WHE-PAGER PHASE 2: DEVELOPMENT OF ANALYTICAL SEISMIC VULNERABILITY FUNCTIONS

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Date:		
Structure type (describe as broadly as possible):	UFB5 unreinforced fired solid brick masonry buildings with reinforced concrete slab	
Geographic or other limitations:	North Pakistan existing urban building stock of most of the city in northeast Pakistan	
		Add rows as desired

Choice of pushover curve parameters

	Units	Parameter	
Pushover X-axis:	mm	Sd	Choose spectral displacement (Sd); or Roof displacement (Deltar). State units
Pushover Y-axis:	m/sec^2	Sa	Choose spectra acceleration (Sa); or base shear (V). State units.
Elastic damping ratio:	%	5	Small-amplitude damping ratio, fraction of critical
1st mode participation factor:		1.4	PFfR; generally 1.3 to 1.5; same as (effective height)/(total roof height)
Effective mass coefficient:		0.8	alpha1; generally 0.7 to 0.8
Building weight:	tons	400	W State units

How were these values & pushover points derived? The values are derived based on the experimental work carried out at the NWFP University of Engineering & Technology Peshawar and its Earthquake Engineering Center on masnory prisms and shear walls and the dynamic analyses performed on the typical UFB5 buildings, 7-structures, in the urban areas of northern Pakistan, (case study Mansehra City).

Ref-1: Ahmad, N., Crowley, H., Pinho, R., Ali, Q., [2010] "Displacement-based earthquake loss assessment of masonry buildings in Mansehra city, Pakistan", Journal of Earthquake Engineering, Vol. 14 (Special Issue), pp. 1-37.
Ref-2: Javed, Mohammad [2009] "Seismic Risk Assessment of Unreinforced Brick Masonry Buildings System of Northern Pakistan" PhD Thesis NWFP University of Engineering and Technology Peshawar Pakistan.

Add rows as desired

Pushover Curve for this structure type-single storey

See Figures 1-4 for sample pushover curves

Pushover curve control point	X	Y	Damping	Comment	
A	0	0			Control point for plotting purposes
B	2	6.232	5	cracking	E.g., yield point?
C	6	7.0148	10	maximum	E.g., ultimate point?
D	13	5.3618	12	ultimate/near-collapse	E.g., beginning of lower plateau?
E	13	0			Add rows as desired

Pushover Curve for this structure type-two storey

See Figures 1-4 for sample pushover curves

Pushover curve control point	X	Y	Damping	Comment	
A	0	0			Control point for plotting purposes
B	4	5.0219	5	cracking	E.g., yield point?
C	7	4.6124	9	maximum	E.g., ultimate point?
D	14	4.3749	11	ultimate/near-collapse	E.g., beginning of lower plateau?
E	14	0			Add rows as desired

Pushover Curve for this structure type-three storey

See Figures 1-4 for sample pushover curves

Pushover curve control point	X	Y	Damping	Comment	
A	0	0			Control point for plotting purposes
B	6	4.3194	5	cracking	E.g., yield point?
C	9	4.0313	8	maximum	E.g., ultimate point?
D	16	3.9998	10	ultimate/near-collapse	E.g., beginning of lower plateau?
E	16	0			Add rows as desired

Pushover Curve for this structure type-four storey

See Figures 1-4 for sample pushover curves

Pushover curve control point	X	Y	Damping	Comment	
A	0	0			Control point for plotting purposes
B	7	3.3629	5	cracking	E.g., yield point?
C	11	3.5326	8	maximum	E.g., ultimate point?
D	18	3.407	10	ultimate/near-collapse	E.g., beginning of lower plateau?
E	18	0			Add rows as desired

Pushover Curve for this structure type-five storey

See Figures 1-4 for sample pushover curves

Pushover curve control point	X	Y	Damping	Comment	
A	0	0			Control point for plotting purposes
B	9	3.1426	5	cracking	E.g., yield point?
C	12	2.9972	7	maximum	E.g., ultimate point?
D	19	3.006	9	ultimate/near-collapse	E.g., beginning of lower plateau?
E	19	0			Add rows as desired

Optional: upper and lower-bound range of pushover curves for this structure type

Upper-bound pushover curve, e.g., 99 out of 100 buildings of this type would have pushover curve inside the area bounded between this curve and the Y-axis?

Author's meaning of "upper bound":

How were these values & pushover points derived? These values are derived from the Monte Carlo simulation following the experimental and dynamic studies on the considered case study buildings.
The values show median capacity curve parameters with the drift limits (mean values) obtained experimentally. The damping shows the viscous damping obtained using the damping model proposed by Ahmad *et al*. [2010]. The capcity curves do take into account the 3D effects of the buildings and idealization to take into consideration the stiffness and strength degradation due to cyclic response following the available recommendations from the the University of Pavia, Italy.
The study conducted by Ahmad *et al*. [2010] derived static nonlinear SDOF system for Pakistani UFB5 building class is used herein in order to derive the limit states strength and deformations.

Add rows as desired

See Figures 1-4 for sample pushover curves

Optional upper-bound pushover curve

Pushover curve control point	X	Y	Damping	Comment	
A	0	0			Control point for plotting purposes
B					E.g., yield point?
C					E.g., ultimate point?
D					E.g., beginning of lower plateau?
E					Add rows as desired

Lower-bound pushover curve, e.g., 99 out of 100 buildings of this type would have pushover curve inside the area bounded between this curve and the X-axis?

Author's meaning of "lower bound":

How were these values & pushover points derived?

Add rows as desired

See Figures 1-4 for sample pushover curves

Optional lower-bound pushover curve

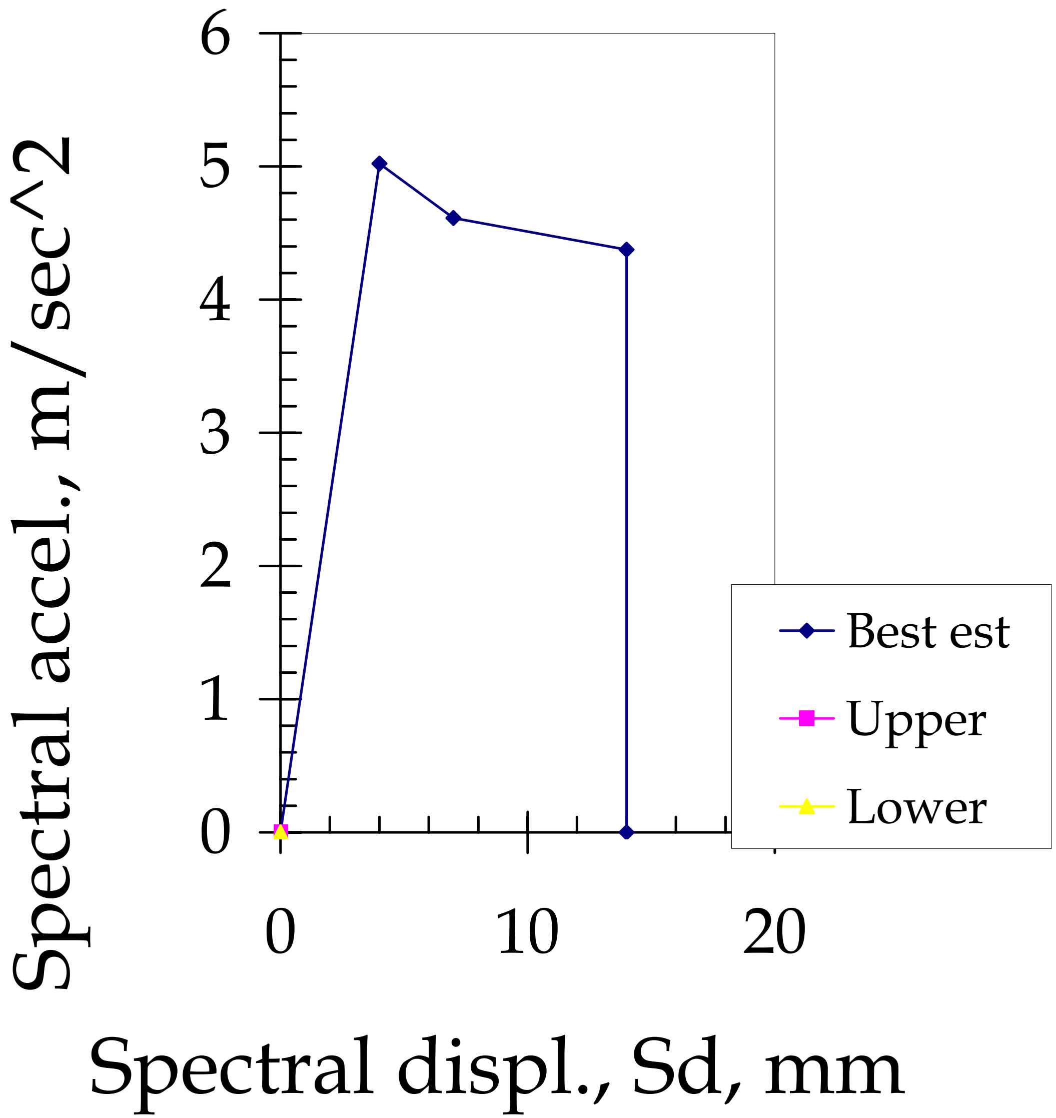
Pushover curve control point	X	Y	Damping	Comment	
A	0	0			Control point for plotting purposes
B					E.g., yield point?
C					E.g., ultimate point?
D					E.g., beginning of lower plateau?
E					Add rows as desired

Other requested parameters

D14	0.46 (%)	median drift (in same units as pushover X-axis) associated with complete structural damage, i.e., drift with 50% chance that the structural component of the building cannot be economically repaired
B14	0.3	logarithmic standard deviation of drift associated with complete structural damage. May need to be guessed
Sdc		the median value of drift (in same units as pushover X-axis) associated with collapse, e.g., Sdc = (roof drift at collapse)/PFfR.
L15		indoor fatality rate given collapse. Many contributors may be unable to provide this value. Porter, Comartin, and Holmes will fill such gaps
PC		mean fraction of building area collapsed, given complete structural damage. Again Porter, Comartin, and Holmes will fill gaps
kshort		If HAZUS-style damping preferred, and author can judge, this is the degradation factor for short-duration (M <= 5.5) events
kmed		If HAZUS-style damping preferred, and author can judge, this is the degradation factor for medium-duration (5.5 < M < 7.5) events
klong		If HAZUS-style damping preferred, and author can judge, this is the degradation factor for long-duration (M >= 7.5) events

Explain how these values were arrived at, providing citations if appropriate

Add rows as desired


Spectral accel., m/sec^2
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5
4
3
2
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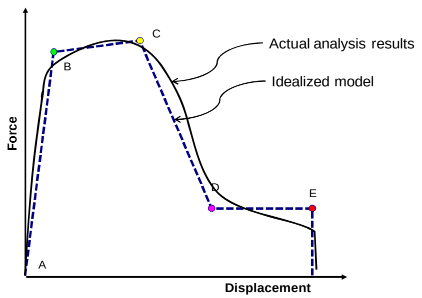

Figure 1: Force-displacement capacity boundary with all idealized segments present

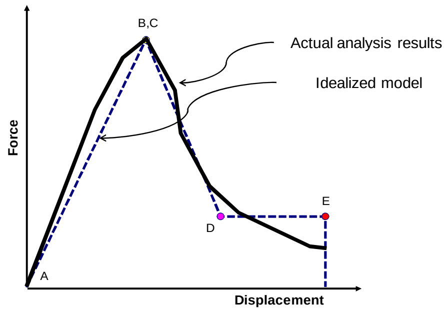

Figure 2: Force-displacement capacity boundary without strain hardening segment (e.g. buckling braced frame)

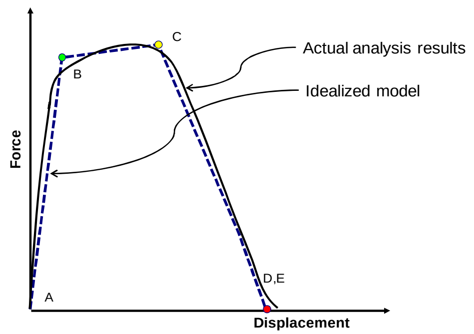

Figure 3: Force-displacement capacity boundary without lower strength plateau (e.g. unreinforced masonry)

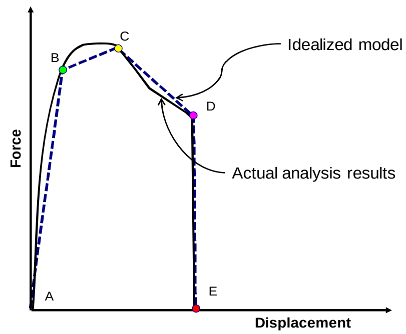

Figure 4: Force-displacement capacity boundary with pre-emptive vertical load failure