



# METEOR

Modelling Exposure Through Earth Observation Routines

# Heuristic Evaluations of Construction Patterns for Generating a Level 1 Exposure Database

This section will introduce key concepts to the audience relating to building vulnerability and development of country-specific mapping schemes.

# Identify Typical Construction Materials/Systems

- Scholarly/Online Reports
  - Earthquake Engineering Research Institute (EERI)
  - World Housing Encyclopedia (WHE)
- Country Specific
  - Census, Hazard/Post-Disaster Reports, IPUMS, etc.
- Building Codes
- User submitted / online imagery
  - Geotagged photos, videos, street-view, etc.

# Scholarly/Online Reports

Pro: In-depth descriptions of structural materials, lateral force resisting systems, construction methodologies, regionality and known structural deficiencies.

Con: Limited structural systems typically available. Limited number of countries available.

## World Housing Encyclopedia

*A Resource on Construction in Earthquake Regions*





an initiative of  
Earthquake Engineering Research  
International Association for Earthquake Engineering

**HOUSING REPORT**  
Pillar walaghar (URM infilled RC frame)

Report#	145
Last Updated	
Country	Nepal
Author(s)	Yukta Bilas Marhat Magar, Gopal Chandra Singh, A
Reviewers	Yogendra Singh, A

**General Information**

<b>Building Type:</b>	Pillar walaghar (URM infilled RC frame buildings)
<b>Country:</b>	Nepal
<b>Author(s):</b>	Yukta Bilas Marhatta Jitendra K Bothara Meen Bahadur Magar Gopal Chapagain
<b>Last Updated:</b>	Buildings of this construction type are commonly found in both urban and rural areas of Nepal. This type of building is perceived as a traditional building type in every respect compared to modern buildings in Nepal. It has all the characteristics of a traditional building type only with the exception that it is not local. It is one of the most common typologies in Nepal. This building typology, however, is sometimes considered as a traditional building type. However, sometimes competent structural engineers are involved in the design. It is its relatively better performance in past earthquakes which record severely hit eastern Nepal. Reinforced concrete frame is constructed later between columns and beams. These buildings are constructed for various purposes such as residential, religious, educational, etc. They are vulnerable to earthquake due to inferior construction materials and technology employed. Due to the lack of construction there is a property due to potentiality of this type. If designed and constructed in accordance with the code, low-rise buildings up to 3 stories can be constructed. Disseminate simple technical measures for these buildings.
<b>Regions Where Found:</b>	

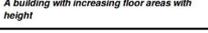
**Typical elevations of a RC frame residential house**



**A long narrow building**



**A building with increasing floor areas with height**



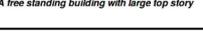
**Typical section of a residential building**



**A stepped building**



**A free standing building with large top story**



<https://meteor-project.org>



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Earthquake Safe Communities in Nepal



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# Country Specific Assessments

Pro: General overview of the built-up environment for a given country is provided. Data is often region specific and will typically provide statistics regarding wall, roof and floor materials.

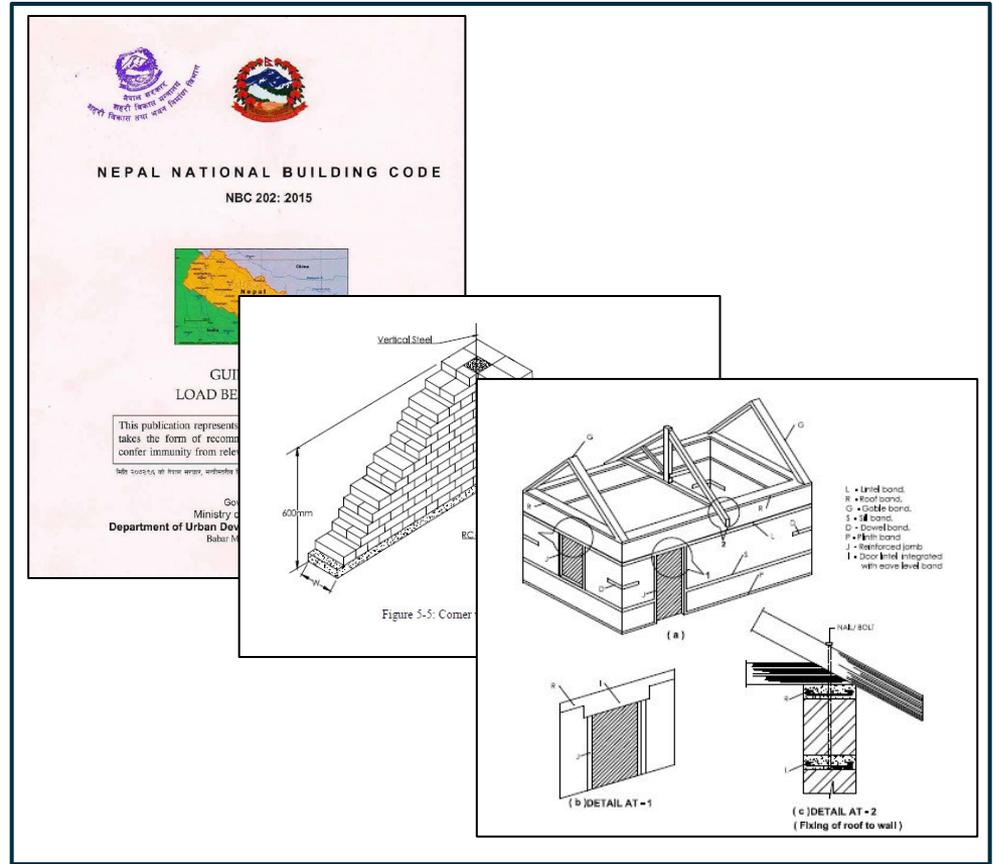
Con: Availability can be limited. Information is typically limited to construction materials (not LFRS).

		Tanzania		Tanzania Mainland		Tanzania Zanzibar	
2012 Population Housing		Number	Percentage	Number	Percentage	Number	Percentage
Volume	<b>Main Materials Used for Flooring</b>						
	Earth/Sand	5,569,460	60.0	5,498,025	60.9	71,436	28.6
	Non Earth	3,650,472	39.3	3,471,757	38.5	178,716	71.4
	Animal Dung	57,064	0.6	57,003	0.6	61	0.0
	<b>Main Materials Used for Walls</b>						
	Stones	96,930	1.0	55,557	0.6	41,373	16.5
	Cement Bricks	1,881,994	20.3	1,743,695	19.3	138,299	55.3
	Sundried Bricks	2,440,081	26.3	2,434,368	27.0	5,713	2.3
	Baked Bricks	2,442,815	26.3	2,441,336	27.0	1,479	0.6
	Timber	54,650	0.6	54,604	0.6	46	0.0
	Timber and Iron Sheets	24,158	0.3	23,955	0.3	203	0.1
	Poles and Mud	2,178,977	23.5	2,117,593	23.5	61,384	24.5
	Grass	148,910	1.6	147,227	1.6	1,683	0.7
	Tent	8,483	0.1	8,451	0.1	32	0.0

# Building Codes

Pro: Country (or region) specific guidelines using applicable materials and construction techniques.

Con: Enforcement can often be limited, therefore specifications (per code) may not be reflected in the field. Access to the code may be limited. Engineering background required to interpret code.



# User submitted / online imagery

Pro: Widely available via online photos, street-view, online photos, etc. Post-event (damage) videos/photos often available. Identify correlation between roof type (shape, covering, etc.) and wall materials/structural system

Con: May be limited (rural regions are often not covered, ground photos only).



Country Name	V	V1	V2	V3	V4	V5	S3	C	C3L	C3N	C3H	RM	M	M1	M2	A	RE	RS	RS1	RS2	RS3	DS	UFE	UCE	MS	TU	INF	UNK
Afghanistan						0.25			0.016							0.707		0.234					0.043					0.25
Angola						0.083				0.159			0.154					0.005					0.07					0.483
Bangladesh			0.04			0.037							0.249										0.047					
Benin																0.667							0.034					
Bhutan	0.1059	0.02	0.15							0.15						0.0235	0.0556		0.36		0.0666		0.0317	0.0317			0.0027	
Burkina Faso						0.0471						0.7232											0.1269				0.1028	
Burundi	0.002					0.02										0.506							0.41	0.062				
Cambodia		0.007		0.563		0.114																	0.126	0.19				
Central African Republic	0.01					0.05			0.05				0.05			0.75							0.04				0.05	
Chad						0.037							0.249			0.667							0.047					
Comoros	0.45																		0.15					0.15			0.25	
the Democratic Republic of the Congo	0.051					0.22							0.065			0.173		0.004					0.273	0.089			0.124	
Djibouti	0.2419					0.1398							0.0022		0.2914		0.0344						0.1355	0.1355			0.1548	
Eritrea	0.069					0.132			0.007							0.416				0.089			0.014	0.117			0.155	
Ethiopia	0.18					0.5							0.05			0.05							0.01	0.01			0.12	
Gambia													0.7			0.125								0.125			0.05	
Guinea								0.02					0.32			0.44											0.22	
Guinea-Bissau								0.02				0.32				0.44											0.22	
Haiti			0.01						0.12									0.02						0.75			0.1	
Kiribati	0.7								0.05															0.25				
the Lao People's Democratic Republic	0.8164																	0.0892					0.0944					
Lesotho						0.0452										0.0327		0.0061		0.328	0.1141		0.0461	0.4278				
Liberia	0.0034					0.7874												0.0079					0.1408	0.0489			0.0117	
Madagascar	0.1					0.15										0.1							0.55				0.1	
Malawi	0.01												0.36			0.47		0.03					0.13					
Mali									0.02		0.04	0.18				0.58								0.18				
Mauritania						0.25			0.35							0.25								0.15				
Mozambique	0.07												0.37			0.4							0.13	0.03				
Myanmar	0.0011					0.5502							0.2575										0.0025				0.1888	
Nepal	0.05					0.171										0.012		0.493					0.204				0.07	
Niger						0.27										0.3							0.05				0.38	
Rwanda	0.0086					0.4388										0.5345		0.0024					0.0125	0.0023			0.001	
Sao Tome and Principe	0.6																						0.15				0.25	
Senegal						0.25			0.35							0.25								0.15				
Sierra Leone	0.0052					0.2581										0.6183		0.0022					0.0054	0.0713			0.0395	
the Solomon Islands	0.9645																							0.0151			0.0205	
Somalia	0.05					0.5							0.15			0.05				0.08			0.02				0.15	
South Sudan	0.07					0.86							0.06										0.01					
Sudan	0.0763					0.4703							0.2746			0.0763							0.0856	0.0169				
the United Republic of Tanzania	0.0219					0.2349										0.263		0.0104					0.2633	0.2029			0.0035	
Timor-Leste	0.3301					0.3084										0.0152		0.0064					0.2862				0.0537	
Togo						0.183										0.3482		0.0374					0.05	0.3			0.08	
Tuvalu	0.2273					0.183		0.559																			0.0307	
Uganda						0.25										0.1		0.05					0.5	0.05			0.05	
Vanuatu	0.0833					0.5641		0.1783																0.1513			0.023	
Yemen						0.0275							0.1343			0.0183		0.4517				0.117		0.2482			0.2482	
Zambia						0.0775							0.0957			0.3088		0.0543					0.2508	0.2128				

# Bangladesh Example

American Journal of Civil Engineering

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 doi: 10.11648/j.ajce.20150901.11  
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## Seismic Vulnerability Assessment of Existing Building Stocks at Chandgaon in Chittagong city, Bangladesh

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**Abstract:** The draft of Bangladesh National Building Code (BNBC)-2012 has been updated the seismic coefficient of 0.25g (with Zone III) for Chittagong region, which is larger than the previous of 0.15g (with Zone II). Chittagong is the largest port city and commercial capital of Bangladesh, which has many development activities as like of planned residential areas. Although BNBC code is up-to-date with earthquake provisions since 1993 with interpreting several new clauses and provisions, but in case of pre-code revision structures it is quite unsafe. Thus it is quite impossible to reduce earthquake damage without considering the safety of pre-code revision structures. In this regards earthquake vulnerability of Chandgaon Residential Area(R/A) has been assessed on the basis of potential structural vulnerability of more than 300 buildings. Initial results reveal that there have large

## EARTHQUAKE RESISTANT NON-ENGINEERED BUILDING CONSTRUCTION FOR RURAL AREA IN BANGLADESH

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### ABSTRACT:

Bangladesh is extremely vulnerable to seismic activity. While the earthquake resistant building design and construction code has been developed in sophisticated national city level, the implementation at the local level has been more of an exception than the rule. People used to make their houses by local materials and local construction technique without any engineering philosophy especially in rural areas. Therefore, there is an imminent need to know the actual physical condition of the rural houses and to estimate the risk associated with them, to bring into force simple, user friendly, non-engineered construction practices for use by the community and the construction artisans. A physical survey has been done on the existing condition of the rural housing. From this information the problems are identified with respect to earthquake resistant non-engineered housing techniques. Techniques of strengthening of existing rural houses to make them earthquake resistant are elaborated and earthquake resistant building technology for new houses are formulated. These techniques may be the guidelines to the rural people for making low cost earthquake resistant house and also will make a pointer towards engineered building from non-engineered construction.

### KEYWORDS:

Non-engineered construction, Earthquake risk assessment, Strengthening techniques

## World Housing Encyclopedia

A Resource on Construction in Earthquake Regions

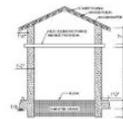


an initiative of  
 Earthquake Engineering Research Institute (EERI) and  
 International Association for Earthquake Engineering (IAEE)

### HOUSING REPORT

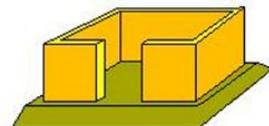
Mud House of Bangladesh

Report#	143
Last Updated	
Country	BANGLADESH
Author(s)	Amrita Das, Mohammad Sharif Islam, Dr. Md. Jahangir Alam, Nusrat Hoque,
Reviewers	Dominik Lang,

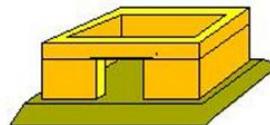


SECTION A-A

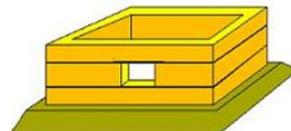
Elevation of the mud house shown in Fig. 5



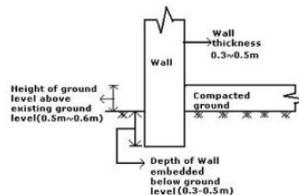
Construction of door with height equal to the wall height



Construction of door with height less than the wall height



Construction of window



Cross-section of wall and floorconnection

# Bangladesh Example (cont.)

Occupancy	Rural Nonres
Sr. No.	19
ISO-twodigit	BD
ISO-3digit	BGD
ISO-numeric	50
Country Name	Bangladesh
ISO_Country_Name	Bangladesh
PAGER Vuln. Code	5
PAGER Rating	Low
Data Source	UN-HABITAT(2007)
Source	Original
WHE_Column_Identifier	0
Neighbor	0
Assignment by WHE-Country	0
PAGER Identifier (Vulnerability)	2
YEAR	2004
W	1.2%
W2	30.1%
UFB3	44.4%
INF	24.3%

Table 2.5 Housing characteristics

Percent distribution of households by housing characteristics, according to residence, Bangladesh 2014

Housing characteristics	Residence		Total
	Urban	Rural	
<b>Flooring material<sup>1</sup></b>			
Earth, sand	32.5	81.5	67.8
Wood planks	0.4	0.2	0.2
Ceramic tiles	5.6	0.3	1.8
Cement	61.0	17.7	29.8
<b>Roof materials</b>			
Natural roof	0.2	1.7	1.3
Palm/bamboo	0.1	0.1	0.1
Wood plank/card board	0.1	0.0	0.0
Tin	70.0	90.8	85.0
Wood	0.2	0.2	0.2
Ceramic tiles	0.5	0.1	0.2
Cement	28.4	5.3	11.8
Roofing shingles	0.3	1.5	1.1
Other	0.1	0.0	0.2
<b>Wall materials</b>			
Jute stick/palm trunk	0.8	2.9	2.3
Mud/dirt	4.4	14.5	11.7
Bamboo with mud	4.5	8.9	7.7
Tin	30.2	48.3	43.3
Cement	52.6	15.9	26.2
Stone with lime/cement	1.6	0.5	0.8
Bricks	4.9	7.0	6.4
Wood planks	0.6	1.1	1.0
Other	0.3	0.9	0.7
<b>Rooms used for sleeping</b>			
One	37.2	31.7	35.2
Two	36.2	37.7	37.3
Three or more	26.7	30.6	29.5
Total	100.0	100.0	100.0
<b>Persons per sleeping room</b>			
1-2	63.2	66.2	65.3
3-4	29.1	26.4	27.2
5-6	6.5	6.5	6.5
7+	1.2	0.8	1.0
Total	100.0	100.0	100.0
Number	4,844	12,456	17,300

<sup>1</sup>Other<sup>1</sup> flooring material is a combination of palm, bamboo, parquet, polished wood, and carpet

Wall Type	PAGER
Jute stick/palm trunk	W3 (Wood)
Mud/dirt	M (Mud Walls)
Bamboo with mud	W5 (Wattle and Daub)
Tin	INF (Informal Construction)
Cement	C3 (Non-ductile RC Frame w/ URM Infill)
Stone with lime/cement	RS (Rubble Stone)
Bricks	UFB (URM Fire Brick)
Wood Planks	W3 (Wood frame unbraced post/beam)
Other	M (Mud Walls)

# Bangladesh Example (cont.)



# Bangladesh Example (cont.)

- Rural
- Single-Family Residential
- High Density Residential
- Urban
- High Urban
- Industrial



# Bangladesh Example (cont.)

Rural: Housing census data for “rural” regions

Single-family residential: Redistribute “rural” mapping

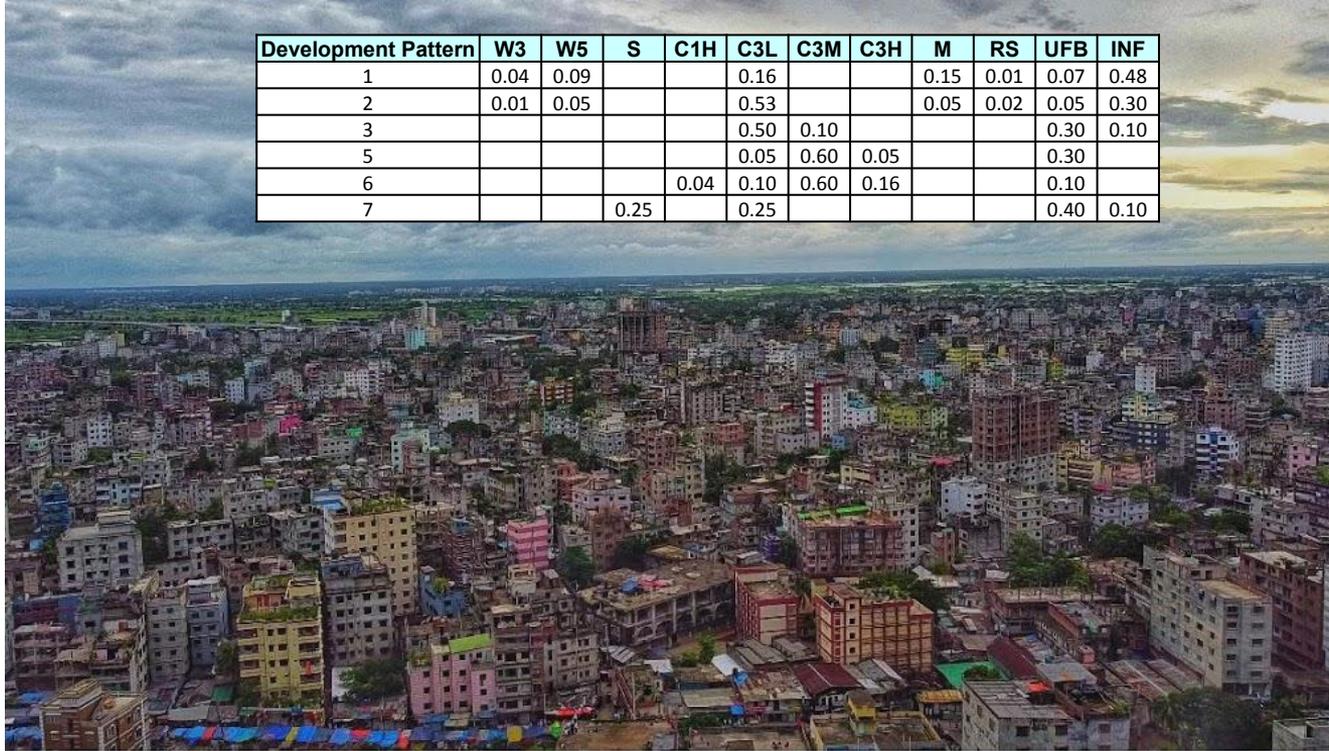
High Density Residential: Redistribute “urban” mapping

Urban: Housing census data for “urban” regions

High Urban: Redistribute “urban” mapping

Industrial: Visual analysis

# Bangladesh Example (cont.)



# Thank you!

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