

FRAGILITY/VULNERABILITY ASSESSMENT

Date:	11/12/2018
Building Type:	UCM-URM2/LR/PD
Authors:	UCL
Sheet:	1 of 4

RUBBLE STONE MASONRY IN MUD MORTAR INDEX BUILDING

GENERAL INFORMATION

Index Building Taxonomy String:

UCM-URM2/LR(1)/PD/FD/NI/SP/SO/RF/NP/OS/PC/VN

1. Main structural system:.....
2. Height range:.....
3. Seismic design level:.....
4. Diaphragm Type:.....
5. Structural Irregularity:.....
6. Wall Panel Length:.....
7. Wall Openings:.....
8. Foundation Type and Flexibility:.....
9. Seismic Pounding Risk:.....
10. Seismic Retrofitting:.....
11. Structural Health Condition:.....
12. Non-Structural Components:.....

Low (LR)	<input checked="" type="checkbox"/>	Medium (MR)	<input type="checkbox"/>	High (HR)	<input type="checkbox"/>
Poor (PD)	<input checked="" type="checkbox"/>	Low (LD)	<input type="checkbox"/>	Medium (MD)	<input type="checkbox"/>
Flexible (FD)	<input checked="" type="checkbox"/>	Rigid (RD)	<input type="checkbox"/>	High (HD)	<input type="checkbox"/>
No (NI)	<input checked="" type="checkbox"/>	Horizontal (HI)	<input type="checkbox"/>	Vertical (VI)	<input type="checkbox"/>
Short (SP)	<input checked="" type="checkbox"/>	Long (LP)	<input type="checkbox"/>	Both (HV)	<input type="checkbox"/>
Small (SO)	<input checked="" type="checkbox"/>	Large (LO)	<input type="checkbox"/>		
Flexible (FF)	<input type="checkbox"/>	Rigid (RF)	<input checked="" type="checkbox"/>		
No (NP)	<input checked="" type="checkbox"/>	Yes (PR)	<input type="checkbox"/>		
Original (OS)	<input checked="" type="checkbox"/>	Retrofitted (RS)	<input type="checkbox"/>		
Poor (PC)	<input checked="" type="checkbox"/>	Good (GC)	<input type="checkbox"/>		
Vulnerable (VN)	<input checked="" type="checkbox"/>	Non Vulnerable (NN)	<input type="checkbox"/>		

INTRINSIC CHARACTERISTICS

General Geometry:

Building Plan Area (m ²):.....	37
Building Total Floor Area (m ²):.....	37
Number of Stories:.....	1
Story Height (m):.....	2.3
Number of Spans in X Direction:.....	2
Typical Span Length in X Direction (m):.....	4.5
Number of Spans in Y Direction (m):.....	1
Typical Span Length in Y Direction (m):.....	4
Wall Thickness (mm):.....	420
Wall Construction:.....	Running Bond
No. of Wythes:.....	Two

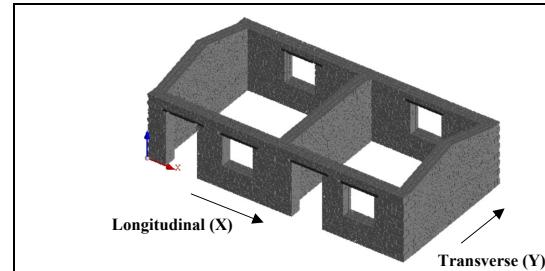
Material Properties of Masonry:

Unit Weight, γ (kg/m ³):.....	2200
Modulus of Elasticity, E (MPa):.....	240
Shear Modulus, G (MPa):.....	96
Compressive Strength, f _m (MPa):....	1.8
Cohesion, c (MPa):.....	0.048
Tensile Strength, f _t (MPa):.....	0.048
Friction Coefficient, μ :.....	0.5

SEISMIC BEHAVIOR

Seismic Weight of IP Walls (kN):.....	380
Fundamental Time Period of IP Walls (sec):.....	0.29

MODELLING PARAMETERS

3D Model

Modelling Consideration

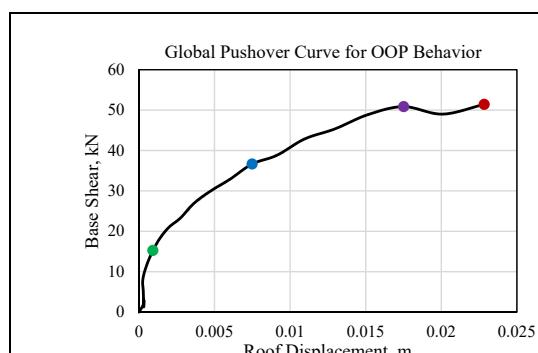
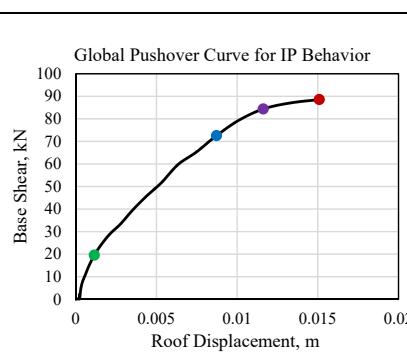
Numerical Model Type:.....	3-D Element-by-Element
Masonry Modelling Approach:.....	Simplified Micro-Modelling

Loads:

Roof Dead Load (D) (kN/m ²):.....	0.9
Design Live Load (L) (kN/m ²):.....	0.0
Load Combination for Seismic Analysis:.....	D+0.25L
Average Load per Square Meter (kN/m ²):.....	0.9

Analysis Considerations:

Global P-Delta Effects:.....	Yes <input checked="" type="checkbox"/>	No <input type="checkbox"/>
Analysis Direction:.....	X <input checked="" type="checkbox"/>	Y <input type="checkbox"/>
Analysis Orientation:.....	(+) <input type="checkbox"/>	(-) <input checked="" type="checkbox"/>

Pushover Curve with Damage State Thresholds:


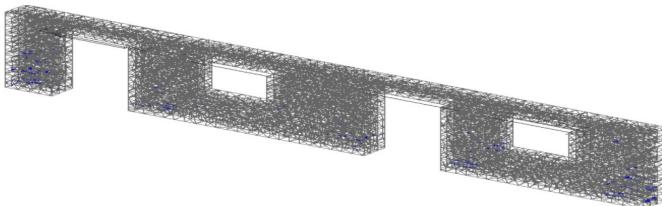
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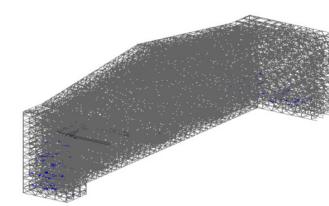
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Damage (Crack Pattern, Width and Extent) Progression

IP Wall Behavior

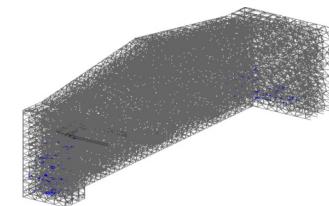
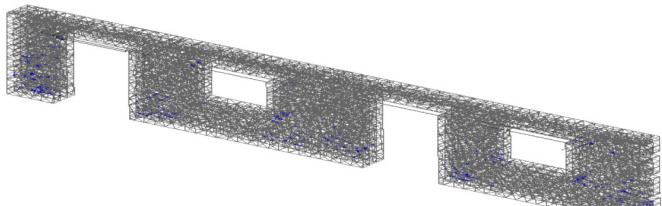


OOP Wall Behavior



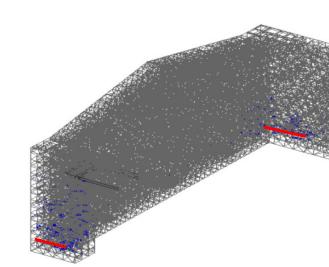
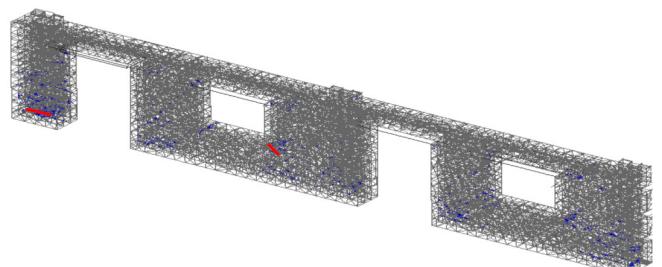
OP Threshold: Hairline cracks (blue) of maximum width 0.1 mm appeared at few corners of doors and windows and in some areas of the wall.

OP Threshold: Hairline cracks (blue) appeared at the connection with the in plane walls. Max crack width 0.1 mm.



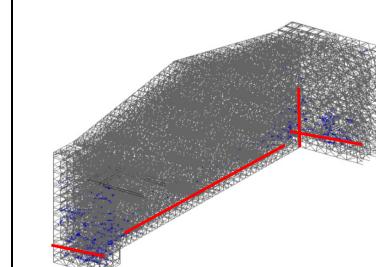
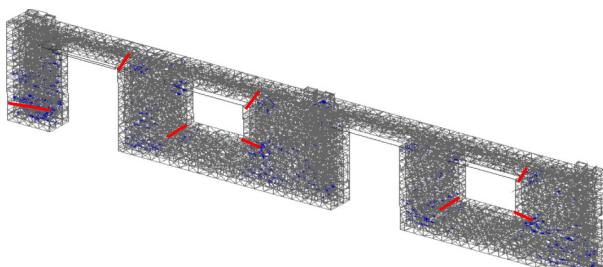
IO Threshold: Hairline to minor cracks (blue) of maximum width 0.5 mm developed at most of the corners of the openings, few piers and spandrels start to develop shear and flexural cracks, respectively.

IO Threshold: Minor cracks (blue) start to extend upward at the IP connection, max crack width 1 mm.



LS Threshold: Left most pier starts to damage in flexure with major cracks (red) of 5 mm maximum width. Other piers also start to develop shear and flexural cracks.

LS Threshold: Major cracks (red) of 4 mm maximum width at the IP walls connection at the bottom. A horizontal crack of maximum opening 1 mm at the bottom appears.



CP Threshold: Most piers and spandrels start to damage in shear/flexure with extensive crack (red) width of more than 5 mm.

CP Threshold: Wall on the verge of collapse. Connection with the IP wall damaged with extensive cracks (red) of width more than 5 mm. Horizontal bottom crack (red) extends to full length with a maximum opening of 4 mm.



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SEISMIC PERFORMANCE ASSESSMENT

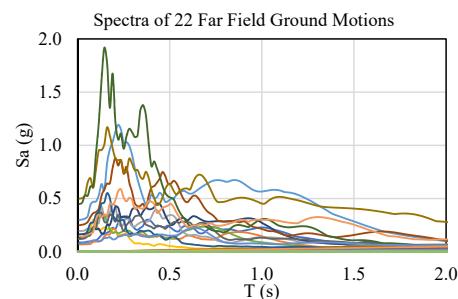
Analysis Considerations:

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

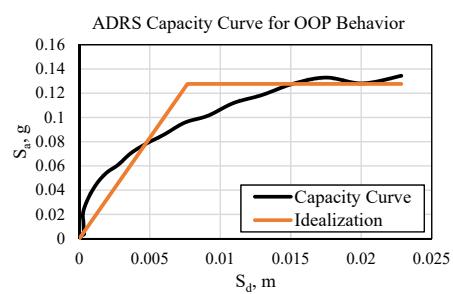
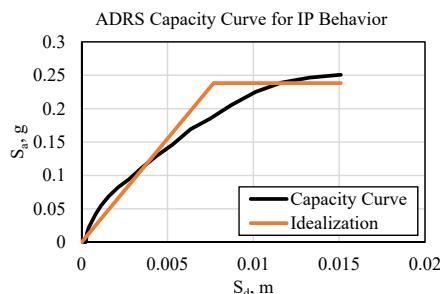
Seismic Ground Motions:

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

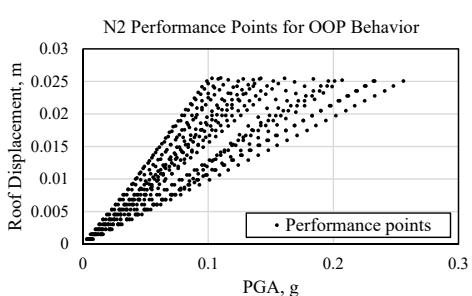
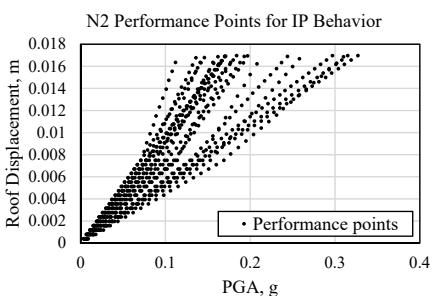
Intensity Measure (IM):..... PGA (g)

Scaling Factor:..... 0.1Minimum IM:..... 0Maximum IM:..... 2g

Bilinear Idealization:



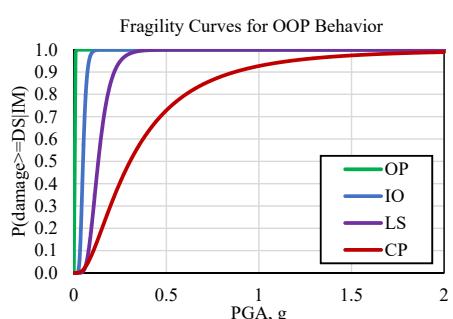
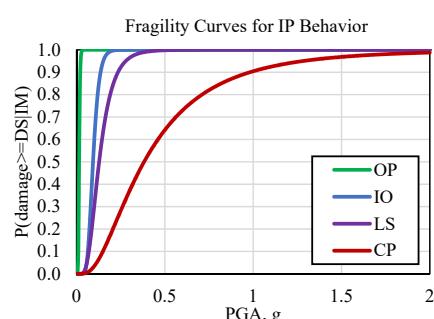
EDP Calculation:



FRAGILITY ASSESSMENT

Integration Methodology:..... Least Square Method

Fragility Functions:



Mean:	OP	IO	LS	CP
Mean:	0.01	0.09	0.13	0.38

Mean:	OP	IO	LS	CP
Mean:	0.01	0.05	0.13	0.30

Standard Deviation... 0.28 0.29 0.47 0.74

Standard Deviation... 0.30 0.30 0.39 0.82

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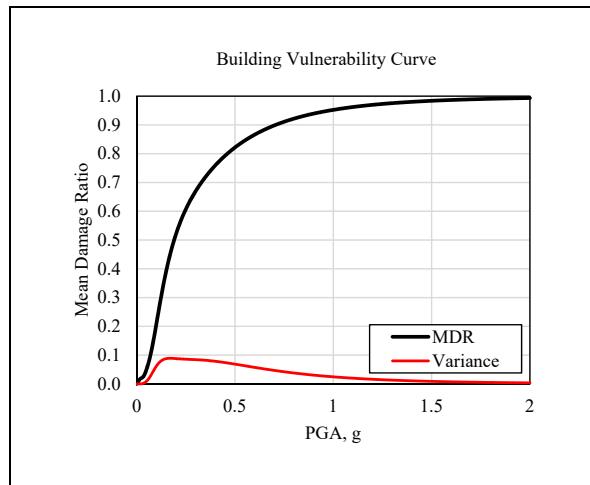
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VULNERABILITY ASSESSMENT

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)