

FRAGILITY/VULNERABILITY ASSESSMENT

Date:	09/12/2018
Building Type:	RM/LR/HD
Authors:	UCL
Sheet:	1 of 4

REINFORCED CONCRETE BLOCK MASONRY INDEX BUILDING

GENERAL INFORMATION

Index Building Taxonomy String:

RM/LR(1)/HD/FD/NI/LP/LO/RF/NP/OS/GC/NN

- | | | | |
|--|---|---|--|
| 1. Main structural system:..... | Reinforced Concrete Block Masonry (RM) | | |
| 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 type="checkbox"/> | Medium (MD) <input type="checkbox"/> High (HD) <input checked="" 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 type="checkbox"/> | Non Vulnerable (NN) <input checked="" type="checkbox"/> | |

INTRINSIC CHARACTERISTICS

General Geometry:

Building Plan Area (m ²):.....	121
Building Total Floor Area (m ²):.....	121
Number of Stories:.....	1
Story Height (m):.....	2.4
Number of Spans in X Direction:.....	3
Typical Span Length in X Direction (m):.....	6
Number of Spans in Y Direction (m):.....	1
Typical Span Length in Y Direction (m):.....	6.7
Wall Thickness (mm):.....	200
Wall Construction:.....	Running Bond
Thickness:.....	Half Brick

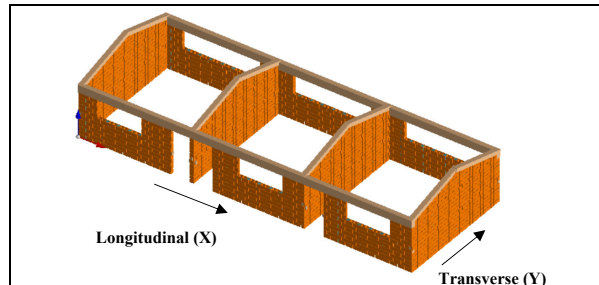
Material Properties:

	Masonry	Grout	Concrete
Unit Weight, γ (kg/m ³):.....	1680	2400	2400
Modulus of Elasticity, E (MPa):.....	8079	21468	22900
Shear Modulus, G (MPa):.....	3284	8587	8587
Compressive Strength, f_m (MPa):.....	9.5	14	21
Cohesion, c (MPa):.....	1.3	1.5	2
Tensile Strength, f_t (MPa):.....	0.63	1.5	2
Friction Coefficient, μ :.....	0.6		

Steel Reinforcement: Yield Strength (MPa) = 280

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/m²):..... 0.3
Design Live Load (L) (kN/m²):..... 0.0
Load Combination for Seismic Analysis:..... D+0.25L
Average Load per Square Meter (kN/m²):..... 0.3

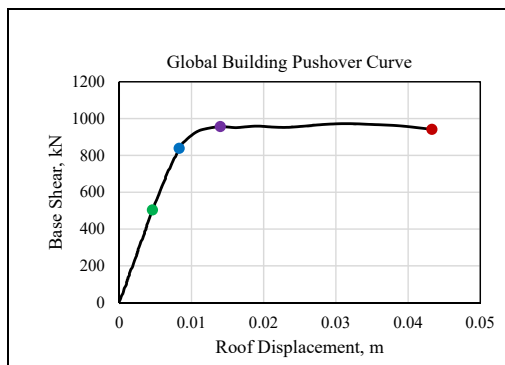
Analysis Considerations:

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

SEISMIC BEHAVIOR

Seismic Weight of IP Walls (kN):.....	520
Fundamental Time Period of IP Walls (sec):.....	0.14

Pushover Curve with Damage State Thresholds:

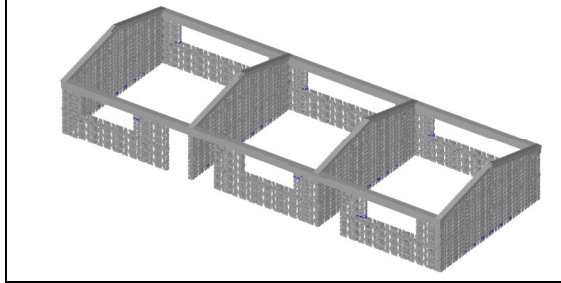


FRAGILITY/VULNERABILITY ASSESSMENT

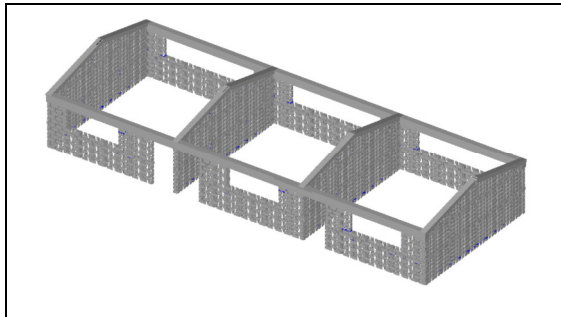
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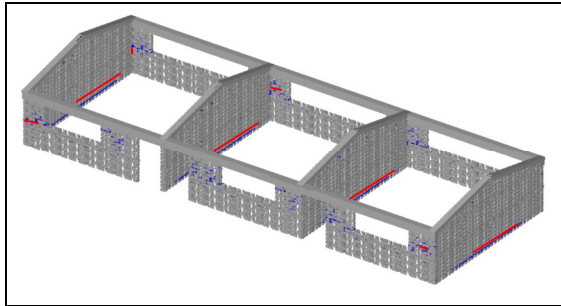
Damage (Crack Pattern, Width and Extent) Progression



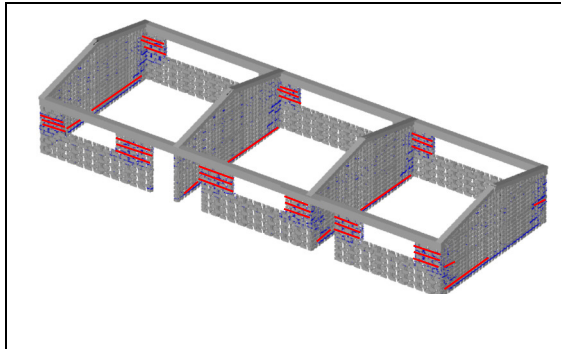
OP Threshold: Hairline cracks (blue) appeared at the bottom of OOP walls, maximum crack width less than 0.5 mm.



IO Threshold: Minor cracks (blue) extended through half of the length of the OOP walls at bottom with a maximum crack opening of 1 mm. Minor shear cracks (blue) started at the corner of openings in IP walls with a maximum crack width of 3 mm.



LS Threshold: Major horizontal bottom crack (red) of maximum opening 2.5 mm developed in OOP walls. Several of the IP piers start to develop extensive shear-flexure cracks (red) of 18 mm maximum width.



CP Threshold: Major horizontal bottom crack (red) of maximum opening 4 mm developed in OOP walls, most of the IP piers develop extensive shear-flexure cracks (red) of 20 mm maximum width.

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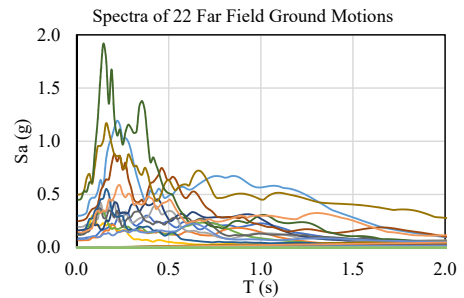
SEISMIC PERFORMANCE ASSESSMENT

Analysis Considerations:

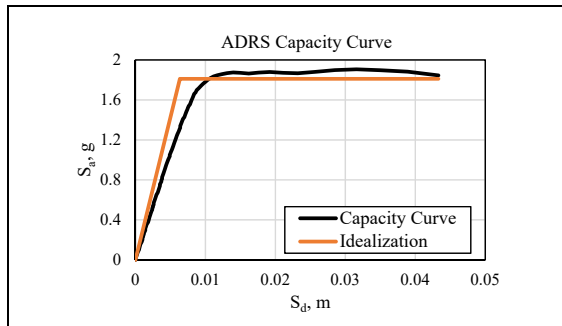
Analysis Methodology:..... Static Analysis (N2 Method)
 Engineering Demand Parameter (EDP):..... Roof Drift

Seismic Ground Motions:

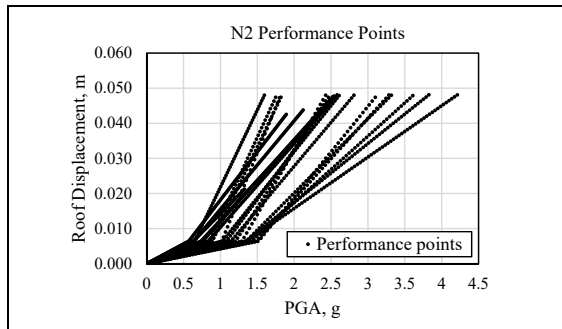
Ground Motion Suite:..... FEMA P695 - 22 Far Field Ground Motions
 Intensity Measure (IM):..... PGA (g)
 Scaling Factor:..... 0.1
 Minimum IM:..... 0
 Maximum IM:..... 4g



Bilinear Idealization:



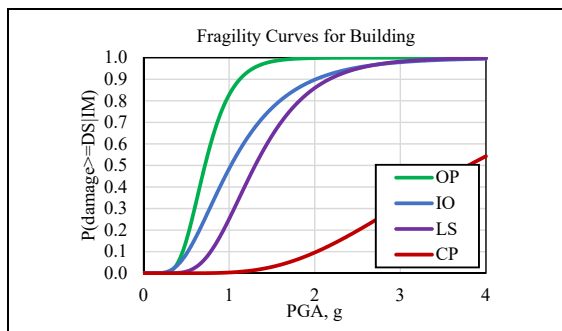
EDP Calculation:



FRAGILITY ASSESSMENT

Integration Methodology:..... Least Square Method

Fragility Functions:



	OP	IO	LS	CP
Mean:.....	0.72	1.02	1.30	3.79
Standard Deviation:.....	0.35	0.53	0.40	0.49

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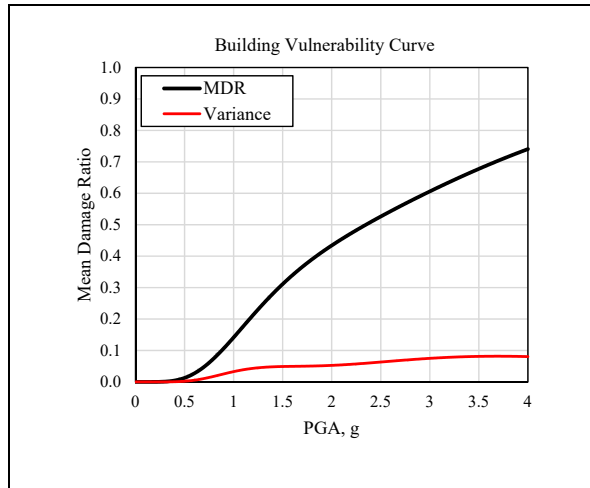
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VULNERABILITY ASSESSMENT

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)