brick/Concrete	19	217	3	1458	70	7132	12	8911
	Other	1	5	-	4	-	14	12	36
	Total	33	409	4	2400	137	9257	34	12274
Wooden house		Dhani/Theke/In leaf	Bamboo	Earth	Wood	Corrugated sheet	Tile/Brick/Concrete	Other	Total
	Bamboo	29	170	-	128	13	6	8	354
	Earth	4	59	14	28	3	3	7	118
	Wood	421	10298	11	14494	852	299	229	26604
	Tile/Brick/Concrete	20	305	1	755	68	335	10	1494
	Other	7	10	-	18	6	2	14	57
	Total	481	10842	26	15423	942	645	268	28627
Bamboo		Dhani/Theke/In leaf	Bamboo	Earth	Wood	Corrugated sheet	Tile/Brick/Concrete	Other	Total
	Bamboo	524	3318	-	23	21	1	91	3978
	Earth	1	72	4	1	1	-	1	80
	Wood	256	2152	6	58	32	2	36	2542
	Tile/Brick/Concrete	1	54	-	2	-	6	1	64
	Other	36	40	-	1	-	-	5	82
	Total	818	5636	10	85	54	9	134	6746
Hut 2 - 3 years		Dhani/Theke/In leaf	Bamboo	Earth	Wood	Corrugated sheet	Tile/Brick/Concrete	Other	Total
	Bamboo	18	77	-	2	-	1	3	101
	Earth	7	23	-	-	5	-	1	36
	Wood	10	67	-	6	3	4	7	97
	Tile/Brick/Concrete	-	3	-	4	-	14	-	21
	Other	2	-	-	-	-	-	3	5
	Total	37	170	-	12	8	19	14	260
Hut 1 year		Dhani/Theke/In leaf	Bamboo	Earth	Wood	Corrugated sheet	Tile/Brick/Concrete	Other	Total
	Bamboo	10	127	-	-	1	-	4	142
	Earth	-	2	-	-	-	-	1	3
	Wood	34	25	-	3	-	-	3	65
	Tile/Brick/Concrete	-	-	-	1	-	-	-	1
	Other	-	1	-	-	-	-	14	15
	Total	44	155	-	4	1	-	22	226
Other		Dhani/Theke/In leaf	Bamboo	Earth	Wood	Corrugated sheet	Tile/Brick/Concrete	Other	Total
	Bamboo	5	56	-	2	2	2	5	72
	Earth	1	12	-	1	3	2	18	37
	Wood	4	115	1	58	10	5	27	220
	Tile/Brick/Concrete	5	12	-	12	10	114	15	168
	Other	3	2	-	-	1	1	80	87
	Total	18	197	1	73	26	124	145	584

Four mapping schemes were proposed for Myanmar, taking into account the variation of construction practice across the country as described below:

- Metropolitan townships of Yangon.
- Metropolitan townships of Mandalay, Nay Pyi Taw and Taunggyi.
- All other urban townships.
- Rural townships.

Table 1.3 shows an example of the mapping scheme used for metropolitan townships in Yangon, and **Table 1.4** shows the mapping scheme used for rural townships. The number of housing units per building class is calculated by multiplying the quantity defined in the census by the associated building class fraction, at each geographical scale.

For the industrial and commercial building inventory, a similar methodology was employed. In this case, the 2015 Myanmar Business Survey reports the total number of enterprises or establishments in each of the 15 top-level administrative divisions of Myanmar, grouped by the primary economic activity of each business. These surveys also include the size of the enterprise based on the number of employees. Mapping schemes were also used to assign a building class based on the typical building use cases associated with each industry group.

Table 1.3. Residential mapping scheme for metropolitan townships of Yangon.

Type residence	**Wall**						
	Dhani/Theke/In leaf	**Bamboo**	**Earth**	**Wood**	**Corrugated sheet**	**Tile/Brick/Concrete**	**Other**
Condominium/Apartment/Flat	-	-	-	W/H:2	W/H:2	M/CR APT	UNK/H:1
Bungalow/Brick house	W+WO/LN/H:1	50% W/H:1 50% W+WBB/LPB+DNO/H:1	EU/LWAL+DNO/H:1	W1-PACCA	30% W/H:1 10% W/H:2 50% W+WO/LN/H:1 8% MIX(M-W)/H:1 2% MIX(M-W)/H:2	M/CR PACCA	50% MUR/LWAL+DNO/H:1 50% W+WO/LN/H:1
Semi-pacca house	W+WO/LN/H:1	W+WBB/LPB+DNO/H:1	EU/LWAL+DNO/H:1	W2-SEMIPACCA	30% W/H:1 15% W/H:2 50% W+WO/LN/H:1 5% MIX(M-W)/H:1	M/CR SEMIPACCA	UNK/H:1
Wooden house	W+WO/LN/H:1	50% W/H:1 50% W+WBB/LPB+DNO/H:1	50% EU/LWAL+DNO/H:1 50% W/H:1	W3-WOOD	30% W/H:1 70% W+WO/LN/H:1	M/CR WOOD	W+WO/LN/H:1
Bamboo	W+WBB/LPB+DNO/H:1	W+WBB/LPB+DNO/H:1	50% EU/LWAL+DNO/H:1 50% W+WBB/LPB+DNO/H:1	W+WBB/LPB+DNO/H:1	W+WBB/LPB+DNO/H:1	MIX(M-W)/H:1	W+WBB/LPB+DNO/H:1
Hut 2 - 3 years	W+WO/LN/H:1	W+WBB/LPB+DNO/H:1	EU/LWAL+DNO/H:1	W+WO/LN/H:1	W+WO/LN/H:1	70% MUR/LWAL+DNO/H:1 30% MIX(M-W)/H:1	UNK/H:1
Hut 1 year	W+WO/LN/H:1	W+WBB/LPB+DNO/H:1	EU/LWAL+DNO/H:1	W+WO/LN/H:1	W+WO/LN/H:1	70% MUR/LWAL+DNO/H:1 30% MIX(M-W)/H:1	UNK/H:1
Other	W+WO/LN/H:1	W+WBB/LPB+DNO/H:1	EU/LWAL+DNO/H:1	W+WO/LN/H:1	W+WO/LN/H:1	70% MUR/LWAL+DNO/H:1 30% MIX(M-W)/H:1	UNK/H:1

Floor	**Classification by Type residence and Wall**						
	W1-PACCA	W2-SEMIPACCA	W3-WOOD	M/CR APT	M/CR PACCA	M/CR SEMIPACCA	M/CR WOOD
Bamboo	70% W/H:1 30% MIX(M-W)/H:1	40% W/H:1 50% W+WO/LN/H:1 10% MIX(M-W)/H:1	60% W/H:1 40% W/H:2	-	40% MUR/LWAL+DNO/H:1 30% MUR/LWAL+DNO/H:2 20% MIX(M-W)/H:1 10% MIX(M-W)/H:2	40% MUR/LWAL+DNO/H:1 30% MUR/LWAL+DNO/H:2 15% MIX(M-W)/H:1 15% MIX(M-W)/H:2	70% MIX(M-W)/H:1 30% MIX(M-W)/H:2
Earth	W+WO/LN/H:1	W+WO/LN/H:1	W+WO/LN/H:1	-	70% MUR/LWAL+DNO/H:1 30% MIX(M-W)/H:1	70% MUR/LWAL+DNO/H:1 30% MIX(M-W)/H:1	MIX(M-W)/H:1
Wood	40% W/H:1 30% W/H:2 15% MIX(M-W)/H:1 15% MIX(M-W)/H:2	20% W/H:1 20% W/H:2 50% W+WO/LN/H:1 8% MIX(M-W)/H:1 2% MIX(M-W)/H:2	30% W/H:1 30% W/H:2 30% W+WO/LN/H:1 8% MIX(M-W)/H:1 2% MIX(M-W)/H:2	40% MUR/LWAL+DNO/H:2 10% MUR/LWAL+DNO/H:3 30% MIX(M-W)/H:2 10% CR/LFINF+DUL/H:2 10% CR/LFINF+DUL/H:3	20% MUR/LWAL+DNO/H:1 30% MUR/LWAL+DNO/H:2 15% MIX(M-W)/H:1 15% MIX(M-W)/H:2 10% CR/LFINF+DUL/H:1 10% CR/LFINF+DUL/H:2	35% MUR/LWAL+DNO/H:1 35% MUR/LWAL+DNO/H:2 15% MIX(M-W)/H:1 15% MIX(M-W)/H:2	50% MIX(M-W)/H:1 50% MIX(M-W)/H:2
Tile/Brick/Concrete	40% W/H:1 30% W/H:2 15% MIX(M-W)/H:1 15% MIX(M-W)/H:2	20% W/H:1 20% W/H:2 40% W+WO/LN/H:1 10% MIX(M-W)/H:1 10% MIX(M-W)/H:2	25% W/H:1 25% W/H:2 30% W+WO/LN/H:1 10% MIX(M-W)/H:1 10% MIX(M-W)/H:2	10% MUR/LWAL+DNO/H:2 20% MUR/LWAL+DNO/H:3 5% CR/LFINF+DUL/H:2 10% CR/LFINF+DUL/H:3 15% CR/LFINF+DUL/H:4 20% CR/LFINF+DUL/H:5 20% CR/LDUAL+DUL/HBET:6-12	20% MUR/LWAL+DNO/H:1 20% MUR/LWAL+DNO/H:2 10% MIX(M-W)/H:1 10% MIX(M-W)/H:2 10% CR/LFINF+DUL/H:1 20% CR/LFINF+DUL/H:2 10% CR/LFINF+DUL/H:3	30% MUR/LWAL+DNO/H:1 30% MUR/LWAL+DNO/H:2 10% MIX(M-W)/H:1 10% MIX(M-W)/H:2 5% CR/LFINF+DUL/H:1 10% CR/LFINF+DUL/H:2 5% CR/LFINF+DUL/H:3	50% MIX(M-W)/H:1 50% MIX(M-W)/H:2
Other	W+WO/LN/H:1	W+WO/LN/H:1	W+WO/LN/H:1	70% MUR/LWAL+DNO/H:2 15% MIX(M-W)/H:2 15% CR/LFINF+DUL/H:2	50% MUR/LWAL+DNO/H:1 30% MUR/LWAL+DNO/H:2 10% MIX(M-W)/H:1 10% MIX(M-W)/H:2	25% MUR/LWAL+DNO/H:1 25% MUR/LWAL+DNO/H:2 25% MIX(M-W)/H:1 25% MIX(M-W)/H:2	MIX(M-W)/H:1

Table 1.4. Mapping scheme for rural townships

Type residence	Wall						
	Dhani/Theke/In leaf	Bamboo	Earth	Wood	Corrugated sheet	Tile/Brick/Concrete	Other
Condominium/Apartment/Flat	-	-	-	W/H:2	W/H:2	M/CR APT	UNK/H:1
Bungalow/Brick house	W+WO/LN/H:1	50% W/H:1 50% W+WBB/LPB+DNO/H:1	EU/LWAL+DNO/H:1	W1-PACCA	30% W/H:1 70% W+WO/LN/H:1	M/CR PACCA	50% MUR/LWAL+DNO/H:1 50% W+WO/LN/H:1
Semi-pacca house	W+WO/LN/H:1	W+WBB/LPB+DNO/H:1	EU/LWAL+DNO/H:1	W2-SEMIPACCA	W+WO/LN/H:1	M/CR SEMIPACCA	UNK/H:1
Wooden house	W+WO/LN/H:1	50% W/H:1 50% W+WBB/LPB+DNO/H:1	50% EU/LWAL+DNO/H:1 50% W/H:1	W3-WOOD	30% W/H:1 70% W+WO/LN/H:1	M/CR WOOD	W+WO/LN/H:1
Bamboo	W+WBB/LPB+DNO/H:1	W+WBB/LPB+DNO/H:1	50% EU/LWAL+DNO/H:1 50% W+WBB/LPB+DNO/H:1	W+WBB/LPB+DNO/H:1	W+WBB/LPB+DNO/H:1	MIX(M-W)/H:1	W+WBB/LPB+DNO/H:1
Hut 2 - 3 years	W+WO/LN/H:1	W+WBB/LPB+DNO/H:1	EU/LWAL+DNO/H:1	W+WO/LN/H:1	W+WO/LN/H:1	70% MUR/LWAL+DNO/H:1 30% MIX(M-W)/H:1	UNK/H:1
Hut 1 year	W+WO/LN/H:1	W+WBB/LPB+DNO/H:1	EU/LWAL+DNO/H:1	W+WO/LN/H:1	W+WO/LN/H:1	70% MUR/LWAL+DNO/H:1 30% MIX(M-W)/H:1	UNK/H:1
Other	W+WO/LN/H:1	W+WBB/LPB+DNO/H:1	EU/LWAL+DNO/H:1	W+WO/LN/H:1	W+WO/LN/H:1	70% MUR/LWAL+DNO/H:1 30% MIX(M-W)/H:1	UNK/H:1

Floor	Classification by Type residence and Wall						
	W1-PACCA	W2-SEMIPACCA	W3-WOOD	M/CR APT	M/CR PACCA	M/CR SEMIPACCA	M/CR WOOD
Bamboo	70% W/H:1 30% MIX(M-W)/H:1	40% W/H:1 50% W+WO/LN/H:1 10% MIX(M-W)/H:1	W/H:1	-	70% MUR/LWAL+DNO/H:1 30% MIX(M-W)/H:1	60% MUR/LWAL+DNO/H:1 40% MIX(M-W)/H:1	MIX(M-W)/H:1
Earth	W+WO/LN/H:1	W+WO/LN/H:1	W+WO/LN/H:1	-	70% MUR/LWAL+DNO/H:1 30% MIX(M-W)/H:1	60% MUR/LWAL+DNO/H:1 40% MIX(M-W)/H:1	MIX(M-W)/H:1
Wood	70% W/H:1 30% MIX(M-W)/H:1	40% W/H:1 50% W+WO/LN/H:1 10% MIX(M-W)/H:1	50% W/H:1 40% W+WO/LN/H:1 10% MIX(M-W)/H:1	40% MUR/LWAL+DNO/H:2 40% MIX(M-W)/H:2 20% CR/LFINF+DUL/H:2	50% MUR/LWAL+DNO/H:1 50% MIX(M-W)/H:1	50% MUR/LWAL+DNO/H:1 50% MIX(M-W)/H:1	80% MIX(M-W)/H:1 20% MIX(M-W)/H:2
Tile/Brick/Concrete	50% W/H:1 50% MIX(M-W)/H:1	30% W/H:1 30% W+WO/LN/H:1 40% MIX(M-W)/H:1	50% W/H:1 20% W+WO/LN/H:1 30% MIX(M-W)/H:1	50% MUR/LWAL+DNO/H:2 20% MIX(M-W)/H:2 30% CR/LFINF+DUL/H:2	MUR/LWAL+DNO/H:1	60% MUR/LWAL+DNO/H:1 40% MIX(M-W)/H:1	80% MIX(M-W)/H:1 20% MIX(M-W)/H:2
Other	W+WO/LN/H:1	W+WO/LN/H:1	W+WO/LN/H:1	70% MUR/LWAL+DNO/H:2 30% MIX(M-W)/H:2	80% MUR/LWAL+DNO/H:1 20% MIX(M-W)/H:1	50% MUR/LWAL+DNO/H:1 50% MIX(M-W)/H:1	MIX(M-W)/H:1

1.3 Mapping Housing Units and Establishments to Buildings

The information used reported the number of housing units or establishments and not the number of buildings directly. Whilst the former is useful to estimate the total built-up area or replacement cost of a given type of construction, it does not allow estimating the number of buildings in a given damage state (e.g. slight damage, moderate damage, collapse) for a specific earthquake. Thus, the number of buildings was estimated by dividing the number of housing units or establishments by the average number of housing units or establishments per story and by the average number of storeys per building. **Table 1.5** shows the fractions assumed at this step for the common dwelling types in Myanmar. Reinforced concrete structures taller than 6 storeys were assumed to exist only in the cities of Yangon, Mandalay, Nay Pyi Taw and Taunggyi. All RC structures in the other urban townships and rural areas are assumed to be low-rise, i.e., between 1–3 stories in height.

1.4 Estimation of Building Areas and Replacement Costs

The final step to complete the exposure model is the estimation of the replacement cost per occupancy and building type. In this context, the replacement cost refers to the value of replacing a building in accordance with the latest building standards applicable for the country, and it includes the cost of the structural and non-structural components (but not the cost of the land). For example, in the case of an unreinforced masonry house, the replacement cost will be the value of building a confined-masonry or reinforced concrete structure at the present time, as current seismic codes do not allow the construction of unreinforced masonry due to its poor seismic performance. An exception was made for huts and bamboo dwellings, for which the replacement cost was assumed to be equal to the current average construction costs for these dwelling types. Since construction costs are commonly found per square meter of housing unit, the average floor area per housing unit type is also required. For informal (non-engineered) construction, both the cost and area estimates were based on data collected during surveys conducted by Myanmar Survey Research (MSR). **Table 1.5** shows the average floor areas and replacement costs assumed at this step for the common non-engineered dwelling types in Myanmar.

For reinforced concrete structures, instead of assigning an average area to each building class, four qualitative categories were selected depending on the construction quality: upper, middle, affordable, and low cost. Each building class was related to one of these categories, considering that lower quality refers to construction built informally, upper quality refers to ductile structures with seismic provisions, and middle quality refers to formal structures that do not meet the necessary specifications to be considered ductile. Construction cost and floor area estimates for engineered buildings used for housing and for different commercial occupancies are available for Yangon (JICA, 2018; Spon Press, 2015). **Table 1.6** shows the average floor areas and replacement costs assumed at this step for the common non-engineered dwelling types in Myanmar.

Table 1.5. Building fractions by number of storeys; average area per dwelling, average building replacement cost, and average contents value as a fraction of the building replacement cost per dwelling type (except RC structures).

Dwelling Type	Fraction by # Storeys			Area per Dwelling (sqm)			Building Replacement Cost		Contents Cost as % of Building Cost
	Single Storey	Double Storey	Three Storey	Single Storey	Double Storey	Three Storey	MMK/sq.ft.	USD/sq.m.	
Hut	100%	-	-	20	-	-	MMK 1,400	$ 10	80%
Bamboo	50%	50%	-	40	40	-	MMK 2,800	$ 20	30%
Wooden	60%	40%	-	55	75	-	MMK 7,000	$ 50	20%
Semi-pucca	25%	60%	15%	90	120	150	MMK 9,200	$ 65	20%
Bungalow	40%	40%	20%	90	120	150	MMK 20,000	$ 140	10%

Table 1.6. Average areas and replacement costs for reinforced concrete structures.

DEVELOPMENT TYPE	Average Floor Area Per Housing Unit (m^2)	Average Replacement Cost ('000 Kyat / m^2)	Average Replacement Cost (USD / m^2)
RESIDENTIAL			
Low Cost	50	180	120
Affordable	80	360	240
Middle	100	525	350
Luxury	150	750	500

DEVELOPMENT TYPE	Average Area Per Establishment (m^2)	Average Replacement Cost ('000 Kyat / m^2)	Average Replacement Cost (USD / m^2)
COMMERCIAL			
Retail	50	525	350
Wholesale	70	600	400
Offices	50	1050	700
Hotels	300	1275	850
INDUSTRIAL			
Construction	60	405	270
Factories - Light	90	450	300
Factories - Heavy	700	405	270

1.5 Exposure Summaries

Table 1.7 shows the population, dwelling counts, estimated building counts, and total estimated replacement value for Myanmar summarized at the state/region level for residential, commercial, and industrial occupancies. **Table 1.8** shows the same summaries per building class. The total building stock is estimated to be valued at $53.6 billion in residential structures, $11.4 billion in commercial structures, and $5.4 billion in industrial structures. These values include the contents costs. Nearly one-third of the residential building value is concentrated in Yangon. Likewise, nearly one-fifth of the commercial and industrial building value is situated in Yangon.

Bamboo and wood houses account for nearly three-quarters of the residential exposure in terms of the number of structures. In terms of replacement costs, however, reinforced concrete structures account for over half of the total replacement cost of the country, although they make up for just around 2.5% of the total number of residential buildings.

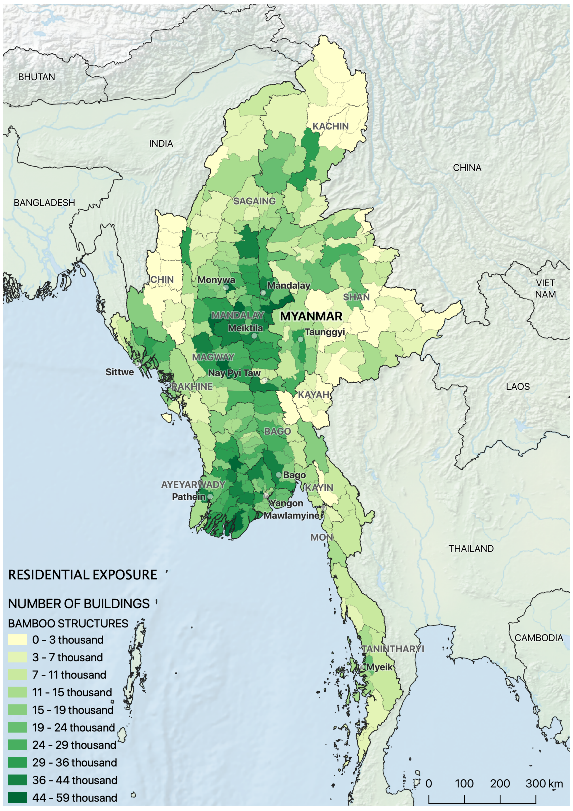
Figure 1.3 shows maps of the distribution of buildings in Myanmar per township for the various construction types.

Table 1.7. Exposure summary by state/region.

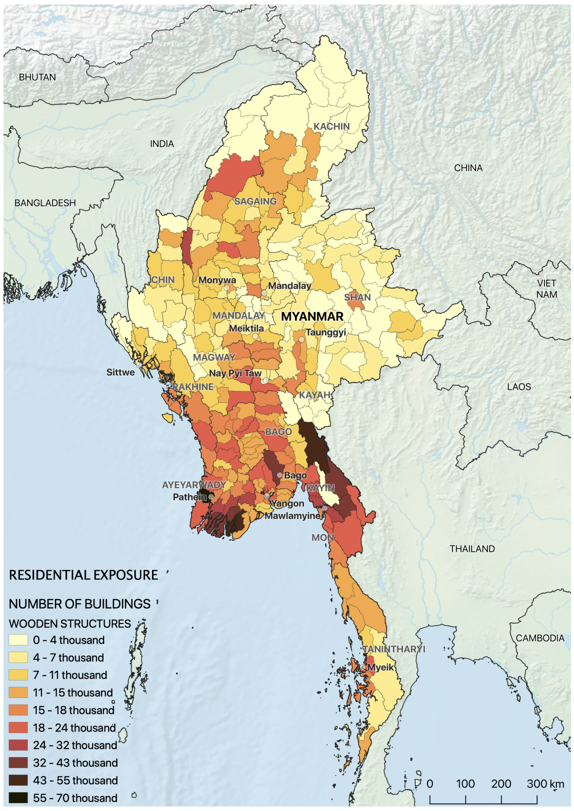
State / Region / UT	Residential				Commercial			Industrial		
	Population	Dwellings	Buildings	Total Replacement Cost (USD)	Establishments	Buildings	Total Replacement Cost (USD)	Establishments	Buildings	Total Replacement Cost (USD)
Ayeyarwady	6,184,804	1,488,983	1,487,757	$ 3,712,046,160	4,293	1,848	$ 502,124,000	2,089	2,089	$ 233,914,500
Bago	4,915,977	1,152,900	1,151,166	$ 4,052,317,420	6,117	3,301	$ 845,810,000	2,981	2,981	$ 306,031,500
Chin	478,801	91,121	91,058	$ 264,888,218	796	477	$ 122,801,000	507	507	$ 46,696,500
Kachin	1,642,846	269,365	268,487	$ 1,090,018,319	1,438	853	$ 187,974,500	655	655	$ 101,047,500
Kayah	300,818	59,818	59,604	$ 318,007,849	631	445	$ 77,007,000	338	338	$ 44,388,000
Kayin	1,393,349	286,713	286,093	$ 1,246,752,807	2,031	1,402	$ 289,250,500	988	988	$ 178,200,000
Magway	3,933,852	922,874	921,690	$ 2,804,156,101	7,447	4,406	$ 979,636,000	3,411	3,411	$ 441,166,500
Mandalay	6,152,651	1,320,489	1,308,118	$ 5,880,844,002	12,819	6,917	$ 1,551,774,000	5,894	5,894	$ 872,154,000
Mon	2,063,600	424,309	423,591	$ 1,937,956,481	6,732	3,022	$ 787,174,500	3,344	3,344	$ 395,793,000
Nay Pyi Taw	1,074,121	242,859	233,174	$ 1,600,114,372	1,719	1,068	$ 233,915,500	877	877	$ 125,158,500
Rakhine	2,098,807	459,772	459,434	$ 1,271,662,827	3,919	2,465	$ 563,468,500	2,014	2,014	$ 251,046,000
Sagaing	5,308,538	1,093,760	1,092,235	$ 3,613,249,488	7,491	3,536	$ 868,791,000	3,508	3,508	$ 474,309,000
Shan	5,863,397	1,176,730	1,169,442	$ 6,842,099,978	7,532	4,742	$ 1,091,762,000	3,294	3,294	$ 451,791,000
Tanintharyi	1,408,399	283,099	282,243	$ 1,324,129,322	7,131	4,854	$ 1,182,513,500	3,578	3,578	$ 446,283,000
Yangon	7,334,744	1,577,002	1,409,365	$ 17,671,358,962	15,069	9,173	$ 2,165,712,500	7,190	7,190	$ 1,038,177,000
Total	50,154,704	10,849,794	10,643,457	$ 53,629,602,303	85,165	48,509	$ 11,449,714,500	40,668	40,668	$ 5,406,156,000

Table 1.8. Exposure summary by building class.

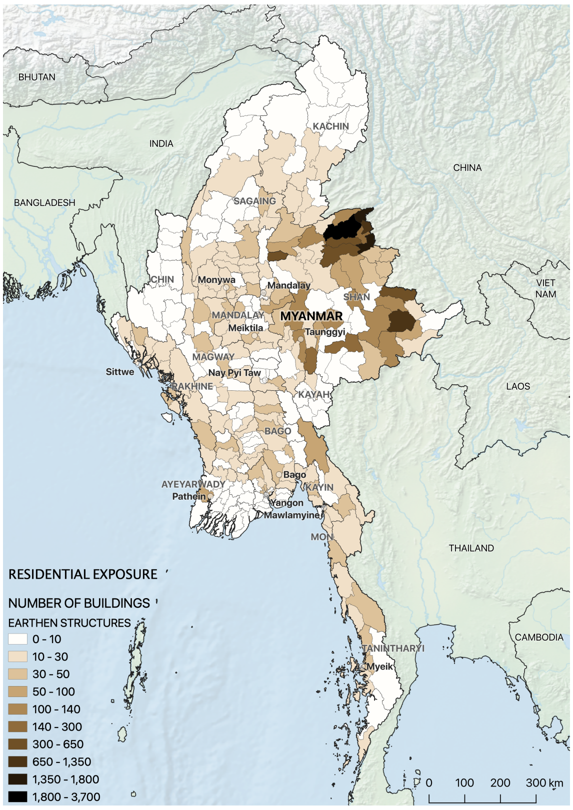
Taxonomy	Residential				Commercial			Industrial		
	Population	Dwellings	Buildings	Total Replacement Cost (USD)	Establishments	Buildings	Total Replacement Cost (USD)	Establishments	Buildings	Total Replacement Cost (USD)
EU/LWAL+DNO/H:1	96,319	18,086	18,086	$ 61,035,920						
W+WBB/LPB+DNO/H:1	23,959,286	5,259,449	5,259,449	$ 7,756,511,660						
W+WO/LN/H:1	6,284,801	1,362,606	1,362,606	$ 4,143,361,060						
W/LFM+DUL/HBET:1-2	10,134,702	2,191,643	2,191,643	$ 7,289,468,993	2,473	1,996	$ 49,164,500	8	8	$ 540,000
MIX(M-W)/LWAL+DNO/HBET:1-2	2,869,828	605,182	605,182	$ 4,733,963,925	5,461	5,461	$ 104,478,500	9,975	9,975	$ 673,312,500
MUR/LWAL+DNO/H:1	2,994,687	633,373	633,373	$ 7,362,685,900	10,153	10,153	$ 228,305,000	851	851	$ 56,551,500
MUR/LWAL+DNO/H:2	1,307,551	267,769	267,769	$ 3,420,842,047						
MUR/LWAL+DNO/H:3	247,070	50,035	16,683	$ 360,402,105						
CR/LFINF+DUL/H:1	177,804	35,677	35,677	$ 867,831,840	11,468	11,468	$ 1,993,964,000			
CR/LFINF+DUL/H:2	752,619	154,002	154,002	$ 5,123,479,680	10,484	7,951	$ 379,295,000			
CR/LFINF+DUL/HBET:3-5	838,861	169,613	42,008	$ 9,012,052,080	37,226	5,384	$ 3,230,132,500			
CR/LDUAL+DUL/HBET:6-12	230,276	46,680	1,300	$ 3,360,960,000	3,307	3,305	$ 4,161,920,000			
CR/LDUAL+DUM/HBET:13-					2,493	691	$ 1,243,655,000			
CR/LFM+DUL/HBET:1-2					1,866	1,866	$ 52,248,000	9,126	9,126	$ 989,658,000
S/LFM+DUL/HBET:1-2					234	234	$ 6,552,000	20,708	20,708	$ 3,686,094,000
UNK/H:1	260,899	55,679	55,679	$ 137,007,093						
Total	50,154,704	10,849,794	10,643,457	$ 53,629,602,303	85,165	48,509	$ 11,449,714,500	40,668	40,668	$ 5,406,156,000



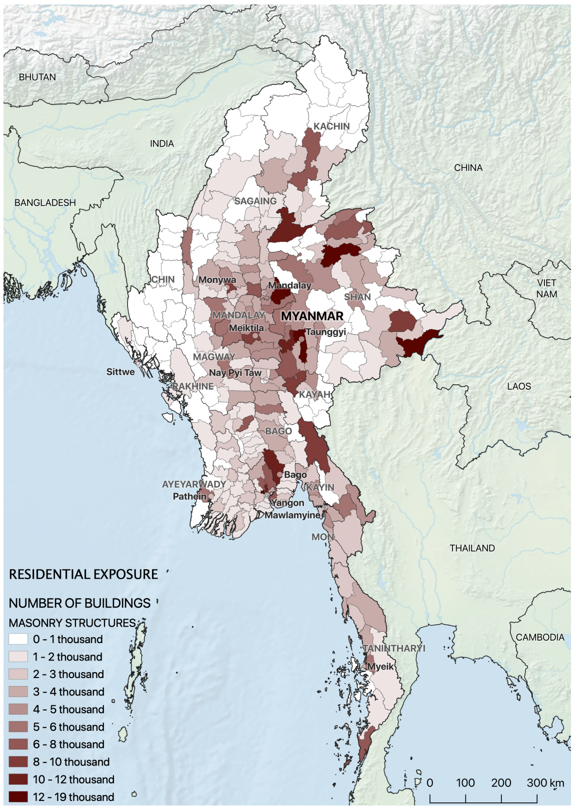
(a) Bamboo structures



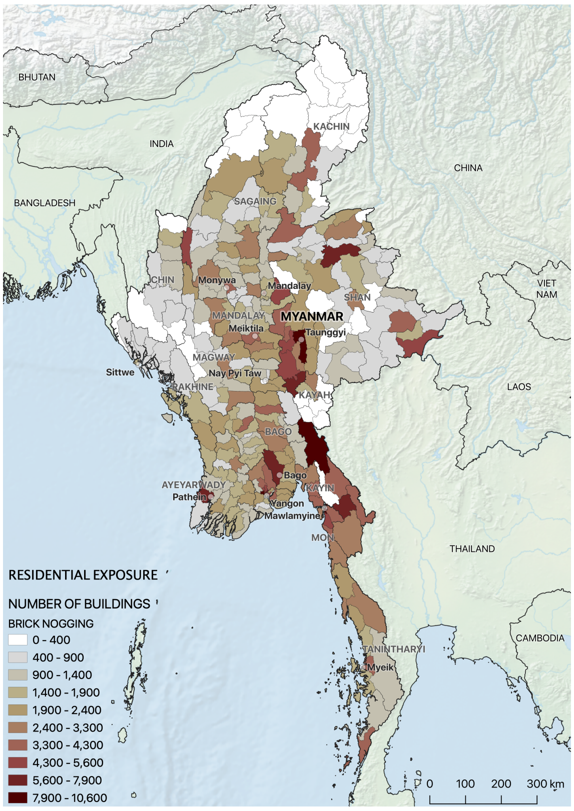
(b) Wooden structures



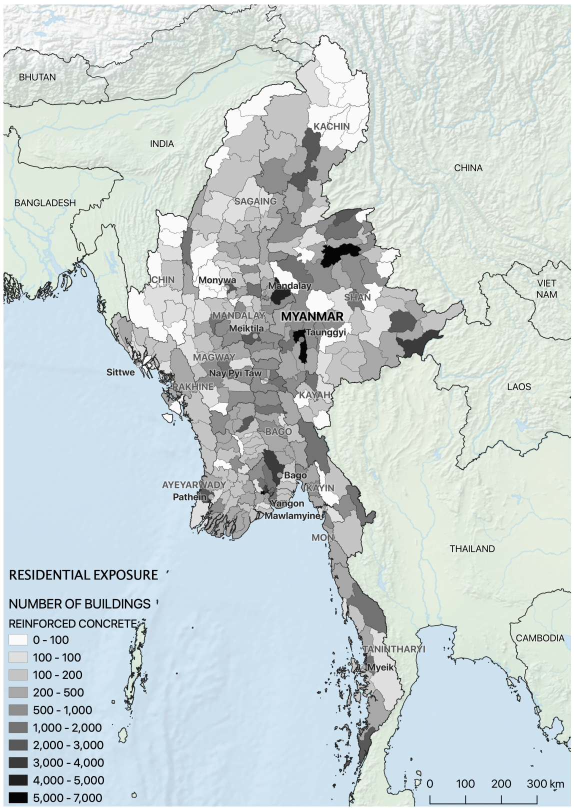
(c) Earthen structures



(d) Masonry structures



(e) Brick nogging structures

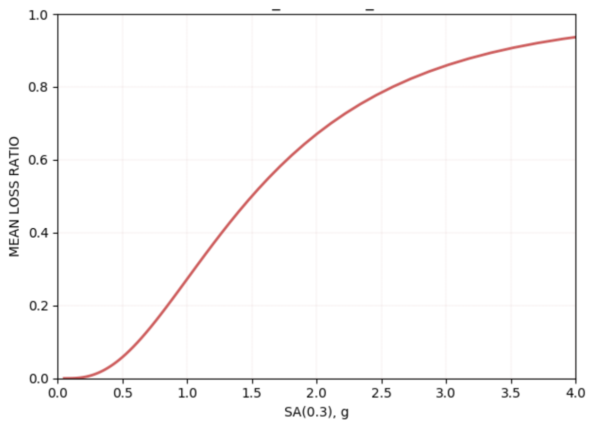


(f) Reinforced concrete structures

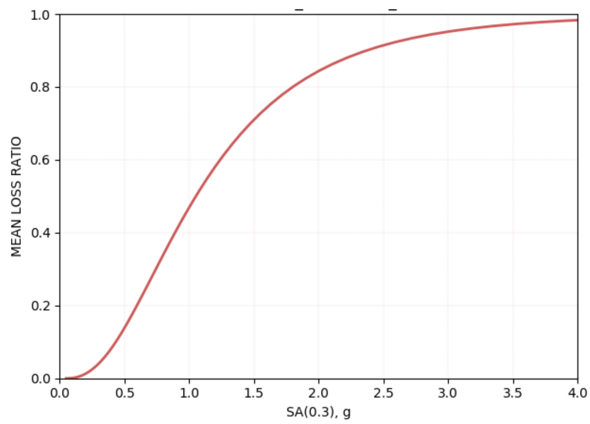
Figure 1.3. Distribution of buildings by construction type per township

2 Development of the Seismic Vulnerability Model

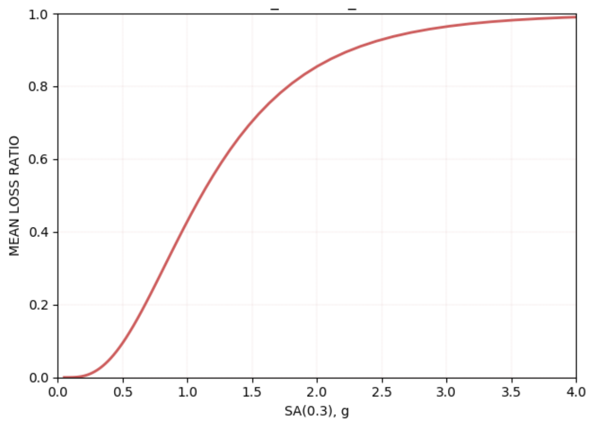
The seismic fragility and vulnerability functions for the Myanmar building stock were carefully selected from GEM's global vulnerability database. The global database (Martins and Silva 2018, Martins and Silva, forthcoming) includes seismic fragility and vulnerability functions for nearly 500 different building classes, representative of most of the building types found around the globe. Seismic zonation for Myanmar was introduced in 2005, and the first national building code was released in 2012. The 2016 update of the Myanmar National Building Code (MES, 2016) is the latest version of the design standard in the country. Adoption of these codes in actual design and construction has been low, and enforcement is also lacking. Thus, the majority of the buildings in the exposure model have been assigned "low-ductility" vulnerability functions for their building classes. **Figure 2.1** shows plots of the seismic vulnerability functions for eight of the common building classes in Myanmar.



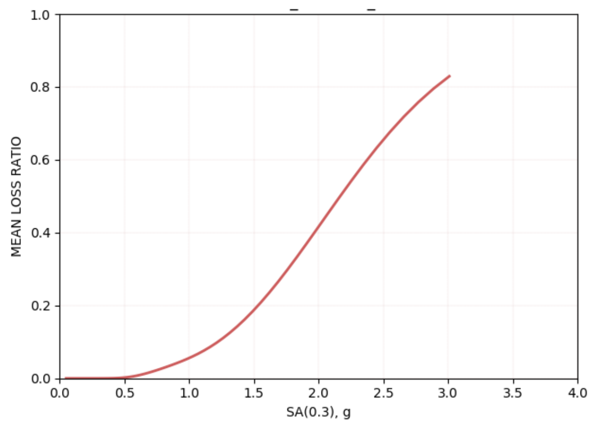
(a) Unreinforced brick masonry, 1-storey



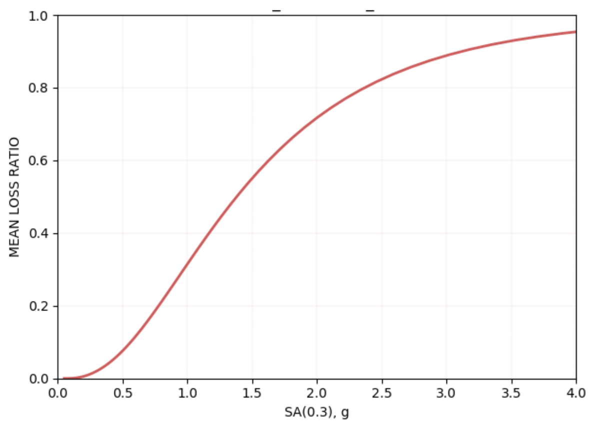
(b) Earthen houses, 1-storey



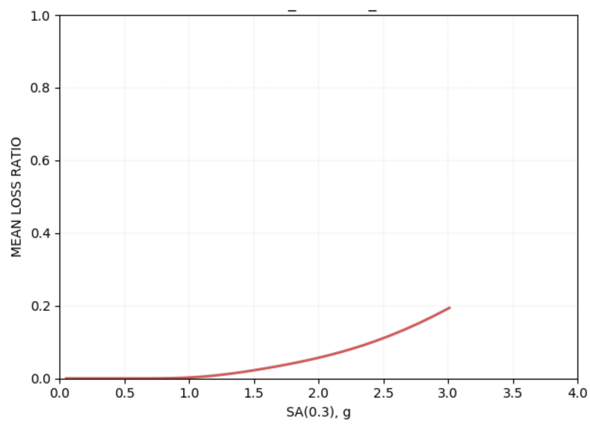
(c) Non-ductile wood structures (huts)



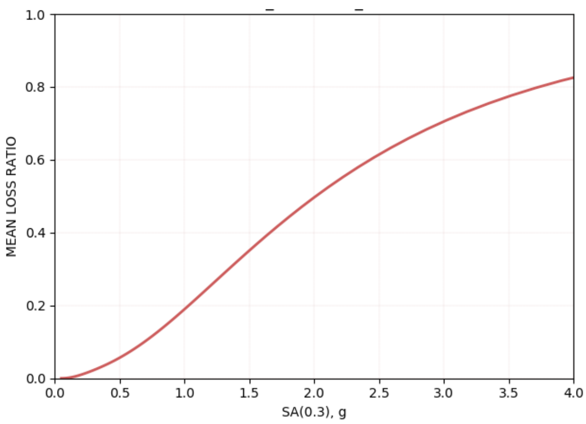
(d) Light wood-frame houses, 1-storey



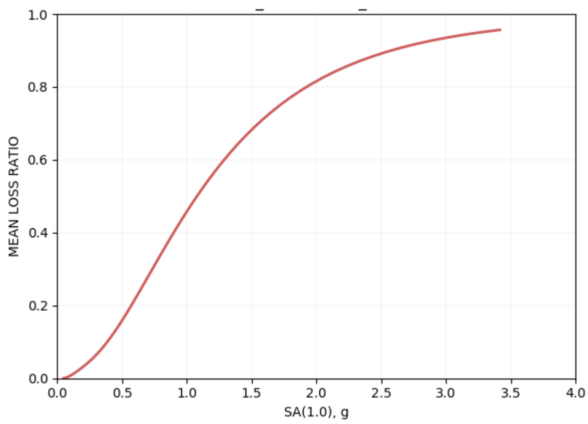
(e) Brick-nogging structures, 2-storey



(f) Bamboo houses, 1-storey



(g) RC moment-frame with infill, 3-storey



(h) RC shear wall low-ductility, 12-storey

Figure 2.1. Seismic vulnerability functions for selected building classes in Myanmar.

3 Probabilistic Seismic Risk Results

The OpenQuake engine (Pagani et al., 2014; Silva et al., 2013) was used to estimate probabilistic risk metrics such as the average annual loss and loss exceedance curves per occupancy class for Myanmar, using the previously described exposure and vulnerability models, in combination with the probabilistic seismic hazard model for continental southeast Asia. **Figure 3.1** shows the seismic hazard map for PGA for 10% probability of exceedance in 50 years for Myanmar, computed using the OpenQuake engine. Additional information regarding the seismic hazard model can be found at https://hazard.openquake.org/gem/models/SEA/ and Chan, 2017.

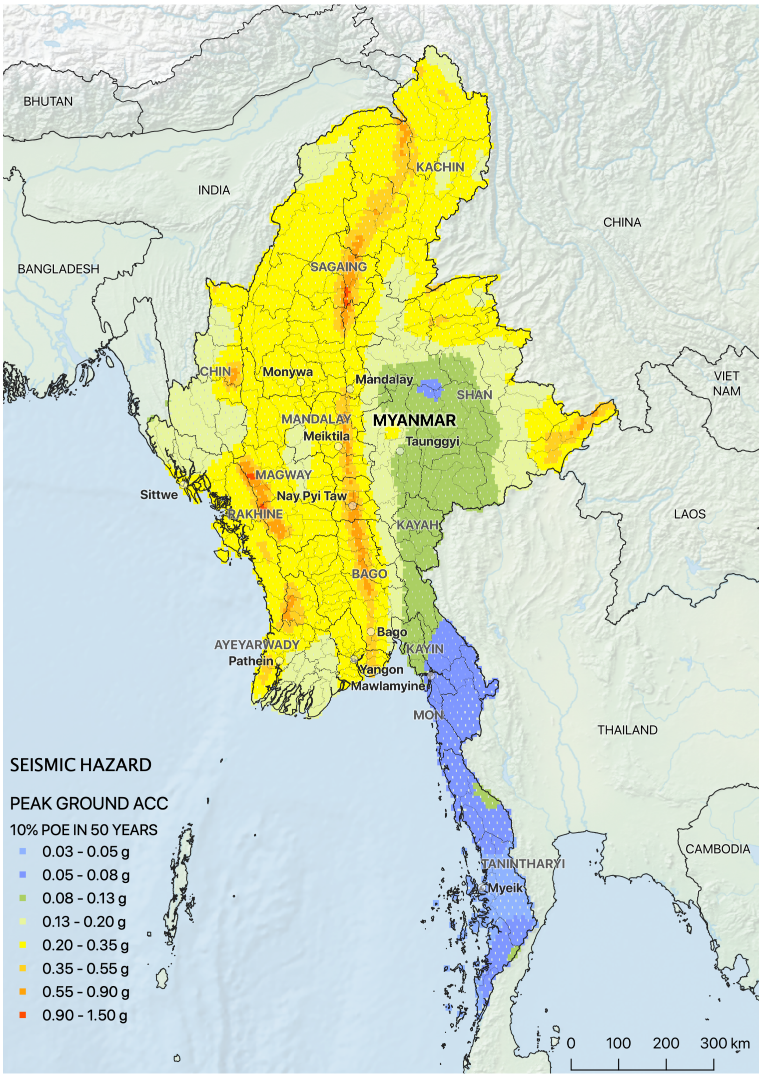


Figure 3.1. Probabilistic seismic hazard map for peak ground acceleration for Myanmar, for 10% probability of exceedance in 50 years

3.1 Average Annual Losses (AAL) and Average Annual Loss Ratios (AALR)

Table 3.1 shows the average annual loss (AAL) and average annual loss ratio (AALR) for Myanmar summarized at the state/region level, and **Table 3.2** shows the AAL and AALR per building class. The AALR represents the AAL normalized by the total exposed value, and can be considered as a measure of relative risk, whereas the AAL estimates the economic loss in absolute terms. **Figure 3.2** shows the AAL map at the state/province level for Myanmar. The highest AAL is observed in Yangon, which has a large fraction of the exposed building stock of the country in terms of replacement value; whereas the highest relative risk in terms of AALR is observed in the Chin state and Sagaing region where the seismic hazard is also the highest in the country. In terms of building classes, bamboo structures can be seen to exhibit the lowest relative risk measured by AALR, whereas unreinforced masonry and brick-nogging structures are the building classes with the highest relative risk.

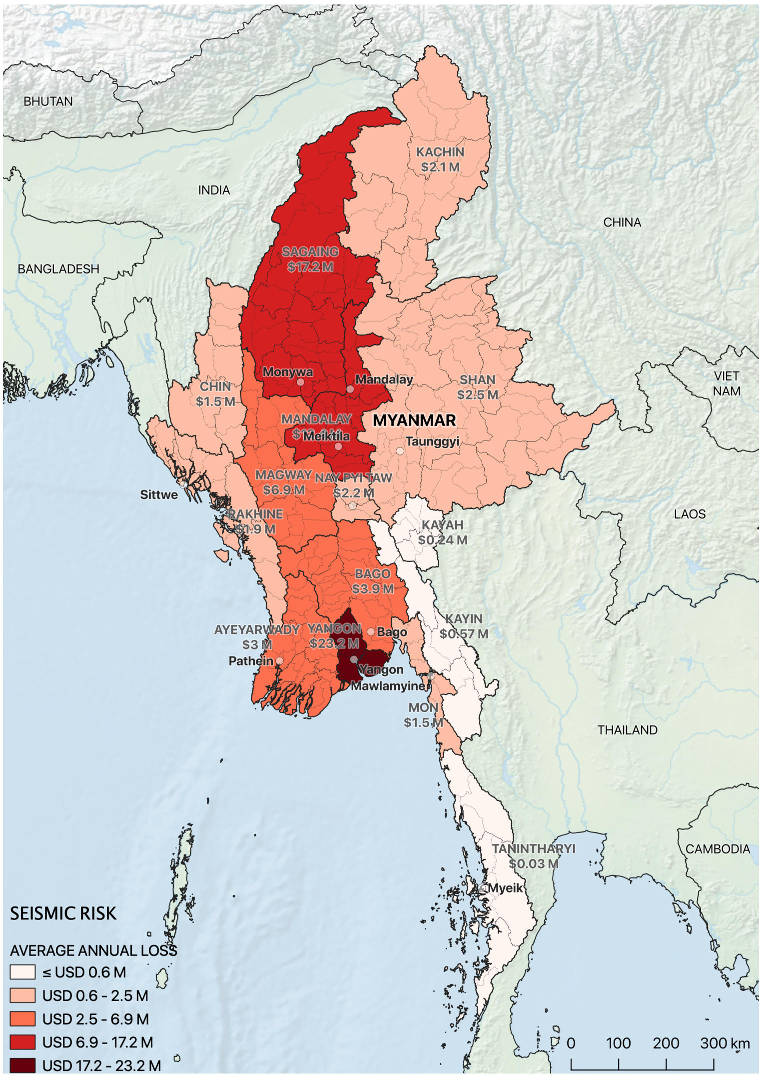


Figure 3.2. Average annual loss map at the state/province level for Myanmar

Table 3.1. Average annual loss (AAL) summary by state/region.

State / Region / UT	Residential			Commercial			Industrial		
	Total Replacement Cost (USD)	Average Annual Loss (USD)	Average Annual Loss Ratio (%)	Total Replacement Cost (USD)	Average Annual Loss (USD)	Average Annual Loss Ratio (%)	Total Replacement Cost (USD)	Average Annual Loss (USD)	Average Annual Loss Ratio (%)
Ayeyarwady	$ 3,712,046,160	$ 2,245,447	0.06%	$ 502,124,000	$ 479,350	0.10%	$ 233,914,500	$ 231,789	0.10%
Bago	$ 4,052,317,420	$ 2,982,353	0.07%	$ 845,810,000	$ 649,387	0.08%	$ 306,031,500	$ 268,803	0.09%
Chin	$ 264,888,218	$ 832,997	0.31%	$ 122,801,000	$ 456,199	0.37%	$ 46,696,500	$ 225,689	0.48%
Kachin	$ 1,090,018,319	$ 1,715,135	0.16%	$ 187,974,500	$ 228,733	0.12%	$ 101,047,500	$ 154,599	0.15%
Kayah	$ 318,007,849	$ 191,232	0.06%	$ 77,007,000	$ 29,126	0.04%	$ 44,388,000	$ 18,879	0.04%
Kayin	$ 1,246,752,807	$ 335,636	0.03%	$ 289,250,500	$ 140,977	0.05%	$ 178,200,000	$ 94,174	0.05%
Magway	$ 2,804,156,101	$ 3,865,245	0.14%	$ 979,636,000	$ 1,975,214	0.20%	$ 441,166,500	$ 1,064,042	0.24%
Mandalay	$ 5,880,844,002	$ 8,926,439	0.15%	$ 1,551,774,000	$ 2,040,472	0.13%	$ 872,154,000	$ 1,418,144	0.16%
Mon	$ 1,937,956,481	$ 849,095	0.04%	$ 787,174,500	$ 448,537	0.06%	$ 395,793,000	$ 203,411	0.05%
Nay Pyi Taw	$ 1,600,114,372	$ 1,786,480	0.11%	$ 233,915,500	$ 241,060	0.10%	$ 125,158,500	$ 144,831	0.12%
Rakhine	$ 1,271,662,827	$ 864,268	0.07%	$ 563,468,500	$ 653,681	0.12%	$ 251,046,000	$ 351,757	0.14%
Sagaing	$ 3,613,249,488	$ 12,232,494	0.34%	$ 868,791,000	$ 2,798,150	0.32%	$ 474,309,000	$ 2,173,673	0.46%
Shan	$ 6,842,099,978	$ 2,218,438	0.03%	$ 1,091,762,000	$ 172,259	0.02%	$ 451,791,000	$ 75,828	0.02%
Tanintharyi	$ 1,324,129,322	$ 19,835	0.00%	$ 1,182,513,500	$ 8,177	0.00%	$ 446,283,000	$ 1,093	0.00%
Yangon	$ 17,671,358,962	$ 19,724,413	0.11%	$ 2,165,712,500	$ 2,249,773	0.10%	$ 1,038,177,000	$ 1,213,216	0.12%
Total	$ 53,629,602,303	$ 58,789,505	0.11%	$ 11,449,714,500	$ 12,571,096	0.11%	$ 5,406,156,000	$ 7,639,928	0.14%

Table 3.2. Average annual loss (AAL) summary by building class

Taxonomy	Residential			Commercial			Industrial		
	Total Replacement Cost (USD)	Average Annual Loss (USD)	Average Annual Loss Ratio (%)	Total Replacement Cost (USD)	Average Annual Loss (USD)	Average Annual Loss Ratio (%)	Total Replacement Cost (USD)	Average Annual Loss (USD)	Average Annual Loss Ratio (%)
EU/LWAL+DNO/H:1	$ 61,035,920	$ 71,773	0.12%						
W+WBB/LPB+DNO/H:1	$ 7,756,511,660	$ 956,642	0.01%						
W+WO/LN/H:1	$ 4,143,361,060	$ 6,385,820	0.15%						
W/LFM+DUL/HBET:1-2	$ 7,289,468,993	$ 4,995,174	0.07%	$ 49,164,500	$ 24,476	0.05%	$ 540,000	$ 574	0.11%
MIX(M-W)/LWAL+DNO/HBET:1-2	$ 4,733,963,925	$ 7,126,171	0.15%	$ 104,478,500	$ 144,984	0.14%	$ 673,312,500	$ 914,422	0.14%
MUR/LWAL+DNO/H:1	$ 7,362,685,900	$ 10,860,951	0.15%	$ 228,305,000	$ 329,034	0.14%	$ 56,551,500	$ 67,855	0.12%
MUR/LWAL+DNO/H:2	$ 3,420,842,047	$ 5,271,914	0.15%						
MUR/LWAL+DNO/H:3	$ 360,402,105	$ 453,628	0.13%						
CR/LFINF+DUL/H:1	$ 867,831,840	$ 184,452	0.02%	$ 1,993,964,000	$ 509,024	0.03%			
CR/LFINF+DUL/H:2	$ 5,123,479,680	$ 5,682,460	0.11%	$ 379,295,000	$ 420,608	0.11%			
CR/LFINF+DUL/HBET:3-5	$ 9,012,052,080	$ 12,563,719	0.14%	$ 3,230,132,500	$ 5,328,669	0.16%			
CR/LDUAL+DUL/HBET:6-12	$ 3,360,960,000	$ 3,937,459	0.12%	$ 4,161,920,000	$ 4,931,290	0.12%			
CR/LDUAL+DUM/HBET:13-				$ 1,243,655,000	$ 832,707	0.07%			
CR/LFM+DUL/HBET:1-2				$ 52,248,000	$ 41,394	0.08%	$ 989,658,000	$ 763,158	0.08%
S/LFM+DUL/HBET:1-2				$ 6,552,000	$ 8,910	0.14%	$ 3,686,094,000	$ 5,893,918	0.16%
UNK/H:1	$ 137,007,093	$ 299,341	0.22%						
Total	$ 53,629,602,303	$ 58,789,505	0.11%	$ 11,449,714,500	$ 12,571,096	0.11%	$ 5,406,156,000	$ 7,639,928	0.14%

3.2 Loss Exceedance Curves and Probable Maximum Losses (PML)

Figure 3.3 shows the loss exceedance curve (often referred to as a probable maximum loss curve, or PML curve) for Myanmar, for each of the three occupancy classes represented in the model. Points along these curves represent the estimated economic loss expected at increasing return periods. **Figure 3.4** shows the same results normalized by the exposed value in each occupancy class. The values of the probable maximum losses are listed in **Table 3.3**.

Table 3.3. Probable maximum losses (PML) per occupancy class for Myanmar.

Return Period (Years)	Residential		Commercial		Industrial	
	Loss Value (USD)	Loss Ratio (%)	Loss Value (USD)	Loss Ratio (%)	Loss Value (USD)	Loss Ratio (%)
5	$ 34,845,000	0.06%	$ 6,401,550	0.06%	$ 1,448,470	0.03%
10	$ 99,667,800	0.19%	$ 20,981,000	0.18%	$ 8,769,940	0.16%
20	$ 234,595,000	0.44%	$ 53,876,800	0.47%	$ 30,883,600	0.57%
50	$ 566,421,000	1.06%	$ 137,316,000	1.20%	$ 96,181,900	1.78%
100	$ 955,756,000	1.78%	$ 232,105,000	2.03%	$ 172,555,000	3.19%
200	$ 1,518,830,000	2.83%	$ 359,774,000	3.14%	$ 273,964,000	5.07%
500	$ 2,625,860,000	4.90%	$ 585,844,000	5.12%	$ 444,269,000	8.22%
1,000	$ 3,946,290,000	7.36%	$ 793,029,000	6.93%	$ 571,024,000	10.56%
2,000	$ 5,714,190,000	10.65%	$ 1,054,580,000	9.21%	$ 710,885,000	13.15%

Figure 3.3. Loss exceedance curves by occupancy class for Myanmar

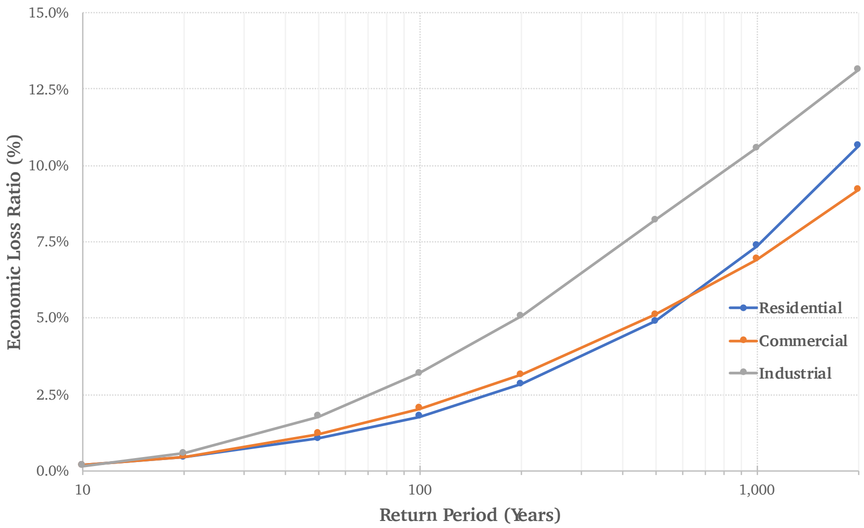


Figure 3.4. Loss exceedance curves by occupancy class for Myanmar, normalized by exposed value

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APPENDIX A A brief report on Myanmar fault sources

Two fault models are found within the Southeast Asia (SEA) hazard model. The first is prepared by the Earth Observatory of Singapore (EOS) and the second by Mahidol University, Thailand (MU). Both models share the same fault traces. However, it is worth noting that the MU model has four faults for each trace (i.e. a fault with any given trace is present four times in the source model .xml file.). It is not clear whether this is intentional or not. The MFDs are generally different for each of the four different versions of each fault.

A.1 Fault Models

A.1.1 Slip rates

One of the most fundamental checks of the fault sources in a hazard model are the slip rates. The fundamental theory is that accumulated elastic strain on a fault will be released, at least partially, during earthquakes. The relation is

$$\dot{M} = \mu A \dot{D}$$

where $\dot{M}$ is the moment release or accumulation rate, μ is the rigidity of the host rock, A is the fault area, and $\dot{D}$ is the displacement rate of the fault. As some of the accumulated seismic moment will may be released aseismically, then we expect that the moment release from seismicity will be less than that calculated through the relation above (the exact fraction is not known; it is reasonable to expect that 10-20% of the moment will be released aseismically).

Although fault magnitude-frequency distributions (MFDs) may be calculated directly from fault slip rates, this is not commonly done. Instead, MFDs are calculated through other methods (such as spatial binning of observed seismicity around a fault). Nonetheless, the 'seismic slip rate' or the fraction of the total slip rate that is released during seismicity, may be back-calculated from the MFD and area of a fault. This number can be compared to observed or estimated slip rates, or larger-scale regional strain rates (such as from geodesy).

Below, we show the seismic slip rates calculated from both the EOS and the MU fault source models.

MU seismic slip rates

The MU faults with estimated seismic slip rates are shown in Figure 1. In general the pattern of these slip rates is consistent with expectations from regional geodesy, fault slip rate studies and instrumental seismicity. However, the rates are too low.

For example, the Sagaing Fault, which runs N-S through the center of Myanmar, has a measured slip rate of ~20 mm/yr. However the four different versions of it in the MU fault model have slip rates from 1 to 8 mm/yr. This is likely due to a collapsed logic tree.

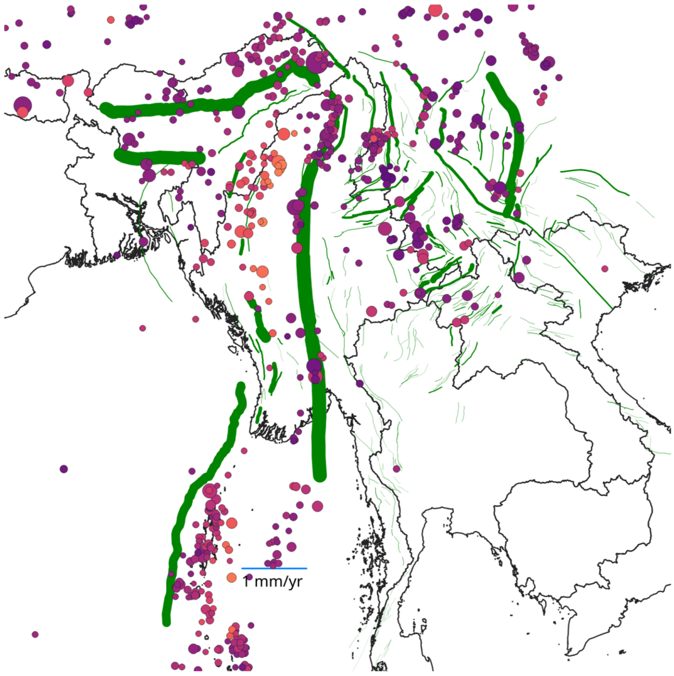

Figure A.1. Faults from the MU model shown in green. Line width is scaled to slip rate; see the blue line in the Andaman sea as a scale. Seismicity from the ISC-GEM catalog is also shown; purple is shallow, orange is deep.

EOS seismic slip rates

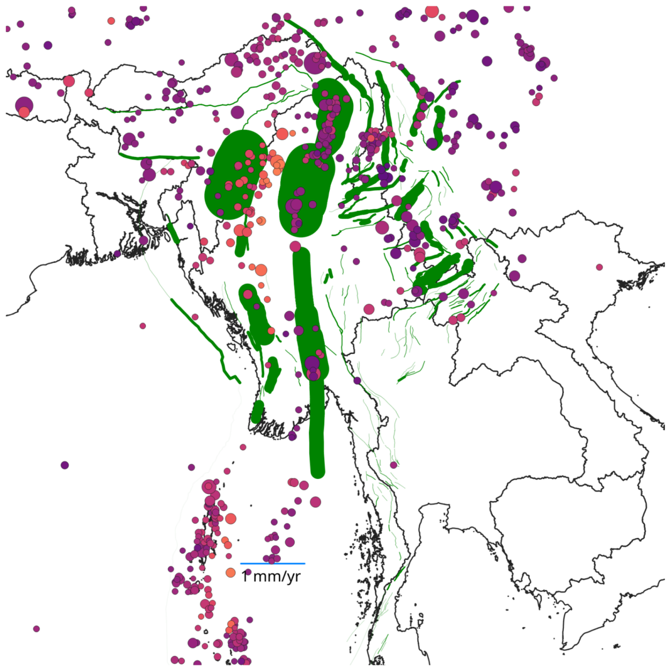

Figure A.2. Faults from the EOS model shown in green. Line width is scaled to slip rate; see the blue line in the Andaman sea as a scale. Seismicity from the ISC-GEM catalogue is also shown; purple is shallow, orange is deep.

The EOS fault model has slip rates that are not easily comparable to expectations based on geodesy or other slip rate observations. However the slip rates appear to correlate well to instrumental seismicity in the region. For example the northern Sagaing Fault has very high slip rates (up to 30 mm/yr) where instrumental seismicity is abundant. Farther south, the slip rates die out as the observed seismicity does as well, despite geologic and geodetic evidence that the slip rate is essentially constant along strike.

Similarly, the modelled seismic slip rate on the Churachandpur-Mao Fault (CMF), to the west of the northern Sagaing Fault, is 31.6 mm/yr, about three times higher than modern geodetic estimates, though it seems that the regional seismicity that the estimate is based on is in the upper mantle (about 60 km depth). Another troubling estimation is of the eastern Main Himalaya Thrust beneath Bhutan and Arunachal Pradesh, India; the shortening rate here is about 15 mm/yr from geologic and geodetic estimates though it is about 1 mm/yr in this model.

A.1.2 MFDs

The total MFDs for the Myanmar crustal component of both branches of the SEA hazard model look similar, and both fit the data fairly well. This isn't a surprise as this was probably a major objective of the modelling process.

MU MFDs

The MU MFDs greatly over-predict seismicity around M6.0, and somewhat over- predict seismicity from M6.5-7.5, though due to the infrequency of events it is difficult to tell whether higher-magnitude seismicity is over-predicted.

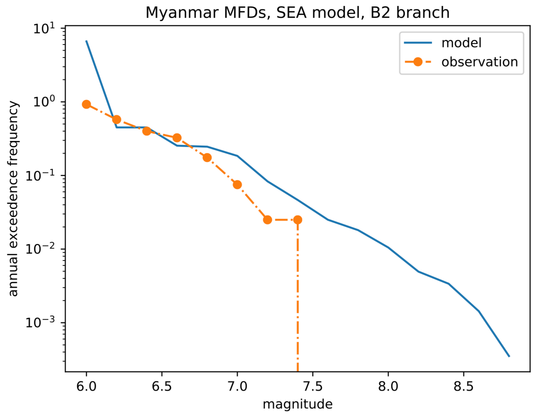

Figure A.3. Observed and modelled MDFs for the B2 (MU) branch of the SEA model, for the Myanmar region.

EOS MFDs

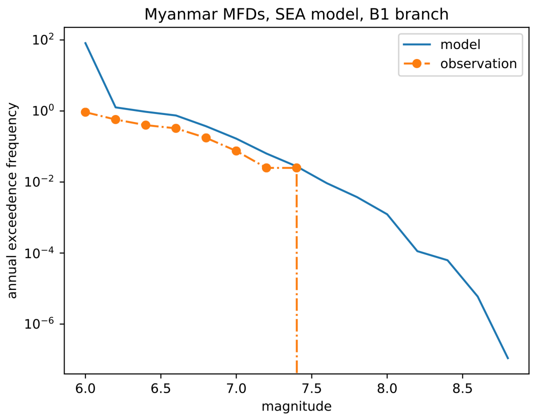

Figure A.4. Observed and modelled MDFs for the B1 (EOS) branch of the SEA model, for the Myanmar region.

The total MFDs produced by the EOS model for the crust (containing both inter- and intraplate sources) generally match shallow seismicity (above 40 km). Seismicity around M6.0 is also over-predicted (or undersampled in the ISC-GEM catalogue from 1976-2013, possibly due to early completeness issues). The match at higher magnitudes is better than in the MU model.