

FRAGILITY/VULNERABILITY ASSESSMENT

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

RECTANGULAR BLOCK IN CEMENT MORTAR MASONRY INDEX BUILDING

GENERAL INFORMATION

Index Building Taxonomy String:

UCM-URM7/MR(2)/LD/RD/NI/LP/LO/RF/NP/OS/GC/NN

Rectangular Block in Cement Mortar Masonry (UCM-URM7)

- | | | | | |
|--|---|---|--|------------------------------------|
| 1. Main structural system:..... | | | | |
| 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:

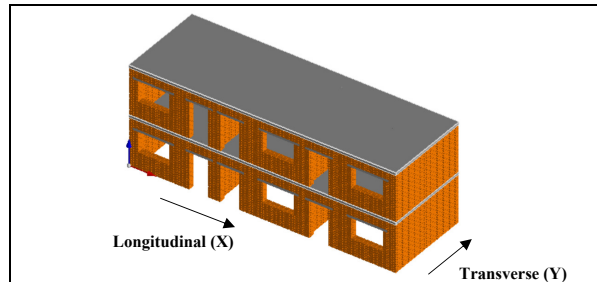
Building Plan Area (m ²):.....	75
Building Total Floor Area (m ²):.....	150
Number of Stories:.....	2
Story Height (m):.....	2.8
Number of Spans in X Direction:.....	3
Typical Span Length in X Direction (m):.....	5
Number of Spans in Y Direction (m):.....	1
Typical Span Length in Y Direction (m):.....	5
Wall Thickness (mm):.....	375
Wall Construction:.....	English Bond
Thickness:.....	One and a Half

Material Properties of Masonry:

Unit Weight, γ (kg/m ³):.....	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/m ²):.....	0.9
Design Live Load (L) (kN/m ²):.....	3.0
Load Combination for Seismic Analysis:.....	D+0.25L
Average Load per Square Meter (kN/m ²):.....	1.7

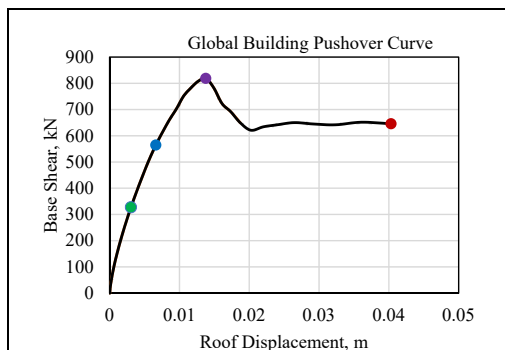
Analysis Considerations:

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

SEISMIC BEHAVIOR

Seismic Weight of IP Walls (kN):.....	2160
Fundamental Time Period of IP Walls (sec):.....	0.28

Pushover Curve with Damage State Thresholds:



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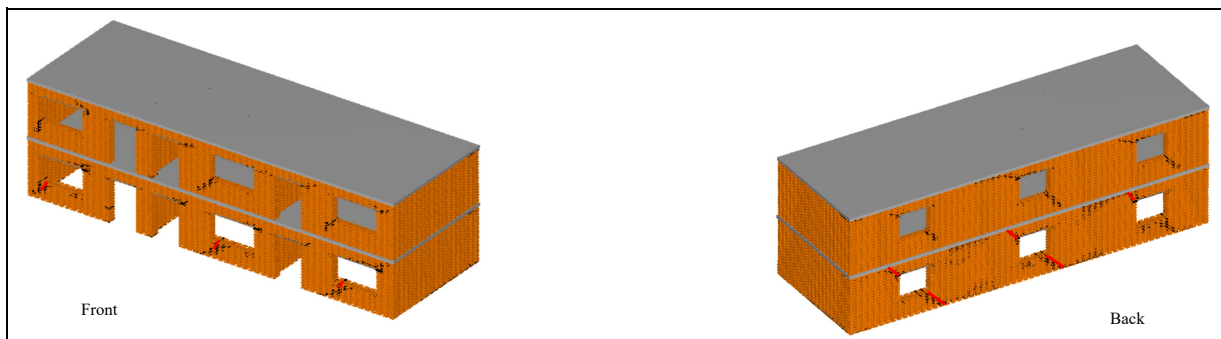
Damage (Crack Pattern, Width and Extent) Progression



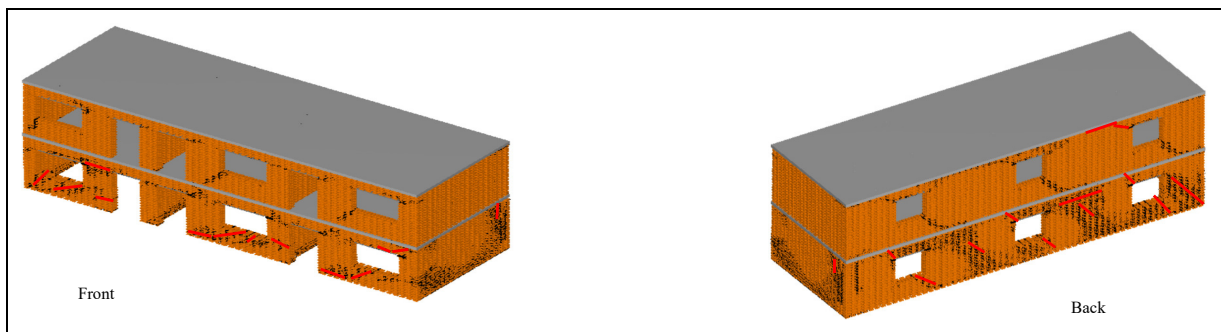
OP Threshold: Hairline cracks (black) of maximum width 0.5 mm appeared at some corners of openings and at the top slab-wall connection.



IO Threshold: Hairline to minor cracks (black) of maximum width of 2 mm appeared in almost all of the corners of openings (mainly on first story walls).



LS Threshold: Minor to major 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 walls in all stories. In the first story, few piers start to develop extensive cracks (red) of up to 12.5 mm width on both the front and back wall. Slabs start to detach from the masonry on roof and first floor. A minor horizontal crack at the base of the OOP walls appeared with a maximum opening of 0.5 mm.



CP Threshold: The front wall in the first story has developed extensive diagonal shear cracks (red) of more than 13 mm width through all the squat walls. Slender piers develop flexural cracks (red) with rocking behavior with a maximum crack opening of 3.5 mm. On the back wall in the first story, extensive diagonal shear cracks (red) of maximum width more than 13 mm developed through the piers as well as through the spandrels.

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Sheet:	3 of 4

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SEISMIC PERFORMANCE ASSESSMENT

Analysis Considerations:

Analysis Methodology:..... Static Analysis (N2 Method)
Engineering Demand Parameter (EDP):..... Roof Drift

Seismic Ground Motions:

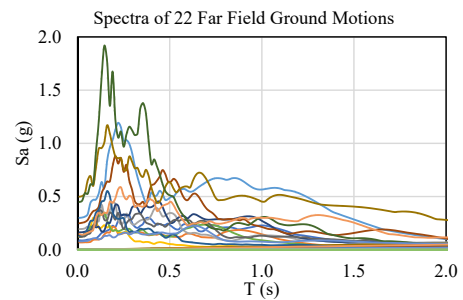
Ground Motion Suite:..... FEMA P695 - 22 Far Field Ground Motions

Intensity Measure (IM):..... PGA (g)

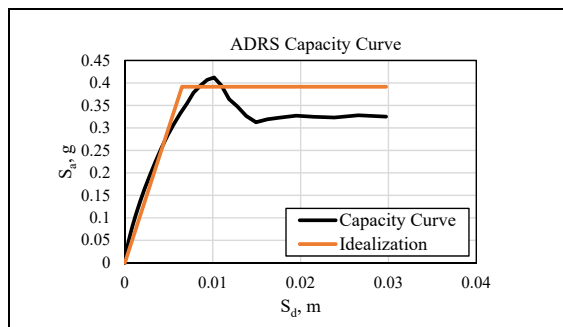
Scaling Factor:..... 0.1

Minimum IM:..... 0

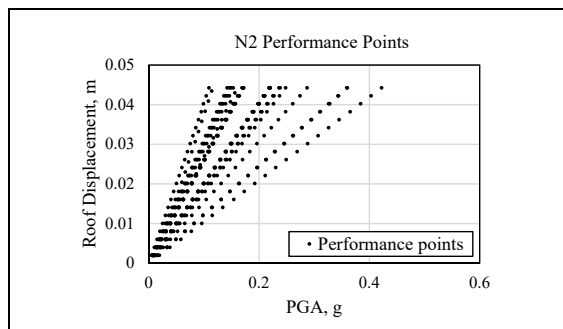
Maximum IM:..... 2g



Bilinear Idealization:



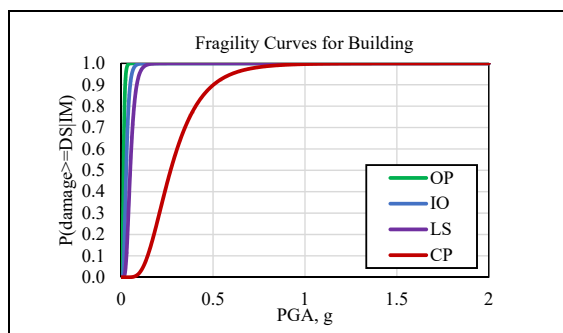
EDP Calculation:



FRAGILITY ASSESSMENT

Integration Methodology:..... Least Square Method

Fragility Functions:



	OP	IO	LS	CP
Mean:.....	0.01	0.03	0.05	0.27
Standard Deviation:.....	0.43	0.46	0.42	0.49

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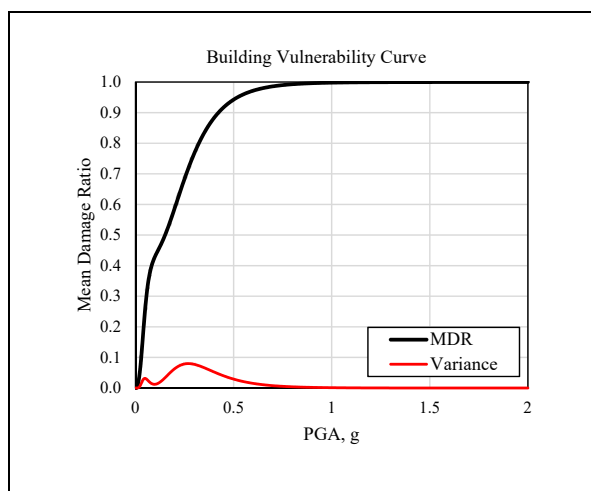
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VULNERABILITY ASSESSMENT

Damage to Loss Function:

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

Vulnerability Function:



GLOSSARY

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)