FRAGILITY VULNERABILITY ASSESSMENT

Date:	9/17/2018
Building Type:	**RC3/HR/PD**
Author:	UNIANDES
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REINFORCED CONCRETE BUILDINGS

GENERAL INFORMATION

Index Building Taxonomy Code: **RC3/HR/PD**/RD/NI/SS/SW/RF/NP/OS/GC/VN

1. Main structural system:…………………………………………………. RC1 [ ] RC2 [ ] RC3 [X] RC4 [ ] RC5 [ ]
2. Height range:…………………………...……………………...………. Low (LR) [ ] Medium (MR) [ ] High (HR) [X]
3. Seismic design level:…………………...……………………………. Poor (PD) [X] Low (LD) [ ] Medium (MD) [ ] High (HD) [ ]
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):…………..…………………………..	3
Typical span length in Y direction (m):…………...……………………….	7
Foundation system:………………………………………………………….	CISF
Typical column dimensions (cm x cm):……………………………….	25X30
Typical beam dimensions (cm x cm):…………….………………………….	20X30
Typical shear wall dimensions (cm x cm):……………………………...…….	-
Typical bracing member section (cm x cm):……………………...………..	-

Material properties:

Concrete:……………………. f'c (MPa):	17	Ec (GPa):	19
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 [X]	

MODELLING PARAMETERS

3D Numerical model:
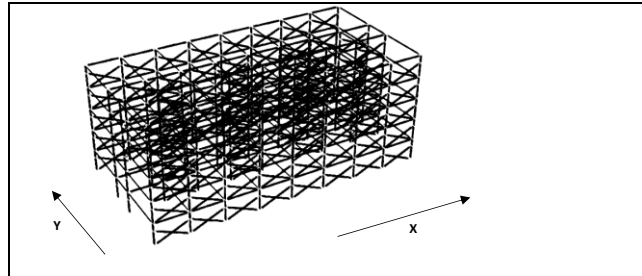
Modelling considerations:

Plasticity model:…………………………………	Lumped [X]	Distributed [ ]
Infill walls modelling approach:………………	Equivalent frame	
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):…………………..…………………………	1.0
Load combination in non-linear analysis:………………………….……	D+0.25L
Average load per square meter (kN/m2):……………………………...…	5.5

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):…....................……………...........	14610	1st mode mass participation (%):………………………………....	87.54
Total weight (L) (kN):…....................……………...........	2841	First floor column area (m2):………………………………...……	2.7
T$_1$ uncracked (sec):……………………...……………….	0.245	Total weight (D+L) /columns area (%f'c):………………………..	38.02
T$_1$ cracked (sec):………......................…………........	0.27	Horizontal first story shear column capacity (g):………………….	0.106

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SEISMIC BEHAVIOR

Capacity Curve:

IBRC-16 (RC3-HR-PD)

IBRC-16 (RC3-HR-PD)
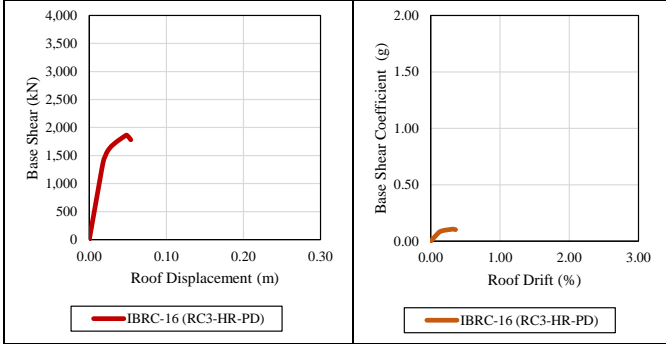
Idealized capacity curve:

Behavior point	Base shear (kN)	Displacement (m)
Yield point:……………..………………	1425	0.019
Maximum capacity:……………………	1830	0.0510
Ultimate capacity:……...……………	-	-

Collapse mechanism: Short column

● IO   ● LS   ● CP
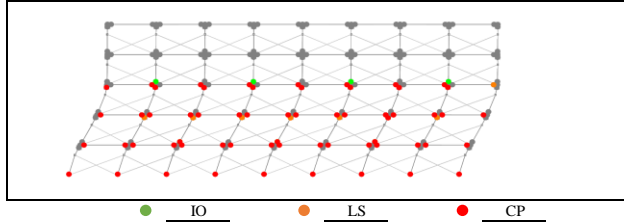
NON-LINEAR ANALYSIS PARAMETERS

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:
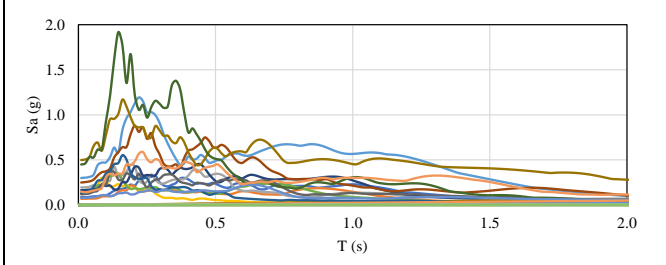
Illustrative EDP:
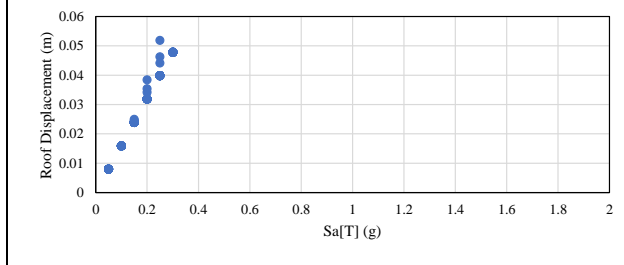
FRAGILITY ASSESSMENT

Damage states (DS):

Intensity Measure:…..………………………………..	Sa[T] (g)
Slight (SD) -Operational (OP) (%):…………………………	0.15
Medium (MD) - Immediate occupancy (IO) (%):………...…	0.20
Extensive (ED) - Life safety (LS) (%):……………………	0.27
Collapse (CD) - Collapse prevention (CP) (%): ……………	0.33
Integration methodology:…………………………………	LSM

	OP	IO	LS	CP:
Mean:…………………	0.14	0.19	0.26	0.32
Deviation:……………	0.10	0.11	0.11	0.21

Fragility function:
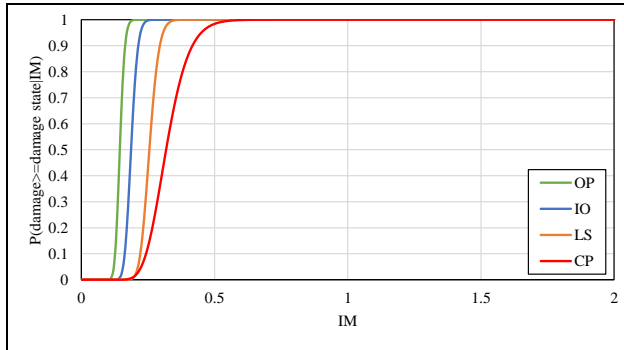
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VULNERABILITY ASSESSMENT

Component model:

Story	Group	Subgroup	Description	Unit	Quantity	Fragility curve	EDP	Correlation
1	E	C1	Column-one beam	Node	8	B1041.091a	Drift	0
1	E	C2	Column-two beams	Node	21	B1041.091b	Drift	0
1	A	F2	Masorny facade	5m x 3m	14	C1011.006a	Drift	1
1	A	M4	Masonry wall	5m x 3m	6	C1011.006b	Drift	1
1	C	S2	Contents	5m x 5m	13	E2022.010a	Drift	0
2	E	C1	Column-one beam	Node	8	B1041.091a	Drift	0
2	E	C2	Column-two beams	Node	21	B1041.091b	Drift	0
2	A	F2	Masorny facade	5m x 3m	14	C1011.006a	Drift	1
2	A	M4	Masonry wall	5m x 3m	6	C1011.006b	Drift	1
2	C	S2	Contents	5m x 5m	13	E2022.010a	Drift	0
3	E	C1	Column-one beam	Node	8	B1041.091a	Drift	0
3	E	C2	Column-two beams	Node	21	B1041.091b	Drift	0
3	A	F2	Masorny facade	5m x 3m	14	C1011.006a	Drift	1
3	A	M4	Masonry wall	5m x 3m	6	C1011.006b	Drift	1
3	C	S2	Contents	5m x 5m	13	E2022.010a	Drift	0
4	E	C1	Column-one beam	Node	8	B1041.091a	Drift	0
4	E	C2	Column-two beams	Node	21	B1041.091b	Drift	0
4	A	F2	Masorny facade	5m x 3m	14	C1011.006a	Drift	1
4	A	M4	Masonry wall	5m x 3m	6	C1011.006b	Drift	1
4	C	S2	Contents	5m x 5m	13	E2022.010a	Drift	0
5	E	C1	Column-one beam	Node	8	B1041.091a	Drift	0
5	E	C2	Column-two beams	Node	21	B1041.091b	Drift	0
5	A	F2	Masorny facade	5m x 3m	14	C1011.006a	Drift	1
5	A	M4	Masonry wall	5m x 3m	6	C1011.006b	Drift	1
5	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)