FRAGILITY VULNERABILITY ASSESSMENT

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

REINFORCED CONCRETE BUILDINGS

GENERAL INFORMATION

Index Building Taxonomy Code: **RC4/HR/HD**/RD/NI/SS/SW/RF/NP/OS/GC/VN

1. Main structural system:	RC1		RC2		RC3		RC4	X	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):	450X20
Typical bracing member section (cm x cm):	-

Material properties:

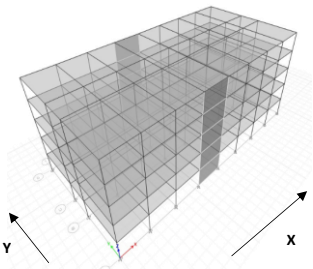
Concrete:	f'c (MPa):	21	Ec (GPa):	21.5
Reinforcement:	fy (Mpa):	420	Es (GPa):	200
Structural steel:	fy (Mpa):	-	Es (GPa):	-
Masonry:	f'm (MPa):	-	γ:	-

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	

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	

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):	8.0

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	(-)		

kv (kN) _____ kh (kN) _____ kθ (kN) _____

SEISMIC BEHAVIOR

Total weight (D) (kN):	19136	1st mode mass participation (%):	70
Total weight (L) (kN):	6048	First floor column area (m2):	8.64
T_1 uncracked (sec):	0.39	Total weight (D+L) /columns area (%f'c):	0.29
T_1 cracked (sec):	0.55	Horizontal first story shear column capacity (g):	0.68

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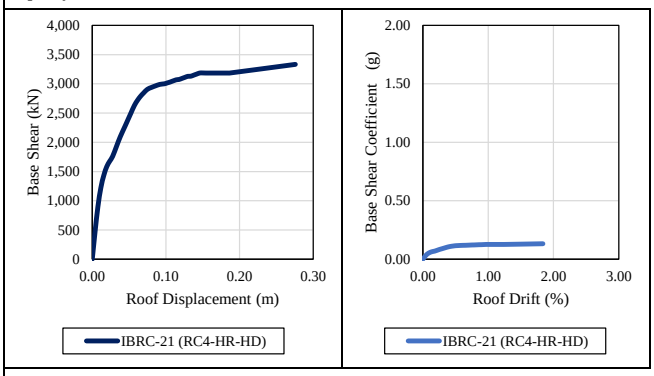
SEISMIC BEHAVIOR

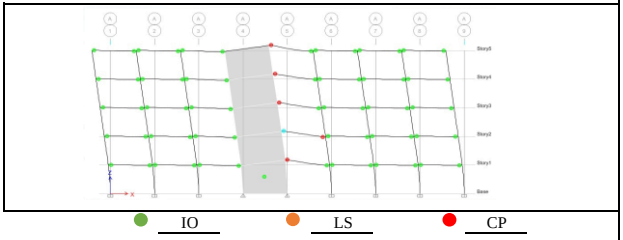
Capacity Curve:



Idealized capacity curve:

Behavior point	Base shear (kN)	Displacement (m)
Yield point:	1650	0.03
Maximum capacity:	3410	0.28
Ultimate capacity:	-	-

Collapse mechanism: Shear wall failure



NON-LINEAR ANALYSIS PARAMETERS

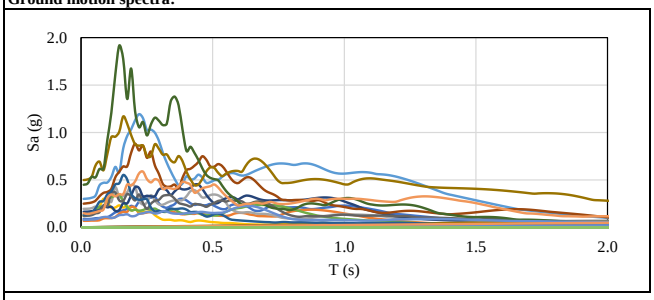
Seismic ground motions:

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

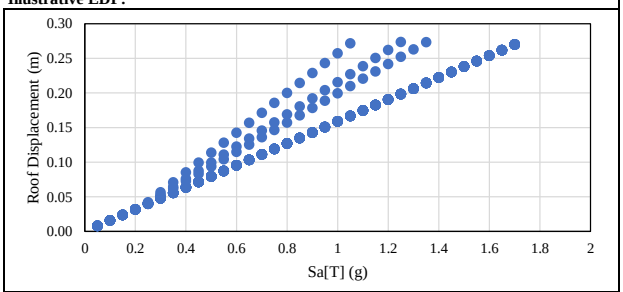
Analysis considerations:

Non-linear analysis:	Static [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:



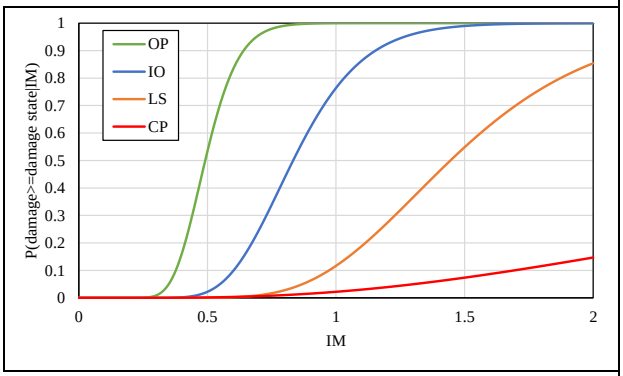
FRAGILITY ASSESSMENT

Damage states (DS):

Intensity Measure:	Sa[T] (g)
Slight (SD) -Operational (OP) (%):	0.50
Medium (MD) - Immediate occupancy (IO) (%):	0.90
Extensive (ED) - Life safety (LS) (%):	1.50
Collapse (CD) - Collapse prevention (CP) (%):	2.20
Integration methodology:	LSM

	OP	IO	LS	CP:
Mean:	0.49	0.83	1.45	4.23
Deviation:	0.21	0.25	0.31	0.72

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
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
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:

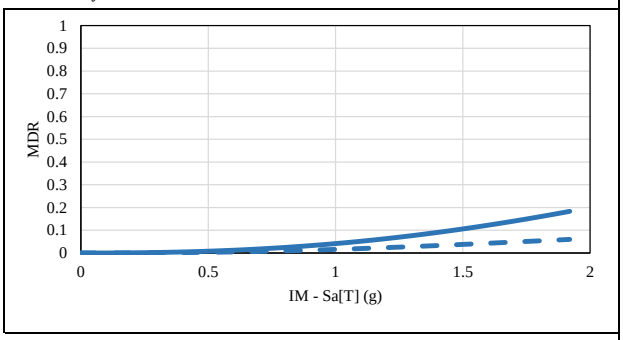
Beta model uncertainty:……	0.3
Number of iteration for model uncertainty:……	20
Number of iterations for damage states uncertainty:……	20
Number of iterations for cost and time uncertainty:……	20

Scale factor for cost:…… Yes [ ] No [X]

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

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)