

CB22. ENGINEERING SEISMOLOGY

EXERCISE No 7

Evaluate, with the use of the Rossetto-Elnashai relationships, the mean fragility curves for the different limit states and for the following cases:

- homogeneous RC buildings
- bare and infilled MRF
- low and mid-rise MRF
- pre-code and old-code MRF

Compare the fragility curves and comment the differences for the referred building cases.

Table 8
Summary of the empirical vulnerability relationships developed for different ground motion parameters and their fit to the observational data

HRC damage state	Curve parameters						Bldgs	Non-weighted data				Weighted data			
	Mean		U90%		L90%			Data sets	$\mu(\epsilon)$	cov (ϵ)	R ²	Data sets	$\mu(\epsilon)$	cov (ϵ)	R ²
	α	β	α	β	α	β									
PGA															
Slight	1.556	1.60	3.950	1.60	0.830	1.60	339872	99	0.27	0.80	0.37	9	0.37	0.77	0.33
Light	1.055	1.80	2.732	1.80	0.620	1.80	339187	90	0.24	1.04	0.29	8	0.37	0.76	0.35
Moderate	0.250	3.00	0.903	3.00	0.102	3.00	331702	69	0.21	0.96	0.34	8	0.26	0.74	0.36
Extensive	0.093	4.00	0.538	4.00	0.010	4.00	329152	49	0.08	1.32	0.27	7	0.08	0.92	0.36
P.Collapse	0.009	5.80	0.162	5.80	0.001	5.80	292839	35	0.03	1.41	0.26	7	0.01	0.78	0.39
Collapse	0.001	8.00	0.005	8.00	0.001	8.00	77876	24	0.01	1.42	0.26	4	0.00	1.51	0.28
Sa_{5%}(T_{elastic})															
Slight	0.633	1.80	1.865	1.80	0.192	1.80	339872	99	0.25	0.84	0.39	15	0.30	1.04	0.39
Light	0.396	1.80	1.356	1.80	0.116	1.80	339187	90	0.22	1.05	0.30	15	0.29	1.05	0.37
Moderate	0.153	1.80	0.524	1.80	0.041	1.80	331702	69	0.17	1.07	0.28	14	0.19	0.99	0.39
Extensive	0.090	2.00	0.447	2.00	0.036	2.00	329152	49	0.08	1.13	0.26	14	0.08	1.00	0.52
P.Collapse	0.050	2.20	0.265	2.20	0.031	2.20	292839	35	0.04	1.40	0.40	13	0.05	1.68	0.49
Collapse	0.010	3.00	0.056	3.00	0.006	3.00	77876	24	0.01	2.29	0.44	8	0.03	2.27	0.49
Sd_{5%}(T_{elastic})															
Slight	25.82	1.10	76.45	1.10	13.72	1.10	339872	99	0.23	0.83	0.37	15	0.23	1.25	0.58
Light	21.08	1.20	73.88	1.20	8.350	1.20	339187	90	0.23	0.93	0.30	15	0.22	1.27	0.59
Moderate	6.500	1.15	29.57	1.15	2.342	1.15	331702	69	0.17	1.02	0.30	14	0.14	1.37	0.50
Extensive	3.000	1.30	17.52	1.30	1.323	1.30	329152	49	0.07	1.32	0.28	13	0.06	0.97	0.49
P.Collapse	2.500	2.00	13.45	2.00	1.200	2.00	292839	35	0.03	1.37	0.28	12	0.02	0.72	0.47
Collapse	2.000	2.40	9.37	2.40	1.119	2.40	77876	24	0.01	1.62	0.36	6	0.02	1.07	0.29
Sd_{μ%}(T_{inelastic})															
Extensive	2.500	1.30	10.18	1.30	0.926	1.30	329152	49	0.08	1.27	0.28	19	0.07	1.56	0.57
P.Collapse	1.600	2.00	7.497	2.00	0.740	2.00	292839	35	0.03	1.40	0.27	16	0.06	1.60	0.48
Collapse	0.600	2.40	1.076	2.40	0.125	2.40	77876	24	0.01	1.42	0.27	5	0.003	0.76	0.45

α and β , the parameters defining the curves according to Eq. (5) for the mean curves, upper and lower 90% confidence bounds (U90% and L90%, respectively). Datasets, no. of datasets used for the derivation and comparison (weighted and non-weighted respectively). $\mu(\epsilon)$, mean error in prediction; cov(ϵ), the coefficient of variation of the error in prediction; R², coefficient of correlation of the data to the fitted curves.

Table A5

The proposed structure-type, height and seismic-code specific empirical curves and their correlation to the weighted and non-weighted observational data

HRC damage state	Class-specific curve parameters						Correlation with weighted class-specific data						Correlation with non-weighted class-specific empirical data									
	Mean		U90%		L90%		Bldgs	Data sets	Class-specific curves			Homogeneous curves			Bldgs	Data sets	Class-specific curves			Homogeneous curves		
	α	β	α	β	α	β			$\mu(\epsilon)$	cov(ϵ)	R ²	$\mu(\epsilon)$	cov(ϵ)	R ²			$\mu(\epsilon)$	cov(ϵ)	R ²	$\mu(\epsilon)$	cov(ϵ)	R ²
Bare MRF																						
Slight	23.830	1.05	76.451	1.10	13.716	1.10	296513	12	0.174	2.102	0.541	0.175	2.092	0.541	296513	43	0.159	0.717	0.603	0.168	0.700	0.595
Light	21.270	1.20	73.881	1.20	8.350	1.20	296300	12	0.201	1.585	0.557	0.200	1.592	0.557	296300	37	0.150	0.924	0.541	0.150	0.926	0.540
Moderate	13.296	1.20	29.570	1.15	2.342	1.15	293579	10	0.195	1.033	0.444	0.149	1.469	0.444	293579	18	0.156	0.851	0.610	0.140	0.899	0.553
Extensive	3.000	1.30	17.518	1.30	1.323	1.30	292828	9	0.099	0.820	0.283	0.099	0.820	0.283	292828	13	0.080	1.053	0.522	0.080	1.053	0.522
P.Collapse	2.500	2.00	13.450	2.00	1.200	2.00	258976	9	0.040	1.014	0.055	0.040	1.014	0.055	258976	10	0.036	1.404	0.401	0.036	1.404	0.401
Collapse	2.000	2.40	9.365	2.40	1.119	2.40	67602	4	0.024	0.993	0.006	0.024	0.993	0.006	67602	4	0.024	1.494	0.453	0.024	1.494	0.453
Infilled MRF																						
Slight	40.000	1.10	76.451	1.10	13.716	1.10	2720	4	0.329	1.406	0.421	0.409	1.000	0.421	2720	8	0.436	0.661	0.438	0.523	0.557	0.447
Light	35.000	1.20	73.881	1.20	8.350	1.20	2720	4	0.374	1.076	0.396	0.434	0.863	0.396	2720	8	0.470	0.629	0.434	0.531	0.561	0.442
Moderate	7.500	1.15	29.570	1.15	2.342	1.15	2720	4	0.220	1.136	0.391	0.226	1.099	0.391	2720	8	0.238	0.868	0.379	0.244	0.847	0.382
Extensive	3.200	1.30	17.518	1.30	1.323	1.30	2460	4	0.004	1.982	0.987	0.003	2.533	0.987	2460	7	0.006	0.864	0.444	0.006	0.889	0.427
Low-rise bare MRF (<3 floors)																						
Slight	25.817	1.10	125.27	1.10	2.390	1.10	5372	9	0.104	2.598	0.720	0.104	2.598	0.720	5372	35	0.140	0.704	0.552	0.140	0.704	0.552
Light	18.560	1.20	80.480	1.20	4.100	1.20	5159	8	0.090	1.205	0.909	0.112	0.910	0.909	5159	29	0.099	0.942	0.395	0.103	0.932	0.430
Moderate	5.500	1.30	30.560	1.30	2.000	1.30	2438	5	0.050	0.875	0.943	0.076	0.660	0.943	2438	10	0.087	1.419	0.179	0.091	1.200	0.197
Extensive	4.671	1.30	16.380	1.30	0.600	1.30	1667	3	0.080	1.832	0.212	0.091	1.587	0.212	1667	5	0.061	1.418	0.284	0.066	1.475	0.266
P.Collapse	5.100	1.60	17.115	1.60	0.500	1.60	1455	3	0.033	1.888	0.020	0.043	1.413	0.020	1455	3	0.033	1.338	0.349	0.043	1.355	0.311
Collapse	3.160	2.00	10.320	2.00	0.300	2.00	1455	3	0.005	2.316	0.004	0.007	1.746	0.004	1455	3	0.005	1.648	0.304	0.007	1.658	0.262
Mid-rise bare MRF (4-7 floors)																						
Slight	48.410	1.05	150.00	1.05	3.000	1.05	290912	7	0.167	2.999	0.418	0.234	1.858	0.418	290912	10	0.151	0.778	0.651	0.261	0.469	0.585
Light	39.000	1.10	140.00	1.10	5.400	1.10	290912	7	0.199	2.176	0.405	0.251	1.539	0.405	290912	10	0.180	0.724	0.643	0.276	0.575	0.572
Moderate	5.300	1.15	105.00	1.15	0.800	1.15	290912	7	0.178	1.399	0.342	0.185	1.316	0.342	290912	10	0.172	0.793	0.561	0.175	0.752	0.584
Extensive	4.000	1.30	21.600	1.30	0.800	1.30	290832	6	0.127	0.291	0.314	0.101	0.396	0.314	290832	8	0.108	1.065	0.567	0.087	0.961	0.579
P.Collapse	3.000	2.40	14.700	2.40	0.500	2.40	257172	6	0.028	0.656	0.365	0.038	0.771	0.365	257172	6	0.028	1.217	0.526	0.038	1.411	0.516
Collapse	2.500	3.00	9.600	3.00	0.300	3.00	66261	2	0.022	1.405	0.969	0.039	1.409	0.969	66261	2	0.022	1.350	0.500	0.039	1.270	0.500

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Table A5 (continued)

HRC damage state	Class-specific curve parameters						Correlation with weighted class-specific data						Correlation with non-weighted class-specific empirical data									
	Mean		U90%		L90%		Bldgs	Data sets	Class-specific curves			Homogeneous curves			Bldgs	Data sets	Class-specific curves			Homogeneous curves		
	α	β	α	β	α	β			$\mu(\epsilon)$	cov(ϵ)	R ²	$\mu(\epsilon)$	cov(ϵ)	R ²			$\mu(\epsilon)$	cov(ϵ)	R ²	$\mu(\epsilon)$	cov(ϵ)	R ²
Pre-seismic code bare MRF																						
Slight	29.430	1.10	222.00	1.10	3.470	1.10	3655	8	0.122	2.043	0.724	0.110	2.359	0.724	3655	31	0.127	0.758	0.582	0.134	0.093	0.564
Light	23.000	1.20	163.00	1.20	2.500	1.20	3442	7	0.123	0.813	0.938	0.109	0.886	0.938	3442	25	0.096	0.938	0.493	0.093	0.084	0.473
Moderate	8.860	1.15	75.000	1.15	2.000	1.15	721	2	0.069	0.584	0.960	0.047	0.686	0.960	721	6	0.085	1.183	0.319	0.085	0.113	0.235
Extensive	5.000	1.30	80.000	1.30	1.700	1.30	256	2	0.099	2.000	0.156	0.113	1.714	0.156	256	3	0.069	1.578	0.287	0.079	0.126	0.267
P.Collapse	5.500	1.60	60.000	1.60	1.200	1.60	64	2	0.041	2.061	0.014	0.055	1.462	0.014	64	2	0.041	1.350	0.358	0.055	0.077	0.335
Collapse	6.000	2.00	36.800	2.00	1.000	2.00	25	1	0.010	0.000	0.001	0.019	0.000	0.001	25	1	0.009	0.000	0.500	0.019	0.000	0.500
Old-seismic code bare MRF																						
Slight	42.000	1.10	320.00	1.10	10.400	1.10	292572	8	0.228	1.763	0.466	0.256	1.486	0.466	292572	10	0.229	0.573	0.557	0.281	0.446	0.543
Light	45.000	1.20	308.00	1.20	2.400	1.20	292572	8	0.240	1.502	0.447	0.266	1.281	0.447	292572	10	0.242	0.537	0.574	0.298	0.511	0.545
Moderate	6.700	1.20	71.200	1.20	1.800	1.20	292572	8	0.187	1.156	0.378	0.188	1.152	0.378	292572	10	0.195	0.670	0.567	0.193	0.645	0.573
Extensive	2.000	1.30	23.500	1.30	1.100	1.30	292572	8	0.093	0.562	0.380	0.089	0.590	0.380	292572	10	0.084	0.986	0.587	0.080	0.939	0.589
P.Collapse	2.000	2.00	10.000	2.00	0.600	2.00	258912	8	0.026	0.691	0.396	0.031	0.747	0.396	258912	8	0.026	1.438	0.526	0.031	1.534	0.520
Collapse	1.100	2.50	4.770	2.50	0.300	2.50	67577	3	0.012	1.200	0.864	0.025	1.213	0.864	67577	3	0.012	1.691	0.499	0.025	1.713	0.499

α and β , the parameters defining the curves according to Eq. (5) for the mean curves, upper and lower 90% confidence bounds (U90% and L90% respectively). Datasets, No. of datasets used for the derivation and comparison (weighted and non-weighted respectively). $\mu(\epsilon)$, mean error in prediction; cov(ϵ), the coefficient of variation of the error in prediction; R², coefficient of correlation of the data to the fitted curves.