

FRAGILITY VULNERABILITY ASSESSMENT

Date:	9/17/2018
Building Type:	RC5/MR/PD
Author:	UNIANDES
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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:.....

RC5/MR/PD/RD/NI/SS/SW/RF/NP/OS/GC/VN

RC1 <input type="checkbox"/>	RC2 <input type="checkbox"/>	RC3 <input type="checkbox"/>	RC4 <input type="checkbox"/>	RC5 <input checked="" type="checkbox"/>
	Low (LR) <input type="checkbox"/>		Medium (MR) <input checked="" type="checkbox"/>	High (HR) <input 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"/>	Retrofitted 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):.....	80
Building total area (m ²):.....	160
Number of stories:.....	2
Story height (m):.....	3
Number of spans in X direction:.....	2
Typical span length in X direction (m):.....	5
Number of spans in Y direction (m):.....	2
Typical span length in Y direction (m):.....	4
Foundation system:.....	CISF
Typical column dimensions (cm x cm):.....	20X20
Typical beam dimensions (cm x cm):.....	15X20
Typical shear wall dimensions (cm x cm):.....	-
Typical bracing member section (cm x cm):.....	-

Material properties:

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

Infill walls:

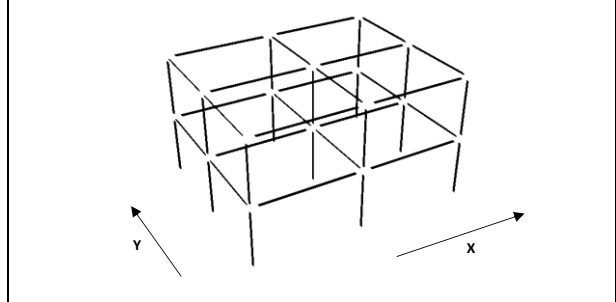
Infill type:.....	Interior walls		Facade walls	
Wall height (m):..... X	<input type="checkbox"/> 3	Y <input type="checkbox"/> 3	X <input type="checkbox"/> 3	Y <input type="checkbox"/> 3
Depth (m):..... X	<input type="checkbox"/> 0.12	Y <input type="checkbox"/> 0.12	X <input type="checkbox"/> 0.12	Y <input type="checkbox"/> 0.12
Isolated from structure:.....	Yes <input type="checkbox"/>	No <input checked="" type="checkbox"/>	Yes <input type="checkbox"/>	No <input checked="" type="checkbox"/>

SEISMIC BEHAVIOR

Total weight (D) (kN):.....	497.7
Total weight (L) (kN):.....	32.3
T ₁ uncracked (sec):.....	0.56
T ₁ cracked (sec):.....	0.74

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"/>
	k _v (kN) _____	k _h (kN) _____
		k _θ (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):.....	3.3

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	Columns <input type="checkbox"/> 0.30
Analysis direction:.....	X <input checked="" type="checkbox"/>	Y <input type="checkbox"/>
Analysis orientation:.....	(+) <input checked="" type="checkbox"/>	(-) <input type="checkbox"/>

1st mode mass participation (%):.....	100
First floor column area (m ²):.....	0.36
Total weight (D+L) /columns area (%f _c):.....	1.47
Horizontal first story shear column capacity (g):.....	0.19

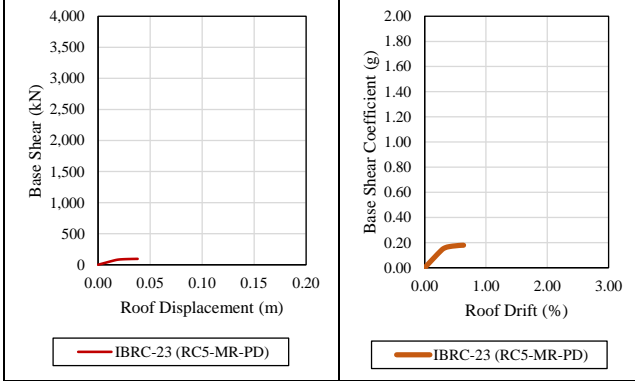
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SEISMIC BEHAVIOR

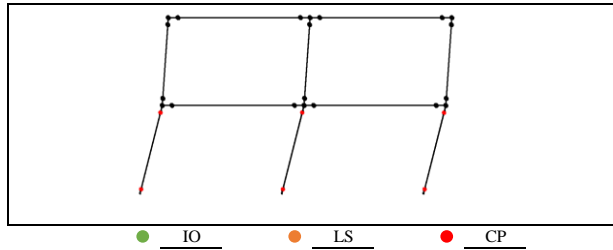
Capacity Curve:



Idealized capacity curve:

Behavior point	Base shear (kN)	Displacement (m)
Yield point:.....	85	0.013
Maximum capacity:.....	115	0.037
Ultimate capacity:.....		

Collapse mechanism: Excessive flexibility



NON-LINEAR ANALYSIS PARAMETERS

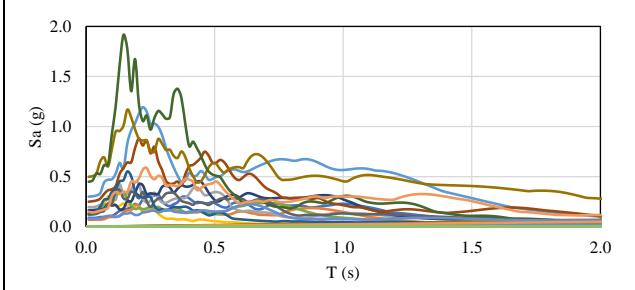
Seismic ground motions:

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

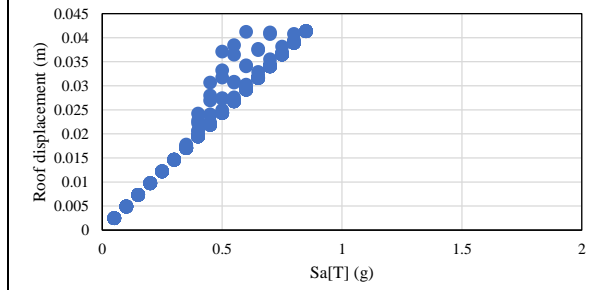
Analysis considerations:

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

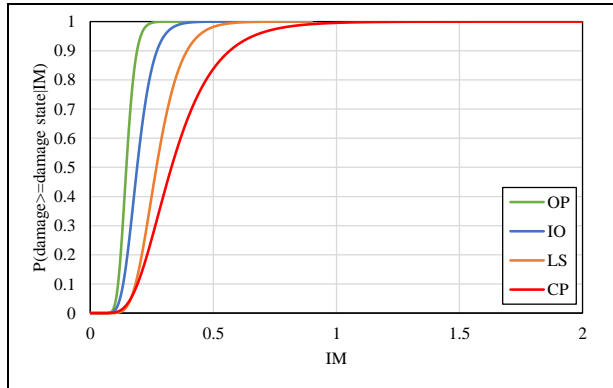
Damage states (DS):

Intensity Measure:.....	Sa[T] (g)			
Slight (SD) -Operational (OP) (%):.....	0.25			
Medium (MD) - Immediate occupancy (IO) (%):.....	0.35			
Extensive (ED) - Life safety (LS) (%):.....	0.48			
Collapse (CD) - Collapse prevention (CP) (%):.....	0.61			

Integration methodology:..... LSM

	OP	IO	LS	CP:
Mean:.....	0.15	0.19	0.27	0.33
Deviation:.....	0.20	0.28	0.30	0.42

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	12	B1041.091a	Drift	0
1	E	C2	Column-two beams	Node	6	B1041.091b	Drift	0
1	A	F2	Masonry facade	5m x 3m	12	C1011.006a	Drift	1
1	A	M4	Masonry wall	5m x 3m	8	C1011.006b	Drift	1
1	C	S2	Contents	5m x 5m	8	E2022.010a	Drift	0
2	E	C1	Column-one beam	Node	12	B1041.091a	Drift	0
2	E	C2	Column-two beams	Node	6	B1041.091b	Drift	0
2	A	F2	Masonry facade	5m x 3m	12	C1011.006a	Drift	1
2	A	M4	Masonry wall	5m x 3m	8	C1011.006b	Drift	1
2	C	S2	Contents	5m x 5m	8	E2022.010a	Drift	0

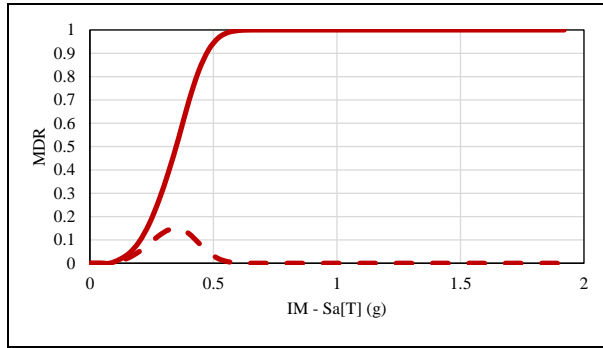
Phase I:

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 <input type="checkbox"/> No <input checked="" type="checkbox"/>

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 (%):	5	IO (%):	15	LS (%):	65	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
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)