

FRAGILITY VULNERABILITY ASSESSMENT

Date: 9/17/2018
Building Type: **RC1/HR/PD**
Author: UNIANDES
Sheet: 1 de 3

REINFORCED CONCRETE BUILDINGS

GENERAL INFORMATION

Index Building Taxonomy Code:

- Main structural system:.....
- Height range:.....
- Seismic design level:.....
- Diaphragm Type:.....
- Structural Irregularity:.....
- Span Length:.....
- Pier Type:.....
- Foundation Type and Flexibility:.....
- Seismic Pounding Risk:.....
- Seismic Retrofitting:.....
- Structural Health Conditions:.....
- Vulnerable Non-Structural Components:.....

RC1/HR/PD/RD/NI/SS/SW/RF/NP/OS/GC/VN

RC1	<input checked="" type="checkbox"/>	RC2	<input type="checkbox"/>	RC3	<input type="checkbox"/>	RC4	<input type="checkbox"/>	RC5	<input type="checkbox"/>
		Low (LR)	<input type="checkbox"/>			Medium (MR)	<input type="checkbox"/>	High (HR)	<input checked="" type="checkbox"/>
Poor (PD)	<input checked="" type="checkbox"/>	Low (LD)	<input type="checkbox"/>			Medium (MD)	<input type="checkbox"/>	High (HD)	<input type="checkbox"/>
		Flexible diaphragm (FD)	<input type="checkbox"/>			Rigid diaphragm (RD)	<input checked="" type="checkbox"/>		
No irreg. (NI)	<input checked="" type="checkbox"/>	Hor. (HI)	<input type="checkbox"/>	Vert. (VI)	<input type="checkbox"/>			Hor. and vert. (HV)	<input type="checkbox"/>
		Short span (SS)	<input checked="" type="checkbox"/>			Slender - weak column (SW)	<input type="checkbox"/>		
		Regular column (RO)	<input checked="" type="checkbox"/>			Regular column (RO)	<input type="checkbox"/>		
		Rigid foundation (RF)	<input checked="" type="checkbox"/>			Flexible foundation (FF)	<input type="checkbox"/>		
		No pounding (NP)	<input checked="" type="checkbox"/>			Pounding risk (PR)	<input type="checkbox"/>		
		Original structure (OS)	<input checked="" type="checkbox"/>			Retrofitting structure (RS)	<input type="checkbox"/>		
		Good condition (GC)	<input checked="" type="checkbox"/>			Poor condition (PC)	<input type="checkbox"/>		
		Non vulnerable (NN)	<input type="checkbox"/>			Vulnerable (VN)	<input checked="" type="checkbox"/>		

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):.....	25X25
Typical beam dimensions (cm x cm):.....	20X30
Typical shear wall dimensions (cm x cm):.....	-
Typical bracing member section (cm x cm):.....	-

Material properties:

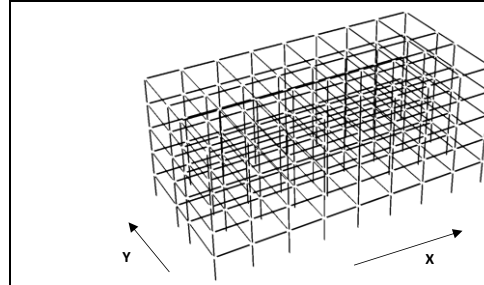
Concrete:..... f _c (MPa):	17	Ec (GPa):	19
Reinforcement:..... f _y (Mpa):	420	Es (GPa):	200
Structural steel:..... f _y (Mpa):	-	Es (GPa):	-
Masonry:..... f _m (MPa):	-	γ:	-

Infill walls:

Infill type:.....	Interior walls	Facade walls
Wall height (m):..... X	- Y <input type="checkbox"/> 3 <input type="checkbox"/>	X <input type="checkbox"/> 1.5 Y <input type="checkbox"/> 3 <input type="checkbox"/>
Depth (m):..... X	- Y <input type="checkbox"/> 0.15 <input type="checkbox"/>	X <input type="checkbox"/> 0.15 Y <input type="checkbox"/> 0.15 <input type="checkbox"/>
Isolated from structure:.....	Yes <input checked="" type="checkbox"/> No <input type="checkbox"/>	Yes <input checked="" type="checkbox"/> No <input type="checkbox"/>

MODELLING PARAMETERS

3D Numerical model:



Modelling considerations:

Plasticity model:.....	Lumped <input checked="" type="checkbox"/>	Distributed <input type="checkbox"/>
Infill walls modelling approach:.....	-	
Roof Diaphragm:.....	Rigid <input checked="" type="checkbox"/>	Flexible <input type="checkbox"/>
Foundation:.....	Rigid <input checked="" type="checkbox"/>	Flexible <input type="checkbox"/>
	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):.....	1.0
Load combination in non-linear analysis:.....	D+0.25L
Average load per square meter (kN/m ²):.....	4.9

Analysis considerations:

Global P-Delta effects:.....	Yes <input checked="" type="checkbox"/>	No <input type="checkbox"/>
Rigid zones:.....	Yes <input checked="" type="checkbox"/>	No <input type="checkbox"/>
Initial effective stiffness:.....	Beams <input type="checkbox"/> 0.35 <input type="checkbox"/>	Columns <input type="checkbox"/> 0.30 <input type="checkbox"/>
Analysis direction:.....	X <input checked="" type="checkbox"/>	Y <input type="checkbox"/>
Analysis orientation:.....	(+) <input checked="" type="checkbox"/>	(-) <input type="checkbox"/>

SEISMIC BEHAVIOR

Total weight (D) (kN):.....	12760	1st mode mass participation (%):.....	81.9
Total weight (L) (kN):.....	2831	First floor column area (m ²):.....	2.25
T ₁ uncracked (sec):.....	2.32	Total weight (D+L) / columns area (%f _c):.....	0.69
T ₁ cracked (sec):.....	2.49	Horizontal first story shear column capacity (g):.....	0.09

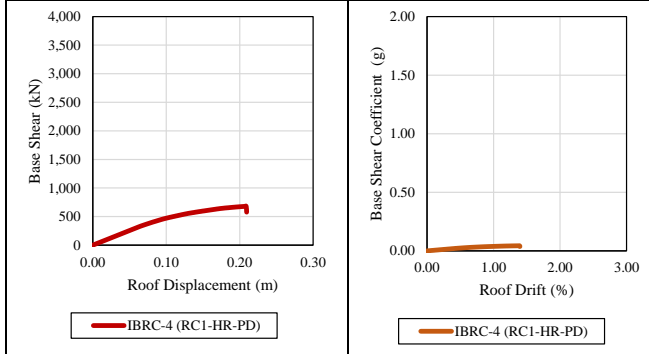
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Sheet:	2 de 3

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SEISMIC BEHAVIOR

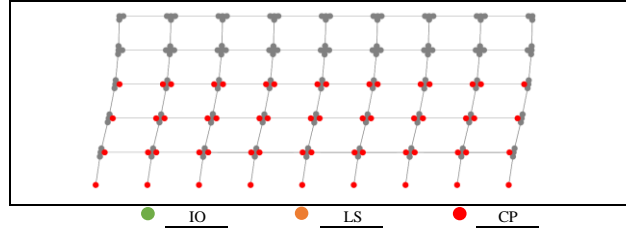
Capacity Curve:



Idealized capacity curve:

Behavior point	Base shear (kN)	Displacement (m)
Yield point:.....	500	0.09
Maximum capacity:.....	610	0.21
Ultimate capacity:.....	-	-

Collapse mechanism: Excessive flexibility



NON-LINEAR ANALYSIS PARAMETERS

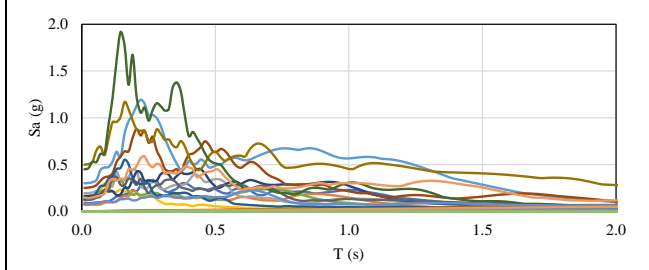
Seismic ground motions:

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

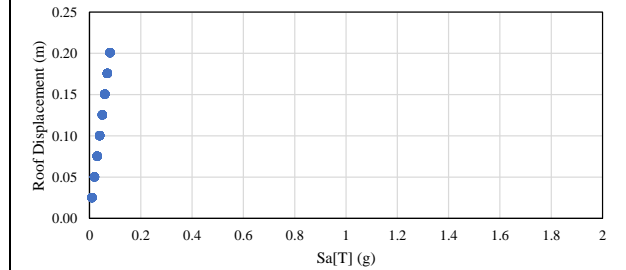
Analysis considerations:

Non-linear analysis:.....	Static <input checked="" type="checkbox"/>	Dynamic <input type="checkbox"/>
Analysis methodology:.....	N2	
Intensity measure parameter (IM):.....	Sa[T] (g)	
Scaling factor:.....	0.1	Minimum: 0.1 Maximum: 2

Ground motion spectra:



Illustrative EDP:



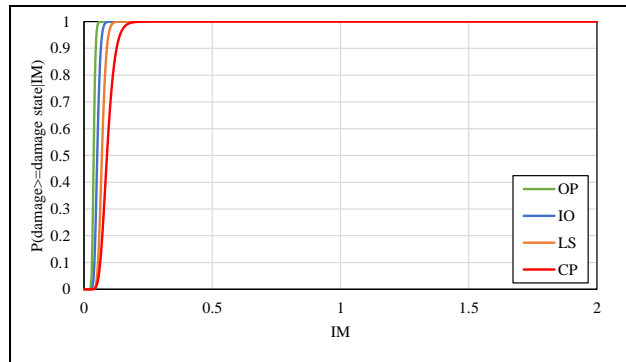
FRAGILITY ASSESSMENT

Damage states (DS):

Intensity Measure:.....	Sa[T] (g)			
Slight (SD) -Operational (OP) (%):.....	0.60			
Medium (MD) - Immediate occupancy (IO) (%):.....	0.85			
Extensive (ED) - Life safety (LS) (%):.....	1.15			
Collapse (CD) - Collapse prevention (CP) (%):.....	1.45			
Integration methodology:.....	LSM			

	OP	IO	LS	CP
Mean:.....	0.04	0.05	0.07	0.09
Deviation:.....	0.15	0.19	0.19	0.27

Fragility function:



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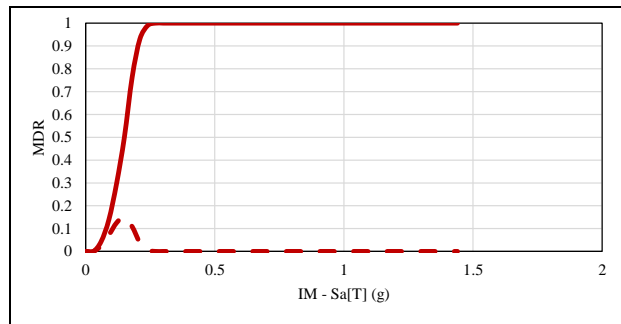
Component model:

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
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

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

Vulnerability function:



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

Fragility to vulnerability weighting percentage:

OP (%): 5 IO (%): 20 LS (%): 60 CP (%): 100

GLOSARY

f _c : Compressive concrete strength	kv: Spring vertical stiffness	IM: Intensity measure
E _c : Concrete elastic module	kh: Spring horizontal stiffness	DM: Damage states
f _y : Tensile steel strength	k _θ : Spring rotational stiffness	OP: Operational
E _s : Steel elastic module	D: Death load	IO: Immediate occupancy
f _m : Masonry compressive strength	L: Live load	LS: Life safety
γ: Masonry density	T ₁ : First mode period	CP: Collapse prevention
CISF: Concrete isolated spread footing	S _a : 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)