

EVALUATION OF VULNERABILITY OF CRITICAL INFRASTRUCTURES DUE TO EARTHQUAKE IN SYLHET CITY

Presented By

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Introduction

Bangladesh National Building Code (1993) has placed Sylhet (Latitude: 24.85°N , Longitude: 91.80°E) in seismic zone 3, the zone of high seismicity. All the major earthquakes having its epicenter inside Bangladesh made the active faults in the region. One of these kinds of active faults is Shazibazar-Lalmai fault from Hobigonj to Comilla. The potential hazardous scenario for Sylhet city has been developed based on the seismic condition and vulnerability of the building stock, especially for the critical infrastructures such as schools, hospitals and fire station.

Rapid Visual Screening (RVS)

- To measure the fact that how prone the buildings are to seismic force, the entire procedure was conducted based on FEMA 154 Report-Rapid Visual Screening (RVS) of Buildings for Potential Seismic Hazards. RVS provides information on the average behavior of different types of structures.

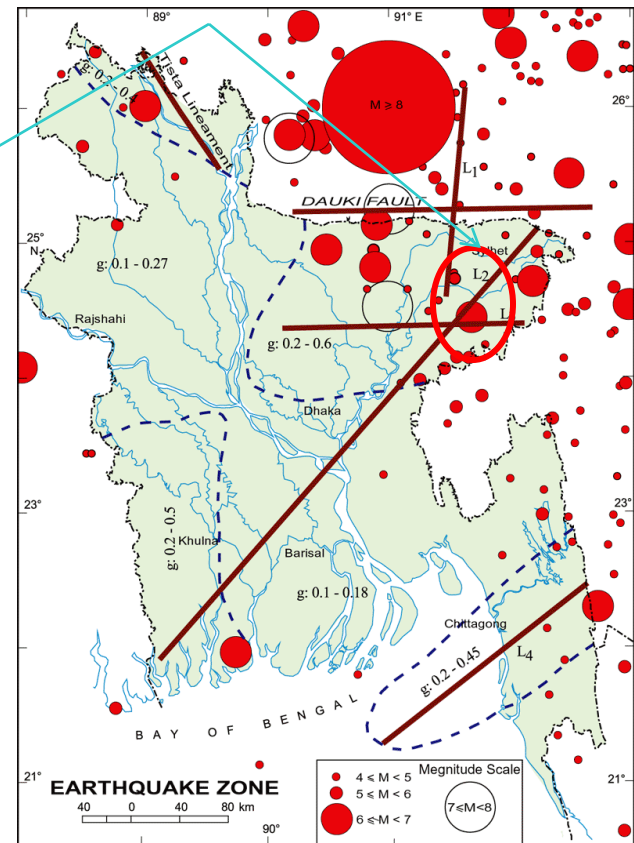
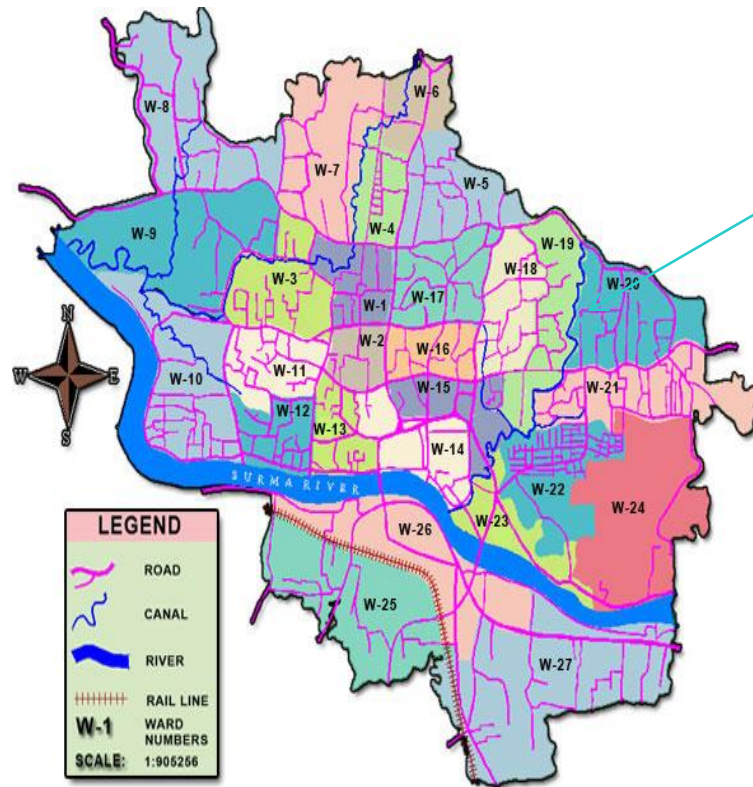
Objectives

- To conduct a data collection and evaluation process to document building location, size, use and vulnerability factors
- Conduction of “sidewalk survey” that enabled users to classify surveyed buildings

Study Area

The buildings of High Schools, Primary Schools, Hospitals and Clinics, and Fire Station under the city of Sylhet are selected. 232 buildings are surveyed in this study.

Sylhet City



Methodology

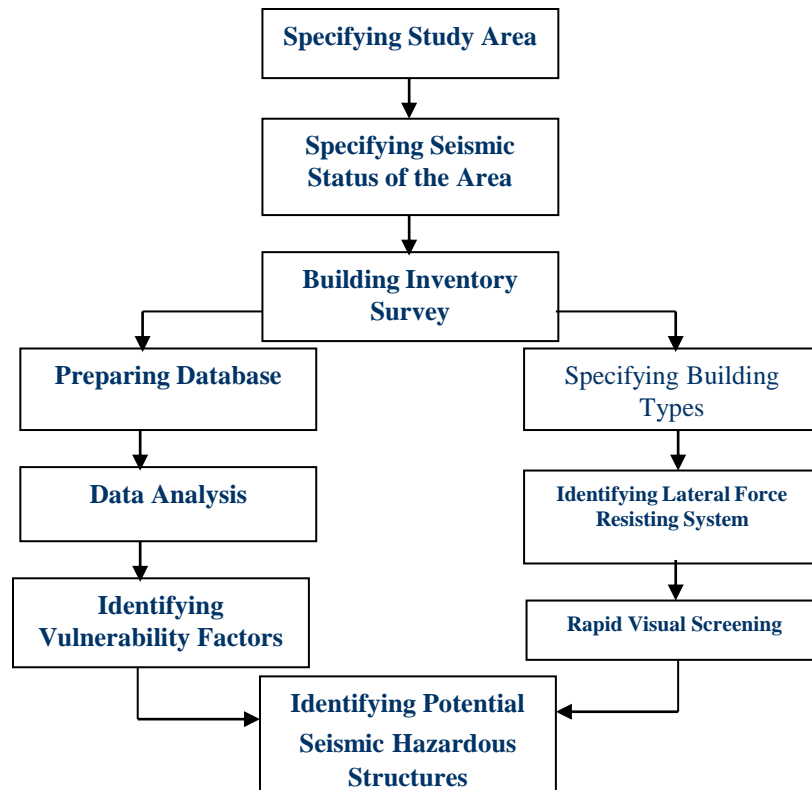
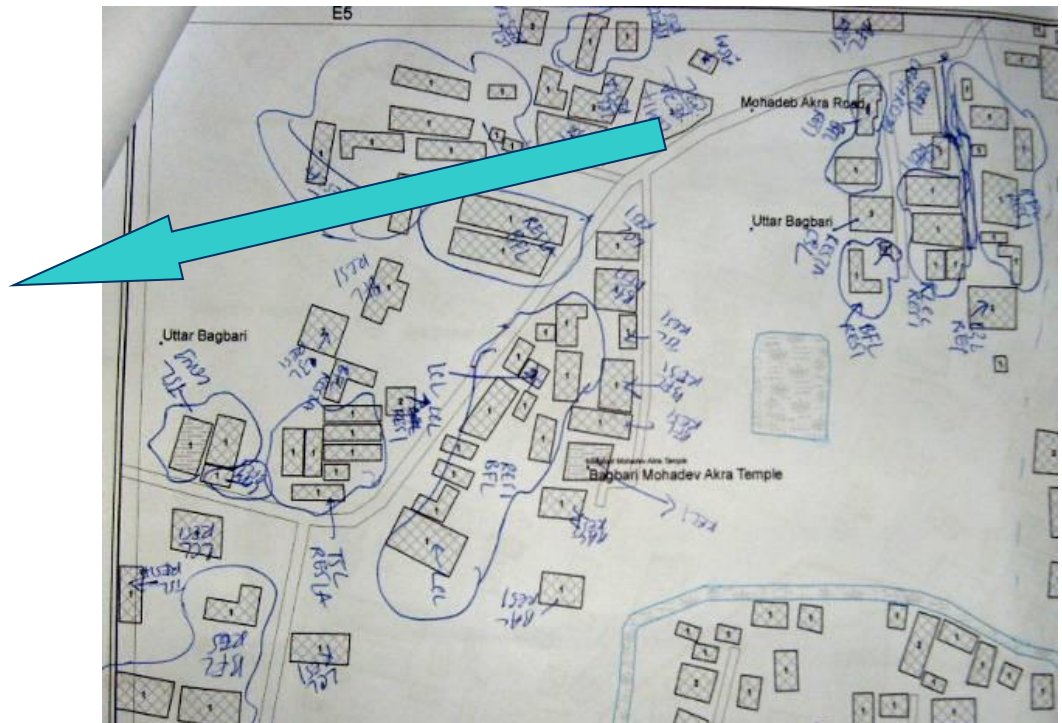


Figure 1: Flowchart for Hazardous Building Identifying Methodology

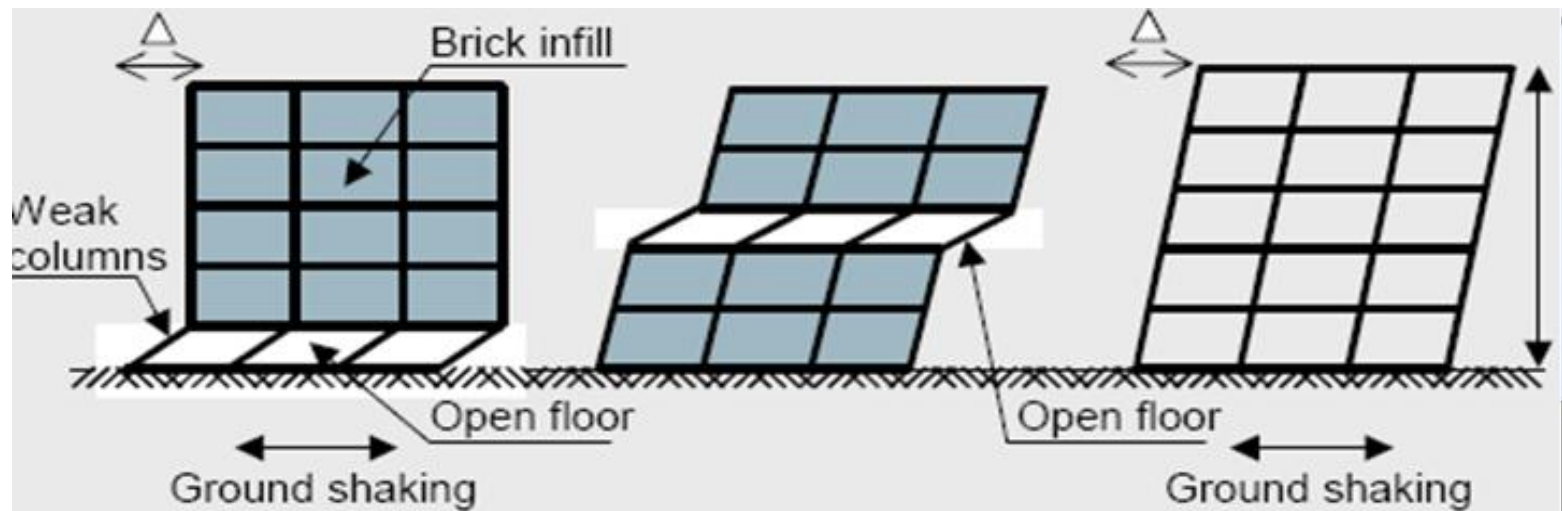
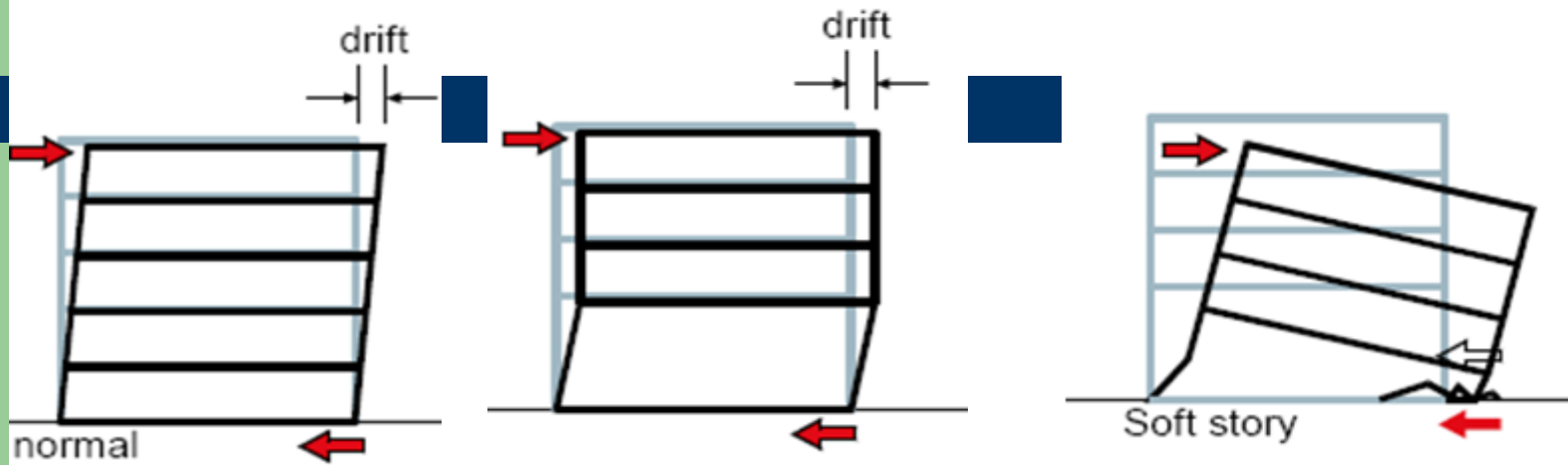
Building Types Considered by the RVS Procedure

- The sample sites survey helped to classify all buildings in Sylhet into six types, EMSA, EMSB1, EMSB2, EMSC, EMSD and EMSF, based on their definition in European Macro-seismic Scale (Grunthal, 1998).
- According to description of Macro-seismic Scale and FEMA 154, the similarity of lateral-load-resisting system exists only EMSB2, EMSC, and EMSD similar to URM, C2 and C3. In Sylhet there are a number of old buildings, which are of unique and completely different types of force resisting system & in structural pattern.

Identification of Building



Soft/Weak Storey

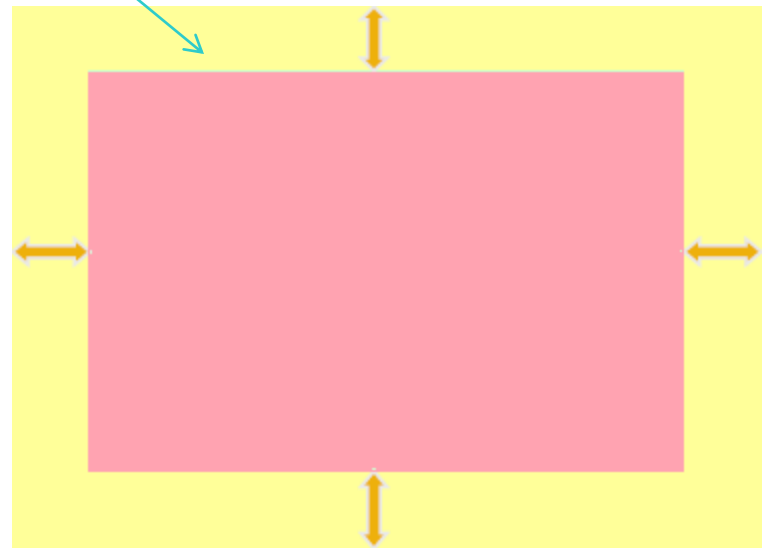


Soft/Weak First Storey



Heavy overhang

Heavy Overhang or cantilever



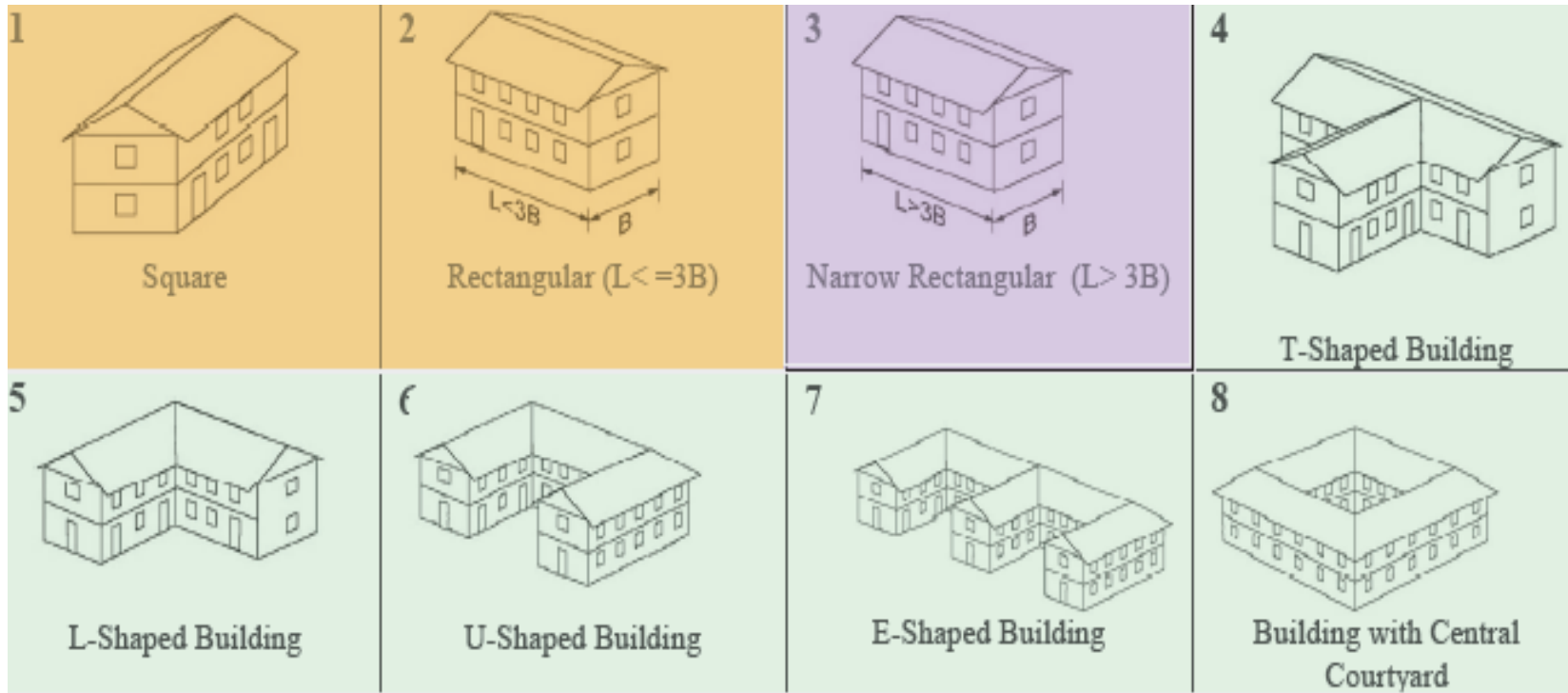
Pounding



Short Column Effect

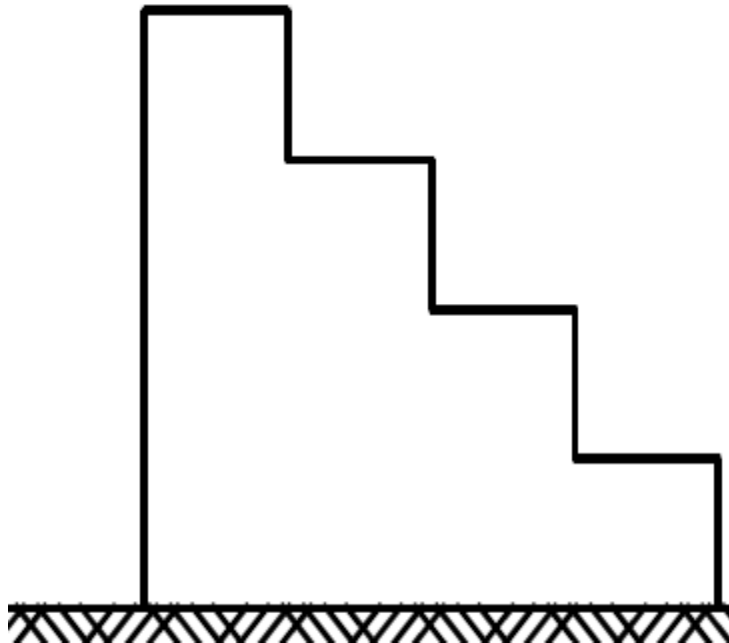


Shape in Building Plan

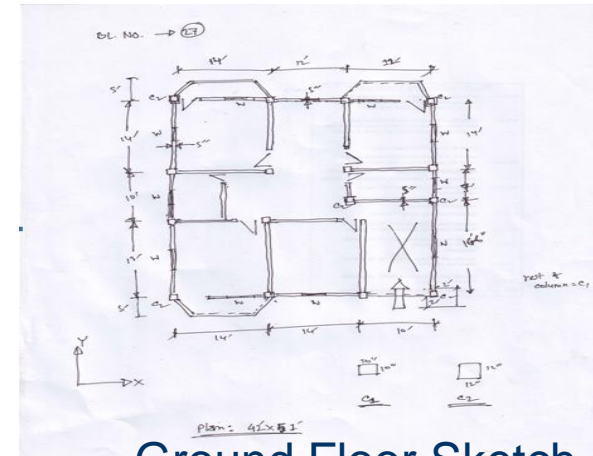


Shape in Building Plan

Setback



Vulnerability Assessment of Different Types of Buildings



Ground Floor Sketch

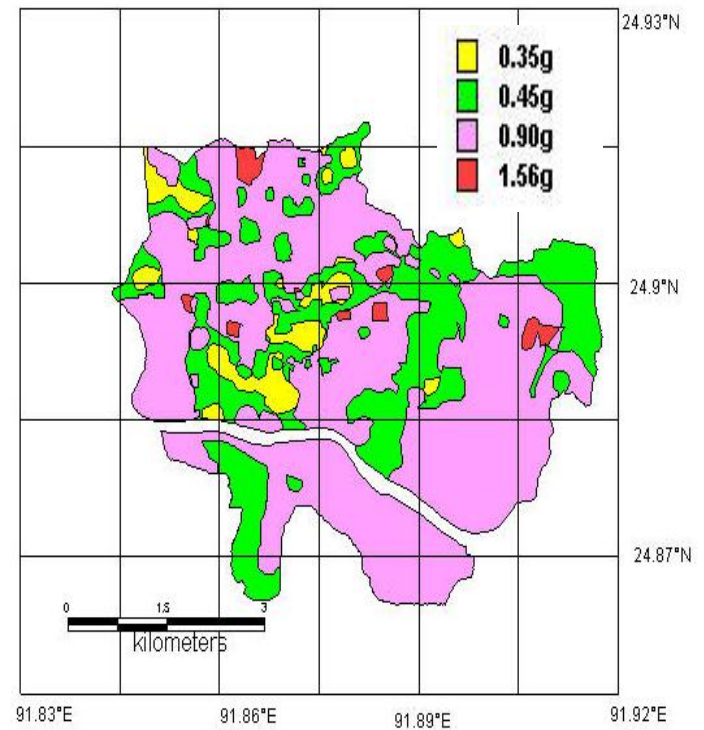
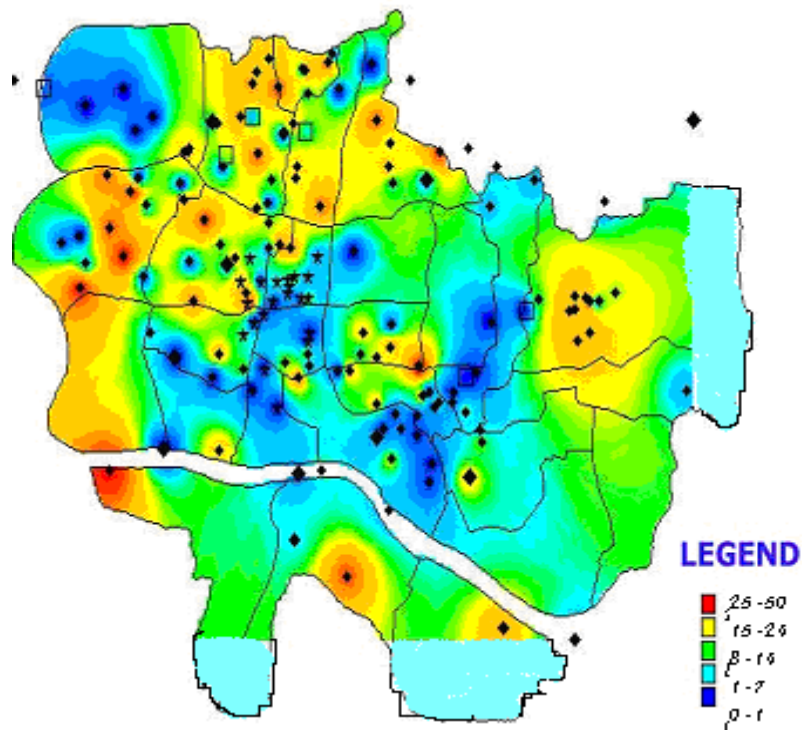
Different Types of Buildings



Soil type

- Soil type were identified and documented on the data collection form. For Sylhet, we have selected the soil types C, D, and E for different geographical locations based on soil intensity.

Liquefaction potential map and soil hazards map for Sylhet City



Distribution of Building Scores

Score	Primary School		High School		Hospital		Total	
	Bldg No	%	Bldg No	%	Bldg No	%	Bldg No	%
<0	2	2.86		0	13	23.21	15	6.47
0-1	9	12.86	5	4.72	21	37.50	35	15.09
1-2	42	60.00	57	53.77	6	10.71	105	45.26
>=2					3	5.36	3	1.29
No scoring	17	24.29	44	41.51	13	23.21	74	31.90
Total	70	30.17	106	45.69	56	24.14	232	

Distribution of Lateral Force Resisting System

Type	Primary School		High School		Hospital		Total	
	Bldg No	%	Bldg No	%	Bldg No	%	Bldg No	%
URM	5	7.14	16	15.09	12	21.43	33	14.22
C3	46	68.57	50	47.17	30	53.57	128	55.17
C2					5	8.93	5	2.16
Other	17	24.29	40	37.74	9	16.07	66	28.45
Total	70	30.17	106	45.69%	56	24.14	232	

Distribution of Building types

Type	Primary School		High School		Hospital		Total	
	Bldg No	%	Bldg No	%	Bldg No	%	Bldg No	%
EMSB1	28	40	49	46.23	11	19.64	88	37.93
EMSB2	5	7.14	16	15.09	12	21.43	33	14.22
EMSC	37	52.86	29	27.36	5	8.93	71	30.60
EMSD			12	11.32	26	46.43	38	16.38
EMS F					2	3.57	2	0.86
Total	70	30.17	106	45.69	56	24.14	232	

Distribution of Buildings having Lifelines

Stories	Primary School		High School		Hospital		Total	
	Bldg No	%	Bldg No	%	Bldg No	%	Bldg No	%
Gas	1	2.08	5	23.81	40	90.91	46	40.71
Electricity	48	100	21	100	44	100	113	100
Phone	8	16.67	18	85.71	43	97.7	69	61
Water	46	95.83	21	100	44	100	111	98.23
No water	2	4.17	0	0	0		2	1.77
Total Institution	48		21		44		113	

Distribution of building storey

Score	Primary School		High School		Hospital		Total	
	Bldg No	%	Bldg No	%	Bldg No	%	Bldg No	%
1 Storied	29	41.43	54	50.94	13	23.21	96	41.38
2 Storied	14	20	38	35.85	9	16.07	61	26.29
3 Storied	21	30	7	6.60	10	17.86	38	16.38
4 Storied	4	5.71	7	6.60	16	28.57	27	11.64
5 Storied	2	2.86			4	7.14	6	2.59
6 Storied					4	7.14	6	1.72

Distribution of Foundation types

type	Primary School		High School		Hospital		Total	
	Bldg No	%	Bldg No	%	Bldg No	%	Bldg No	%
Foot	55	78.57	71	66.98	50	89.29	176	75.86
Pilling			1	0.94	5	8.93	6	2.59
None	15	21.43	34	32.08	1	1.79	50	21.55
total	70	30.17	106	45.69	56	24.14	232	

Distribution of building Shape

Shape	Primary School		High School		Hospital		Total	
	Bldg No	%	Bldg No	%	Bldg No	%	Bldg No	%
L	9	12.86	11	10.38	3	5.36	23	9.91
R	57	81.43	91	85.85	25	44.64	173	74.57
Irregular	4	5.71	4	3.77	28	50.0	36	15.52
total	70	30.17	106	45.69	56	24.14	232	

Distribution of buildings having Continuous Lintel

Continu ous Lintel	Primary School		High School		Hospital		Total	
	Bldg No	%	Bldg No	%	Bldg No	%	Bldg No	%
Yes	59	84.29	77	72.64	24	42.86	160	68.97
No	11	15.71	29	27.36	32	57.14	72	31.03
Total	70	30.17	106	45.69	56	24.14	232	

Distribution of buildings` population

Population	Primary School		High School		Hospital		Total	
	Bldg No	%	Bldg No	%	Bldg No	%	Bldg No	%
<100	16	22.86	40	37.74	49	87.50	105	45.26
100-200	8	11.43	17	16.04	2	3.57	27	11.64
200-500	28	40	39	36.79	4	7.14	71	30.60
500-1000	18	25.71	8	7.55	1	1.79	27	11.64
>1000			2				2	0.86
Total	70	30.17	106	45.69	56	24.14	232	

Distribution of Buildings in Age

Age (yrs)	Primary School		High School		Hospital		Total	
	Bldg No	%	Bldg No	%	Bldg No	%	Bldg No	%
<=10	37	52.86	39	36.79	20	35.71	96	41.38
11-25	21	30	23	21.7	20	35.71	64	27.59
26-50	8	11.43	29	27.36	10	17.86	47	20.26
51-100	3	4.29	6	5.66	6	10.71	15	6.47
>100	1	1.43	9				10	4.31
Total	70	30.17	106	45.69	56	24.14	232	

Distribution of Buildings by road width

Width (ft)	Primary School		High School		Hospital		Total	
	Bldg No	%	Bldg No	%	Bldg No	%	Bldg No	%
<=10	13	27.08	5	23.81	4	9.09	22	19.47
11-20	23	47.92	11	52.38	25	56.82	59	52.21
>20	12	25	5	23.81	15	34.09	32	28.32
Total	48	42.48	21	18.58	44	38.94	113	

Distribution of data for the Fire Station

No								
	Use	Age (yrs)	Story	Frame	Wall	Foundation	Column	Shape
1	Garage	40	2	RC	10"	No	Yes	Irregu
2	Barrack	40	1	RC	10"	No	Yes	R
3	Tower	40	70 ft	RC	20"	Foot	No	R

Conclusion

We have identified some factors regarding with vulnerability

- Information of different buildings is recorded on the RVS sheet and final scores are determined. Considering the final score, S (for most of the buildings below 2) of the buildings it can be decided as per FEMA 154 Handbook (2nd edition) that the surveyed buildings are hazardous and require detailed seismic evaluation.

Continue

- The old, weak 1-storied brick masonry & tin shed buildings (EMSB1 type), found in schools mainly, are very much vulnerable, and a moderate earthquake can cause them to collapse. These buildings cannot be evaluated by RVS.

Continue

- It seems that some traditional bamboo or wooden buildings & Assam-type (EMSF type) houses may show poor response due to being old & aged; but in reality they are proven to have good seismic performance against earthquake because their box type pattern.

Suggestions

- Improved Design techniques such as Base Isolation system and Seismic Dampers should be introduced.
- Quality of materials should be maintained
- Building code should be followed.



Thank you all



Rapid Visual Survey



Assessment of Building construction and construction material