

FRAGILITY/VULNERABILITY ASSESSMENT

Date:	11/12/2018
Building Type:	UCM-URM6/LR/MD
Authors:	UCL
Sheet:	1 of 4

DRESSED STONE IN CEMENT MORTAR MASONRY INDEX BUILDING

GENERAL INFORMATION

Index Building Taxonomy String:

UCM-URM6/LR(1)/MD/FD/NI/SP/SO/RF/NP/OS/GC/VN

Dressed Stone in Cement Mortar Masonry (UCM-URM6)	
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):.....	55
Building Total Floor Area (m ²):.....	55
Number of Stories:.....	1
Story Height (m):.....	2.5
Number of Spans in X Direction:.....	3
Typical Span Length in X Direction (m):.....	4.8
Number of Spans in Y Direction (m):.....	1
Typical Span Length in Y Direction (m):.....	3.8
Wall Thickness (mm):.....	480
Wall Construction:.....	Running Bond
Thickness:.....	Two

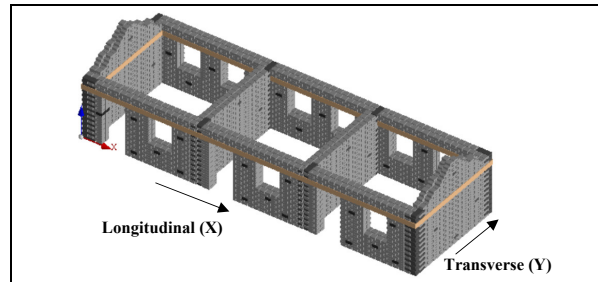
Material Properties of Masonry:

Unit Weight, γ (kg/m ³):.....	2200
Modulus of Elasticity, E (MPa):.....	4629
Shear Modulus, G (MPa):.....	1200
Compressive Strength, f_m (MPa):.....	37
Cohesion, c (MPa):.....	0.36
Tensile Strength, f_t (MPa):.....	0.12
Friction Coefficient, μ :.....	0.63

Seismic Enhancement Features: | Lintel Band Beam

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

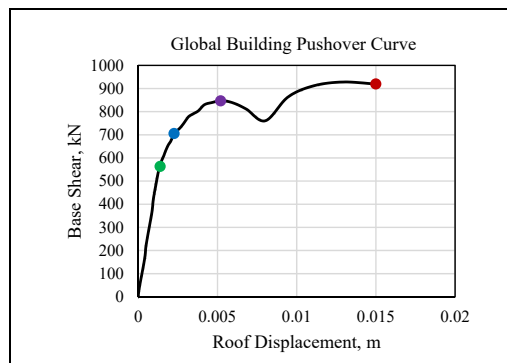
Analysis Considerations:

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

SEISMIC BEHAVIOR

Seismic Weight of IP Walls (kN):.....	1100
Fundamental Time Period of IP Walls (sec):.....	0.1

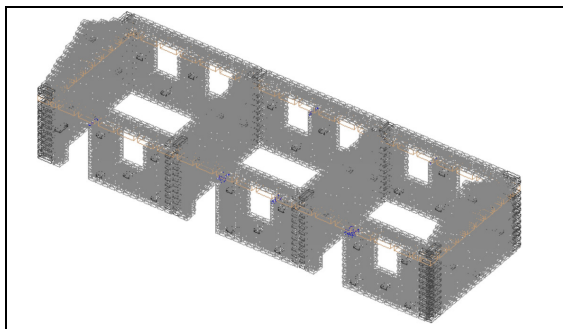
Pushover Curve with Damage State Thresholds:



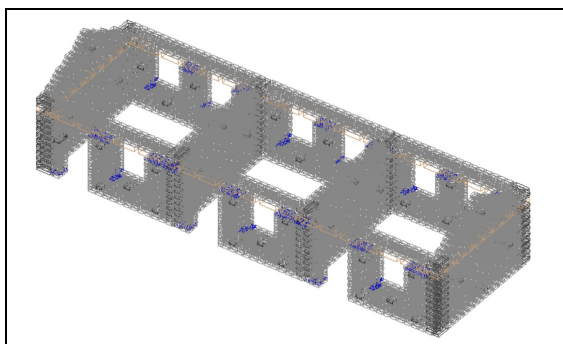
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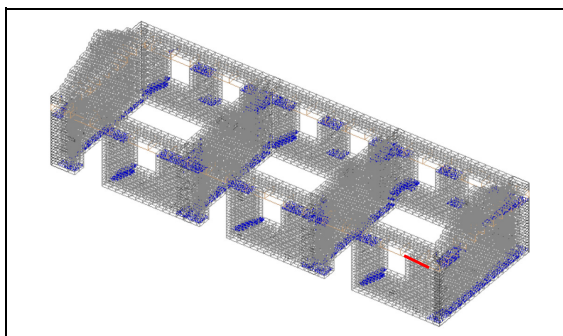
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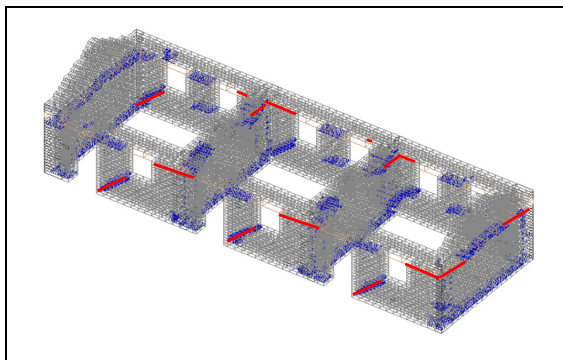
OP Threshold: Hairline cracks (blue) of maximum width 0.5 mm appeared at few corners of doors and windows.



IO Threshold: Hairline to minor cracks (blue) of maximum width 2.5 mm developed at most of the corners of the openings, hairline cracks developed at the connection between lintel band beam and the walls.



LS Threshold: Major shear cracks (blue) developed in several of the piers with a maximum width of 10 mm. Minor cracks extended at the connection with the lintel band beam with maximum opening of 0.5 mm. OOP walls develop a full length horizontal crack at the base with a maximum opening of 1 mm. Extensive cracks (red) of 12.5 mm width started at the connection between the lintel band beam and the IP wall at right corner.



CP Threshold: Most of the IP wall piers in the front (and the left most pier in the back wall) develop extensive shear cracks (red) of width more than 12.5 mm, lintel band beam separation with the walls becomes visible with a maximum crack opening of more than 5 mm. Horizontal bottom crack in OOP walls have an opening of 3 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:

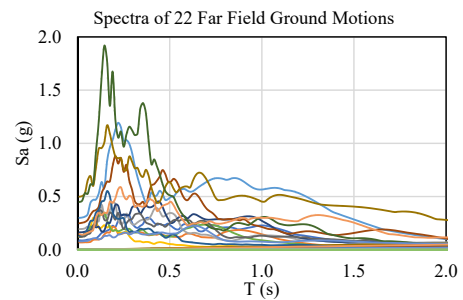
Ground Motion Suite:.....FEMA P695 - 22 Far Field Ground Motions

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

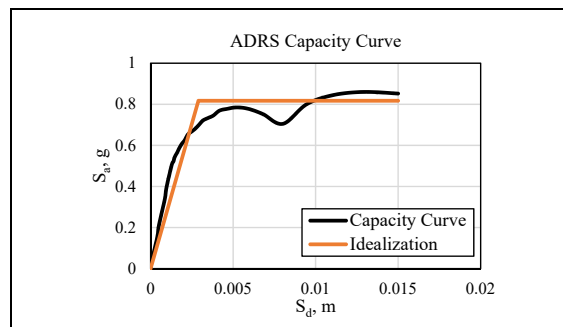
Scaling Factor:..... 0.1

Minimum IM:..... 0

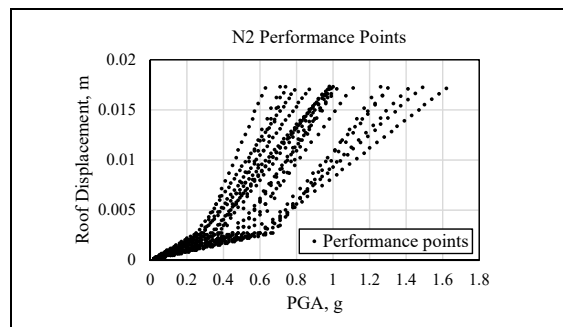
Maximum IM:..... 2g



Bilinear Idealization:



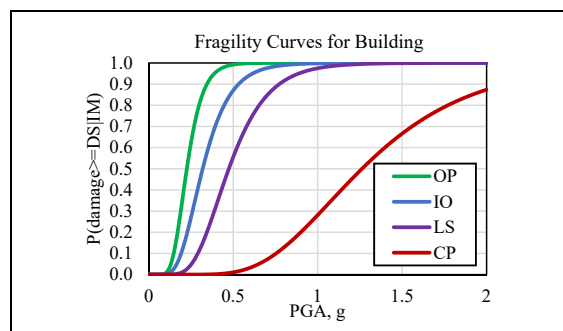
EDP Calculation:



FRAGILITY ASSESSMENT

Integration Methodology:..... Least Square Method

Fragility Functions:



	OP	IO	LS	CP
Mean:.....	0.23	0.32	0.47	1.26
Standard Deviation:.....	0.33	0.40	0.38	0.40

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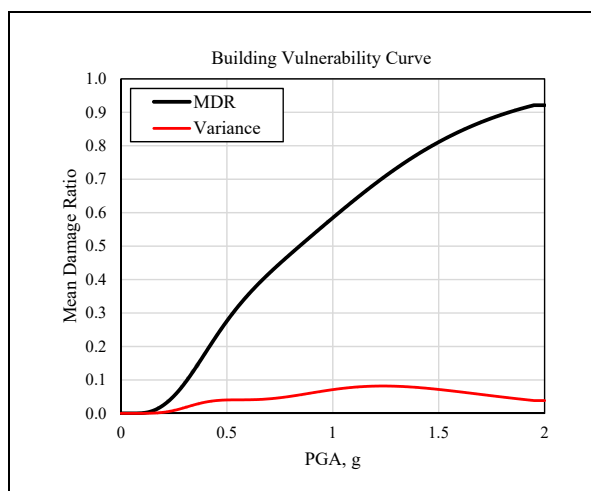
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VULNERABILITY ASSESSMENT

Damage to Loss Function:

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

Vulnerability Function:



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)