Seismic deaggregation analysis and ground motion selection for Chiang Mai and Chiang Rai

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1. INTRODUCTION

In this study, seismic deaggregation analysis is applied for Chiang Mai and Chiang Rai in Northern Thailand to assess the combined effect of all magnitudes and distances on the probability of exceeding a given ground motion level. Deaggregation of peak ground acceleration and spectral acceleration at 1s at different return periods are derived. From comparing the hazard maps from different major cities, it could be concluded that both cities have similar hazard estimates for considered return periods but by deaggregating the hazard, the controlling earthquake scenarios are different, partly due to the location of considered cities and seismicity level of background seismicity and considered active faults. The deaggregation results presented are further used to selecte ground motion at different return periods for structural engineers for testing the adequacy of the design of new structures or the response of existing ones and developing fragility curves of local buildings.
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2. SEISMIC HAZARD DEAGGREGATION (SHD)

In this study, a SHDA for Chiang Mai and Chiang Rai are carried out. Of major cities in the Northern Thailand, Chiang Mai and Chiang Rai has the highest seismic hazard for all considered structural periods and probabilities of exceedance. For short and long ground motions (PGA and SA at 0.6s), the predicted high ground motions are about0.9g and 0.4g for 2% probability of exceedance in 50 years.

Some of the SHDA for Chiang Mai and Chiang Rai are presented by 3D bar graphs in Figures 2 to 5, where the height of each bar shows the contribution to hazard by the earthquake scenario that the bar represents, while the location of the bar shows the magnitude (Mw) and source-to-site distance (R) of the earthquake scenario. The hazard is represented by the PGA and SA at structural periods of 0.6 sec for return periods of 2475 years.

The SHD results show that the seismic hazard at Chiang Rai at SA (T = 0.2s) at return period of 2,475 is dominated by both earthquakes of magnitude 5.25 at 12 km and earthquake magnitude of 6.75 from the Mae Chan fault central segment, which is less than 25 km distance to the city center. However for SA (T=0.6s), Figure 1. Chiang Rai is mostly contributed by Mae Chan fault. For Chiang Mai, the controlling earthquake scenario is earthquake with magnitude 5.25 at 12 km from City Center. In contrasting to the SA (T = 0.2s), the deaggregation result from the SA (T = 0.6s) is highly contributed from the magnitude of 6.5 at distance 25 km from Mae Tha fault with some contribution from background seismicity.

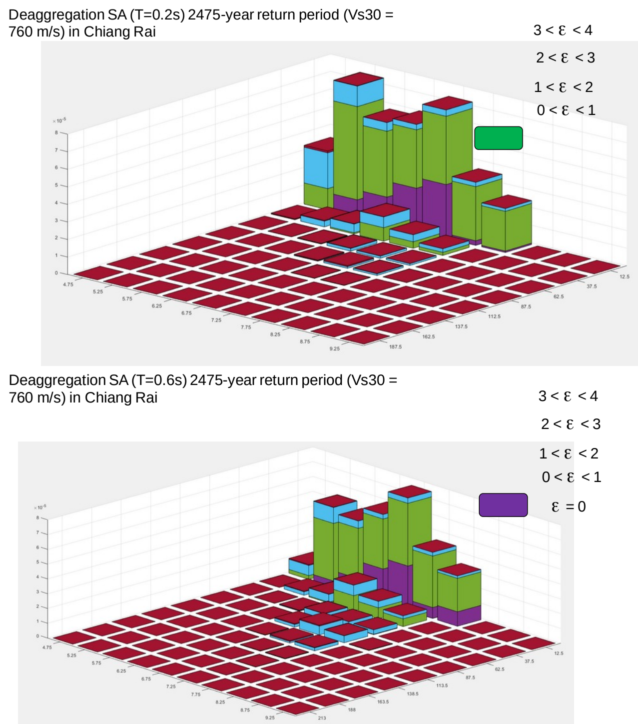


Figure 1. The 3-D deaggregation for PGA and SA (T-0.6s) at Chiang Rai at 2,475-year return period corresponding to 2 % of excceedance in 50 years.

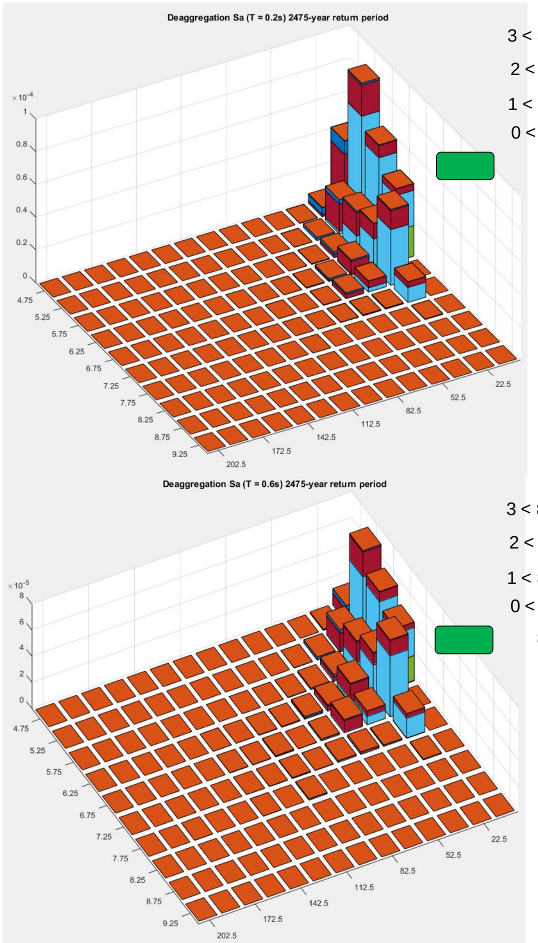


Figure 2. Figure 1. The 3-D deaggregation for PGA and SA (T-0.6s) at Chiang Mai at 2,475-year return period corresponding to 2 % of excceedance in 50 years.

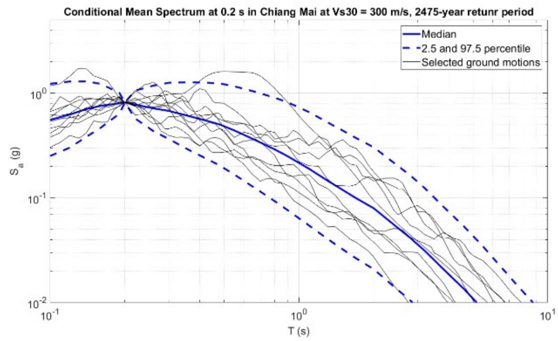
3. CONDITIONAL GROUND MOTION SELECTION

Figure 3 shows example ground motions selected to match a target CMS at 0.2s for 2475-year return period for Chiang Mai. This approach is simple, and produces ground motions whose Sa(T*) values exactly match the target value upon which all CMS calculations are based. An alternative approach is to scale each ground motion so that the average response spectrum over the periods of interest is equal to the average of the target spectrum over the same periods. Table 1 display illustrates selected and scaled ground motion for CMS at 0.6s at 2475-year return period for Chiang Mai of data, obtained from ground motions in the NGA and Thailand database (Chiou et al. 2008).

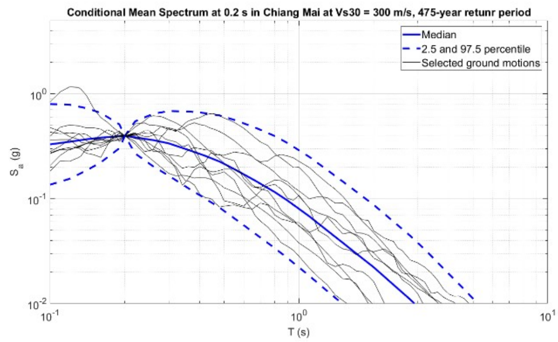
Table 1. Selected and scaled Ground motion for CMS at 0.6s at 2475-year return period for Chiang Mai.

CMS (0.6s)-Summary of Properties of Rotated & Scaled Horizontal Records

Comp.	NGA#	MSE	ScaleF	Tp(s)	D5-95(s)	Event	Year	tation	Mag	Mechanism	Rrup (km)	Vs30 (m/s)
GM	68	-	2.23	– –	5.2 13.4	"San Fernando"	1971	"LA - Hollywood Stor FF"	6.61	Reverse	22.77	316.46
GM	339	-	1.81	– –	10.4 19.7	"Coalinga-01"	1983	"Parkfield - Fault Zone 15"	6.36	Reverse	29.38	307.59
GM	346	-	1.38	– –	6.1 12.7	"Coalinga-01"	1983	"Parkfield - Fault Zone 8"	6.36	Reverse	29.94	308.84
GM	547	-	1.2	– –	3.1 11.5	"Chalfant Valley-01"	1986	"Zack Brothers Ranch"	5.77	strike slip	6.39	316.19
GM	692	-	0.63	– –	1.8 6	"Whittier Narrows-01"	1987	"Santa Fe Springs - E. Joslin"	5.99	Reverse Oblique	18.49	339.06
GM	714	-	1.86	– –	1.4 6.2	"Whittier Narrows-02"	1987	"LA - Obregon Park"	5.27	Reverse Oblique	13.62	349.43
GM	953	-	0.43	– –	6 9.3	"Northridge-01"	1994	"Beverly Hills - 14145 Mulhol"	6.69	Reverse	17.15	355.81
GM	1039	-	1.35	– –	7.7 16.1	"Northridge-01"	1994	"Moorpark - Fire Sta"	6.69	Reverse	24.76	341.58
GM	3968	-	0.21	– –	6 35.3	"Tottori_ Japan"	2000	"TTRH02"	6.61	strike slip	0.97	310.21
GM	Tarlay		1.5499			Tarlay	2011	MASE	6.8	strike slip	28	300



a)



b)

Figure 2. Selected and scaled 10 pairs of ground motion should be related to the percentage of controlling earthquake from deaggregation analysis for Chiang Mai at a) 2475- and b) 475- year return period, respectively.

4. CONCLUDING REMARKS

An approach has been described that allows one to compute the expected response spectrum associated with a target spectral acceleration (Sa) value at a single period, using knowledge of the magnitude, distance and ε value that caused occurrence of that target Sa. Some challenges still remain for implementing this approach, relating to implementation for structures sensitive to excitation at multiple periods and accurate quantification of variability in response. Work is in progress to more completely address those challenges, but recent experience with this approach suggests that even in its current form it is a useful tool with several advantages relative to the alternative UHS.

5. REFERENCE

[1] Baker, J. W., and Jayaram, N. (2008). "Correlation of spectral acceleration values from NGA ground motion models." Earthquake Spectra, 24(1), 299-317

6. AUTHOR BIOGRAPHIES

Teraphan Ornthammarath is an Associate Professor at the Department of Civil Environmental Engineering, at Mahidol University. He obtained PhD at Roseschool, IUSS Pavia, Italy in 2010. He has research experience in seismic hazard analysis, strong ground motion, and seismic risk/loss assessment for various infrastructure projects in South-East Asia. He has been involved in interdisciplinary and international collaboration through his work with the UK's Earthquake Engineering Field Investigation (EEFIT) and Global Earthquake Model (GEM).

Prof. Pennung Warnitchai has considerable experience when it comes to conducting research projects in the area of seismic hazard and risk assessment. Some of the notable research project that Prof. Warnitchai has conducted include: Seismic Hazard and Risk Assessment of Six Cities in Bangladesh; Action Plan for Earthquake Disaster Prevention and Mitigation in Bangkok, Study on Seismic Design and Retrofit of Building in Thailand. The research and consulting assignment conducted by Prof. Warnitchai covers national (Thailand) as well as regional (South East Asia, and South Asia).