

FRAGILITY VULNERABILITY ASSESSMENT

Date: 9/17/2018
Building Type: RC4/HR/LD
Author: UNIANDES
Sheet: 1 de 3

REINFORCED CONCRETE BUILDINGS

GENERAL INFORMATION

Index Building Taxonomy Code:

1. Main structural system:.....
2. Height range:.....
3. Seismic design level:.....
4. Diaphragm Type:.....
5. Structural Irregularity:.....
6. Span Length:.....
7. Pier Type:.....
8. Foundation Type and Flexibility:.....
9. Seismic Pounding Risk:.....
10. Seismic Retrofitting:.....
11. Structural Health Conditions:.....
12. Vulnerable Non-Structural Components:.....

RC4/HR/LD/RD/NI/SS/SW/RF/NP/OS/GC/VN

RC1 ☐	RC2 ☐	RC3 ☐	RC4 ☒	RC5 ☐
	Low (LR) ☐		Medium (MR) ☐	High (HR) ☒
Poor (PD) ☐	Low (LD) ☒		Medium (MD) ☐	High (HD) ☐
	Flexible diaphragm (FD) ☐		Rigid diaphragm (RD) ☒	
No irreg. (NI) ☒	Hor. (HD) ☐	Vert. (VD) ☐		Hor. and vert. (HV) ☐
	Short span (SS) ☒		Slender - weak column (SW) ☐	
	Regular column (RO) ☒		Regular column (RO) ☐	
	Rigid foundation (RF) ☒		Flexible foundation (FF) ☐	
	No pounding (NP) ☒		Pounding risk (PR) ☐	
	Original structure (OS) ☒		Retrofitted structure (RS) ☐	
	Good condition (GC) ☒		Poor condition (PC) ☐	
	Non vulnerable (NN) ☐		Vulnerable (VN) ☒	

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):.....	35X35
Typical beam dimensions (cm x cm):.....	35X40
Typical shear wall dimensions (cm x cm):.....	450X15
Typical bracing member section (cm x cm):.....	-

Material properties:

Concrete:..... f _c (MPa):	21	Ec (GPa):	21.5
Reinforcement:..... f _y (Mpa):	420	Es (GPa):	200
Structural steel:..... f _y (Mpa):	-	Es (GPa):	-
Masonry:..... f _m (MPa):	-	γ:.....	-

Infill walls:

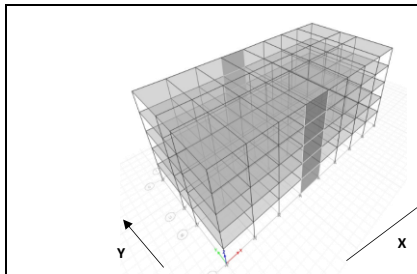
Infill type:.....	Interior walls	Facade walls
Wall height (m):..... X ☐ - Y ☐ 3	X ☐ 1.5 Y ☐ 3	X ☐ 1.5 Y ☐ 3
Depth (m):..... X ☐ - Y ☐ 0.15	X ☐ 0.15 Y ☐ 0.15	X ☐ 0.15 Y ☐ 0.15
Isolated from structure:..... Yes ☒ No ☐	Yes ☒ No ☐	Yes ☒ No ☐

SEISMIC BEHAVIOR

Total weight (D) (kN):.....	17139
Total weight (L) (kN):.....	6048
T ₁ uncracked (sec):.....	0.43
T ₁ cracked (sec):.....	0.62

MODELLING PARAMETERS

3D Numerical model:



Modelling considerations:

Plasticity model:.....	Lumped ☒	Distributed ☐
Infill walls modelling approach:.....	-	
Roof Diaphragm:.....	Rigid ☒	Flexible ☐
Foundation:.....	Rigid ☒	Flexible ☐
	kv (kN) _____	kh (kN) _____ kθ (kN) _____

Loads:

Over imposed design dead load (D) (kN/m ²):.....	1.2
Design Live load (L) (kN/m ²):.....	2.0
Load combination in non-linear analysis:.....	D+0.25L
Average load per square meter (kN/m ²):.....	7.4

Analysis considerations:

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

1st mode mass participation (%):.....	69.2
First floor column area (m ²):.....	4.41
Total weight (D+L) /columns area (%f _c):.....	0.53
Horizontal first story shear column capacity (g):.....	0.40

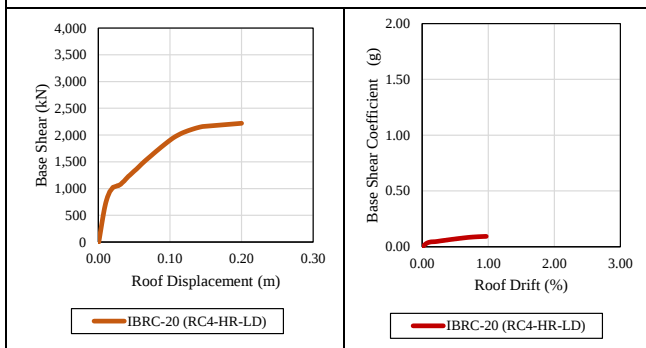
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SEISMIC BEHAVIOR

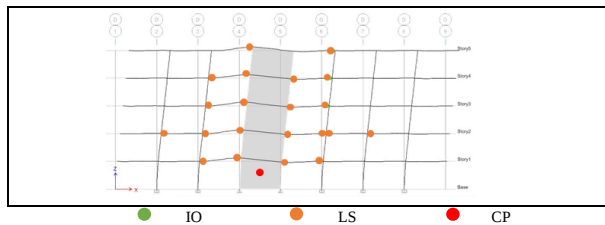
Capacity Curve:



Idealized capacity curve:

Behavior point	Base shear (kN)	Displacement (m)
Yield point:.....	1500	0.02
Maximum capacity:.....	3330	0.28
Ultimate capacity:.....	-	-

Collapse mechanism: Shear wall failure



NON-LINEAR ANALYSIS PARAMETERS

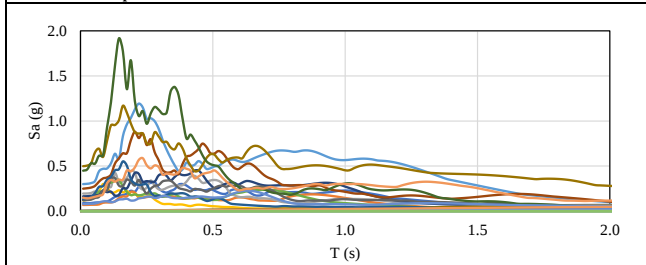
Seismic ground motions:

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

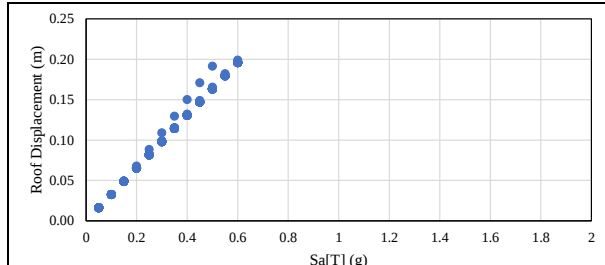
Analysis considerations:

Non-linear analysis: Static ☒ 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

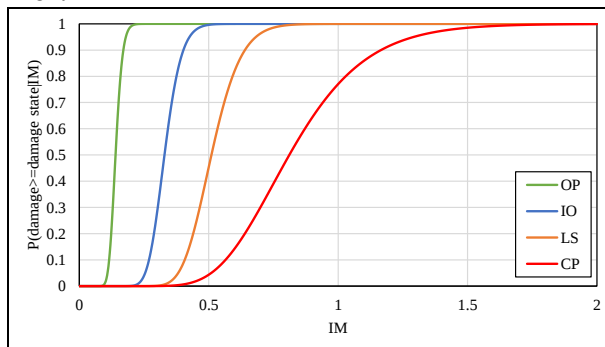
Damage states (DS):

Intensity Measure: Sa[T] (g)
Slight (SD) - Operational (OP) (%): 0.3
Medium (MD) - Immediate occupancy (IO) (%): 0.7
Extensive (ED) - Life safety (LS) (%): 1.1
Collapse (CD) - Collapse prevention (CP) (%): 1.5

Integration methodology: LSM

	OP	IO	LS	CP:
Mean:.....	0.14	0.329	0.51	0.811
Deviation:.....	0.152	0.157	0.176	0.283

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	Masonry 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	Masonry 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
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	Masonry 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
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	Masonry facade	5m x 3m	14	C1011.006a	Drift	1
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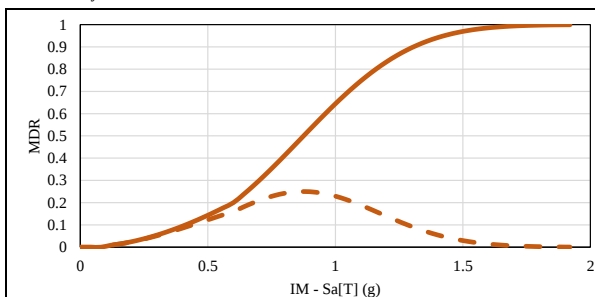
Phase I:

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 (%):	20	LS (%):	60	CP (%):	100
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GLOSARY

fc: 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
fm: 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) = $(\sqrt{f_c}/6) \cdot (A_{col}/W)$

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)