FRAGILITY VULNERABILITY ASSESSMENT

Date:	9/17/2018
Building Type:	**RC2/HR/HD**
Author:	UNIANDES
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REINFORCED CONCRETE BUILDINGS

GENERAL INFORMATION

Index Building Taxonomy Code: **RC2/HR/LD**/RD/NI/SS/SW/RF/NP/OS/GC/VN

1. Main structural system:	RC1		RC2	X	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):	3
Typical span length in Y direction (m):	7
Foundation system:	CISF
Typical column dimensions (cm x cm):	35x55
Typical beam dimensions (cm x cm):	30x40
Typical shear wall dimensions (cm x cm):	-
Typical bracing member section (cm x cm):	-

Material properties:

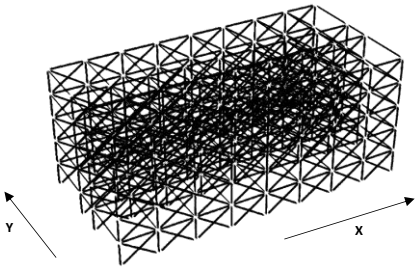
Concrete:	f'c (MPa):	21	Ec (GPa):	21.5
Reinforcement:	fy (Mpa):	420	Es (GPa):	200
Structural steel:	fy (Mpa):	-	Es (GPa):	-
Masonry:	f'm (MPa):	-	γ:	-

Infill walls:

Infill type:	Interior walls				Facade walls			
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):	2.0
Load combination in non-linear analysis:	D+0.25L
Average load per square meter (kN/m2):	8.2

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):	19064.78	1st mode mass participation (%):	87.21
Total weight (L) (kN):	6662	First floor column area (m2):	6.16
T_1 uncracked (sec):	0.25	Total weight (D+L) /columns area (%f'c):	19.88
T_1 cracked (sec):	0.28	Horizontal first story shear column capacity (g):	0.545

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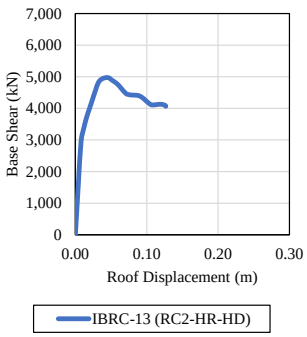
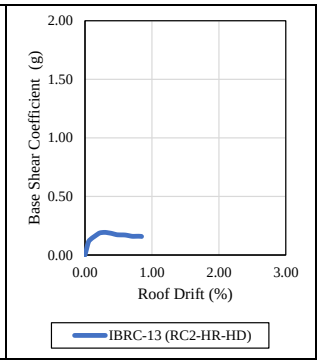
SEISMIC BEHAVIOR

Capacity Curve:

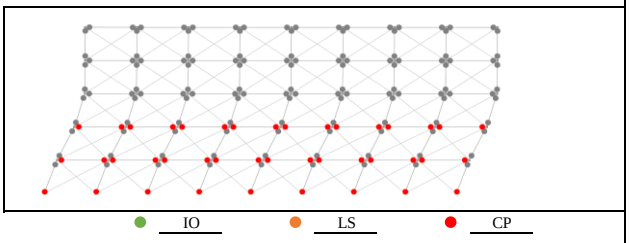




Idealized capacity curve:

Behavior point	Base shear (kN)	Displacement (m)
Yield point:……	2953.5	0.008
Maximum capacity:……	4972.3	0.0460
Ultimate capacity:……	4065.5	0.127

Collapse mechanism: Soft story



NON-LINEAR ANALYSIS PARAMETERS

Seismic ground motions:

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

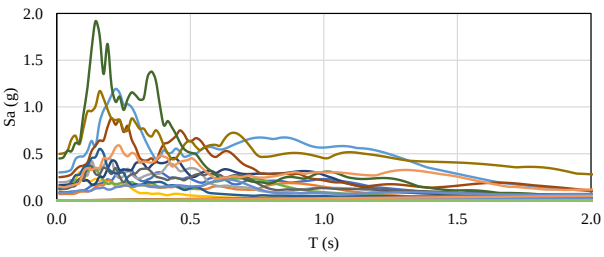
Analysis considerations:

Non-linear analysis:…… Static [X] Dynamic [ ]

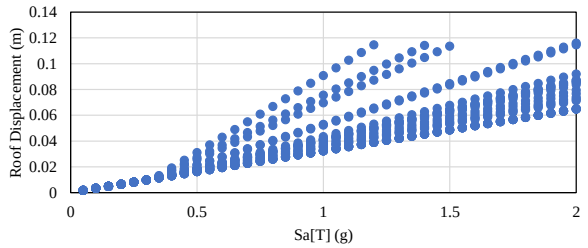
Analysis methodology:……	N2
Intensity measure parameter (IM):……	Sa[T] (g)

Scaling factor: 0.1 Minimum: 0.1 Maximum: 2

Ground motion spectra:



Illustrative EDP:



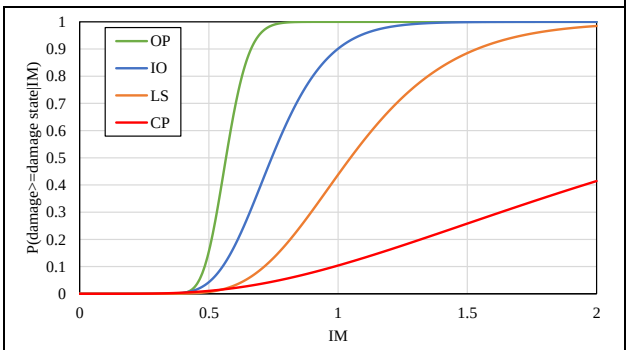
FRAGILITY ASSESSMENT

Damage states (DS):

Intensity Measure:……	Sa[T] (g)
Slight (SD) -Operational (OP) (%):……	0.13
Medium (MD) - Immediate occupancy (IO) (%):……	0.19
Extensive (ED) - Life safety (LS) (%):……	0.29
Collapse (CD) - Collapse prevention (CP) (%): ……	0.50
Integration methodology:……	LSM

	OP	IO	LS	CP:
Mean:……	0.57	0.74	1.05	2.31
Deviation:……	0.12	0.23	0.30	0.66

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

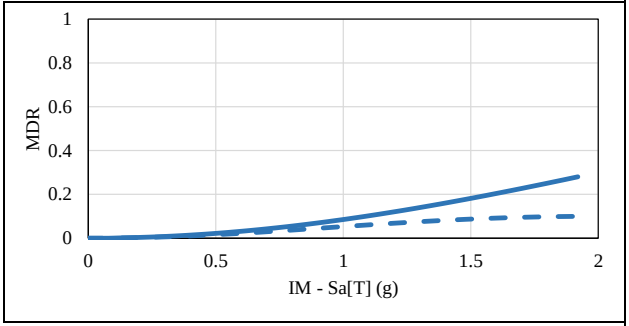
Phase I:

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 (%):	IO (%):	LS (%):	CP (%):
0	10	50	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) = (√(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)