Date:	11/12/2018
Building Type:	**UCM-URM4/MR/LD**
Authors:	UCL
Sheet:	1 of 4

FRAGILITY/VULNERABILITY ASSESSMENT

RECTANGULAR BLOCK IN MUD MORTAR MASONRY INDEX BUILDING

GENERAL INFORMATION

Index Building Taxonomy String: **UCM-URM4/MR(2)/LD**/RD/NI/SP/SO/RF/NP/OS/GC/NN

1. Main structural system:…………………………………..   Rectangular Block in Mud Mortar Masonry (UCM-URM4)
2. Height range:……………………………………………..   Low (LR) ☐   Medium (MR) ☒   High (HR) ☐
3. Seismic design level:……………………………………   Poor (PD) ☐   Low (LD) ☒   Medium (MD) ☐   High (HD) ☐
4. Diaphragm Type:………………….…………………….   Flexible (FD) ☐   Rigid (RD) ☒
5. Structural Irregularity:……………..….……………….   No (NI) ☒   Horizontal (HI) ☐   Vertical (VI) ☐   Both (HV) ☐
6. Wall Panel Length:……………………......…………….   Short (SP) ☒   Long (LP) ☐
7. Wall Openings:………………….…..………………….   Small (SO) ☒   Large (LO) ☐
8. Foundation Type and Flexibility:…………….…………   Flexible (FF) ☐   Rigid (RF) ☒
9. Seismic Pounding Risk:…………….…..……………….   No (NP) ☒   Yes (PR) ☐
10. Seismic Retrofitting:……………......………………….   Original (OS) ☒   Retrofitted (RS) ☐
11. Structural Health Condition:………….……………….   Poor (PC) ☐   Good (GC) ☒
12. Non-Structural Components:……..………………….   Vulnerable (VN) ☐   Non Vulnerable (NN) ☒

INTRINSIC CHARACTERISTICS

General Geometry:

Building Plan Area (m²):…………………...………………	143
Building Total Floor Area (m²):…………………….....……	285
Number of Stories:……………………………..…………	2
Story Height (m):…………………..………………………	2.4
Number of Spans in X Direction:……………....…………	3
Typical Span Length in X Direction (m):……….....…………	4.6
Number of Spans in Y Direction (m):	2
Typical Span Length in Y Direction (m):……...……………	5
Wall Thickness (mm):……………...……………………	375
Wall Construction:………………...……………………	English Bond
Thickness………………………………………………	One and a Half

Material Properties of Masonry:

Unit Weight, γ (kg/m²):……………	1768
Modulus of Elasticity, E (MPa):……	274
Shear Modulus, G (MPa):…………	111
Compressive Strength, f'm (MPa):…	1.82
Cohesion, c (MPa):………………..	0.086
Tensile Strength, f_t (MPa):…………	0.086
Friction Coefficient, μ:……………	0.4

MODELLING PARAMETERS

3D Model

Longitudinal (Y)   Transverse (X)
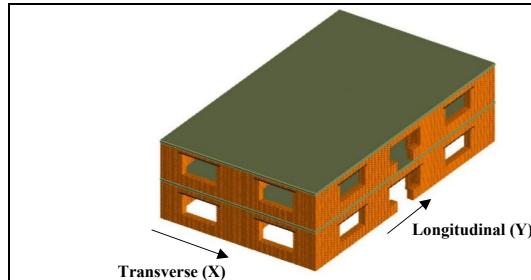
Modelling Consideration

Numerical Model Type:………………………	3-D Element-by-Element
Masonry Modelling Approach:……………..	Simplified Micro-Modelling

Loads:

Roof Dead Load (D) (kN/m2):………….............................	0.9
Design Live Load (L) (kN/m²):…………………..…………….	3.0
Load Combination for Seismic Analysis:………….…..…........	D+0.25L
Average Load per Square Meter (kN/m²):…………....……….	1.7

Analysis Considerations:

Global P-Delta Effects:…………………	Yes ☒ No ☐
Analysis Direction:……………….…...	X ☒ Y ☐
Analysis Orientation:……………………	(+) ☒ (-) ☐

SEISMIC BEHAVIOR

Seismic Weight of IP Walls (kN):…............................	2870
Fundamental Time Period of IP Walls (sec):………….…	0.31

Pushover Curve with Damage State Thresholds:

Global Building Pushover Curve

FRAGILITY/VULNERABILITY ASSESSMENT

### RECTANGULAR BLOCK IN MUD MORTAR MASONRY INDEX BUILDING
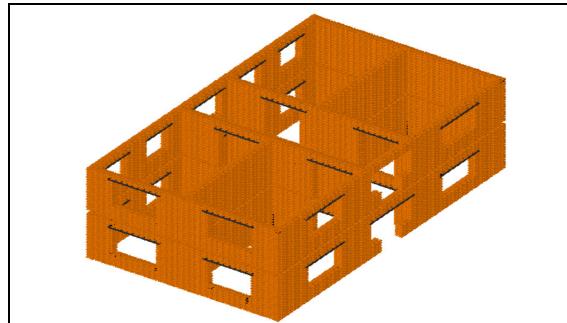
OP Threshold: Hairline cracks of maximum width 0.5 mm appeared at few corners of doors and windows in the first story walls.
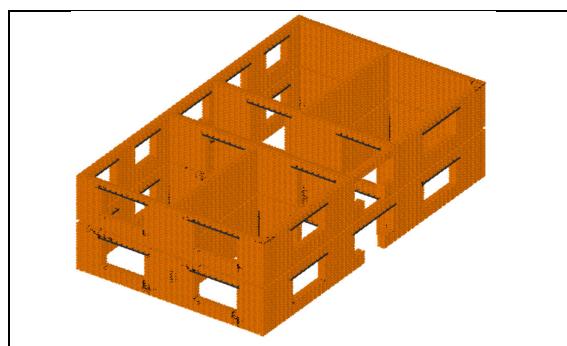
IO Threshold: Hairline to minor shear cracks (black) appeared in most of the corners of the openings in the first story walls, some minor cracks appeared at the wall slab connection. Maximum crack width in most of the crack surface is about 1.5 mm.
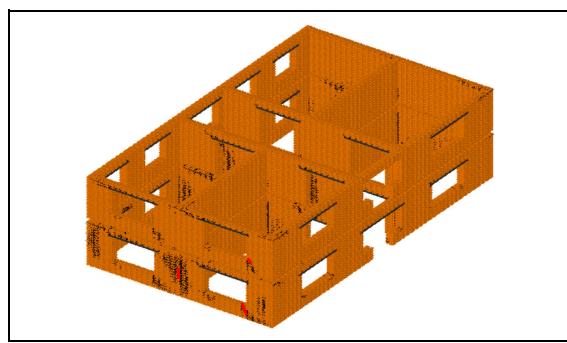
LS Threshold: Major shear cracks of max width 5 to 7.5 mm developed in most of the piers on the left two side walls in all stories. In the first story, flexural as well as shear sliding cracks of max width 3 mm appeared in the right side wall. Slabs start to dethatch from the masonry on roof and first floor. A minor horizontal crack at the base of the OOP wall on back side developed throughout the length with a max opening of 1 mm.
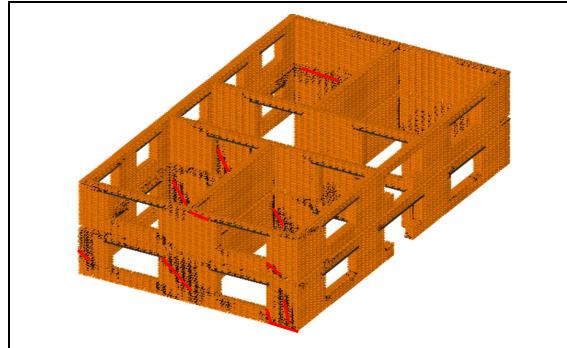
CP Threshold: Left side wall in the first story has developed extensive diagonal shear cracks (red) of more than 7.5 mm width and hence looses strength. Similarly the second side wall from left also starts to develop extensive shear cracks of similar width.

FRAGILITY/VULNERABILITY ASSESSMENT

## RECTANGULAR BLOCK IN MUD MORTAR MASONRY INDEX BUILDING

SEISMIC PERFORMANCE ASSESSMENT

**Analysis Considerations:**

Analysis Methodology:………………….…..…….   Static Analysis (N2 Method)

Engineering Demand Parameter (EDP):……………   Roof Drift

Seismic Ground Motions:

Ground Motion Suite:………FEMA P695 - 22 Far Field Ground Motions

Intensity Measure (IM):…….PGA (g)

Scaling Factor:………………   0.1

Minimum IM:………………   0

Maximum IM:………………   2g

Spectra of 22 Far Field Ground Motions

Bilinear Idealization:

ADRS Capacity Curve
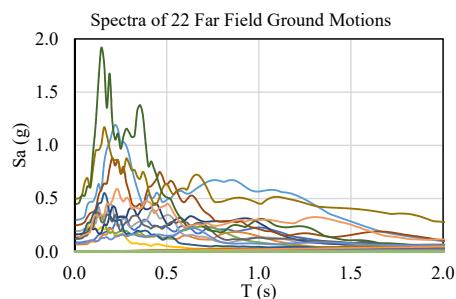
— Capacity Curve
— Idealization

EDP Calculation:

N2 Performance Points

· Performance points
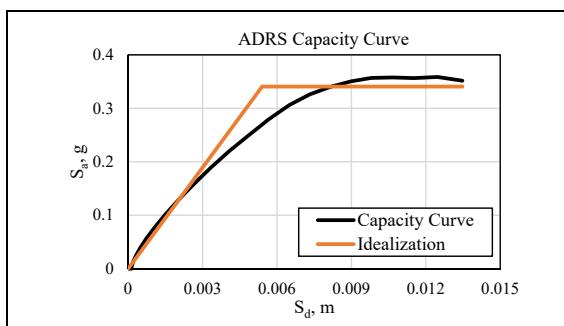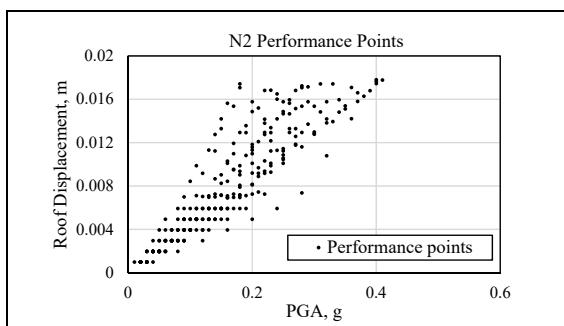
FRAGILITY ASSESSMENT

Integration Methodology:…………………..……..   Least Square Method

Fragility Functions:
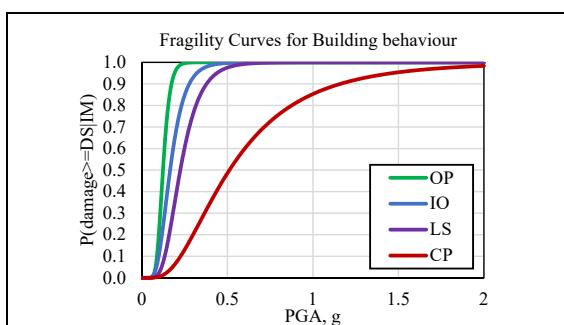
Fragility Curves for Building behaviour

— OP
— IO
— LS
— CP

	OP	IO	LS	CP
Mean:…………………….	0.12	0.16	0.22	0.51
Standard Deviation:……..	0.27	0.41	0.41	0.64

IB6_LBM_UCM-URM4_MR_LD

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**RECTANGULAR BLOCK IN MUD MORTAR MASONRY INDEX BUILDING**

VULNERABILITY ASSESSMENT

Damage to Loss Function:

OP (%): 2   IO (%): 10   LS (%): 43.5   CP (%): 100

Vulnerability Function:

Building Vulnerability Curve
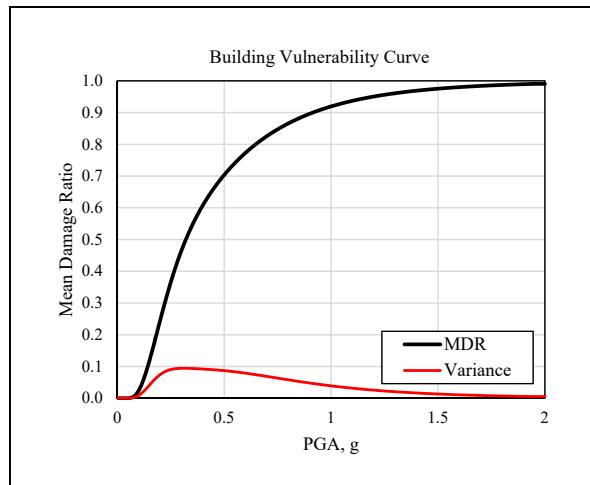
GLOSARY

IP = In Plane   OOP = Out of Plane
OP = Operational   IO = Immediate Occupancy   LS = Life Safety   CP = Collapse Prevention
IM = Intensity Measure   EDP = Engineering Demand Parameter
ADRS = Acceleration Displacement Response Spectra
Sa = Spectral Acceleration   Sd = Spectral Displacement
PGA = Peak Ground Acceleration
T (s) = Time (second)

PRINCIPAL REFERENCES

Reference Project:………………………   Global Library of School Infrastructure - GLoSI

Main Bibliographical References:………   GLoSI Technical Report
FEMA P-695
ASCE 41-17
N2 Method (Fajfar, 2000)
GEM Analytical Vulnerability Assessment Guideline (D'Ayala et al., 2015)
FUNVUL (www.ecapra.org)

IB6_LBM_UCM-URM4_MR_LD