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

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Structure type (describe as broadly as possible):	Non-Ductile Reinforced Concrete 4 Storey Residential Building with Open First Storey
Geographic or other limitations:	North-Eastern India , Modern Building Construction, Nonductile detailing
	The building was originally designed without considering strength and stiffness of masonry infills. Large number of buildings in Ind

Add rows as desired

Choice of pushover curve parameters

	Units	Parameter	
Pushover X-axis:	Sd(m)		Choose spectral displacement (Sd); or Roof displacement (Deltar). State units
Pushover Y-axis:	Sa(g)		Choose spectra acceleration (Sa); or base shear (V). State units.
Elastic damping ratio:	0.05		Small-amplitude damping ratio, fraction of critical
1st mode participation factor:	0.9		PFfR; generally 1.3 to 1.5; same as (effective height)/(total roof height)
Effective mass coefficient:	0.65		alpha1; generally 0.7 to 0.8
Building weight:	13000 kN	Weight of the	W State units

How were these values & pushover points derived? Based on analytical simulations of a four storey residential building in Guwahati, Assam, India. Actual performace of real buildings may be different.

Ref: Bhattacharya, S.K. (2009), "Strengthening of existing open ground-storey reinforced concrete buildings", Master of Technolog

Add rows as desired

Pushover Curve for this structure type

See Figures 1-4 for sample pushover curves

Pushover curve control point	X	Y	Damping	Comment	
A	0	0	0.06	Damping at P	Control point for plotting purposes
B	0.004	0.1		Yield Point	E.g., yield point?
C	0.092	0.4		Ultimate Point	E.g., ultimate point?
D	0.092	0.4		Collapse	E.g., beginning of lower plateau?
E					Add rows as desired

Analysis could not be continued after Point D due to failure of many columns in the open first storey of the building. This may be a limitation of program and modeling.

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?

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

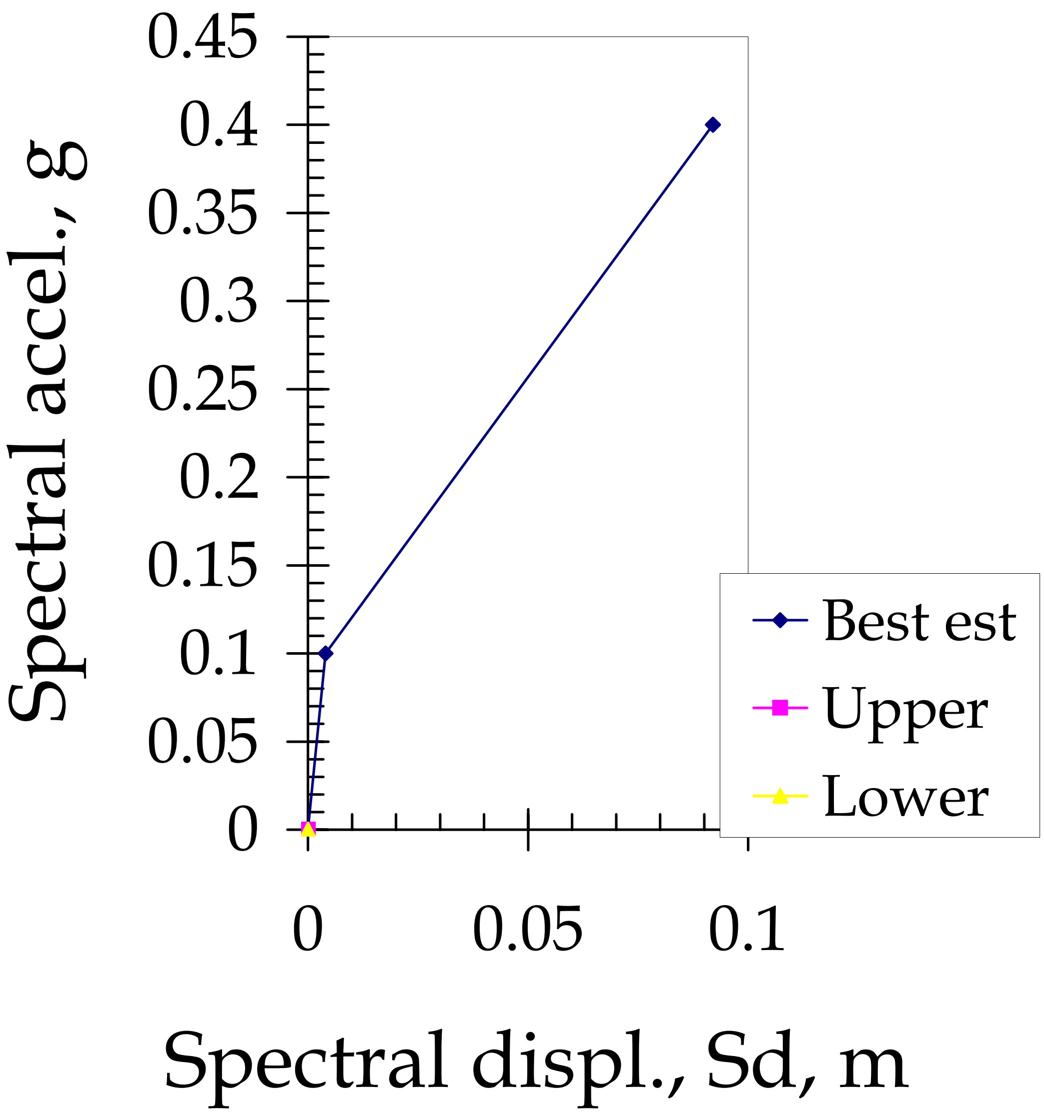
Pushover curve control point	X	Y	Damping	Comment	
A	0	0			Control point for plotting purposes
B					E.g., yield point?
C					E.g., ultimate point?
D					E.g., beginning of lower plateau?
E					Add rows as desired

Other requested parameters

D14		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		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


0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
Spectral accel., g
0
0.05
0.1
Spectral displ., Sd, m
Best est
Upper
Lower

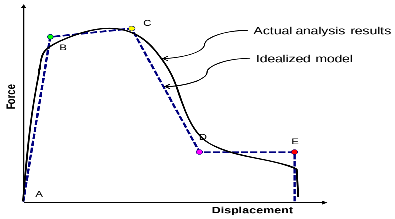


Figure 1: Force-displacement capacity boundary with all idealized segments present

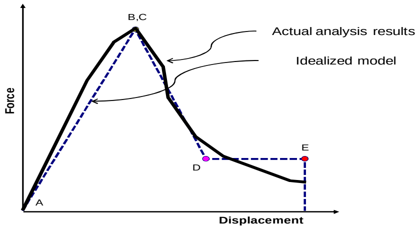


Figure 2: Force-displacement capacity boundary without strain hardening segment (e.g. buckling braced frame)

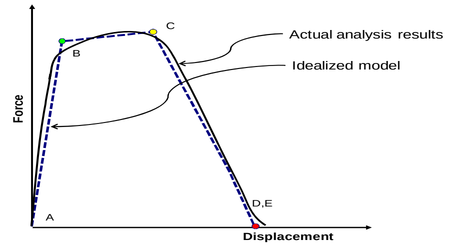


Figure 3: Force-displacement capacity boundary without lower strength plateau (e.g. unreinforced masonry)

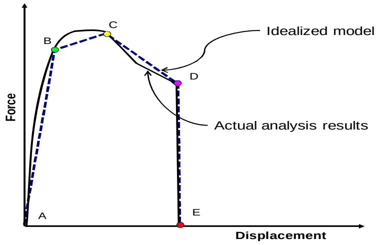


Figure 4: Force-displacement capacity boundary with pre-emptive vertical load failure