THE WORLD BANK — GFDRR — Universidad de los Andes — UCL

FRAGILITY VULNERABILITY ASSESSMENT

Date:	9/17/2018
Building Type:	**RC1/HR/HD**
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Sheet:	1 de 3

REINFORCED CONCRETE BUILDINGS

GENERAL INFORMATION

Index Building Taxonomy Code: **RC1/HR/HD**/RD/NI/SS/SW/RF/NP/OS/GC/VN

1. Main structural system:……………………………….……	RC1 [X]	RC2 [ ]	RC3 [ ]	RC4 [ ]	RC5 [ ]
2. Height range:……………………...…………………...……	Low (LR) [ ]		Medium (MR) [ ]		High (HR) [X]
3. Seismic design level:…………………………………...……	Poor (PD) [ ]	Low (LD) [ ]	Medium (MD) [ ]		High (HD) [X]
4. Diaphragm Type:……………………………….……	Flexible diaphragm (FD) [ ]		Rigid diaphragm (RD) [X]		
5. Structural Irregularity:…………………….……	No irreg. (NI) [X]	Hor. (HI) [ ]	Vert. (VI) [ ]		Hor. and vert. (HV) [ ]
6. Span Length:………………………………………		Short span (SS) [X]	Slender - weak column (SW) [ ]		
7. Pier Type:……………………………………..…		Regular column (RO) [X]	Regular column (RO) [ ]		
8. Foundation Type and Flexibility:……………………………....		Rigid foundation (RF) [X]	Flexible foundation (FF) [ ]		
9. Seismic Pounding Risk:………………………………….……		No pounding (NP) [X]	Pounding risk (PR) [ ]		
10. Seismic Retrofitting:……………………………….……		Original structure (OS) [X]	Retrofitted structure (RS) [ ]		
11. Structural Health Conditions:……………………………………		Good condition (GC) [X]	Poor condition (PC) [ ]		
12. Vulnerable Non-Structural Components:…………………...……		Non vulnerable (NN) [ ]	Vulnerable (VN) [X]		

INTRINSIC CHARACTERISTICS

General Geometry:

Building plane area (m^2):……………………...……………………...………	630
Building total area (m^2):………………………...……………………...……	3150
Number of stories:……………………………………………...……	5
Story height (m):……………………………………………………	3
Number of spans in X direction:…………………………………	8
Typical span length in X direction (m):………………………………	4.5
Number of spans in Y direction (m):…………………………	4
Typical span length in Y direction (m):………………………	7
Foundation system:………………………………………	CISF
Typical column dimensions (cm x cm):………………………	40X60
Typical beam dimensions (cm x cm):…………………………	40X50
Typical shear wall dimensions (cm x cm):………………………	-
Typical bracing member section (cm x cm):………………………….....	-

Material properties:

Concrete:…………………f'c (MPa):	21	Ec (GPa):	21.5
Reinforcement:……………fy (Mpa):	420	Es (GPa):	200
Structural steel:…………… fy (Mpa):	-	Es (GPa):	-
Masonry:…………………… f'm (MPa):	-	γ:………..	-

Infill walls:

	Interior walls		**Facade walls**	
Infill type:……………………				
Wall height (m):………………...…X	-	Y 3	X 1.5	Y 3
Depth (m):……………………………X	-	Y 0.15	X 0.15	Y 0.15
Isolated from structure:……………..	Yes [X]	No [ ]	Yes [X]	No [ ]

MODELLING PARAMETERS

3D Numerical model:
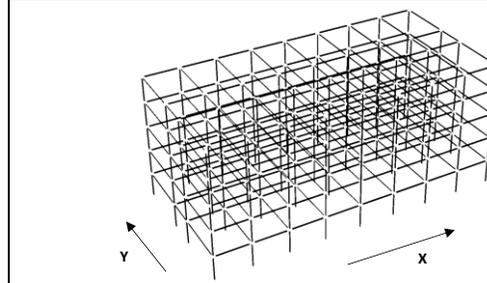
Modelling considerations:

Plasticity model:………………………………	Lumped [X]	Distributed [ ]	
Infill walls modelling approach:………………	-		
Roof Diaphragm:…………………………..	Rigid [X]	Flexible [ ]	
Foundation:…………………………….……..	Rigid [X]	Flexible [ ]	
	kv (kN) ____	kh (kN) ____	kθ (kN) ____

Loads:

Over imposed design dead load (D) (kN/m2):………………………	1.2
Design Live load (L) (kN/m2):…………………..……………………	2.0
Load combination in non-linear analysis:………………………………	D+0.25L
Average load per square meter (kN/m2):……………………………	5.0

Analysis considerations:

Global P-Delta effects:………………………	Yes [X]	No [ ]
Rigid zones:………………..…………………	Yes [X]	No [ ]
Initial effective stiffness:…………………… Beams 0.35	Columns 0.30	
Analysis direction:………………..…………	X [X]	Y [ ]
Analysis orientation:…………….……………	(+) [X]	(-) [ ]

SEISMIC BEHAVIOR

Total weight (D) (kN):…......................……………………....	12960	1st mode mass participation (%):……………………………………	81.9
Total weight (L) (kN):…......................……………………...	2870	First floor column area (m2):……………………………………..	8.64
T$_1$ uncracked (sec):……………………………………………	0.98	Total weight (D+L) /columns area (%f'c):………………………	0.25
T$_1$ cracked (sec):………………………………………………	1.33	Horizontal first story shear column capacity (g):………………	0.45

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REINFORCED CONCRETE BUILDINGS

SEISMIC BEHAVIOR

Capacity Curve:

IBRC-6 (RC1-HR-HD)
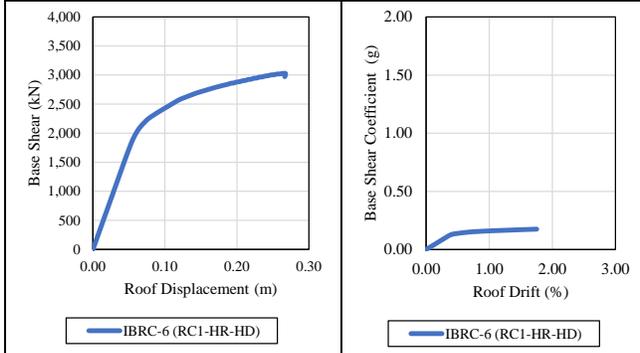
Idealized capacity curve:

Behavior point	Base shear (kN)	Displacement (m)
Yield point:………….…………….	2350	0.06
Maximum capacity:……………….	2932	0.27
Ultimate capacity:……..………….	-	-

Collapse mechanism: Excessive flexibility

IO   LS   CP
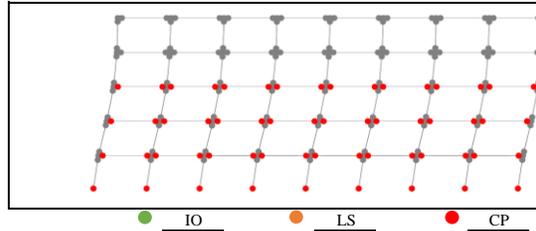
NON-LINEAR ANALYSIS PARAMETERS

Seismic ground motions:

Number of ground motions used:………………………….	22
Soil type:………………………………………………….	C
Source type:……………………………………………….	Far field
Retrieved from:……………………………….…………….	PEER-NGA

Analysis considerations:

Non-linear analysis:………………………………	Static [X] Dynamic [ ]
Analysis methodology:………………………………	N2
Intensity measure parameter (IM):……………………	Sa[T] (g)

Scaling factor: 0.1   Minimum: 0.1   Maximum: 2

Ground motion spectra:
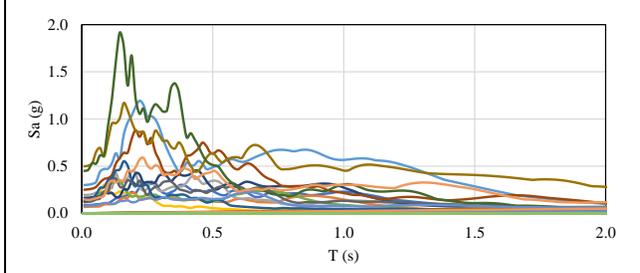
Illustrative EDP:
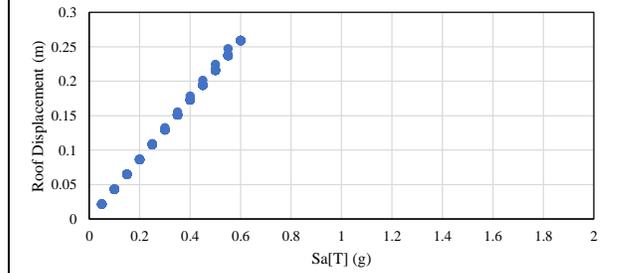
FRAGILITY ASSESSMENT

Damage states (DS):

Intensity Measure:….………………………………….	Sa[T] (g)
Slight (SD) -Operational (OP) (%):……………………	0.70
Medium (MD) - Immediate occupancy (IO) (%):………	1.20
Extensive (ED) - Life safety (LS) (%):…………………	1.60
Collapse (CD) - Collapse prevention (CP) (%): ……….	2.00
Integration methodology:………………………………	LSM

	OP	IO	LS	CP:
Mean:………………	0.25	0.43	0.58	0.76
Deviation:……………	0.15	0.17	0.22	0.30

Fragility function:
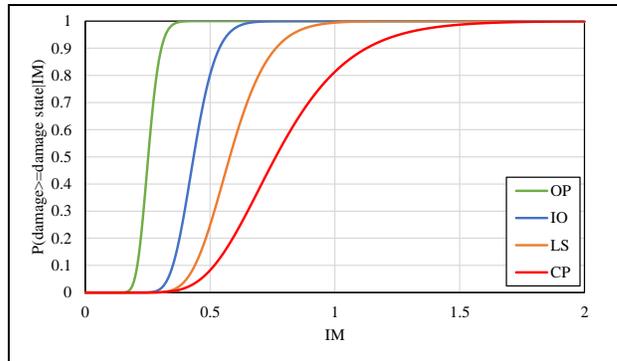
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VULNERABILITY ASSESSMENT

Component model:

Story	Group	Subgroup	Description	Unit	Quantity	Fragility curve	EDP	Correlation
1	E	C1	Column-one beam	Node	8	B1041.001a	Drift	0
1	E	C2	Column-two beams	Node	21	B1041.001b	Drift	0
1	A	F2	Masorny facade	5m x 3m	14	C1011.001a	Drift	1
1	A	M4	Masonry wall	5m x 3m	6	C1011.001a	Drift	1
1	C	S2	Contents	5m x 5m	13	E2022.010a	Drift	0
2	E	C1	Column-one beam	Node	8	B1041.001a	Drift	0
2	E	C2	Column-two beams	Node	21	B1041.001b	Drift	0
2	A	F2	Masorny facade	5m x 3m	14	C1011.001a	Drift	1
2	A	M4	Masonry wall	5m x 3m	6	C1011.001a	Drift	1
2	C	S2	Contents	5m x 5m	13	E2022.010a	Drift	0
2	E	C1	Column-one beam	Node	8	B1041.001a	Drift	0
2	E	C2	Column-two beams	Node	21	B1041.001b	Drift	0
2	A	F2	Masorny facade	5m x 3m	14	C1011.001a	Drift	1
2	A	M4	Masonry wall	5m x 3m	6	C1011.001a	Drift	1
2	C	S2	Contents	5m x 5m	13	E2022.010a	Drift	0
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2	E	C2	Column-two beams	Node	21	B1041.001b	Drift	0
2	A	F2	Masorny facade	5m x 3m	14	C1011.001a	Drift	1
2	A	M4	Masonry wall	5m x 3m	6	C1011.001a	Drift	1
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2	E	C1	Column-one beam	Node	8	B1041.001a	Drift	0
2	E	C2	Column-two beams	Node	21	B1041.001b	Drift	0
2	A	F2	Masorny facade	5m x 3m	14	C1011.001a	Drift	1
2	A	M4	Masonry wall	5m x 3m	6	C1011.001a	Drift	1
2	C	S2	Contents	5m x 5m	13	E2022.010a	Drift	0

Phase I:

Beta model uncertainty:……………………………………..………………… 0.3

Number of iteration for model uncertainty:………..……………………… 20

Number of iterations for damage states uncertainty:…………………… 20

Number of iterations for cost and time uncertainty:…………………… 20

Scale factor for cost:……………………………………… Yes ☐ No ☒

Phase II:

Lower intensity to no damage (g/g):……………………………………… 0.1

Maximum allowable residual drift for demolition (%):………………………… 1.5

Percentage of building replacement value (%):……………………………… 100

Bidirectional factor for total cost model:………………………………… 1

Intensity level for building evacuation (g/g):………………………………… 2

Vulnerability function:
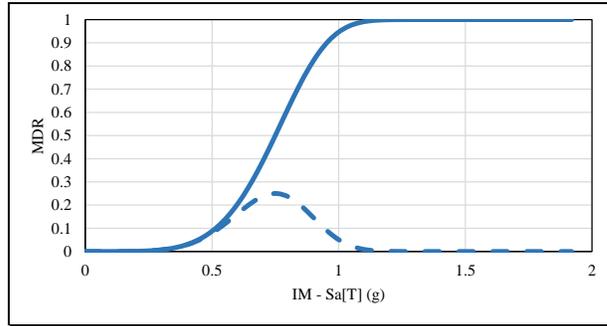
Fragility to vulnerability weighting percentage:

OP (%):	0	IO (%):	10	LS (%):	50	CP (%):	100

GLOSARY

f'c:	Compressive concrete strength	kv:	Spring vertical stiffness	IM:	Intensity measure
Ec:	Concrete elastic module	kh:	Spring horizontal stiffness	DM:	Damage states
fy:	Tensile steel strength	kθ:	Spring rotational stiffness	OP:	Operational
Es:	Steel elastic module	D:	Death load	IO:	Immediate occupancy
f'm:	Masonry compressive strength	L:	Live load	LS:	Life safety
γ:	Masonry density	T1:	First mode period	CP:	Collapse prevention
CISF:	Concrete isolated spread footing	Sa:	Pseudo acceleration	EDP:	Engineering demand parameters

Horizontal first story shear column capacity (g) = $(\sqrt{f'c}/6)*(A\_col/W)$

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)