FRAGILITY/VULNERABILITY ASSESSMENT

Date:	11/12/2018
Building Type:	**UCM-URM7/LR/LD**
Authors:	UCL
Sheet:	1 of 4

RECTANGULAR BLOCK IN CEMENT MORTAR MASONRY INDEX BUILDING

GENERAL INFORMATION

Index Building Taxonomy String: **UCM-URM7/LR(1)/LD/RD/HI/LP/LO/RF/NP/OS/GC/NN**

1. Main structural system:	Rectangular Block in Cement Mortar Masonry (UCM-URM7)							
2. Height range:	Low (LR)	X	Medium (MR)		High (HR)			
3. Seismic design level:	Poor (PD)		Low (LD)	X	Medium (MD)		High (HD)	
4. Diaphragm Type:	Flexible (FD)		Rigid (RD)	X				
5. Structural Irregularity:	No (NI)		Horizontal (HI)	X	Vertical (VI)		Both (HV)	
6. Wall Panel Length:	Short (SP)		Long (LP)	X				
7. Wall Openings:	Small (SO)		Large (LO)	X				
8. Foundation Type and Flexibility:	Flexible (FF)		Rigid (RF)	X				
9. Seismic Pounding Risk:	No (NP)	X	Yes (PR)					
10. Seismic Retrofitting:	Original (OS)	X	Retrofitted (RS)					
11. Structural Health Condition:	Poor (PC)		Good (GC)	X				
12. Non-Structural Components:	Vulnerable (VN)		Non Vulnerable (NN)	X				

INTRINSIC CHARACTERISTICS

General Geometry:

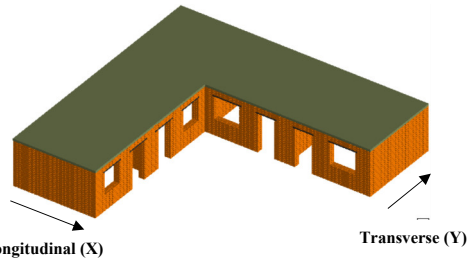
Building Plan Area (m^2):	125
Building Total Floor Area (m^2):	125
Number of Stories:	1
Story Height (m):	2.8
Number of Spans in X Direction:	3
Typical Span Length in X Direction (m):	5
Number of Spans in Y Direction (m):	3
Typical Span Length in Y Direction (m):	5
Wall Thickness (mm):	375
Wall Construction:	English Bond
Thickness	One and a Half

Material Properties of Masonry:

Unit Weight, γ (kg/m^2):	1920
Modulus of Elasticity, E (MPa):	263
Shear Modulus, G (MPa):	158
Compressive Strength, f'm (MPa):	4.14
Cohesion, c (MPa):	0.069
Tensile Strength, f_t (MPa):	0.069
Friction Coefficient, μ:	0.6

MODELLING PARAMETERS

3D Model



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/m^2):	1.0
Load Combination for Seismic Analysis:	D+0.25L
Average Load per Square Meter (kN/m^2):	1.2

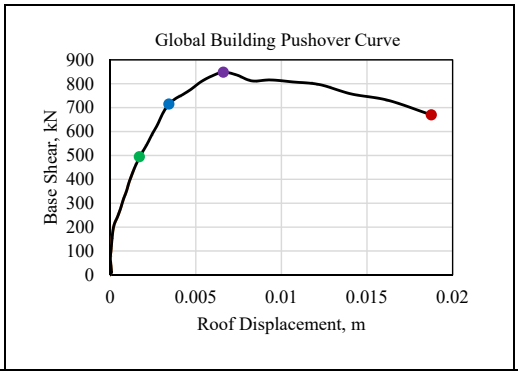
Analysis Considerations:

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

SEISMIC BEHAVIOR

Seismic Weight of IP Walls (kN):	1400
Fundamental Time Period of IP Walls (sec):	0.15

Pushover Curve with Damage State Thresholds:



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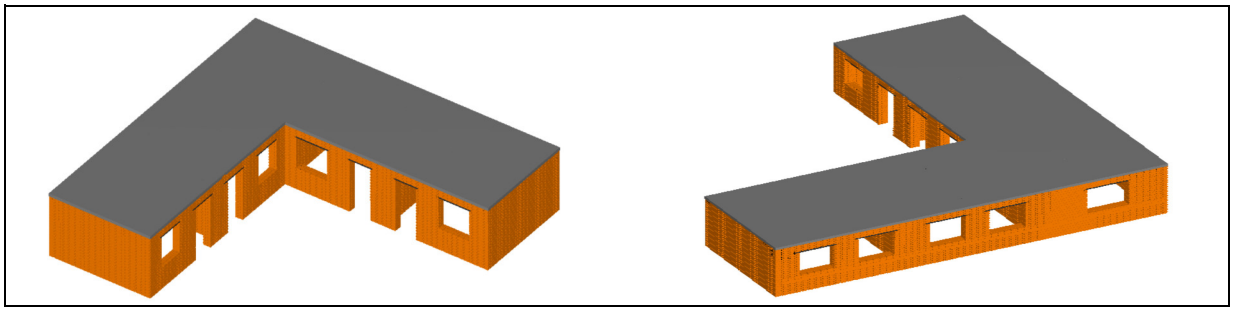
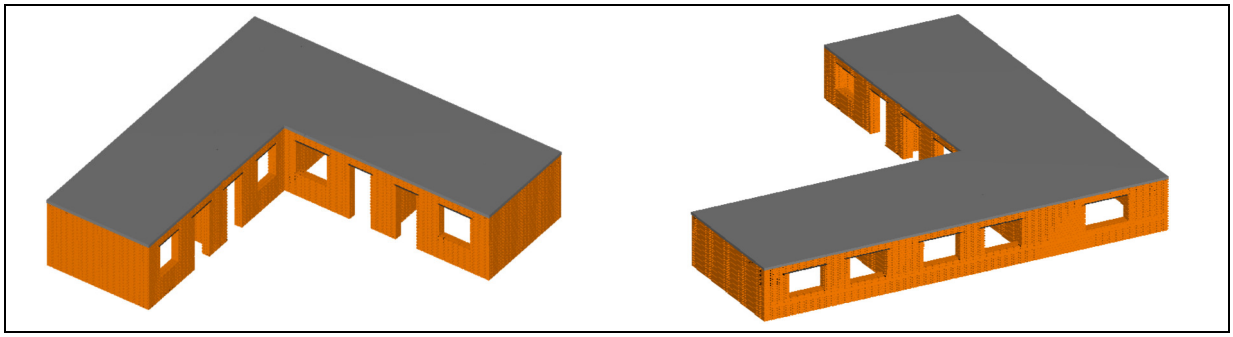
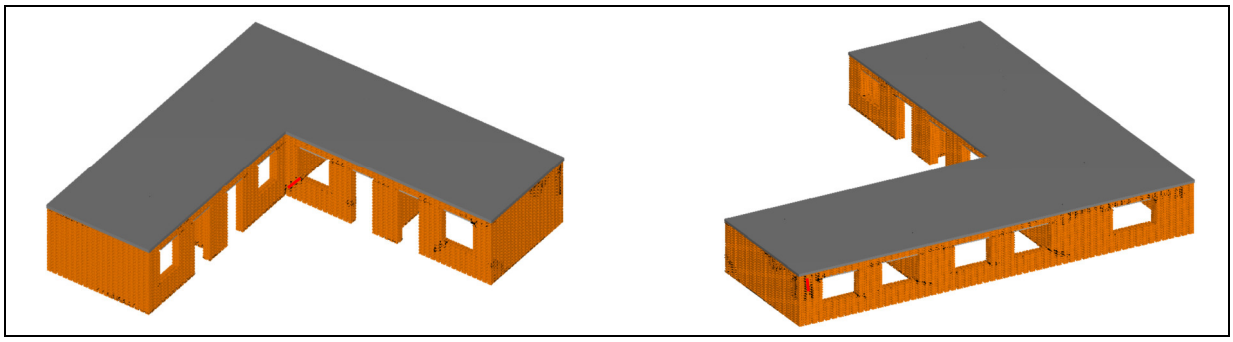


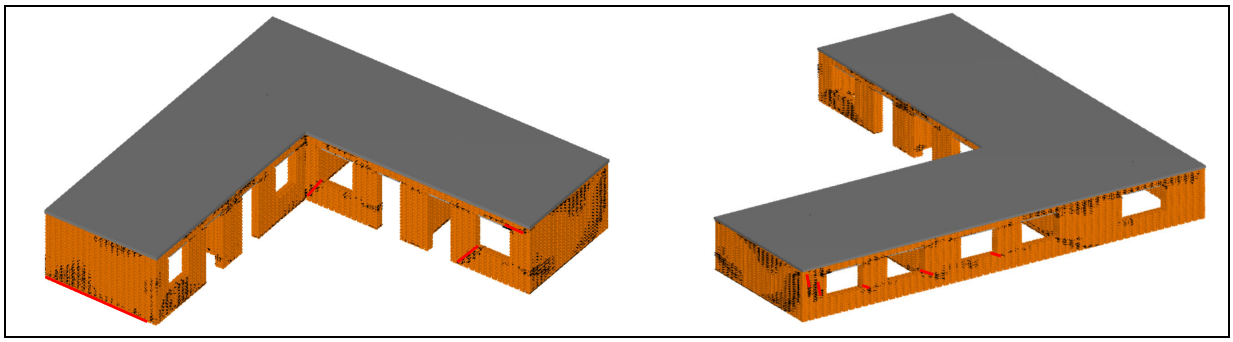
OP Threshold: hairline cracks (black) with maximum crack width of 5 mm appeared at some corners of openings and at the top floor slab connection.



IO Threshold: Hairline to minor cracks (black) of maximum crack width 2 mm appeared at most of the corners of openings.



LS Threshold: Diagonal shear cracks (black) of average width 5 mm (in squat piers) and flexural cracks (in more slender piers) developed in most of the piers on all the IP walls. The pier at the inner corner develops an extensive shear crack (red) of 12 mm width. Slab starts to detach from the masonry on roof. A minor horizontal crack at the base of the OOP walls appeared with a max opening of 0.5 mm.



CP Threshold: Major cracks (black, shear and flexural) of average width 7 mm extended through all the wall surfaces. Several piers (mainly on the front side walls) developed shear cracks of width more than 12.5 mm and flexural cracks of opening more than 4 mm. A major horizontal crack (red) of 4 mm opening appeared in the solid IP walls.

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SEISMIC PERFORMANCE ASSESSMENT

Analysis Considerations:

Analysis Methodology:…… Static Analysis (N2 Method)

Engineering Demand Parameter (EDP):…… Roof Drift

Seismic Ground Motions:

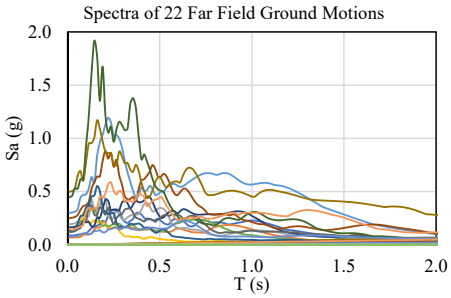
Ground Motion Suite:……FEMA P695 - 22 Far Field Ground Motions

Intensity Measure (IM):……PGA (g)

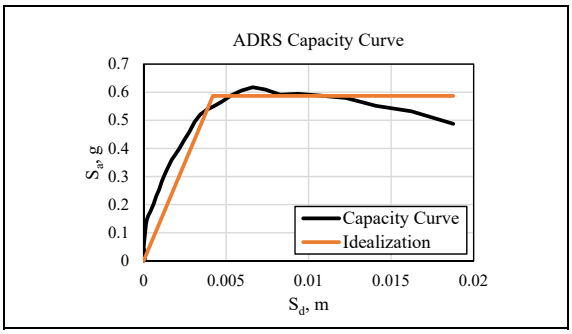
Scaling Factor:…… 0.1

Minimum IM:…… 0

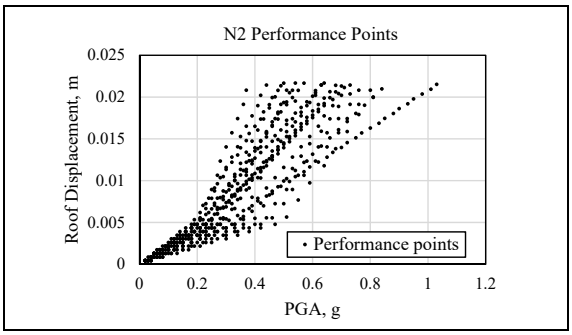
Maximum IM:…… 2g



Bilinear Idealization:



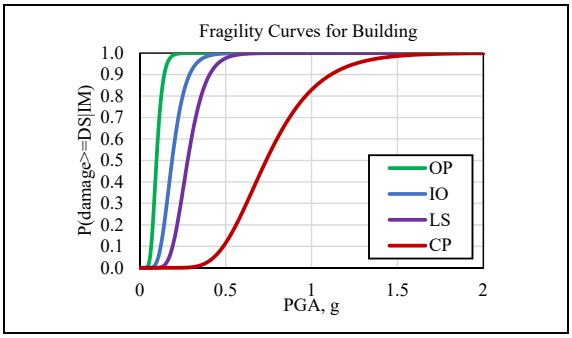
EDP Calculation:



FRAGILITY ASSESSMENT

Integration Methodology:…….. Least Square Method

Fragility Functions:



	OP	IO	LS	CP
Mean:……	0.10	0.19	0.28	0.74
Standard Deviation:……	0.30	0.34	0.29	0.32

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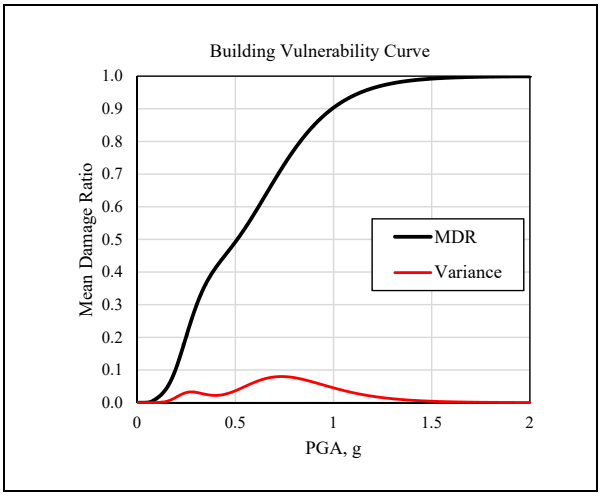
VULNERABILITY ASSESSMENT

Damage to Loss Function:

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

Vulnerability Function:



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)