VULNERABILITY OF BUILDING STRUCTURES TO SEISMIC HAZARD IN JORDAN

By

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To:

My Mother

My Brothers and Sister

My Parents and Friends

Mazen

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NOMENCLATURE

Normal upper case

A	Area
A_{sh}	Area of transverse reinforcement
A_{tot}	Total floor area
D	Damage
	Displacement of the single SDOF system
E	Modulus of elasticity
E_c	Modulus of elasticity of concrete
E_s	Modulus of elasticity of steel
EI	Section stiffness
EI_{eff}	Effective section stiffness
EI_p	Section stiffness of the pier
EI_{sp}	Section stiffness of the spandrel
F	Lateral story force
F_E	Force acting on the equivalent SDOF system
F_i	Horizontal storey force
G	Shear modulus
H_{tot}	Total building height
I	Second moment of area
M_{cr}	Bending moment at cracking
M_y	Bending moment at yield
M_U	Bending moment at ultimate

N	Normal force
S_a	Spectral acceleration
S_d	Spectral displacement
T	Duration
V	Shear force
V_b	Base shear of the building
V_{be}	Equivalent elastic base shear of the building
V_{bm}	Shear capacity of the building
V_{bcr}	Base shear at cracking
V_c	Shear carried by the concrete
V_{cr}	Shear force at the onset of cracking of a wall
V_m	Shear capacity of the wall
V_s	Shear carried by transverse reinforcement
V_{shear}	Shear strength of concrete wall

Normal lower case

a_g	Maximum ground acceleration (peak or effective)
ai	Floor acceleration
f	Frequency
f_l	Fundamental frequency
f_c	Cube compressive strength of concrete
f_{ct}	Tensile strength of concrete
f_u	Ultimate strength of reinforcement
f_y	Yield strength of reinforcement

g	Acceleration due to gravity
h	Height of a wall element
h_0	Height of zero moment
h_E	Equivalent height
h_{eff}	Effective height
h_i	Height of the i-th story from the base
h_{im}	Height of the mid height of the i-th story from the base
h_p	Height of the pier
h_{st}	Story height
k	Stiffness of the building
k_E	Equivalent stiffness
k_{eff}	Effective stiffness of the wall
$k_{s,tot}$	Shear stiffness of one storey
l	Length
l_o	Length of spandrel
L_p	Length of plastic hinge
L_w	Wall length
L_x	Length of the building in x-direction
L_y	Length of the building in y-direction
m_E	Equivalent mass
m_i	Concentrated storey mass
qfl	Total floor load
t	Thickness of wall, wall element, pier

x_{cr} — Depth of neutral axes at cracking

x_u — Depth of neutral axes at ultimate

x_y — Depth of neutral axes at yield

Greek upper case

G — Modal participation factor

Δ — Horizontal top displacement

Δ_{be} — Equivalent elastic top displacement of the building

Δ_{bu} — Ultimate top displacement of the building

Δ_{by} — Yield top displacement of the building

Δ_{cr} — Top displacement at the onset of cracking

Δ_u — Ultimate top displacement of the wall

Δ_y — Yield top displacement of the wall

Greek lower case

ε_c — Concrete compressive strain at the extreme compressive fiber

ε_{ct} — Concrete tensile strain at the extreme tensile fiber at the onset of cracking

ε_{cu} — Ultimate compressive strain of concrete

ε_s — Strain in the extreme tensile reinforcement

ε_y — Yield strain of reinforcement

$\square_{cr}$ — Equivalent curvature at cracking on the bilinear moment- Curvature relationship

□’$_{cr}$	Curvature at cracking
□$_i$	First mode displacement at i-th story
□n	First mode displacement at the n-th story
□p	Plastic curvature
□u	Ultimate curvature
□’y	First yield curvature
□y	Yield curvature
μ	Ductility
μ_D	Ductility demand
μ_φ	Rotational ductility of a wall section
μ_w	Displacement ductility of the building

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ABSTRACT

The presented study addresses the establishment of a seismic vulnerability method on a building-specific basis, accounting for the different structural and architectural aspects of the construction practice in Jordan. Structural vulnerability refers to the damage susceptibility of those parts of a building that are required for physical support when subjected to an intense earthquake or other hazard. The vulnerability is commonly expressed by functions or matrices which can be obtained either by statistical studies of damaged buildings in earthquake-struck areas or by simulations using numerical or analytical models of the buildings.

The suggested approach involves the use of an existing vulnerability method which was developed by Kerstin Lang for the city of Basel. This method was adopted for the evaluation of the vulnerability of existing buildings with regard to an earthquake scenario; this involved the evaluation of residential and school buildings that are of interest and then varying the relevant features of the target building types.

By using this method to assess vulnerability, it was found that building population that is regular in form and which has no outstanding construction defects are not vulnerable to the expected level of seismic demand in the city of Amman .

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Seismic vulnerability assessment of urban centers is a challenging issue that needs to be faced accurately for the earthquake risk of large territorial areas. The selection of suitable methods is a crucial aspect that must be treated according to different evaluation processes, depending on the size of the problem and on the available calculation capacities.Â On the basis of this premises, this paper deals with the seismic vulnerability assessment of the historic center of Campotosto, in Abruzzi region. To this purpose, two methodologies are applied at different scales.Â As mentioned before, this hazard can be exacerbated by the presence of side effects.