

FRAGILITY/VULNERABILITY ASSESSMENT

Date: 09/12/2018
Building Type: A/LR/LD
Authors: UCL
Sheet: 1 of 4

ADOBE MASONRY INDEX BUILDING

GENERAL INFORMATION

Index Building Taxonomy String:

A/LR(1)/LD/FD/NI/LP/LO/RF/NP/OS/GC/VN

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

INTRINSIC CHARACTERISTICS

General Geometry:

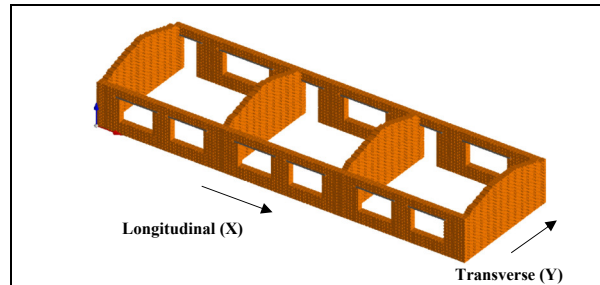
Building Plan Area (m ²):.....	157
Building Total Floor Area (m ²):.....	157
Number of Stories:.....	1
Story Height (m):.....	2.9
Number of Spans in X Direction:.....	3
Typical Span Length in X Direction (m):.....	7.5
Number of Spans in Y Direction (m):.....	1
Typical Span Length in Y Direction (m):.....	7
Wall Thickness (mm):.....	400
Wall Construction:.....	Running Bond
No. of Wythes:.....	Two

Material Properties of Masonry:

Unit Weight, γ (kg/m ³):.....	1800
Modulus of Elasticity, E (MPa):.....	192
Shear Modulus, G (MPa):.....	50
Compressive Strength, f_m (MPa):.....	0.84
Cohesion, c (MPa):.....	0.036
Tensile Strength, f_t (MPa):.....	0.053
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):.....	0.3
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):.....	0.3

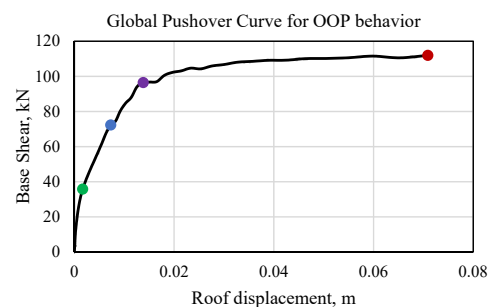
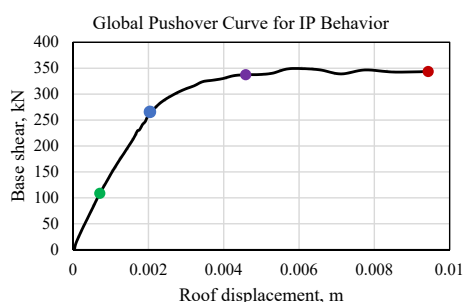
Analysis Considerations:

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

SEISMIC BEHAVIOR

Seismic Weight of IP Walls (kN):.....	800	Seismic Weight of OOP Walls (kN):.....	720
Fundamental Time Period of IP Walls (sec):.....	0.14	Fundamental Time Period of OOP Walls (sec):.....	0.36

Pushover Curve with Damage State Thresholds:



FRAGILITY/VULNERABILITY ASSESSMENT

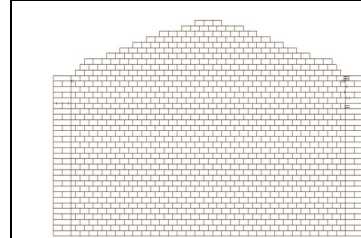
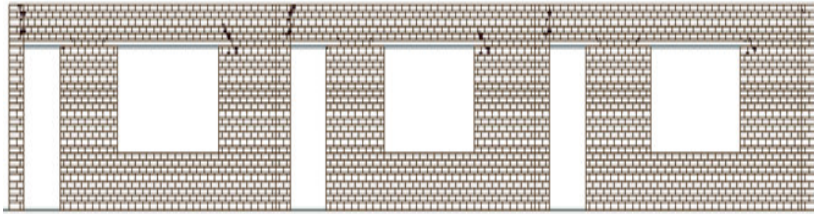
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Damage (Crack Pattern, Width and Extent) Progression

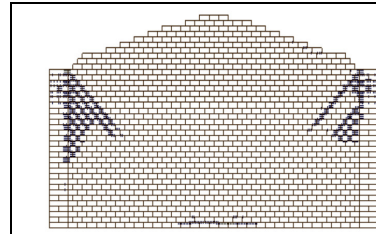
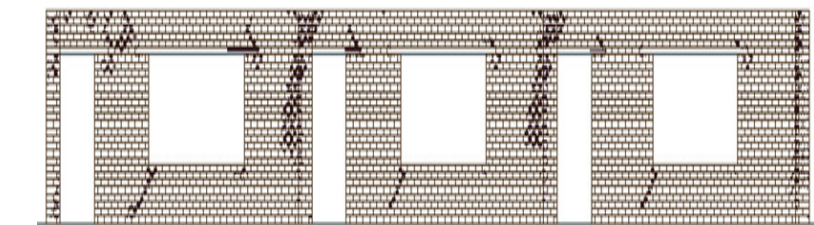
IP Wall Behavior

OOP Wall Behavior



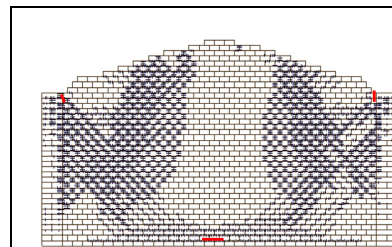
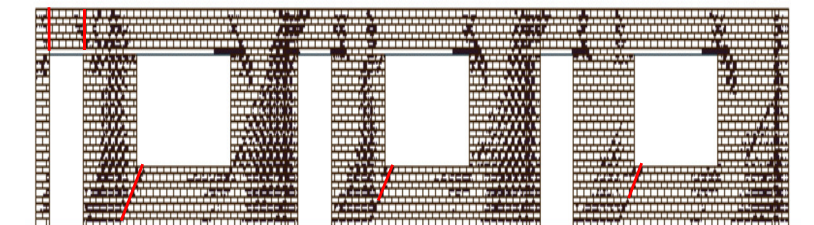
OP Threshold: Hairline cracks (black) of maximum width 0.5 mm appeared at few corners of openings.

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



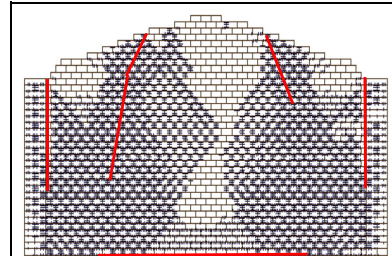
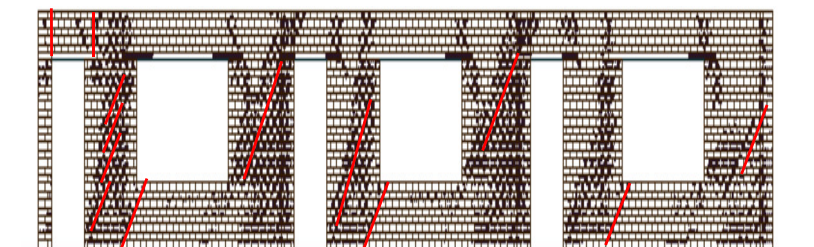
IO Threshold: Hairline to minor cracks (black) of maximum width 2 mm developed at almost all the corners of the openings, few piers and spandrels start to develop shear and flexural cracks, respectively.

IO Threshold: Minor cracks (black) start to develop at the IP connection, max crack width 2 mm. A minor horizontal crack of maximum opening 1 mm started at the bottom center.



LS Threshold: Right most spandrel and pier start to damage in flexure and shear respectively, with a maximum crack width (red) of 4 mm. Minor to major shear cracks of 2 to 4 mm width appeared in most of the piers.

LS Threshold: Minor to major (red) cracks of 5 mm maximum width the IP walls connections. A horizontal crack (red) of maximum opening 1.2 mm at the bottom appears.



CP Threshold: Most piers developed major shear cracks (red) of 5 mm maximum width.

CP Threshold: Wall on the verge of collapse. Connections with the IP walls damaged with major cracks (red) of width more than 5 mm. Horizontal bottom crack (red) extends to full length with a maximum opening of 2.5 mm.

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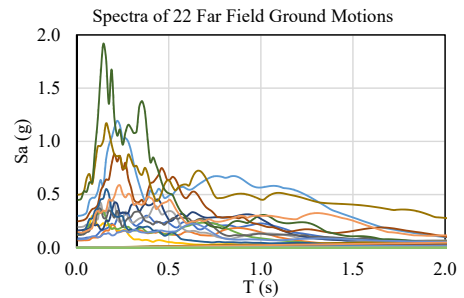
SEISMIC PERFORMANCE ASSESSMENT

Analysis Considerations:

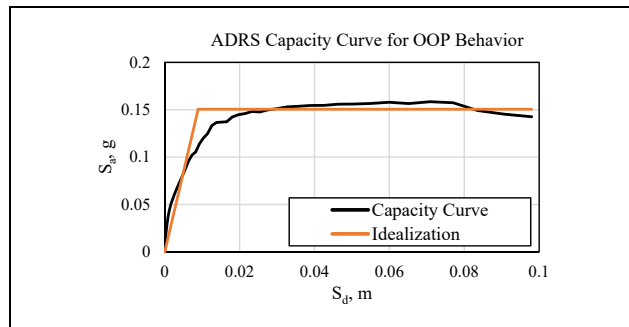
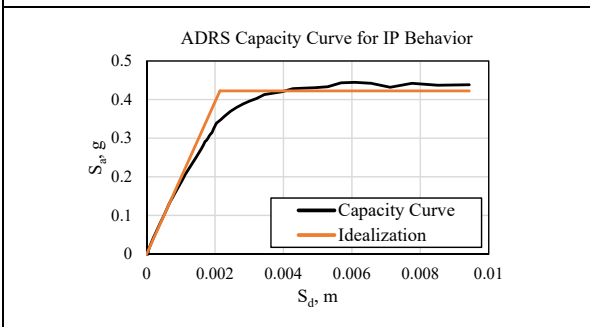
Analysis Methodology:..... Static Analysis (N2 Method)
 Engineering Demand Parameter (EDP):..... Roof Drift

Seismic Ground Motions:

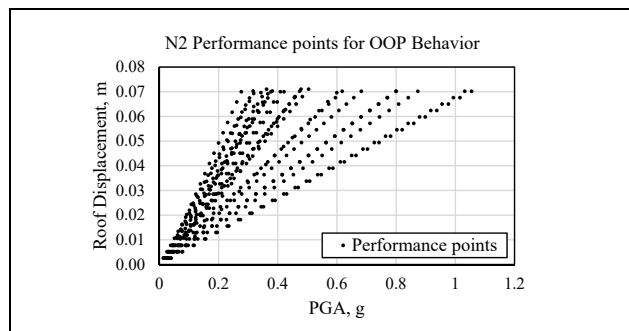
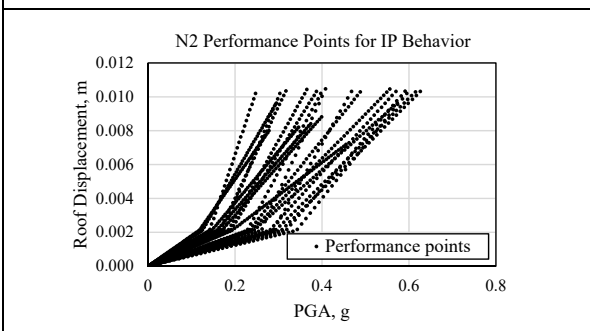
Ground Motion Suite:..... FEMA P695 - 22 Far Field Ground Motions
 Intensity Measure (IM):..... PGA (g)
 Scaling Factor:..... 0.1
 Minimum IM:..... 0
 Maximum IM:..... 2g



Bilinear Idealization:



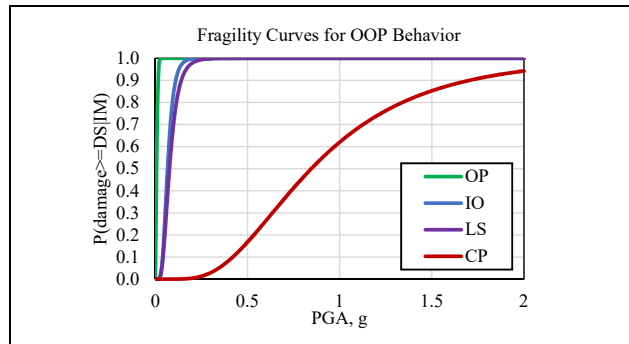
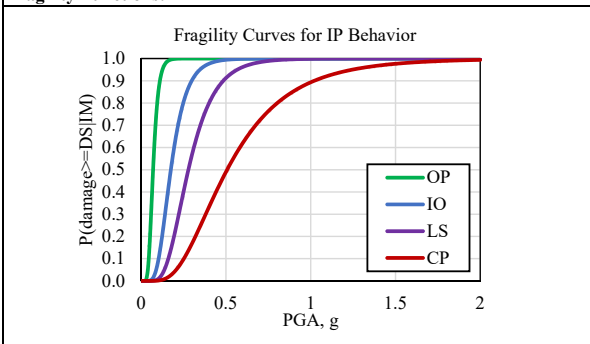
EDP Calculation:



FRAGILITY ASSESSMENT

Integration Methodology:..... Least Square Method

Fragility Functions:



Mean:.....	<u>OP</u>	<u>IO</u>	<u>LS</u>	<u>CP</u>
	0.07	0.17	0.28	0.51
Standard Deviation:..	0.35	0.42	0.43	0.55

Mean:.....	<u>OP</u>	<u>IO</u>	<u>LS</u>	<u>CP</u>
	0.01	0.07	0.08	0.85
Standard Deviation:..	0.45	0.40	0.48	0.55

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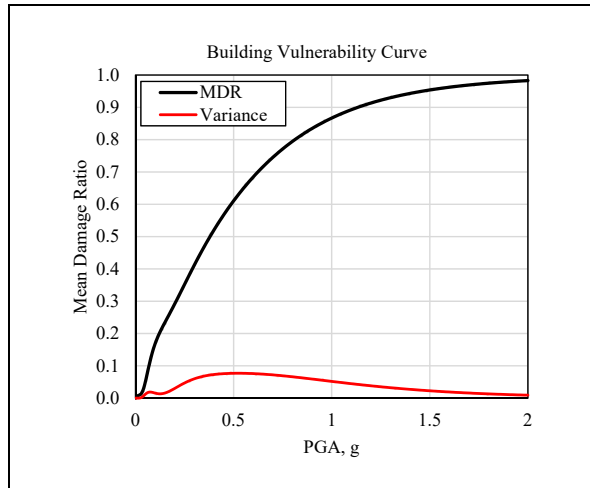
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VULNERABILITY ASSESSMENT

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:.....	Building Taxonomy for LBM and RC School Buildings - GLoSI Technical Report (Deliverable D1)
	FEMA P-695
	ASCE 41-17
	N2 Method (Fajfar, 2000)
	GEM Analytical Vulnerability Assessment Guideline (D'Ayala et al., 2015)
	FUNVUL (www.ecapra.org)