

# FRAGILITY VULNERABILITY ASSESSMENT

Date: 9/17/2018  
 Building Type: RC4/MR/HD  
 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:.....

#### RC4/MR/HD/RD/NI/SS/SW/RF/NP/OS/GC/VN

RC1	<input type="checkbox"/>	RC2	<input type="checkbox"/>	RC3	<input type="checkbox"/>	RC4	<input checked="" type="checkbox"/>	RC5	<input type="checkbox"/>
		Low (LR)	<input type="checkbox"/>			Medium (MR)	<input checked="" type="checkbox"/>	High (HR)	<input type="checkbox"/>
Poor (PD)	<input type="checkbox"/>	Low (LD)	<input checked="" 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 <sup>2</sup> ):.....	304
Building total area (m <sup>2</sup> ):.....	608
Number of stories:.....	2
Story height (m):.....	3
Number of spans in X direction:.....	7
Typical span length in X direction (m):.....	4.5
Number of spans in Y direction (m):.....	3
Typical span length in Y direction (m):.....	3.5
Foundation system:.....	CISF
Typical column dimensions (cm x cm):.....	40X30
Typical beam dimensions (cm x cm):.....	30X35
Typical shear wall dimensions (cm x cm):.....	-
Typical bracing member section (cm x cm):.....	-

#### Material properties:

Concrete:..... f <sub>c</sub> (MPa):	21	E <sub>c</sub> (GPa):	21.5
Reinforcement:..... f <sub>y</sub> (Mpa):	420	E <sub>s</sub> (GPa):	200
Structural steel:..... f <sub>y</sub> (Mpa):	-	E <sub>s</sub> (GPa):	-
Masonry:..... f <sub>m</sub> (MPa):	-	γ:	-

#### Infill walls:

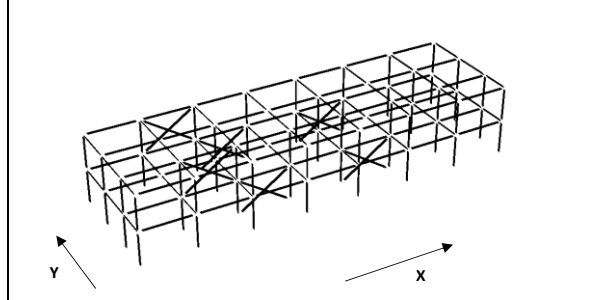
Infill type:.....	<b>Interior walls</b>	<b>Facade walls</b>
Wall height (m):..... X <input type="checkbox"/> - Y <input type="checkbox"/> 3	X <input type="checkbox"/> 1.5 Y <input type="checkbox"/> 3	X <input type="checkbox"/> 1.5 Y <input type="checkbox"/> 3
Depth (m):..... X <input type="checkbox"/>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

### SEISMIC BEHAVIOR

Total weight (D) (kN):.....	4354
Total weight (L) (kN):.....	359.9
T <sub>1</sub> uncracked (sec):.....	0.20
T <sub>1</sub> cracked (sec):.....	0.32

### 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 <sub>v</sub> (kN) _____	k <sub>h</sub> (kN) _____
		k <sub>θ</sub> (kN) _____

#### Loads:

Over imposed design dead load (D) (kN/m <sup>2</sup> ):.....	1.2
Design Live load (L) (kN/m <sup>2</sup> ):.....	2.0
Load combination in non-linear analysis:.....	D+0.25L
Average load per square meter (kN/m <sup>2</sup> ):.....	7.8

#### 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 (%):.....	87.5
First floor column area (m <sup>2</sup> ):.....	3.84
Total weight (D+L) /columns area (%f <sub>c</sub> ):.....	0.15
Horizontal first story shear column capacity (g):.....	0.5

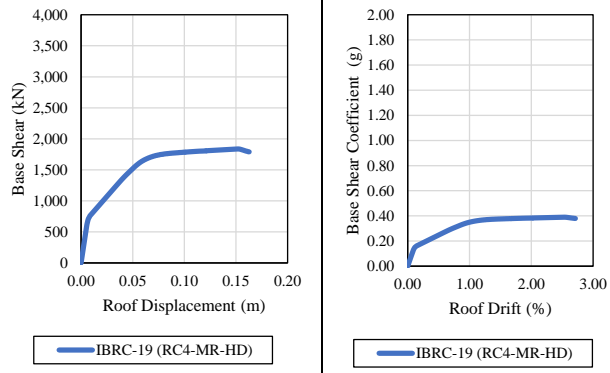
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## REINFORCED CONCRETE BUILDINGS

### SEISMIC BEHAVIOR

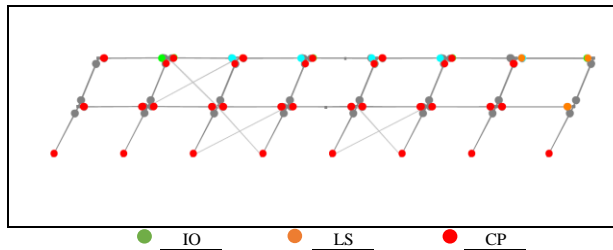
#### Capacity Curve:



#### Idealized capacity curve:

Behavior point	Base shear (kN)	Displacement (m)
Yield point:.....	800	0.10
Maximum capacity:.....	1690	0.15
Ultimate capacity:.....	-	-

**Collapse mechanism:** Steel frame failure



### NON-LINEAR ANALYSIS PARAMETERS

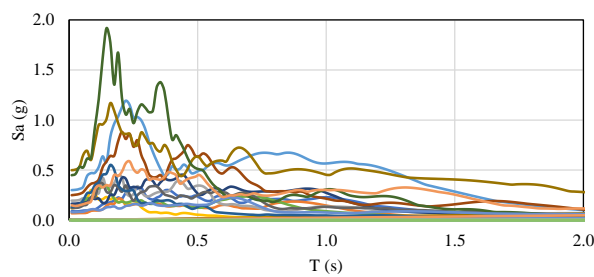
#### Seismic ground motions:

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

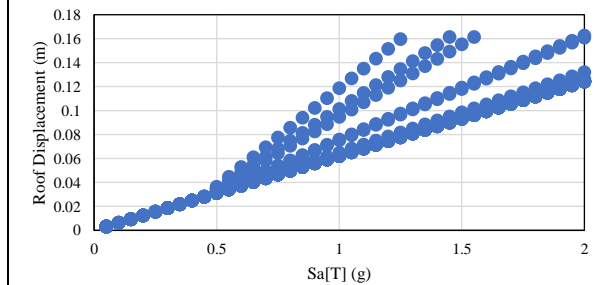
#### Analysis considerations:

Non-linear analysis:.....	Static <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:



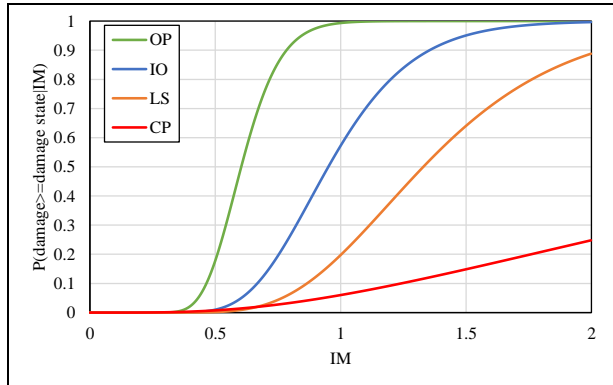
### FRAGILITY ASSESSMENT

#### Damage states (DS):

Intensity Measure:.....	Sa[T] (g)
Slight (SD) -Operational (OP) (%):.....	0.60
Medium (MD) - Immediate occupancy (IO) (%):.....	1.00
Extensive (ED) - Life safety (LS) (%):.....	1.50
Collapse (CD) - Collapse prevention (CP) (%):.....	2.35
Integration methodology:.....	LSM

	OP	IO	LS	CP:
Mean:.....	0.603	0.951	1.33	3.431
Deviation:.....	0.204	0.276	0.335	0.794

#### Fragility function:



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### REINFORCED CONCRETE BUILDINGS

#### 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	Masonry 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	Masonry 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

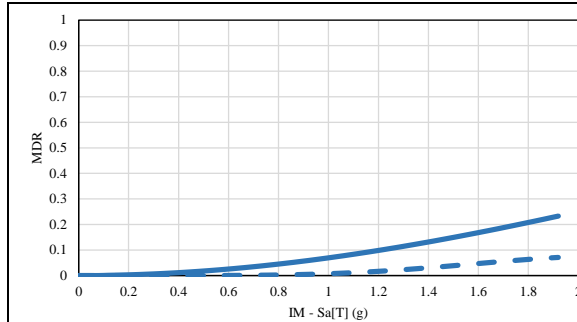
##### Phase I:

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 <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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##### GLOSSARY

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 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 ( <a href="http://www.ecapra.org">www.ecapra.org</a> )