

## FRAGILITY/VULNERABILITY ASSESSMENT

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

### RECTANGULAR BLOCK IN MUD MORTAR MASONRY INDEX BUILDING

#### GENERAL INFORMATION

**Index Building Taxonomy String:**

UCM-URM4/LR(1)/LD/FD/NI/SP/SO/RF/NP/OS/GC/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 type="checkbox"/>	Low (LD)	<input checked="" 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 type="checkbox"/>	Good (GC)	<input checked="" type="checkbox"/>		
Vulnerable (VN)	<input checked="" type="checkbox"/>	Non Vulnerable (NN)	<input type="checkbox"/>		

#### INTRINSIC CHARACTERISTICS

**General Geometry:**

Building Plan Area (m <sup>2</sup> ):.....	72
Building Total Floor Area (m <sup>2</sup> ):.....	72
Number of Stories:.....	1
Story Height (m):.....	2.6
Number of Spans in X Direction:.....	3
Typical Span Length in X Direction (m):.....	5.5
Number of Spans in Y Direction (m):.....	1
Typical Span Length in Y Direction (m):.....	4.4
Wall Thickness (mm):.....	375
Wall Construction:.....	English Bond
Thickness.....	One and a Half

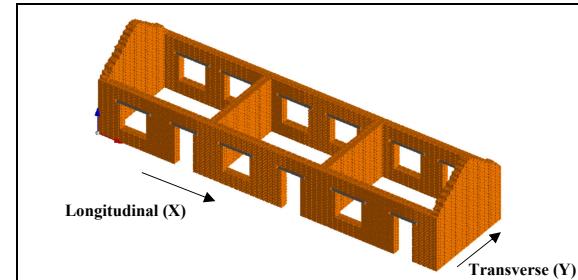
**Material Properties of Masonry:**

Unit Weight, $\gamma$ (kg/m <sup>3</sup> ):.....	1768
Modulus of Elasticity, E (MPa):.....	45
Shear Modulus, G (MPa):.....	18
Compressive Strength, f <sub>m</sub> (MPa):....	1.21
Cohesion, c (MPa):.....	0.047
Tensile Strength, f <sub>t</sub> (MPa):.....	0.047
Friction Coefficient, $\mu$ :.....	0.5

#### SEISMIC BEHAVIOR

Seismic Weight of IP Walls (kN):.....	420
Fundamental Time Period of IP Walls (sec):.....	0.27

#### MODELLING PARAMETERS

**3D Model**

**Modelling Consideration**

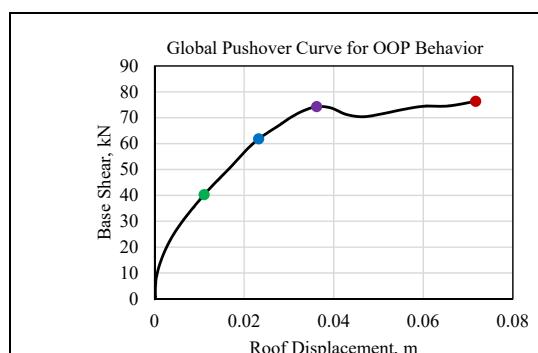
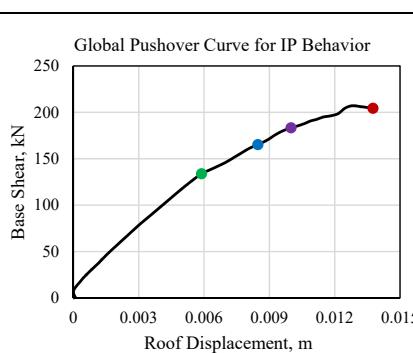
Numerical Model Type:.....	3-D Element-by-Element
Masonry Modelling Approach:.....	Simplified Micro-Modelling

**Loads:**

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

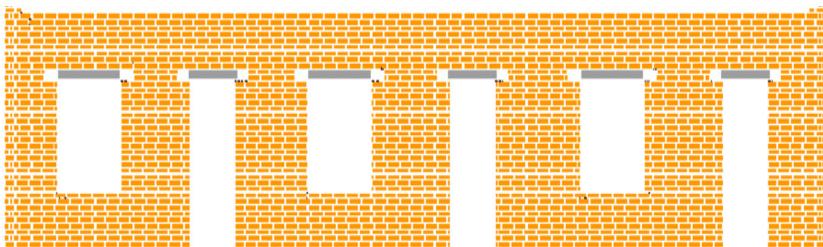
**Pushover Curve with Damage State Thresholds:**


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IP Wall Behavior

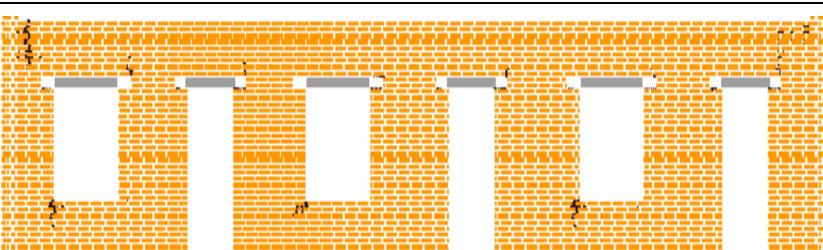


**OP Threshold:** Hairline cracks (black) of maximum width 0.3 mm appeared at few corners of doors and windows.

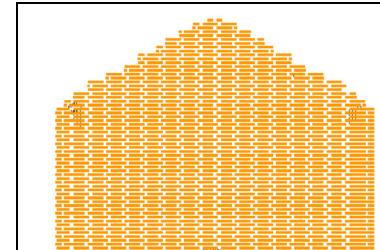
OOP Wall Behavior



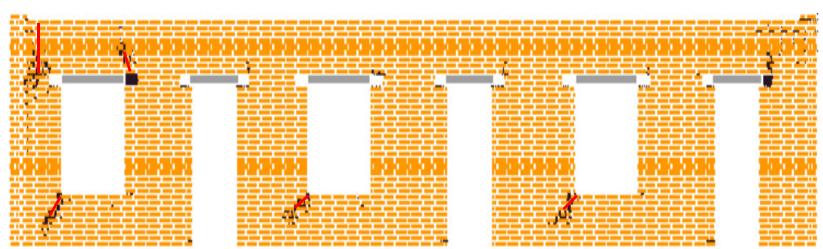
**OP Threshold:** Hairline cracks (black) starts to appear at the top connection with the in plane walls. Max crack width 0.2 mm.



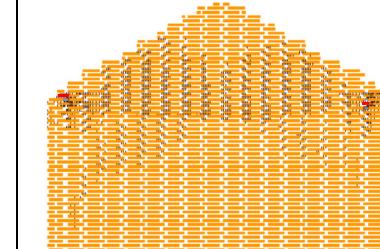
**IO Threshold:** Hairline to minor cracks (black) of maximum width 5 mm developed at most of the corners of the openings.



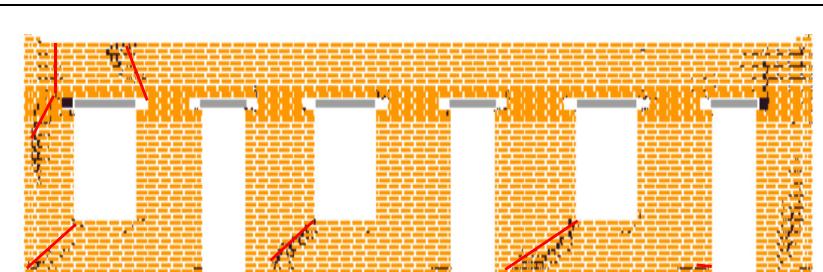
**IO Threshold:** Minor cracks (black) start to extend downward at the IP connection, max crack width 3 mm. A minor horizontal bottom crack appears in the central part.



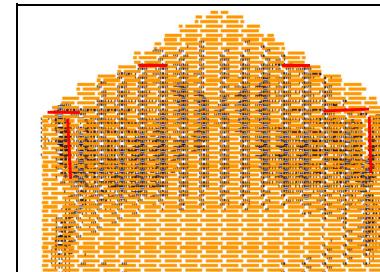
**LS Threshold:** Left pier and spandrel start to damage in shear and flexure with extensive cracks of 9 mm maximum width (red). Other piers also start to develop extensive shear and flexural cracks.



**LS Threshold:** Minor cracks (black) extended to most of the wall surface and at the connection with the IP walls. A horizontal crack of maximum opening 2 mm at the bottom appears. Some gable portions on the verge of collapse.



**CP Threshold:** Most piers have developed extensive shear cracks (red) of width of more than 10 mm. Left most spandrel on the verge of collapse. Horizontal flexural cracks of maximum width 3 mm appeared in some piers at the base.



**CP Threshold:** Minor to major cracks extended everywhere in the wall (black). Portions of gables damaged. Horizontal bottom crack extends to full length with a maximum opening of 4 mm (red). Vertical shear cracks also extended to half of the length at IP wall connections, with a max crack width of 5 mm (red).



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## 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:

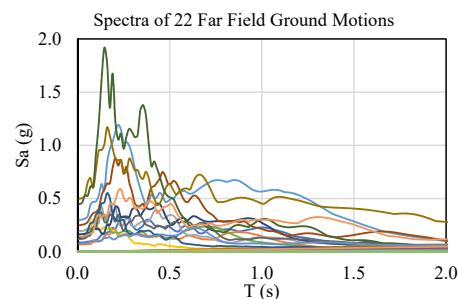
Ground Motion Suite:..... FEMA P695 - 22 Far Field Ground Motions

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

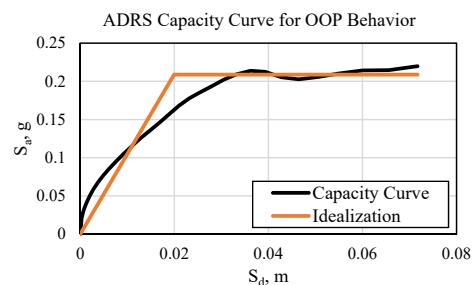
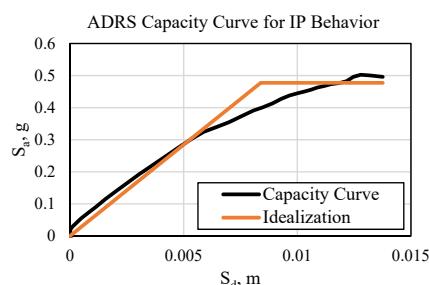
Scaling Factor:..... 0.1

Minimum IM:..... 0

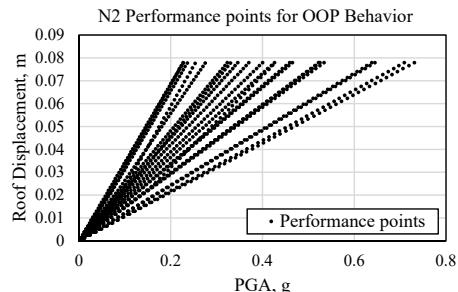
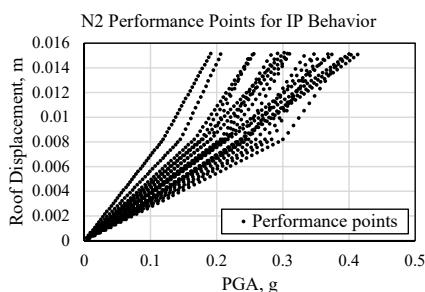
Maximum IM:..... 2g



## Bilinear Idealization:



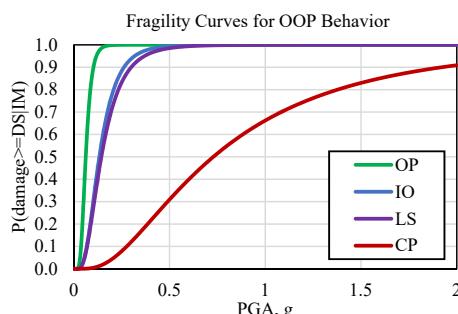
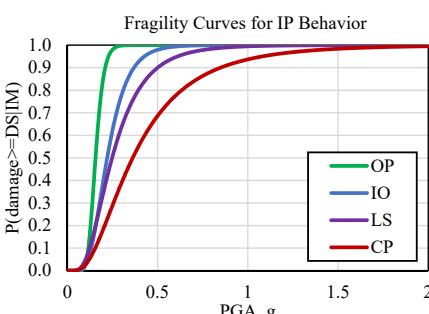
## EDP Calculation:



## FRAGILITY ASSESSMENT

Integration Methodology:..... Least Square Method

## Fragility Functions:



Mean:	OP	IO	LS	CP
Mean:	0.16	0.22	0.25	0.36

Mean:	OP	IO	LS	CP
Mean:	0.06	0.13	0.14	0.73

Standard Deviation...: 0.23    0.40    0.55    0.67

Standard Deviation...: 0.39    0.53    0.57    0.76

## FRAGILITY/VULNERABILITY ASSESSMENT

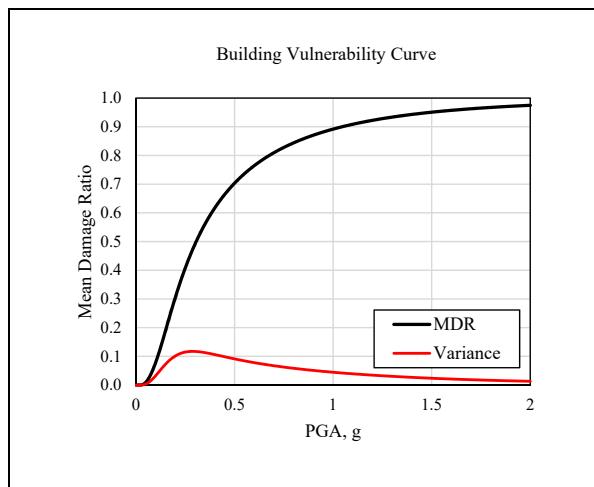
RECTANGULAR BLOCK IN MUD MORTAR MASONRY INDEX BUILDING

### VULNERABILITY ASSESSMENT

#### Damage to Loss Function:

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

#### Vulnerability Function:



### 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 ( <a href="http://www.ecapra.org">www.ecapra.org</a> )