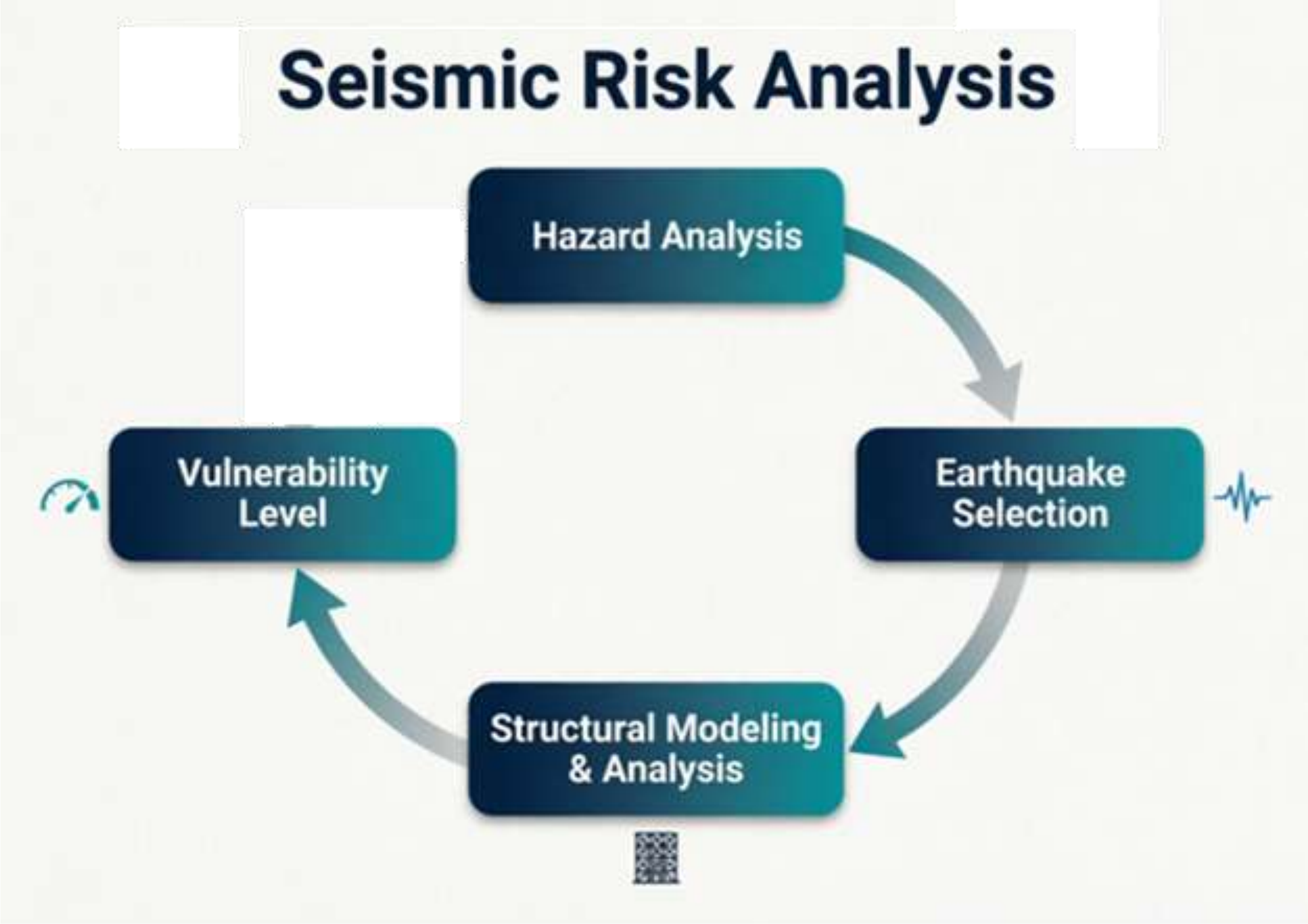
پژوهشگاه بین‌المللی
زلزله‌شناسی و مهندسی زلزله

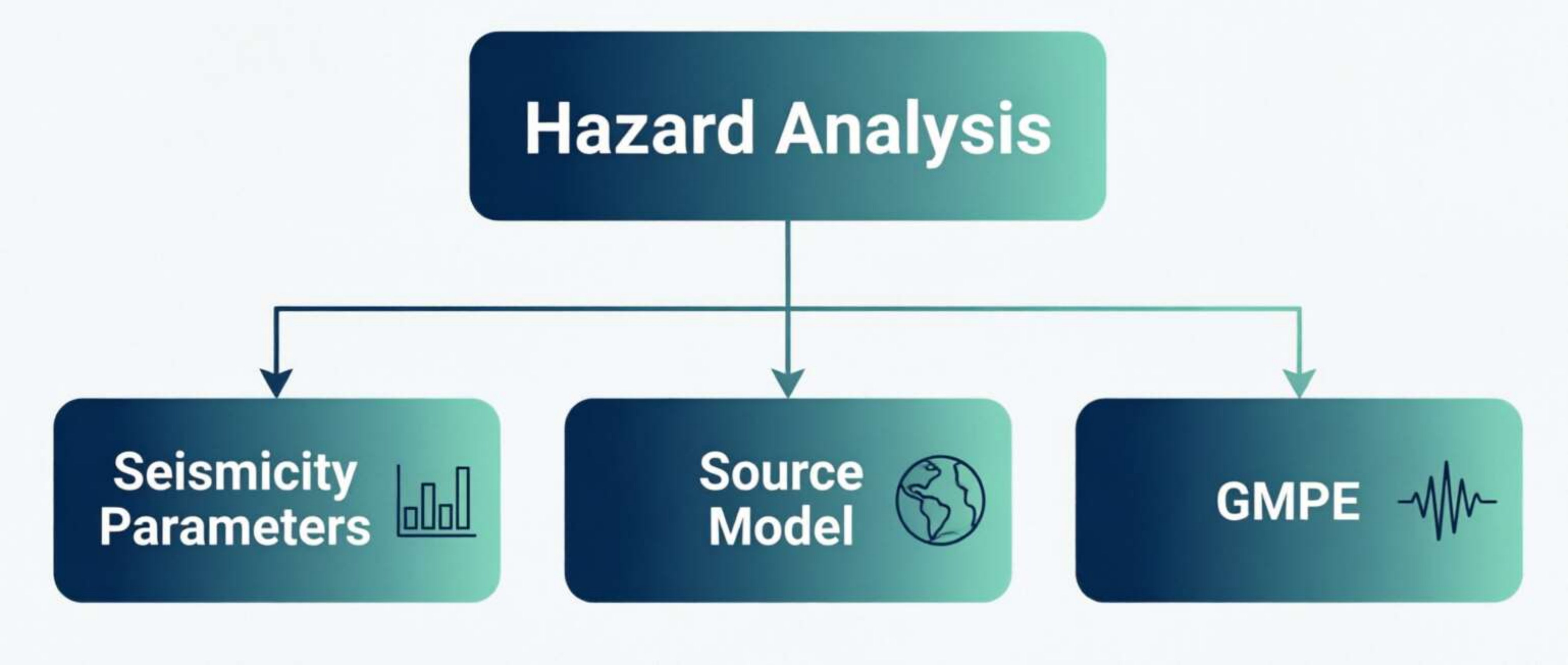
بررسی عدم قطعیت منبع لرزه ای در تحلیل ریسک سازه های شهری

پژوهشگاه بین‌المللی
زلزله‌شناسی و مهندسی زلزله

فهرست مطالب



Seismic Risk Analysis
Hazard Analysis
Earthquake Selection
Structural Modeling & Analysis
Vulnerability Level


Hazard Analysis
Seismicity Parameters
Source Model
GMPE

پژوهشگاه بین‌المللی
زلزله‌شناسی و مهندسی زلزله

Earthquake Selection for UHS Based — Spectral Shape

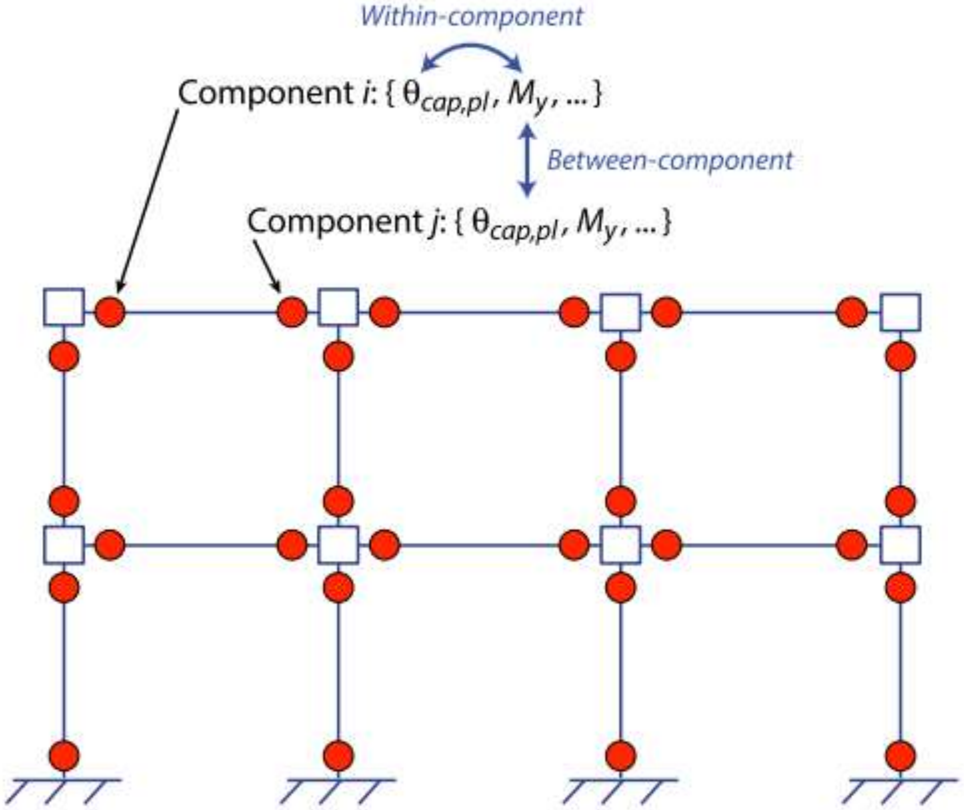
Spectral Shape Criteria

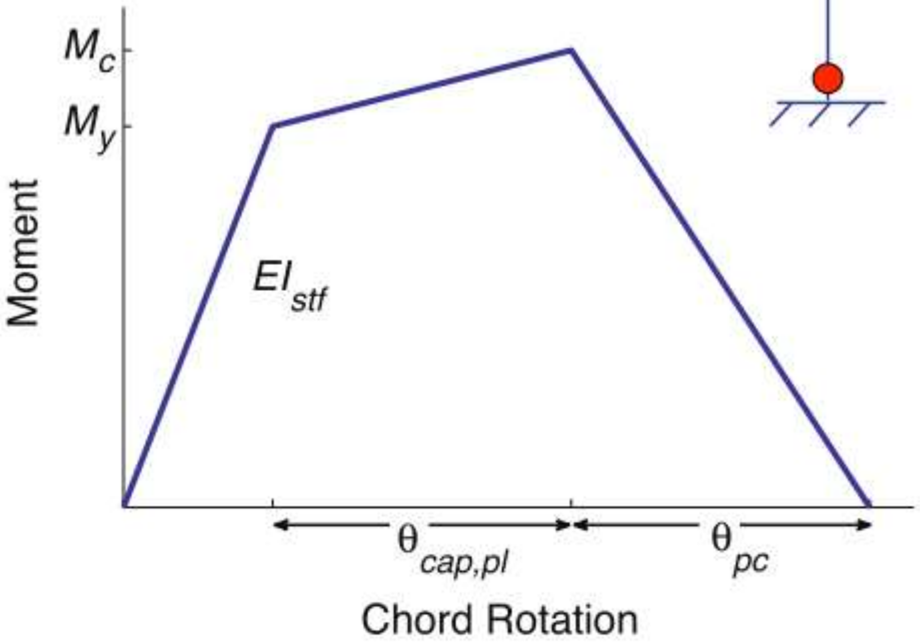
1. Target Spectrum Matching
2. Period Range Coverage (T_1–T_2)
3. Significant Frequency Content Preservation

UHS Requirements

1. Hazard Level Consistency (e.g., 2% in 50 yr)
2. Site-Specific Amplification Consideration

پژوهشگاه بین‌المللی
زلزله‌شناسی و مهندسی زلزله





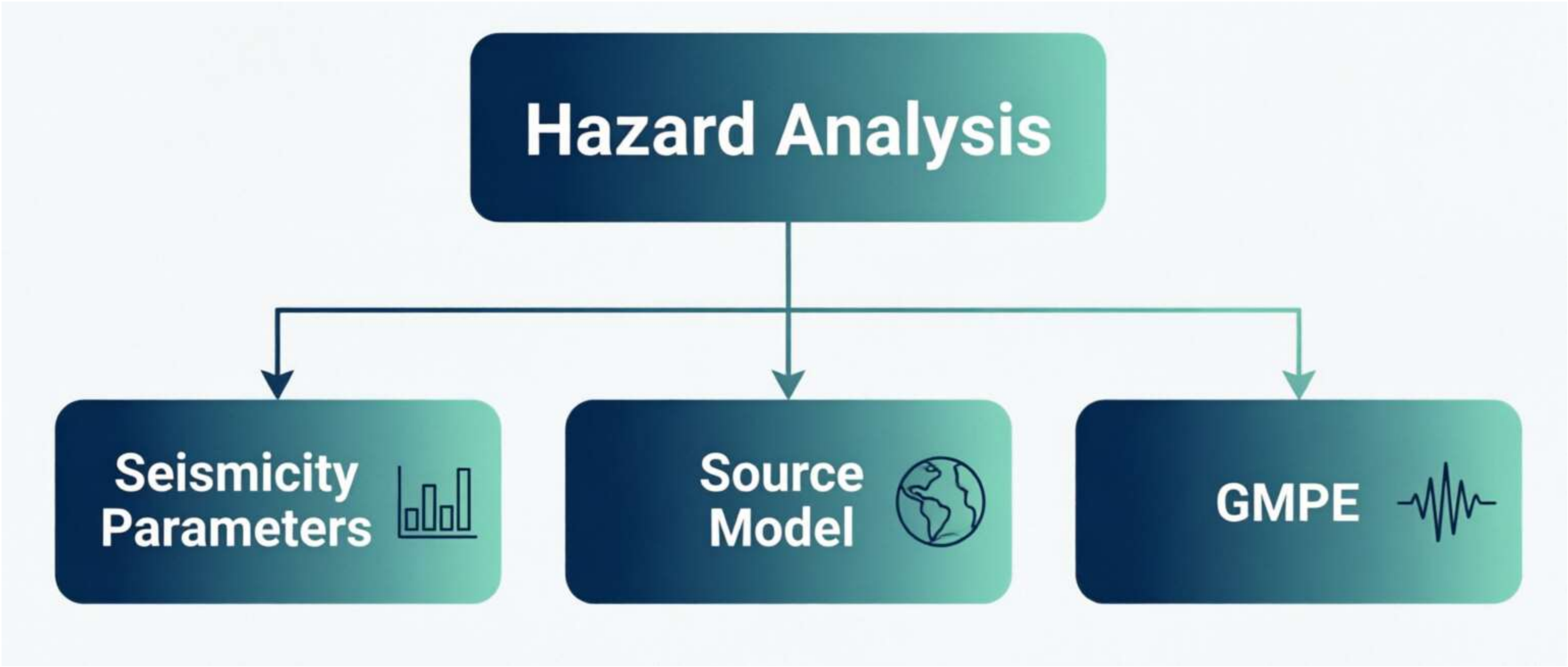
		Component i						Component j					
		θ_{cap,pl_i}	$\left(\frac{EI_{stf}}{EI_y}\right)_i$	M_{y_i}	$\left(\frac{M_c}{M_y}\right)_i$	θ_{pc_i}	γ_i	θ_{cap,pl_j}	$\left(\frac{EI_{stf}}{EI_y}\right)_j$	M_{y_j}	$\left(\frac{M_c}{M_y}\right)_j$	θ_{pc_j}	γ_j
Component i	θ_{cap,pl_i}	1.0000	-0.0183	0.0578	0.2538	0.2083	-0.0260	0.6839	0.0106	0.0277	0.0975	0.0533	-0.0202
	$\left(\frac{EI_{stf}}{EI_y}\right)_i$		1.0000	0.1354	-0.1018	0.0375	0.0799		0.6853	0.0612	-0.0950	-0.0305	0.0379
	M_{y_i}			1.0000	0.2838	0.1067	0.0722			0.9263	0.2482	0.0951	0.0549
	$\left(\frac{M_c}{M_y}\right)_j$				1.0000	0.0077	0.1681				0.6728	0.0415	0.0192
	θ_{pc_i}		(sym.)			1.0000	0.2195		(sym.)			0.3466	0.0357
	γ_i						1.000						0.4102

پژوهشگاه بین‌المللی
زلزله‌شناسی و مهندسی زلزله

Damage State	Description	Residual Story Drift Ratio $\Delta / h^{(1)}$
DS1	No structural realignment is necessary for structural stability; however, the building may require adjustment and repairs to nonstructural and mechanical components that are sensitive to building alignment (e.g., elevator rails, curtain walls, and doors).	0.2% (equal to the maximum out-of-plumb tolerance typically permitted in new construction)
DS2	Realignment of structural frame and related structural repairs required to maintain permissible drift limits for nonstructural and mechanical components and to limit degradation in structural stability (i.e., collapse safety)	0.5%
DS3	Major structural realignment is required to restore margin of safety for lateral stability; however, the required realignment and repair of the structure may not be economically and practically feasible (i.e., the structure might be at total economic loss).	1%
DS4	Residual drift is sufficiently large that the structure is in danger of collapse from earthquake aftershocks (note: this performance point might be considered as equal to collapse, but with greater uncertainty).	High Ductility Systems $4\% < 0.5V_{design}/W$
		Moderate Ductility Systems $2\% < 0.5V_{design}/W$
		Limited Ductility Systems $1\% < 0.5V_{design}/W$

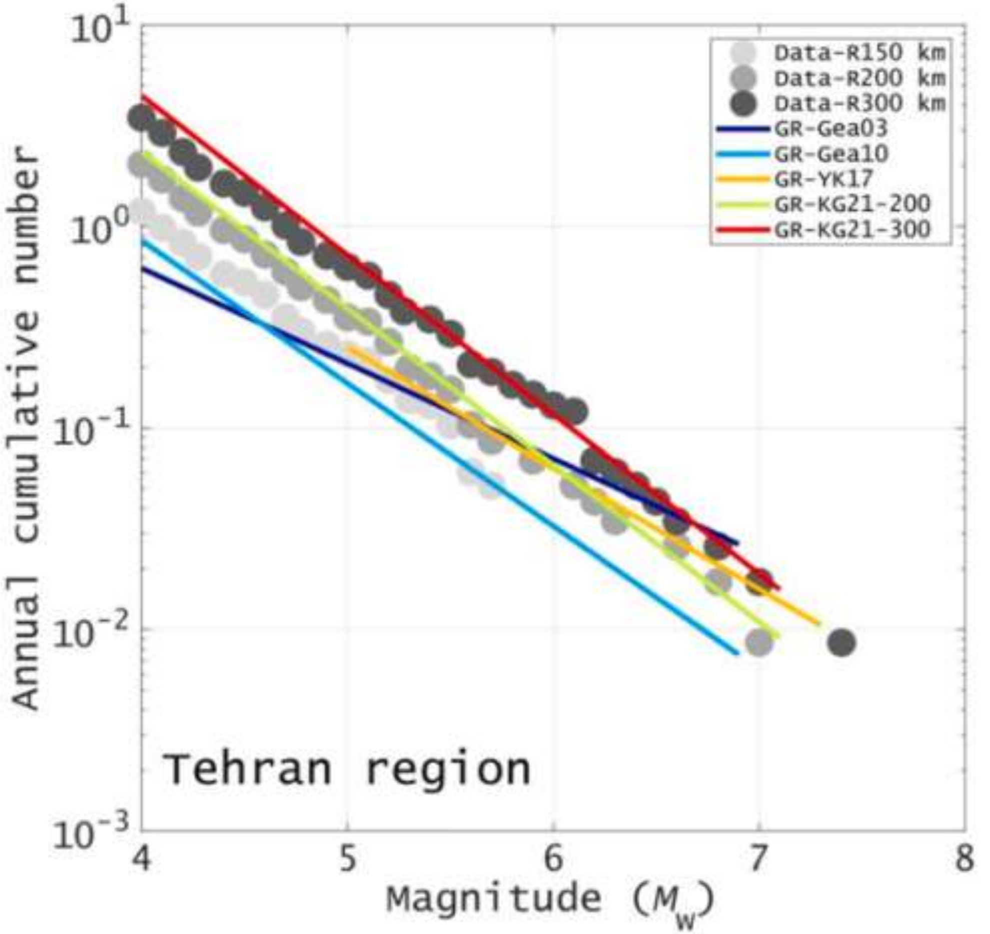
Damage state	Typical description (residential)	HAZUS mean damage ratio (repair/replacement)
None	No damage	0%
Slight	Minor cosmetic cracking, small plaster/drywall cracks	~2%
Moderate	Wider cracks, damage to finishes/utilities, partial chimney damage	~10%
Extensive	Major structural/non-structural damage, partial collapse, building unusable	~50%
Complete	Collapse or imminent danger of collapse [[4]]	~100%

پژوهشگاه بین‌المللی
زلزله‌شناسی و مهندسی زلزله



پژوهشگاه بین‌المللی
زلزله‌شناسی و مهندسی زلزله

Seismicity Parameters



پژوهشگاه بین‌المللی
زلزله‌شناسی و مهندسی زلزله

Seismicity Parameters

Earthquake declucster catalog

Gardner and Knopoff 1974

Reasenberg 1985

ETAS 2009
epidemic-type aftershock sequence

SML 2025
supervised machine learning

Maximum magnitude

Annual rate

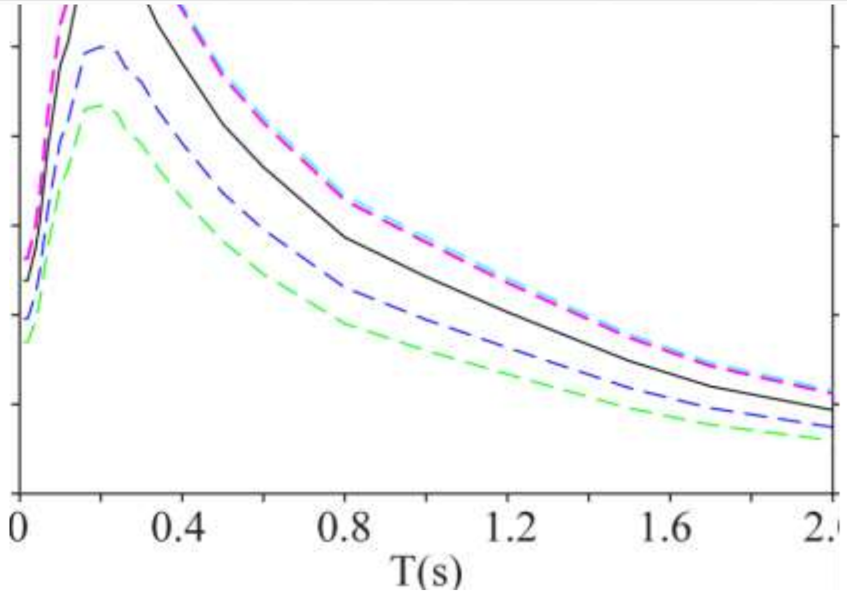
b-Value

پژوهشگاه بین‌المللی
زلزله‌شناسی و مهندسی زلزله

Seismicity Parameters

Table 6 *a* value and *b* value in the declustered catalog of Iran's major tectonic zones using different methods

Zone	Declustering method																	
	Re		Uh		G-K		Gr		ETAS-0.5		ETAS-0.6		ETAS-0.7		ETAS-0.8		ETAS-0.9	
	a	*B*	*a*	*b*	*A*	*b*	*a*	*b*	*a*	*b*	*a*	*b*	*a*	*b*	*a*	*b*	*a*	*b*
North of Iran	5.13	0.92	5.10	0.94	4.79	0.88	4.46	0.82	5.08	0.94	5.01	0.93	4.96	0.92	4.72	0.88	4.57	0.86
East of Iran	4.78	0.84	4.56	0.81	4.25	0.76	3.91	0.70	4.55	0.83	4.49	0.82	4.39	0.80	4.10	0.75	3.76	0.71
Zagros	5.56	0.89	5.40	0.88	4.95	0.81	4.36	0.71	5.56	0.94	5.54	0.95	5.45	0.94	5.33	0.93	4.82	0.89



پژوهشگاه بین‌المللی
زلزله‌شناسی و مهندسی زلزله

Seismicity Parameters

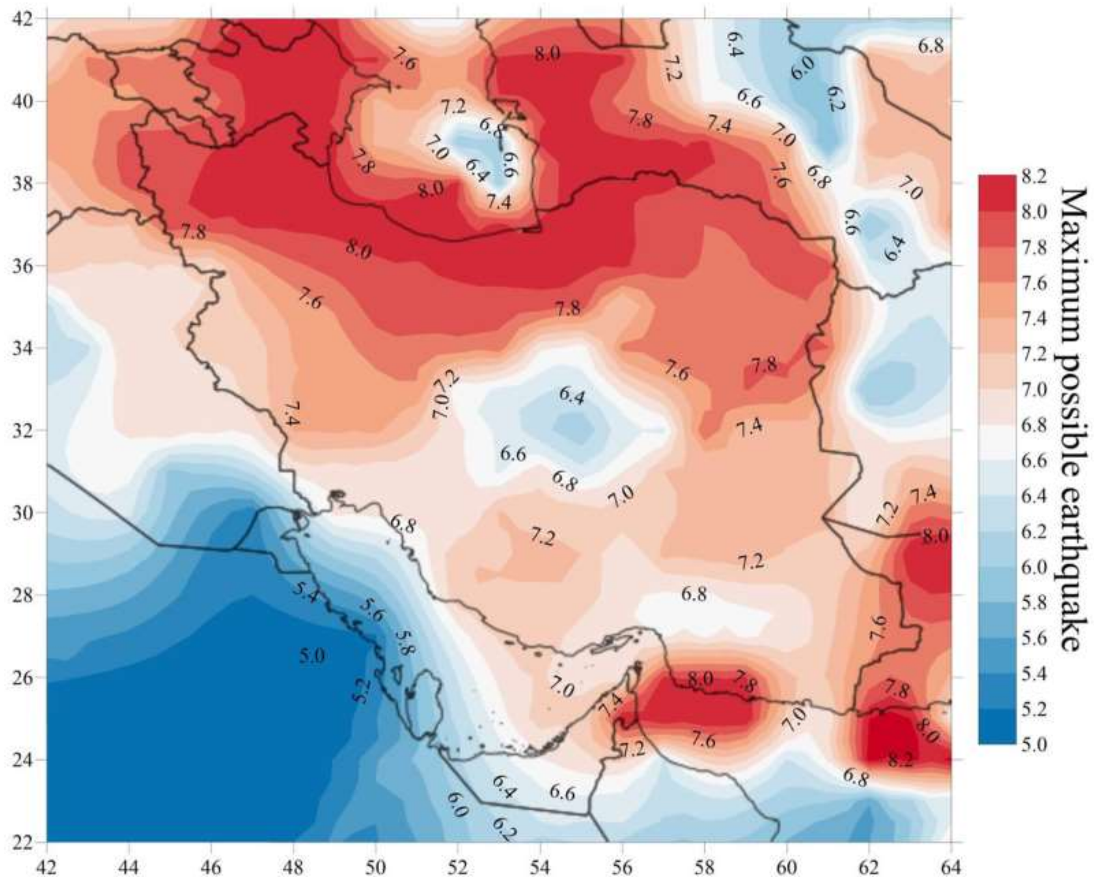


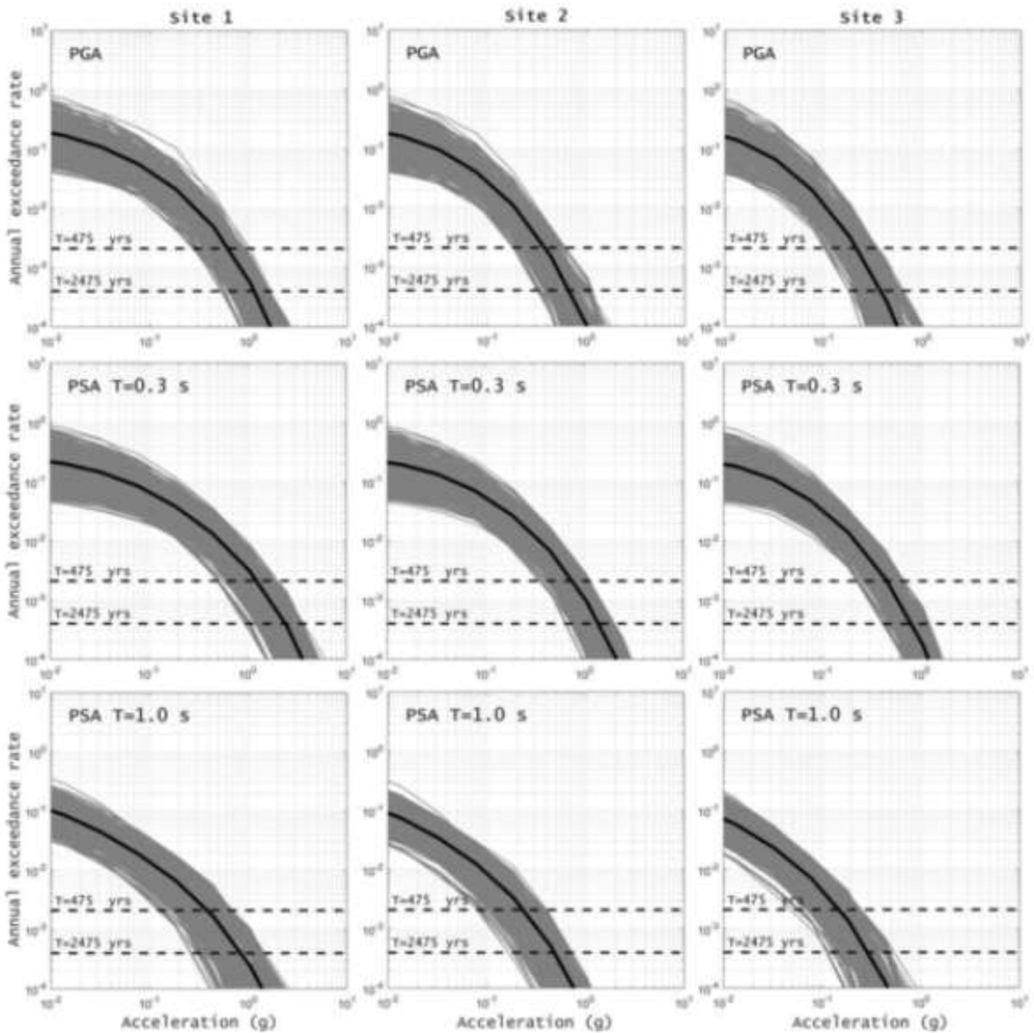
Table 1 Magnitude-scaling relations to estimate the maximum earthquake magnitude for the Iranian Plateau

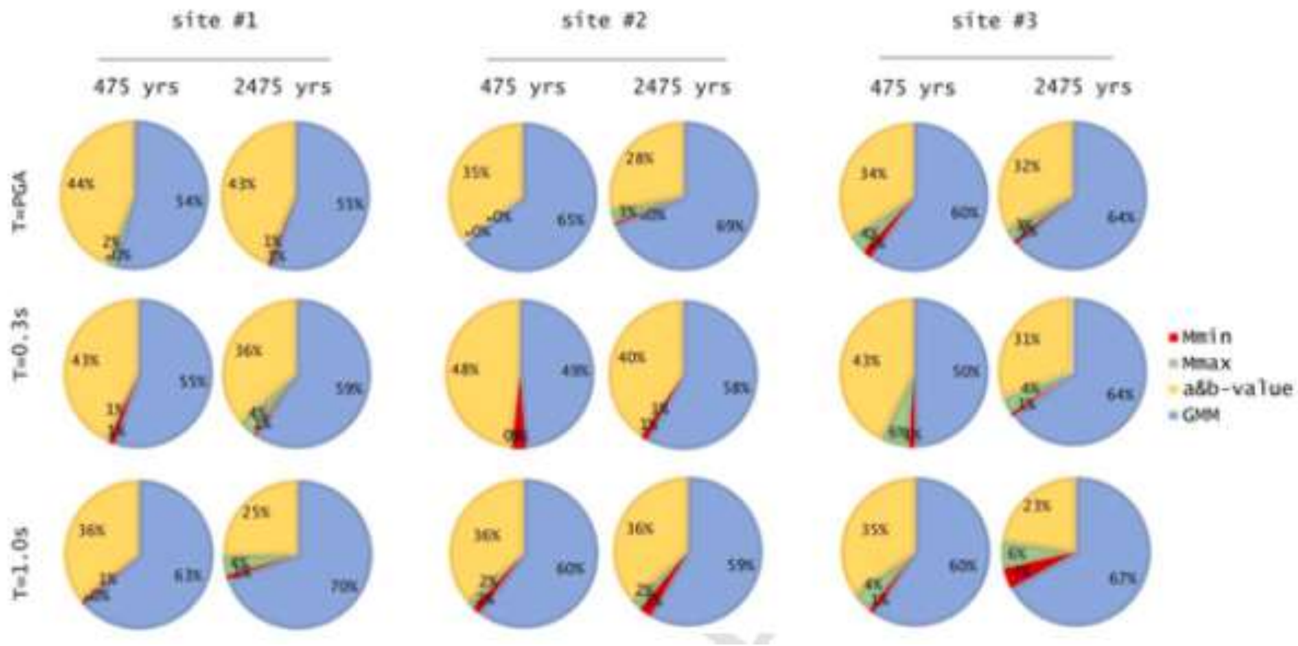
Reference	Style of faulting	Relationship
Wells and Coppersmith (1994)	Strike slip	$M_w = 1.12 \log L + 5.16$
	Reverse	$M_w = 1.22 \log L + 5.00$
	Normal	$M_w = 1.32 \log L + 4.86$
Leonard (2010)	Strike slip	$M_w = 1.67 \log L + 4.17$
	Dip slip	$M_w = 1.67 \log L + 4.24$
Nowroozi (2010)	All	$M_w = 0.86 \log L + 5.36$
Ghassemi (2016)	Strike slip	$M_w = 0.81 \log L + 5.66$
	Thrust	$M_w = 0.97 \log L + 5.29$
Thingbaijam et al. (2017)	Strike slip	$M_w = 1.47 \log L + 4.32$
	Reverse	$M_w = 1.63 \log L + 4.38$
	Normal	$M_w = 2.06 \log L + 3.55$

The rupture length in all relationships is expressed in kilometres

پژوهشگاه بین‌المللی
زلزله‌شناسی و مهندسی زلزله

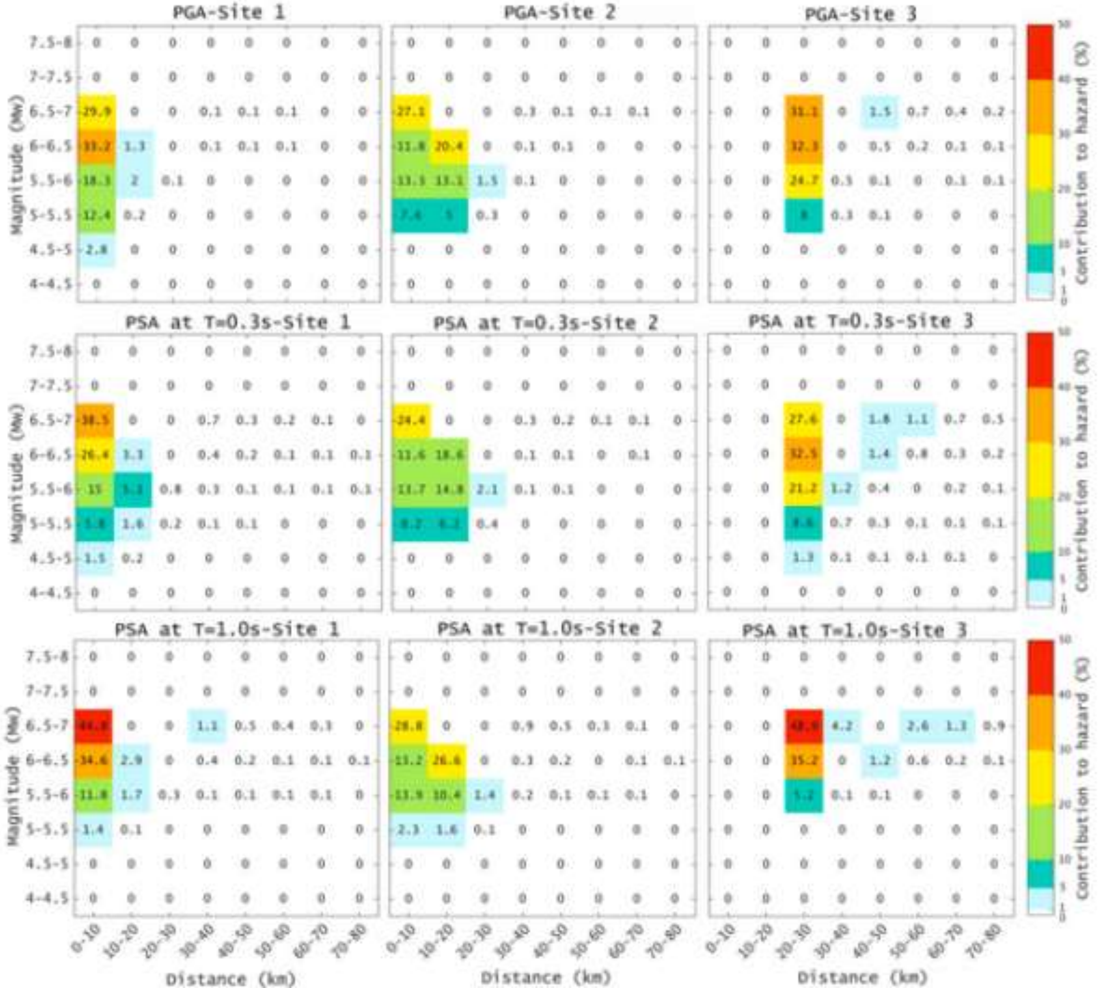
Seismicity Parameters

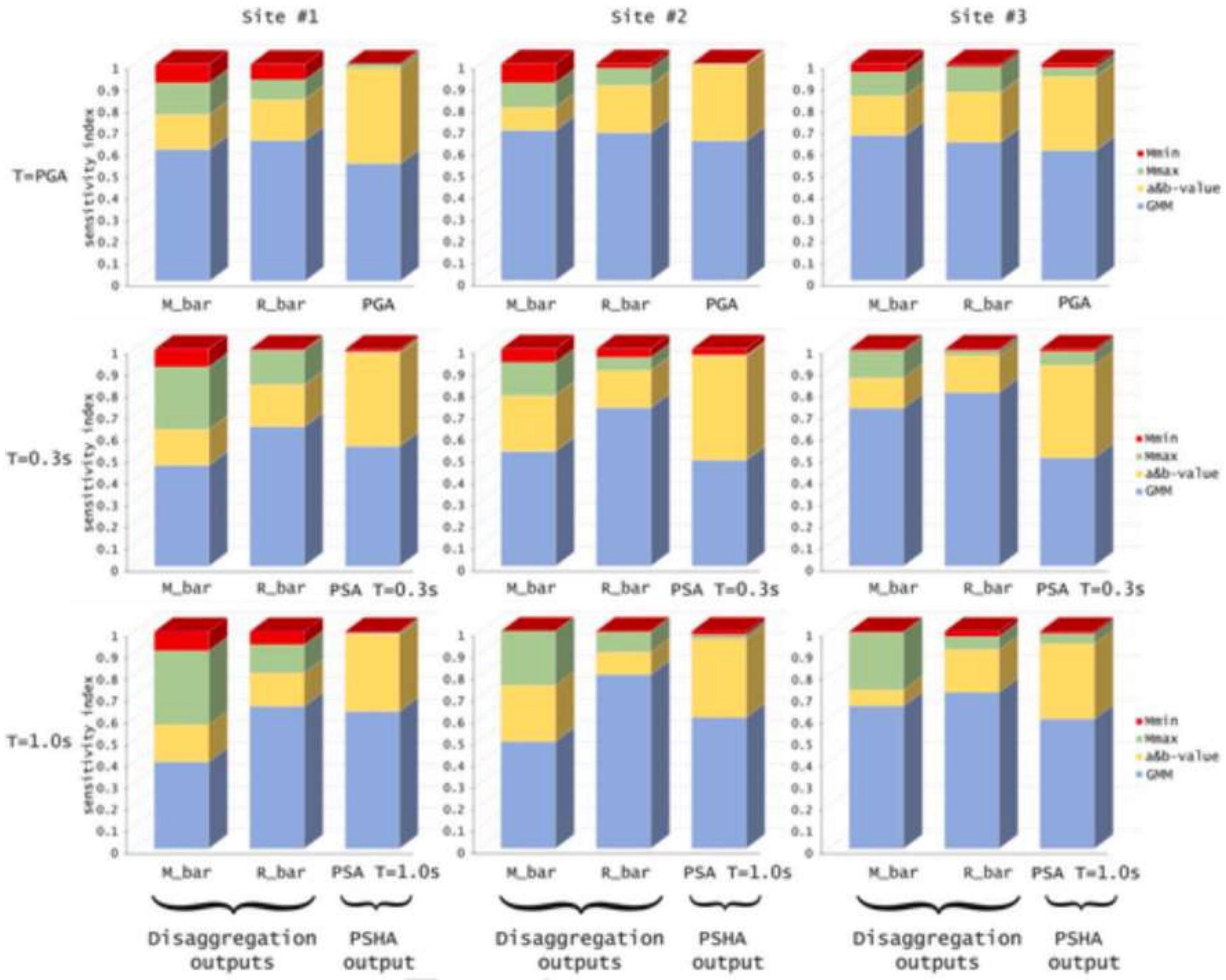




پژوهشگاه بین‌المللی زلزله‌شناسی و مهندسی زلزله

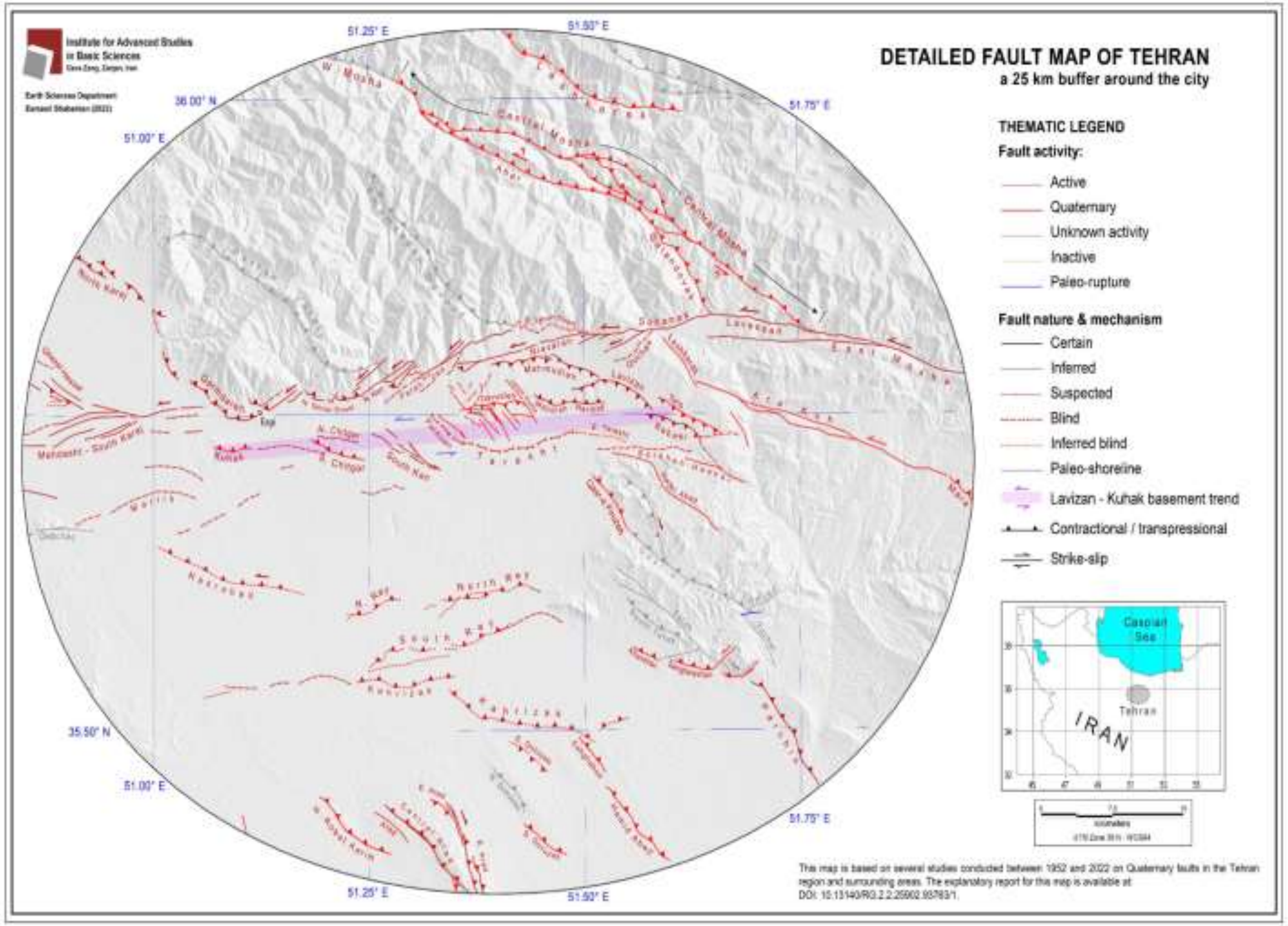
Seismicity Parameters





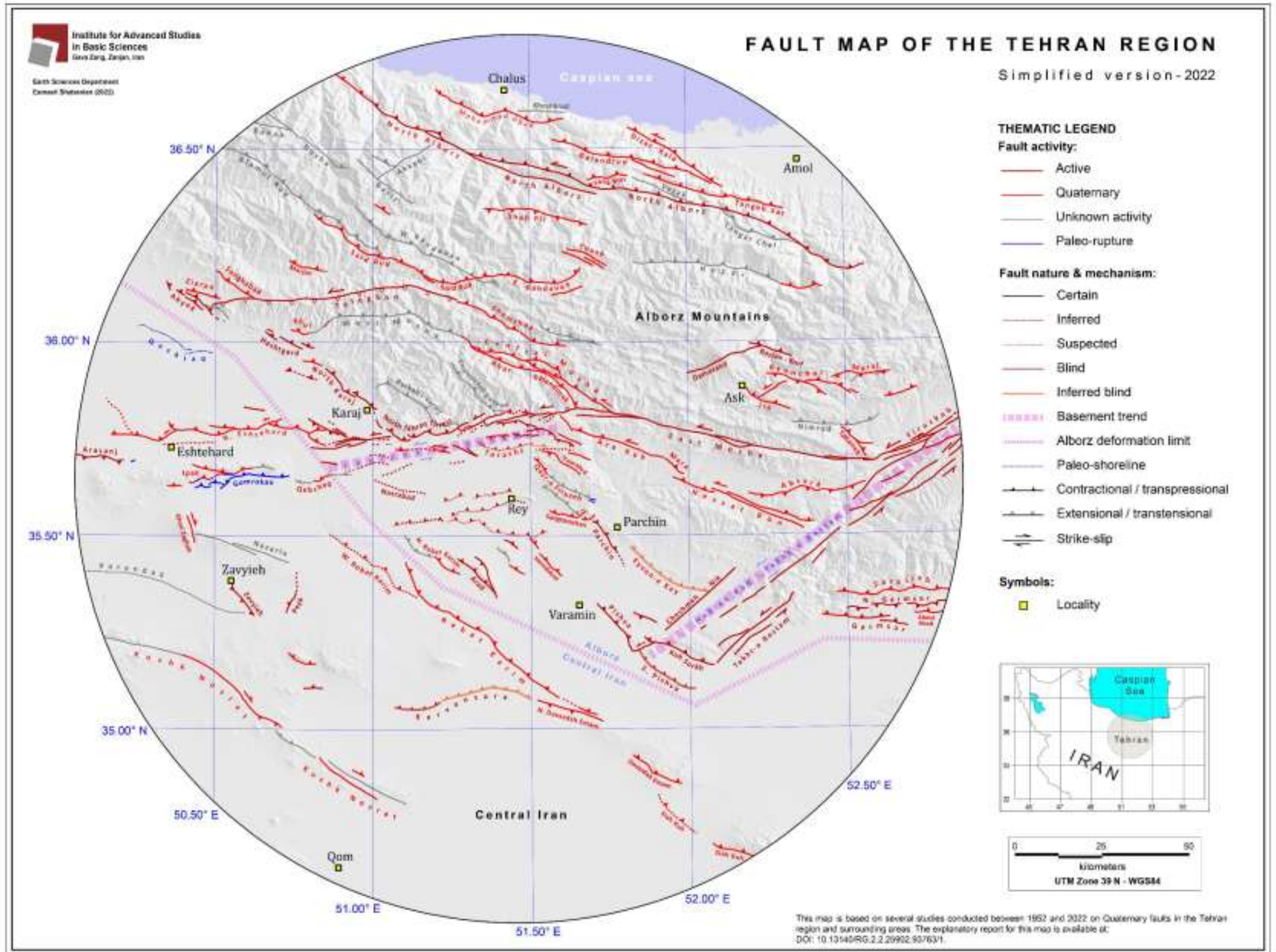
پژوهشگاه بین‌المللی
زلزله‌شناسی و مهندسی زلزله

Source Model



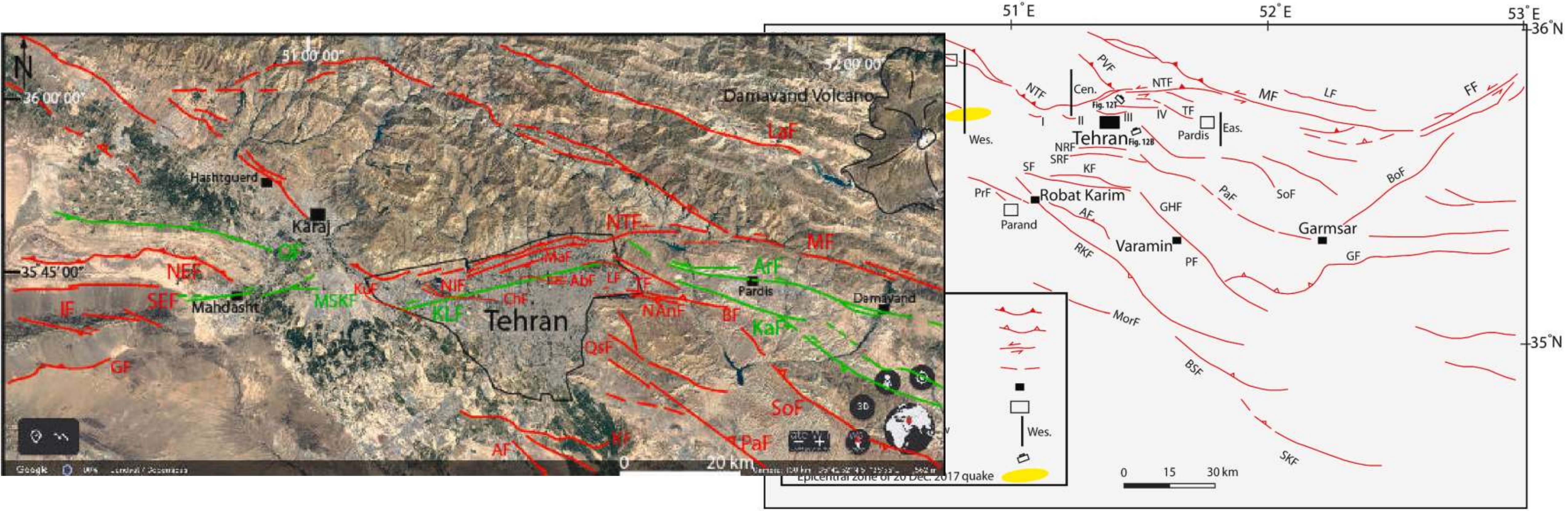
پژوهشگاه بین‌المللی
زلزله‌شناسی و مهندسی زلزله

Source Model



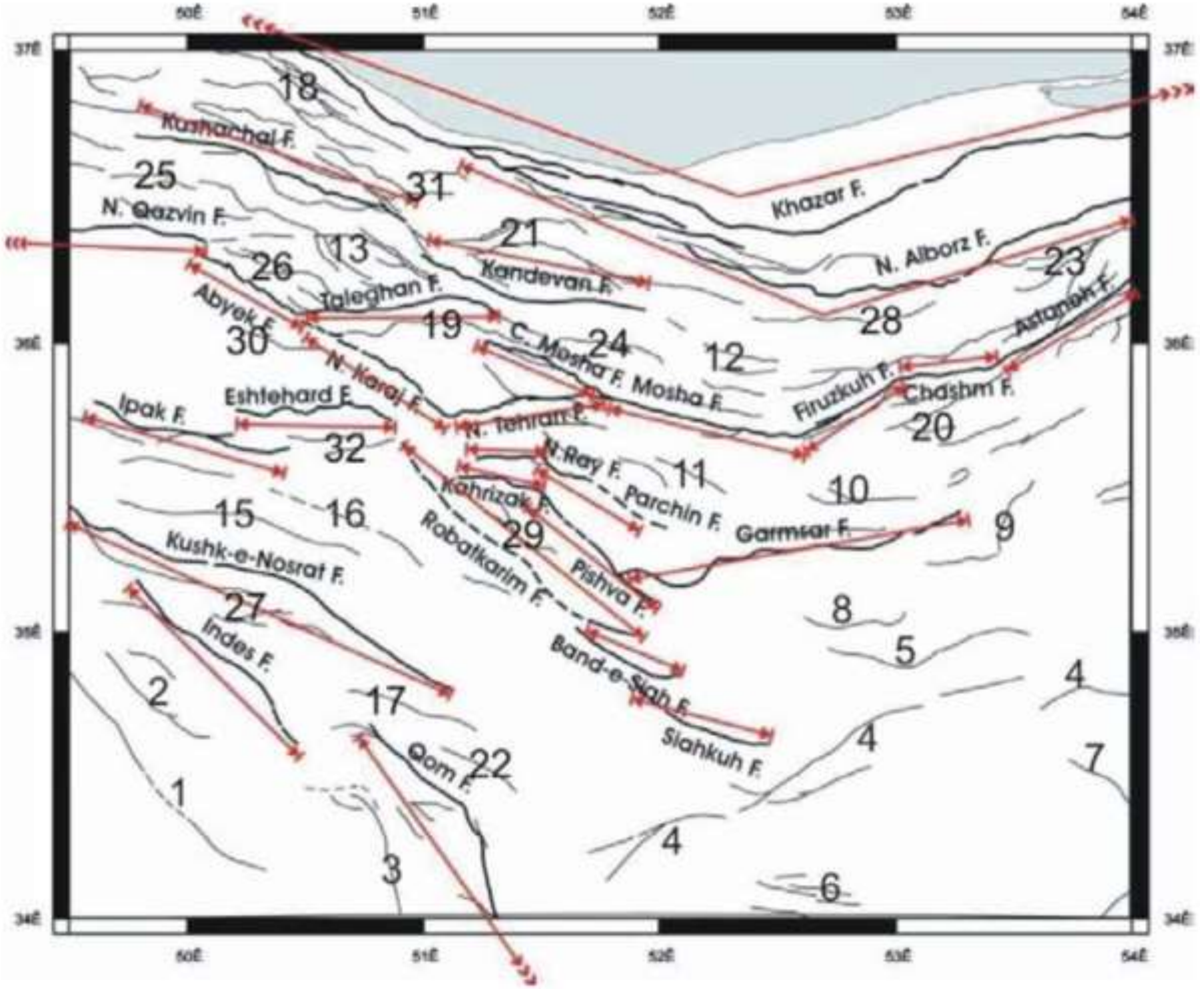
پژوهشگاه بین‌المللی
زلزله‌شناسی و مهندسی زلزله

Source Model



پژوهشگاه بین‌المللی
زلزله‌شناسی و مهندسی زلزله

Source Model



پژوهشگاه بین‌المللی
زلزله‌شناسی و مهندسی زلزله

Source Model

اسم گسل	طول	ریک	عمق	مکانیزم	longS	latS	longE	latE
مشا خاوری	55	75 شمال	13.5	نرمال	50.7538	36.0082	51.3606	35.9549
مشا مرکزی	67	60شمال	13.5	معکوس	51.3606	35.9549	51.7698	35.8101
مشا باختری	65	70 شمال	13.5	نرمال	51.7698	35.8101	52.18	35.7248
شمال تهران خاوری	60	50 شمال	12	معکوس	51.0743	35.757	51.4687	35.7973
شمال تهران باختری	48	50 شمال	12	معکوس	51.4687	35.7973	51.7677	35.8059
نیاوران	21	60 شمال	12	معکوس	51.2914	35.7419	51.5131	357887
کهریزک	70	75 شمال	10	معکوس	51.2777	35.5459	51.5499	35.5061
ایوانکی	70	45 شمال	10	معکوس	51.5465	35.5752	51.8439	35.474
رباط کریم	145	60شمال	10	معکوس	50.9112	35.6252	51.9156	34.9679
ایپک	110	80 شمال	10	راستالغز	50.4637	35.6886	50.7281	35.6714
قزلحصار	45	80 جنوب	10	معکوس	51.5351	35.6672	51.6036	35.6297
اشتهارد	70	85 جنوب	9	راستالغز	50.4725	35.7669	50.8555	35.7397
لویزان	45	80 شمال	9	راستالغز	51.1784	35.6945	51.4723	35.7512
آرا کوه	47	80 شمال	9	راستالغز	51.4723	35.7512	51.3719	35.512
کاجان	65	70 جنوب	9	معکوس	51.6754	35.7403	51.9104	35.6844
پرندک	60	70 شمال	10	معکوس	50.4379	35.5838	50.6448	35.6277

لواسان	راستا لغز	active	certain	51.7622	35.8146	51.6454	35.8289
سوهانک	راستا لغز	active	certain	51.6454	35.8289	51.5031	35.8138
نیاوران	راستا لغز	active	certain	51.499	35.8156	51.3511	35.7909
فرحزاد	راستا لغز	active	certain	51.4155	35.8173	51.2999	35.7764
حصارک	راستا لغز	active	certain	51.27	35.7953	51.2343	35.7735
شمال کن	راستا لغز	active	certain	51.3018	35.7929	51.2403	35.7652
دار اباد- دربند	راستا لغز	quaternary	inffered	51.4962	35.8123	51.4226	35.8234
حصارک	راستا لغز	quaternary	certain	51.3129	35.7828	51.2931	35.7822
کن- دره وردیج	معکوس	active	certain	51.2393	35.7656	51.1764	35.7676
گرمدره 1	معکوس	active	certain	51.1199	35.7499	51.0674	35.7611
گرمدره 2	معکوس	active	certain	51.0658	35.7642	51.0423	35.7788
گرمدره 3	معکوس	active	certain	51.0283	35.7791	51.0111	35.802
بابایی	معکوس	active	certain	51.6335	35.7297	51.5713	35.7497
لویزان	معکوس	active	certain	51.5781	35.7541	51.5234	35.7775
محمودیه 1	معکوس	active	certain	51.516	35.7791	51.4607	35.7977
محمودیه 2	معکوس	active	certain	51.4588	35.7932	51.3913	35.7894
مجیدیه- نارمک	معکوس	active	certain	51.522	35.7589	51.4411	35.7653
پردیسان	راستا لغز	active	blind	51.3697	35.727	51.3223	35.7494
طرشت	راستا لغز	active	blind	51.3747	35.7258	51.4862	35.736
طرشت شرقی	راستا لغز	active	inffered blind	51.4881	35.7358	51.5477	35.7277
کن جنوبی	راستا لغز معکوس	active	certain	51.2521	35.7356	51.3259	35.7067
شمال چیتگر	راستا لغر	active	certain	51.1896	35.7342	51.2374	35.728
جنوب چیتگر	معکوس	quaternary	certain	51.1819	35.7311	51.2445	35.7147
کوهک	راستا لغز معکوس	quaternary	certain	51.07	35.7252	51.1146	35.724
قصر فیروزه	معکوس	quaternary	certain	51.5018	35.6974	51.5438	35.6543
پارچین	معکوس	active	certain	51.6888	35.5341	51.7656	35.4504
ایوانکی	معکوس	active	inffered blind	51.802	35.4662	52.0542	35.351
سنگ تراشان	معکوس	quaternary	certain	51.5523	35.5614	51.6788	35.5363

اسم گسل	ریک	عمق	مکانیزم	longS	latS	longE	latE
خزر1	35 جنوب	10	معکوس	50.2288	37.1173	52.3554	36.3865
خزر2	36 جنوب	10	معکوس	52.3524	36.38.35	54.2676	36.7887
شمال البرز1	50 جنوب	10	معکوس	51.1763	36.6556	52.7147	36.152
شمال البرز 2	51 جنوب	10	معکوس	52.7147	36.152	54.0651	36.5088
کاشاچال	80 شمال	10	ر استالغز	49.7746	36.7034	50.9249	36.4032
کندوان	50 شمال	10	معکوس	51.0015	36.2849	51.9255	36.1032
شمال قزوین	50 شمال	10	معکوس	49.2181	36.3804	50.07	36.342
ابیک	45 شمال	10	معکوس	50.0732	36.2835	50.4629	36.0801
طالقان	55 جنوب	10	نرمال	50.498	36.0963	51.3026	36.0915
مشا	65 شمال	10	راستالغز	51.7841	35.7959	52.5905	35.6642
مشا مرکزی	70 جنوب	10	نرمال	51.2494	35.992	51.7658	35.8109
فیروزکوه	45 شمال	10	معکوس	52.5905	35.6518	53.0405	35.8628
چشم	90	10	راستا	53.0099	35.8628	53.4145	35.8997
استانه	50 شمال	10	معکوس	53.3992	35.8873	54.0016	36.2039
شمال تهران	52 جنوب	10	معکوس	51.1202	35.7245	51.7734	35.7984
شمال کرج	45 شمال	10	معکوس	50.5088	36.0614	51.1125	35.7345
اپیک	60 شمال	10	معکوس	49.6055	35.78	50.4257	35.6196
اشتهارد	45 شمال	10	معکوس	50.2086	35.7568	50.8728	35.7224
رباط کریم	45 شمال	10	معکوس	50.9112	35.6252	51.9156	34.9679
بند سیاه	45 شمال	10	معکوس	51.6483	35.0019	52.0807	34.8333
سیاه کوه	45 شمال	10	معکوس	51.9205	34.7899	52.4583	34.5938
شمال ری	45 شمال	10	معکوس	51.2044	35.5788	51.4991	35.5909
پارچین	45 شمال	10	معکوس	51.4991	35.5781	51.9881	35.3537
کهریزک	45 شمال	10	معکوس	51.1328	35.5191	51.5145	35.4813
پیشوا	45 شمال	10	معکوس	51.5069	35.4788	52.0221	35.1608
گرمسار	45 شمال	10	معکوس	52.019	35.1545	53.2659	35.3982
کوشک نصرت	45 شمال	10	معکوس	49.5025	35.4191	51.1221	34.7909
ایندس	45 شمال	10	معکوس	49.7847	35.1645	50.4657	34.5891
قم	45 شمال	10	معکوس	50.792	34.6636	51.4796	33.7601

پژوهشگاه بین‌المللی
زلزله‌شناسی و مهندسی زلزله

Soil Dynamics and Earthquake Engineering xxx (xxxx) 108558

Contents lists available at ScienceDirect

Soil Dynamics and Earthquake Engineering

journal homepage: www.elsevier.com/locate/soildyn

ELSEVIER

Uncertainty and sensitivity assessments on the inputs of probabilistic seismic hazard assessment: A case study of the North Tehran fault

Milad Kowsari [a, *], Nasrollah Eftekhari [b, **], Ehsan Yousefi Dadras [c]

[a] *Faculty of Civil and Environmental Engineering, School of Engineering and Natural Sciences, University of Iceland, Reykjavik, Iceland*
[b] *Faculty of Technology and Mining, Yasouj University, Choram, Iran*
[c] *Faculty of Civil Engineering, School of Engineering, University of Kurdistan, Sanandaj, Iran*

ARTICLE INFO

Keywords:
The uncertainty and sensitivity analyses
PSHA
Disaggregation
North Tehran fault

ABSTRACT

Probabilistic seismic hazard analysis (PSHA) often incorporates significant uncertainty in its inputs, which have the potential to substantially affect the estimated hazards. To improve the reliability of seismic hazards, the present work examines how these uncertainties impact the variability of PSHA and disaggregation results. For this purpose, uncertainty and sensitivity analyses have been performed for different sites in the Tehran region, with the seismic source of the North Tehran Fault as a case study. The results show that uncertainties in the input parameters have a moderate to significant effect on the PSHA and disaggregation results. The uncertainty and sensitivity analyses of this study provide a better understanding of the various PSHA parameters and their associated uncertainties. Therefore, such analyses establish confidence in the PSHA results and expose the main sources of uncertainty, which enable the prioritization of endeavors to reduce hazard variability.