Seismic Reevaluation of Nuclear Facilities in Taiwan

Development of the Hazard Input Document for Taiwan Using SSHAC Level 3 Methodology

WORKSHOP #2 PROCEEDINGS

October 2016

National Center for Research on Earthquake Engineering
National Applied Research Laboratories

LIST OF ABBREVIATIONS and COMMON ACRONYMS

AEC	Atomic Energy Council
AFE	Annual Frequency of Exceedance
ANS	American Nuclear Society
ANSI	American National Standards Institute
BBP	Broadband Platform (SCEC)
CA/Mex	California/Mexico
CBR	Center, Body and Range
CEUS	Central and Eastern United States
CFR	Code of Federal Regulations
CGS	Central Geological Survey
CWB	Central Weather Bureau
DBE	Design Basis Earthquake
DCPP	Diablo Canyon Power Plant
DCR	Design Change Request
DSHA	Deterministic Seismic Hazard Analysis
EE	Evaluator Expert
EPRI	Electric Power Research Institute
ESEL	Expedited Seismic Equipment List
ESEP	Expedited Seismic Evaluation Process
FCR	Field Change Request
FLEX	The Diverse and FLEXible Coping Capability
FSAR	Final Safety Analysis Report
GEM	Global Earthquake Model
GIS	Geographic Information Systems
GMC	Ground Motion Characterization
GMM	Ground Motion Models
GMPE	Ground Motion Prediction Equation
GMRS	Ground Motion Response Spectrum
GPS	Global Positioning System
GS	Geometric Spreading
HCLPF	High Confidence of Low Probability of Failure
HID	Hazard Input Document
IES	Institute of Earth Sciences (Academia Sinica)

JGR	Journal of Geophysical Research
MTN(IES)	Seismic Array in the Taiwan Mountain Area
NCREE	National Center for Research on Earthquake Engineering
NCU	National Central University
NGA	Next Generation Attenuation
NML	Normal Fault Mechanisms
NPP	Nuclear Power Plant
NRC	Nuclear Regulatory Commission
NTTF	Near Term Task Force
NTU	National Taiwan University
NUREG	Nuclear Regulation
ODB	Ocean Data Bank
PEER	Pacific Earthquake Engineering Research Center
PFDHA	Probability Fault Displacement Hazard Analysis
PGA	Peak Ground Acceleration
PM	Project Manager
PPRP	Participatory Peer Review Panel
PSHA	Probabilistic Seismic Hazard Analysis
PTI	Project Technical Integrator
PVNGS	Palo Verde Nuclear Generating Station
QA	Quality Assurance
RB	Reactor Building
RE	Resource Expert
REV	Reverse Fault Mechanisms
RG	Regulatory Guide
RLGM	Review Level Ground Motion
SCEC	Southern California Earthquake Center
SFP	Spent Fuel Pool
SMA	Seismic Margin Assessment
SMA	Strong Motion Accelerographs Network (IES)
SMART1	Strong Motion Accelerograph Array in Taiwan, Phase1 (IES)
SMART2	Strong Motion Accelerograph Array in Taiwan, Phase2 (IES)
SONGS	San Onofre Nuclear Generating Station
SPID	Screening, Prioritization and Implementation Details
SPRA/SPSA	Seismic Probability Risk (Safety) Assessment

SS	Strike-Slip Fault Mechanisms
SSC	Seismic Source Characterization
SSCs	Structures, Systems and Components
SSE	Safety Shutdown Earthquake
SSHAC	Senior Seismic Hazard Analysis Committee
SSI	Soil-Structure Interaction
SWUS	Southwestern United States
TAO	Terrestrial, Atmospheric and Oceanic Sciences
TDI	Technical Defensible Interpretation
TEC	Taiwan Earthquake Research Center
TI	Technical Integrator
TNGA	Taiwan Next Generation of Attenuation Relations
TPC	Taiwan Power Company
TSMIP	Taiwan Strong Motion Instrumentation Project
UHRS	Uniform Hazard Response Spectrum

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Workshop #2 Introduction

In response to the 50.54(f) letter issued in March 2012, an updated probabilistic seismic hazard analysis (PSHA) based on a Senior Seismic Hazard Analysis Committee (SSHAC) Level 3 process (Budnitz et al., 1997; NRC 2012, NUREG 2117) is required to be conducted for all operating nuclear power plants in the United States. In Taiwan, the Atomic Energy Council (AEC) requested Taiwan Power Company (TPC) to reevaluate seismic hazard and review the seismic design basis of nuclear facilities in Taiwan based on the suggestions in NTTF 2.1: Seismic. As the result, TPC launched the "Seismic Reevaluation of Nuclear Facilities" Project executed by the National Center for Research on Earthquake Engineering (NCREE). A seismic hazard analysis will be performed for four nuclear power plants assigned by the Taiwan Power Company (TPC) by developing the Seismic Source Characterization (SSC) model and the Ground Motion Characterization (GMC) model as basic inputs to a site-specific probabilistic seismic hazard analysis (PSHA). SSC describes the future earthquake potential (e.g., magnitudes, locations and rates), and GMC describes the distribution of the ground motion as a function of magnitude, style of faulting, source-to-site geometry and site condition. For the seismic hazard analysis, both of these models will be developed following the guidelines of the Senior Seismic Hazard Analysis Committee (SSHAC) Level 3 process (Budnitz et al., 1997; NRC, 2012). The SSC model developed in this study is majorly specific to the region of the study sites with a 320-kilometer radius. The GMC model for the rock ground motions applicable to the study sites will be developed in this study in parallel. The GMC logic tree model will incorporate relevant empirical ground motion models as well as results from numerical simulations. The PSHA calculations and the development of surface response spectra considering site-specific site amplification are not part of this project and will be performed subsequent to the SSC and GMC SSHAC Level 3 studies by another project. The hazard results of four study sites evaluated by using the SSC and GMC models developed in this study will meet the requirements of SSHAC Level 3 methodology.

The objective of this study is to develop SSC and GMC models that capture the center, body and range (CBR) of the technically defensible interpretations (TDI) with SSHAC Level 3 methodology as described in NUREG 2117 (NRC, 2012) for use in PSHA for the study sites. TDI are defined as the development, assessment, and weighting of the scientifically justifiable and defensible interpretations of earth science and geotechnical data by appropriate experts in these fields using a structured process of evaluation and integration with full access to all available data. The purpose of this Project Plan is to describe how the SSHAC Level 3 process will be applied to develop the SSC and GMC models for the study sites

This is the second out of three Workshops that will be conducted in accordance with the applicable SSHAC Level 3 guidelines.

Objective:

The primary goal of Workshop #2 is to use the PEs to explore the center, body, and range of TDI for the SSC and GMC, with a focus on those parameters in SSC and GMC models that are most significant to hazard.

Preparation:

SSC and GMC TI Teams will evaluate the data, information, and interpretations provided by the REs in Workshop #1, and additional information collected from the ongoing field and research programs through a series of working meetings and internal work between working meetings. The project geospatial database

and reference database are to be updated and utilized during the working meetings. Primary objectives are to identify the range of potential alternative interpretations or models resulting from the evaluation of available data, and to identify PEs to discuss and defend these alternative interpretations or models.

The SSC and GMC TI Teams will compile and evaluate additional relevant data identified in Workshop 1, consider the range of alternative interpretations of these data, and develop sensitivity logic trees that constitute SSC and GMC model. The primary purpose for this initial updated model is to perform sensitivity analyses to identify those models and/or interpretations of the data that are most significant to hazard. The Hazard Analyst will perform the sensitivity analysis. The sensitivity analyses will be used to (1) assist the SSC and GMC TI Teams in their evaluation of the data, and (2) identify potential PEs for invitation to Workshop #2. Working meetings of the TI Teams include presentations of hazard sensitivity results by the Hazard Analysts. One or more members of PPRP will attend the working meetings as observers. Prior to Workshop #2, PEs will be identified for PPRP to review. The PEs will be contacted prior to the workshop and provided with a specific request for discussion topics.

Process:

Workshop 2 will last for five days and be attended by PTI, the TI Teams and staff, PPRP, the Hazard Analysts, and the Proponent Experts (PEs). In the case for the PEs to identify other alternative models or technical issues not captured in the current model, these alternative models or technical issues will be indicated during the Workshop for future evaluation by the TI Team and will be considered for inclusion in later versions of the SSC and GMC models, as appropriate. The workshop will provide a forum to explore alternate interpretations of data and alternative hypotheses derived from the data in a series of presentations and structured dialog between various PEs and the TI Teams. The information gained from these interactions will, combined with information within the project geospatial database and reference database, form the basis for defining the center, body, and range of the TDI and be used to update the SSC and GMC model. Workshop #2 also will be used to identify additional data gaps, data needs, and/or analyses that may be performed to further evaluate alternative models or key model parameters and uncertainties. Digital video files of the workshop and electronic files of presentation materials will be posted on the project website and be made publicly available following the meeting.

PPRP will attend Workshop 2 as observers, and provided verbal comments at the end of each day and at the conclusion of the workshop. Following the five-day workshop, the PPRP caucused to review the workshop proceedings. The PPRP prepared written comments and feedback to the Project Sponsor, PTI and TI Team. The PTI and TI Team Lead provided written responses to the PPRP comments. Following the workshop, the proceedings will be documented in a brief workshop summary for distribution to the Project Sponsor and members of the PPRP. The Workshop summary and PPRP letter will be publically available and become part of the final documentation of the Taiwan SSHAC Level 3 project.

Topics and Issues:

- Summarize project overview and objectives.
- Review of SSHAC procedures and workshop ground rules.
- Presentation of sensitivity analyses on the SSC and GMC models.

- Presentations of new collected data and information.
- Present the proponent models and discuss their strengths and weaknesses through interactive discussion with the Proponent Experts and Resource Experts.
- Evaluate the proponent models with comparisons to data, as appropriate.
- Exploration of key parameters, data or model uncertainties, and alternative models.
- Identification of additional data gaps, data needs, and/or analyses.

Workshop #2 Agenda & Focused Questions

Taiwan SSHAC Level 3 Project - Workshop #2 Agenda

October 3-7, 2016, Tsai Lecture Hall of National Taiwan University, Taipei, Taiwan

	Day 1	Day 2	Day 3	Day 4	Day 5
	Session	**Session**	**Session**	**Session**	**Session**
09:00 ~ 09:10	Opening: Introduction to the Day's Topic and the Rules of Workshop #2				
09:10 ~ 10:40	Project Introduction SSC Tasks and Issues	Primary Fault Sensitivity Model - I	Subduction Zone - I	Large Magnitude Scaling	Host to Target Adjustment Factor
10:40 ~ 11:00	*Break*				
11:00 ~ 12:30	Earthquake Catalog	Primary Fault Sensitivity Model - II	Subduction Zone - II	HW Effect and Listric Fault of Crustal Event	Proponent Taiwan GMMs: Median
12:30 ~ 13:30	*Lunch (Rm1401, 1402)*				
13:30 ~ 15:00	Areal Source	Primary Fault Sensitivity Model - III	Introduction Hazard Sensitivity Analysis	Normal Fault Effect of Crustal Event	Proponent Taiwan GMMs: Tau and Phi_ss
15:00 ~ 15:20	*Break*				
15:20 ~ 16:50	Geodetic Data	Other Offshore Fault	Ground Motion Database	Stochastic Ground Motion Simulation	Available Tau and Phi_ss Models
16:50 ~ 17:00	*Break*				
17:00 ~ 17:40	Summary of the Day				
17:40 ~ 18:00	Comments and Questions from Observers				
18:00	*Adjourn*				
18:00~19:00	*Closed Meeting: PPRP, Sponsor, PM, PTI and TI Lead*				

Taiwan SSHAC Level 3 Project
Workshop #2 Agenda – Day 1

October 3, 2016 (Monday)

Tsai Lecture Hall of National Taiwan University, Taipei, Taiwan

Session	Time	Topic	Dur. (min.)	Speaker	PE & RE	Questions
09:00 ~ 10:40 Chaired by PM & B.S. Huang (黃柏壽)						
Project Introduction	09:00 ~ 09:10	Opening & Project Introduction	10	K.C. Chang (張國鎮) C.L. Wu (吳俊霖)	-	
	09:10 ~ 09:30	SSHAC Training	20	N. Abrahamson	-	
SSC Tasks and Issues	09:30 ~ 10:20	Progression of SSC Tasks and Issues	20	B.S. Huang (黃柏壽)	-	● Summarize current sensitivity fault models, areal source model, and subduction zone models.
		SSC Sensitivity	30	C.H. Loh (羅俊雄)	-	● Hazard sensitivity results for areal source, primary faults, other faults, subduction zone, interface, intraslab, and volcanic seismic issues.
	10:20 ~10:30	SSC Sensitivity Gutenberg-Richter Relation	10	Y.B. Tsai (蔡義本)	-	● Implications for SSC sensitivity of an alternative representation of the Gutenberg-Richter relation
	10:30 ~ 10:50	*Discussion*			-	
10:50 ~ 11:00		*Break*				
11:00 ~ 12:30 Chaired by B.S. Huang (黃柏壽)						
Earthquake Catalog	11:00 ~11:10	Issues Related to EQK Catalog for HID	10	B.S. Huang (黃柏壽)	-	● How and why did we use the earthquake catalog data in our hazard model? ● What are the most significant aspects and issues of the earthquake catalog?
	11:10 ~ 11:40	Historical Earthquake Catalog	30	S.N. Cheng (鄭世楠)	Y.M. Wu (吳逸民) K.W. Guo (郭鎧紋) C.H. Chang (張建興) S.N. Cheng (鄭世楠) M.S. Lin (林明聖) Y.T. Shieh (謝英宗) Kaim Ang (翁佳音) Y.C. Liu (劉益昌)	● Can you present the historical and reported evidence for the 1694 and 1867 Shanchiao fault earthquakes? ● What is the evidence or your opinion for the segmentation of the primary faults in our model as described by the earthquake catalog? ● Please present your simulation of 1867 Keelung earthquake. ● Can you estimate fault rupture length and depth from the earthquake catalog? ● Can you provide slip rate, last event, fault geometry for faults related to 1694 and 1867 earthquakes? ● Any other major historical earthquakes related to primary faults near NPP sites?
	11:40 ~ 12:10	Earthquake Catalog	30	Y.M. Wu (吳逸民)		● What is the most prevalent focal mechanism source type of each zoning scheme? ● What are the focal mechanisms of the 1959 (M7.1), 1978 (M7.0), 1996 (ML7.1) Lanyu offshore earthquakes? ● What are the dominant focal mechanisms of crustal earthquakes offshore of the northeastern and southern coasts? Can they be grouped by area?
	12:10 ~ 12:30	*Discussion*				

12:30 ~ 13:30		*Lunch (Rm1401, 1402)*				
13:30 ~ 15:00 Chaired by K. Clahan						
Areal Source	13:30 ~13:40	SSC Areal Source	10	K. Clahan	-	● Introduction to Taiwan areal sources in the current hazard sensitivity model.
	13:40 ~ 13:55	Magnitude Scaling Relationships	15	Y.T. Yen (顏銀桐)	K.F. Ma (馬國鳳) W.Y. Chien (簡文郁) K.P. Chen (陳桂寶) Y.T. Yen (顏銀桐) Y.T. Yeh (葉永田) K.E. Ching (景國恩)	● What relations are most applicable to Taiwan for crustal eq. (area vs length; Yen and Ma, W&C, Sterling, Hanks, etc.)? ● What relations would be most applicable to Taiwan for subduction interface earthquakes?
	13:55 ~ 14:25	Zoning Scheme of A,B,S	30	C.T. Cheng (鄭錦桐)		● What are the data and evidence that support the boundaries of the current zoning schemes A, B, S? ● Are there alternative zoning schemes we need to consider? ● What is the data and evidence that support the depths of the shallow and deep zoning schemes? ● What is your opinion of a zoneless scheme and whether it should be considered for our model? ● Should the areal sources use a smoothed activity rate or a uniform rate? ● What is the distribution of dips, focal depths and rupture types for each areal source zone? ● Is there any preferred orientation of fault ruptures within each areal source zone?
	14:25 ~ 14:35	Alternative Gutenberg -Richter Relations	10	Y.B. Tsai (蔡義本)		● Alternative Gutenberg-Richter relations for Taiwan earthquakes in different depth ranges.
	14:35 ~ 15:00	*Discussion*				
15:00 ~ 15:20		*Break*				
15:20 ~ 16:50 Chaired by B.S. Huang (黃柏壽)						
Geodetic Data	15:20 ~15:25	How We Use Geodetic Data in Our Model	5	B.S. Huang (黃柏壽)	-	● How are we considering using (or not using) geodetic data?
	15:25 ~ 15:55	GPS	30	K.E. Ching (景國恩)	R.J. Rau (饒瑞鈞) Y.J. Hsu (許雅儒)	● What are the ways geodetic data can be used to support our seismic source model? ● What faults are creeping and what is the evidence to support this? ● Can geodetic data determine the depth to which faults are creeping? Can geodetic data decipher between short term slip rates and long term slip rates? ● Can geodetic data determine how much surface slip or crustal deformation is directly attributed to faulting vs. off fault or aseismic deformation? ● Can you compare slip rates determined by PS-INSAR Data, Geologic data, and GPS data? ● Please present the results of two transects across the Taiwan arc-continent collision zone (including onshore and offshore). How does the geodetic data change along these transects and why?
	15:55~ 16:05	PS – InSAR	10	C.P. Chang (張中白)	C.P. Chang (張中白) L. Luor (羅立) Y.C. Chan (詹瑜璋) K.J. Chang (張國楨)	● Can you estimate the slip rate on selected primary faults? ● Can you provide the location and lengths of primary faults within our model? ● Can you evaluate the presence of the ST-II landward extension with satellite or LiDAR data? ● How many creep/aseismic structures are captured by satellite data? ● How has the data been used previously in Taiwan to estimate fault location and geometry? ● Has the LiDAR or InSAR data been used to estimate fault parameters? If so, which faults? ● Do we have any evidence to support fault segmentation from satellite or LiDAR data?
	16:05 ~ 16:20	LiDAR	15	K.J. Chang (張國楨)		
	16:20 ~ 16:30	Alternative Geodynamic Framework for Taiwan	10	Y.B. Tsai (蔡義本)		● Potential implications for SSC of an alternative geodynamic framework for Taiwan.
	16:30 ~ 16:50	*Discussion*				
16:50 ~ 17:00		*Break*				
17:00 ~ 17:40		Summary of Workshop #2 - Day 1 (Chaired by N. Abrahamson)				
17:40 ~ 18:00		Comments and Questions from Observers (Chaired by PM)				
18:00		*Adjourn*				

18:00 ~ 19:00	*Closed Meeting: PPRP, Sponsor, PM, PTI and TI Lead*

Taiwan SSHAC Level 3 Project
Workshop #2 Agenda – Day 2
October 4, 2016 (Tuesday)
Tsai Lecture Hall of National Taiwan University, Taipei, Taiwan

Session	Time	Topic	Dur. (min.)	Speaker	PE & RE	Question
09:00 ~ 10:40 Chaired by C.H. Yeh (葉錦勳)						
Primary Fault Sensitivity Model-I	09:00 ~ 09:10	Opening and Introduction of Workshop Ground Rule	10	C.L. Wu (吳俊霖)	-	
	09:10 ~ 09:20	Current SSC Active Fault Map	10	C.H. Yeh (葉錦勳)	-	● Introduce our active fault map (primary faults, active faults, other offshore faults). What sources are our active faults derived from and why?
	09:20 ~ 09:30	Current SSC Shanchiao and ST-II Fault Sensitivity Model	10	K. Clahan	C.T. Chen (陳致同) Y.H. Lee (李元希) Y.C. Chan (詹瑜璋) L. Luor (羅立)	● Introduce the Shanchiao fault system and the ST-II fault system seismic sources parameters.
	09:30 ~ 09:50	Shanchiao Fault Geometry	20	C.T. Chen (陳致同)		● Please provide your interpretation of the seismic source parameters of the Shanchiao fault including length, segmentation, dipping angle(s), rupture depth, activity, slip rate, recurrence interval, etc. What parameters have the greatest uncertainty? ● What is your opinion of ST-II extending onshore?
	09:50 ~ 10:10	Shanchiao and Kanchiao Fault Trace Interpretation	20	Y.C. Chan (詹瑜璋)		● Does LiDAR reveal evidence for onshore ST-II faulting? ● How does the LiDAR interpretation define the Shanchiao fault onshore? ● Is there any evidence for activity of the Kanchiao fault? How does this fault fit into the regional tectonic model?
	10:10 ~ 10:40	*Discussion*				
10:40 ~ 10:50		*Break*				
10:50 ~ 12:30 Chaired by K. Clahan						
Primary Fault Sensitivity Model-II	10:50 ~ 11:00	Current SSC Hengchun Fault System Sensitivity Model	10	K. Clahan	-	● Introduce the geometry and seismic source parameters of the Hengchun fault in our current hazard sensitivity model.

	11:00 ~ 11:25	Hengchun Fault Geometry and Its Southern Offshore Extension	25	Sinotech Engineering Consultants, Ltd. (中興公司)	Y.H. Lee (李元希) J. Bruce H. Shyu (徐澔德) L. Luor (羅立) C.S. Liu (劉家瑄)	● Please provide your interpretation of the geometry and seismic source parameters of the Hengchun fault including length, segmentation, dipping angle(s), rupture depth, activity, slip rate, recurrence interval, etc. What parameters have the greatest uncertainty? ● What is your segmentation model for this fault? ● What is your interpretation of the fault geometry and location of the Hengchun fault as it comes onshore from the south? ● What is your interpretation of how the Hengchun fault interacts with the Chaochou fault to the north?
	11:25 ~ 11:45	SW Hengchun Fault and Landward Extension	20	Sinotech Engineering Consultants, Ltd. (中興公司)	Y.H. Lee (李元希) J. Bruce H. Shyu (徐澔德) L. Luor (羅立) C.S. Liu (劉家瑄)	● What is your interpretation of the geometry of the offshore SW Hengchun fault? Does it project onshore? If so, what is geometry? What is the segmentation model for this fault? What are the seismic source parameters? ● Does any data reveal the trace of the SW Hengchun fault onshore extension? ● What is the data to suggest there is an active West Hengchun fault as you have interpreted? Is the West Hengchun fault related to the SW Hengchun fault? ● What is the activity or slip rate of the SW Hengchun fault?
	11:45 ~ 12:00	West Hengchun Offshore Structure	15	C.S. Liu (劉家瑄)		● Please provide your interpretation of the geometry and seismic source parameters of the West Hengchun offshore structure including length, segmentation, dipping angle(s), rupture depth, activity, slip rate, recurrence interval, etc. What parameters have the greatest uncertainty? ● What evidence is there for mud diapirism near the Hengchun Peninsula and how does it fit in or affect the regional fault models?
	12:00 ~ 12:30	*Discussion*				
12:30 ~ 13:30		*Lunch (Rm1401, 1402)*				
13:30 ~ 15:00 Chaired by A.T. Lin (林殿順)						
Primary Fault Sensitivity Model-III	13:30 ~ 13:40	Current SSC Aoti Offshore Fault,S Fault, North Ilan Fault System, BinHai Fault Sensitivity Model	10	A.T. Lin (林殿順)	-	● Introduce the geometry and seismic source parameters of the primary faults around NPP 4 in our current hazard sensitivity model.
	13:40 ~ 13:55	Geometry of Aoti Offshore Fault and North Ilan offshore fault	15	K.Y. Chen (陳冠宇)	K.Y. Chen (陳冠宇) L. Luor (羅立) J. Bruce H. Shyu	● Please provide your interpretation of the geometry and seismic source parameters of the Aoti fault including length, segmentation, dipping angle(s), rupture depth, activity, slip rate, recurrence interval, etc. What parameters have the greatest uncertainty? ● Does the Aoti fault extend onshore? If so, what is its geometry? What is your segmentation model for the Aoti fault?

	13:55 ~ 14:10	S Fault	15	Sinotech Engineering Consultants, Ltd. (中興公司)	(徐澔德)	● Please provide your interpretation of the geometry and seismic source parameters of the S fault including length, segmentation, dipping angle(s), rupture depth, activity, slip rate, recurrence interval, etc. What parameters have the greatest uncertainty? ● Is there any more planned work to be done to reduce the uncertainty of any of the seismic source parameters of the S fault?
	14:10 ~ 14:25	BinHai Fault	15	J. Bruce H. Shyu (徐澔德)		● Please provide your interpretation of the geometry and seismic source parameters of the BinHai fault including length, segmentation, dipping angle(s), rupture depth, activity, slip rate, recurrence interval, etc. What parameters have the greatest uncertainty?
	14:25 ~ 15:15	*Discussion*				
15:15 ~ 15:35		*Break*				
15:20~17:00 Chaired by A.T. Lin (林殿順)						
Other Offshore Fault	15:35 ~ 15:40	Offshore Active Fault Models for Hengchun Ridge Offshore Fault, Taitung Canyon Fault, Luzon Strike Slip Fault, and East HC Offshore Fault	5	A.T. Lin (林殿順)	-	● Introduce the geometry and seismic source parameters of the offshore faults around NPP 3 in our current hazard sensitivity model.
	15:40 ~ 15:50	Hengchun Ridge Offshore Fault	10	S.C. Fuh (傅式齊)	C.S. Liu (劉家瑄) S.C. Fuh (傅式齊) W.B. Cheng (鄭文彬)	● Please provide your interpretation of the geometry and seismic source parameters of the Accretionary fault including length, segmentation, dipping angle(s), rupture depth, activity, slip rate, recurrence interval, etc. What parameters have the greatest uncertainty? ● What is the evidence to support its existence and should it be considered a part of our seismic source model?
	15:50 ~ 16:10	North Luzon Strike Slip Fault and East HC Offshore Fault	20	W.B. Cheng (鄭文彬)		● Please provide your interpretation of the geometry and seismic source parameters of the North Luzon strike slip and East Hengchun offshore fault including length, segmentation, dipping angle(s), rupture depth, activity, slip rate, recurrence interval, etc. What parameters have the greatest uncertainty? ● What is the evidence to support their existence and should they be considered a part of our seismic source model? How do they fit into the regional seismotectonic model?
	16:10 ~ 17:00	*Discussion*				
17:00 ~ 17:10		*Break*				
17:10 ~ 17:40		Summary of Workshop #2 - Day 2 (Chaired by N. Abrahamson)				
17:40 ~ 17:50		Comments and Questions from Observers (Chaired by PM)				
17:50		*Adjourn*				
18:00 ~ 19:00		*Closed Meeting: PPRP, Sponsor, PM, PTI and TI Lead*				

Taiwan SSHAC Level 3 Project
Workshop #2 Agenda – Day 3

October 5, 2016 (Wednesday)

Tsai Lecture Hall of National Taiwan University, Taipei, Taiwan

Session	Time	Topic	Dur. (min.)	Speaker	PE & RE	Question
09:00 ~ 10:20 Chaired by A.T. Lin (林殿順)						
Subduction Zone-I	09:00 ~ 09:10	Opening and Introduction of Workshop Ground Rule	10	C.L. Wu (吳俊霖)	-	
	09:10 ~ 09:20	Introduction SSC Ryukyu Subduction Zone Model	10	A.T. Lin (林殿順)	-	● Introduce the geometry and seismic source parameters of the Ryukyu subduction zone in our current hazard sensitivity model.
	09:20 ~ 09:40	Subduction Zone Slip Rate Estimate (α)	20	Y.J. Hsu (許雅儒)	C.S. Liu (劉家瑄) Y.J. Hsu (許雅儒)	● Please provide your interpretation of the geometry and seismic source parameters of the Ryukyu subduction zone including length, segmentation, dipping angle(s), rupture depth, activity, slip rate, recurrence interval, etc. What parameters have the greatest uncertainty? What is the supporting data for each parameter? ● Can you specifically discuss the termination, segmentation, dip, depth, and Interface area? ● Please provide your interpretation of the geometry and seismic source parameters of the strike slip faults associated with the Ryukyu subduction zone including length, segmentation, dipping angle(s), rupture depth, activity, slip rate, recurrence interval, etc. What parameters have the greatest uncertainty?
	09:40 ~ 10:20	*Discussion*				
10:20 ~ 10:40		*Break*				
10:40 ~ 12:30 Chaired by A.T. Lin (林殿順)						
Subduction Zone-II	10:40 ~ 10:50	Introduction of SSC Manila Subduction Zone Model	10	A.T. Lin (林殿順)	-	● Introduce the geometry and seismic source parameters of the Manilla subduction zone in our current hazard sensitivity model.
	10:50 ~ 11:20	Manila Subduction	30	C.S. Liu (劉家瑄)	H. Kou-Chen (郭陳澔) J.Y. Lin (林靜怡) T.Y. Chang (張翠玉) Y.J. Hsu (許雅儒)	● Please provide your interpretation of the geometry and seismic source parameters of the Manilla subduction zone including length, segmentation, dipping angle(s), rupture depth, activity, slip rate, recurrence interval, etc. What parameters have the greatest uncertainty? ● Please provide your interpretation of the geometry and seismic source parameters of the splay fault including length, segmentation, dipping angle(s), rupture depth, activity, slip rate, recurrence interval, etc. What parameters have the greatest uncertainty?
	11:20 ~ 11:50	*Discussion*				
	11:50 ~ 12:30	Summary	40	N. Abrahamson	-	
12:30 ~ 13:30		*Lunch (Rm1401, 1402)*				

13:30 ~ 15:00 Chaired by K.L. Wen (溫國樑)						
Project Introduction	13:30 ~ 13:40	Opening & Project Introduction	10	K.C. Chang, (張國鎮) C.L. Wu (吳俊霖)	-	
Introduction and Hazard Sensitivity Analysis	13:40 ~ 14:00	SSHAC Training	20	N. Abrahamson	-	
	14:00 ~ 14:10	Introduction to Workshop Agenda and Roadmap of Following Presentations	10	K.L. Wen (溫國樑)	-	
	14:10 ~ 14:30	Candidate GMMs after Screening and Comparison of Available Ground Motion Models	20	N. Abrahamson	-	
	14:30 ~ 14:50	Hazard Feedback Using Current Candidate GMMs	20	N. Abrahamson	-	
	14:50 ~ 15:10	*Discussion*			-	
15:10 ~ 15:20		*Break*				
15:20 ~ 16:50 Chaired by P.S. Lin (林柏伸)						
Ground Motion Database	15:20 ~ 15:50	Summary of Taiwan and Foreign Ground Motion Database	30	P.S. Lin (林柏伸)	R. Archuleta N. Kuehn A. Sandikkaya J. Zhao (趙興權) H. Si (司宏俊) Y.H. Chen (程毅豪) K.S. Liu (劉坤松) Y.J. Wang (王郁如) T.Y. Chang (張翠玉)	● Strength and weakness of the available data (foreign and Taiwan) for: – Taiwan GMPE for median – Host target adjustment factor – Taiwan Tau and Phi_ss model – Limitation for normal faulting, HW and listric fault – Limitation for large magnitude and short distance
	15:50 ~ 16:20	Evaluation of Regional Difference in Ground Motion within Taiwan	30	N. Kuehn		● Are there sufficient data to regionalize ground motion in Taiwan? ● What is the size of ground-motion difference between northern and southern Taiwan? ● Describe the regionalized ground motion characteristics of southern subduction zone earthquake
	16:20 ~ 16:50	*Discussion*				
16:50 ~ 17:00		*Break*				
17:00 ~ 17:40		Summary of Workshop #2 - Day 3 (Chaired by N. Abrahamson)				
17:40 ~ 18:00		Comments and Questions from Observers (Chaired by PM)				
18:00		*Adjourn*				
18:00 ~ 19:00		*Closed Meeting: PPRP, Sponsor, PM, PTI and TI Lead*				

Taiwan SSHAC Level 3 Project
Workshop #2 Agenda – Day 4

October 6, 2016 (Thursday)

Tsai Lecture Hall of National Taiwan University, Taipei, Taiwan

Session	Time	Topic	Dur. (min.)	Speaker	RE & PE	Question
09:00 ~ 10:40 Chaired by B. Chiou (丘士正)						
Large Magnitude Scaling	09:00 ~ 09:10	Opening and Introduction of Workshop Ground Rule	10	C.L. Wu (吳俊霖)	R. Archuleta N. Kuehn A. Sandikkaya J. Zhao (趙興權) H. Si (司宏俊) Y.H. Chen (程毅豪) K.S. Liu (劉坤松) Y.J. Wang (王郁如) T.Y. Chang (張翠玉)	
	09:10 ~ 09:40	Large Magnitude Scaling of Ground Motion for Crustal and Subduction Events	30	H. Si (司宏俊)		● Summarize and compare the magnitude scaling in your GMM and other GMMs. ● Are there physical/empirical bases for setting the breaks in the ground-motion magnitude scaling relations for crustal and subduction earthquakes? ● Summarize the data range and the scaling with source depth in your GMM.
	09:40 ~ 10:10	Large Magnitude Source Scaling of Crustal and Subduction Events	30	R. Archuleta		● What are the physical/empirical bases for setting the breaks in the ground-motion magnitude scaling relations for crustal and subduction earthquakes? (large slab event with Mw>7)
	10:10 ~ 10:40	*Discussion*				
10:40 ~ 11:00		*Break*				
11:00 ~ 12:30 Chaired by N. Abrahamson						
HW Effect and Listric Fault of Crustal Event	11:00 ~ 11:20	The Scaling of Hanging-Wall Ground Motions Suggested by the Candidate GMMs	20	N. Abrahamson	R. Archuleta N. Kuehn A. Sandikkaya J. Zhao (趙興權) H. Si (司宏俊) Y.H. Chen (程毅豪) K.S. Liu (劉坤松) Y.J. Wang (王郁如) T.Y. Chang (張翠玉)	● Basis for the HW scaling for GMMs (empirical, simulation or judgement). ● How to extrapolate to low dip angle case? ● Summarize the SWUS simulation and composite model of HW effect (check if they cover the Taiwan SSC model) ● Other study except NGA West 2 models (ex. New Zealand) related to HW effect? ● Is there other simulation study (ex. dynamic rupture model) for HW effect?
	11:20 ~ 12:00	Application of the Candidate GMMs to Listric Fault	40	Y.T. Yen (顏銀桐)		● Evaluate method for specifying the dip to use in GMPE for additional geometries. – Does the method work for the range of dips, depth, magnitudes in the SSC model? – Is the Rjb based distance metric viable for listric fault? ● What is the variability of scale factor from simulations for the individual simulations (not just the average of 30)? ● Are there any ground motion data for listric fault (check Italy)?
	12:00 ~ 12:30	*Discussion*				

12:30 ~ 13:30		*Lunch (Rm1401, 1402)*				
13:30 ~ 15:00 Chaired by H.C. Chiu (邱宏智)						
Normal Fault Effect of Crustal Event	13:30 ~ 13:50	Normal Faulting Effect on Ground Motions of Crustal Events – I	20	S.H. Chao (趙書賢)	R. Archuleta N. Kuehn A. Sandikkaya J. Zhao (趙興權) H. Si (司宏俊) Y.H. Chen (程毅豪) K.S. Liu (劉坤松) Y.J. Wang (王郁如) T.Y. Chang (張翠玉)	● Summarize and compare the normal faulting factor in your GMM and other GMMs. ● What may be the physical processes that cause the normal faulting effect? (optional) ● What are the physical and empirical bases for normal faulting effect in your GMM? What is the level of uncertainty associated with the estimated normal faulting effect? ● What is the range of magnitude and dip angle used in the estimation of normal fault factors? What is the number of records and earthquakes used in the estimation of normal fault factors? Can the estimated factors be extrapolated for application to large magnitude and low dip angle earthquakes? ● Are the normal faulting factors of your model applicable to Shan-Chiao Fault (a listric fault) in Taiwan?
	13:50 ~ 14:10	Normal Faulting Effect on Ground Motions of Crustal Events – II	20	H. Si (司宏俊)		
	14:10 ~ 14:30	Normal Faulting Effect on Ground Motions of Crustal Events – III	20	A. Sandikkaya (Remote)		
	14:30 ~ 15:00	*Discussion*				
15:00 ~ 15:20		*Break*				
15:20 ~ 16:50 Chaired by K.L. Wen (溫國樑)						
Stochastic Ground Motion Simulation	15:20 ~ 15:50	Overview of the Input Models of Stochastic GM Simulation for Shallow Crust and Subduction Zone Earthquakes	30	S.C. Wen (溫士忠)	R. Archuleta N. Kuehn A. Sandikkaya J. Zhao (趙興權) H. Si (司宏俊) Y.H. Chen (程毅豪) K.S. Liu (劉坤松) Y.J. Wang (王郁如) T.Y. Chang (張翠玉)	● Discuss available input models of stochastic GM simulation for crustal and subduction events in Taiwan and foreign regions (Japan, California, and Italy) and describe how they were calibrated (ex. by matching empirical GM data or other techniques). ● What calibrated input models you would recommend to use in performing (foreign) host-to-Taiwan adjustment of ground motions?
	15:50 ~ 16:20	FAS GMMs for Shallow Crust and Subduction Zone Earthquakes	30	N. Kuehn		● Describe Taiwan and foreign (Japan, California and Italy) FAS GMMs of crustal and subduction sources that were calibrated for each region by fitting the ground-motion data. ● Which FAS GMMs you would recommend to use in performing host-to-Taiwan adjustment of ground motions?
	16:20 ~ 16:50	*Discussion*				
16:50 ~ 17:00		*Break*				
17:00 ~ 17:40		Summary of Workshop #2 - Day 4 (Chaired by N. Abrahamson)				
17:40 ~ 18:00		Comments and Questions from Observers (Chaired by PM)				
18:00		*Adjourn*				
18:00 ~ 19:00		*Closed Meeting: PPRP, Sponsor, PM, PTI and TI Lead*				

Taiwan SSHAC Level 3 Project
Workshop #2 Agenda – Day 5

October 7, 2016 (Friday)

Tsai Lecture Hall of National Taiwan University, Taipei, Taiwan

Session	Time	Topic	Dur. (min.)	Speaker	RE & PE	Question
09:00 ~ 10:40 Chaired by K.L. Wen (溫國樑)						
Host to Target Adjustment Factor	09:00 ~ 09:10	Opening and Introduction of Workshop Ground Rule	10	C.L. Wu (吳俊霖)	-	
	09:10 ~ 09:40	Preliminary Evaluation of the Taiwan Proponent Input Models of Stochastic GM Simulation against Taiwan Ground Motion Data	30	J.Y. Huang (黃雋彥)	R. Archuleta N. Kuehn A. Sandikkaya J. Zhao (趙興權) H. Si (司宏俊) Y.H. Chen (程毅豪) K.S. Liu (劉坤松) Y.J. Wang (王郁如) T.Y. Chang (張翠玉)	● Describe the applicability of the proponent Taiwan input model of stochastic GM simulation against Taiwan ground motion data.
	09:40 ~ 10:10	Initial Correction Factor Based on Candidate Host and Target Inputs of Stochastic GM Simulation	30	J.Y. Huang (黃雋彥)		● Describe the example application of host-to-target correction for all regions.
	10:10 ~ 10:40	*Discussion*				
10:40 ~ 11:00		*Break*				
11:00 ~ 12:30 Chaired by C.H. Loh (羅俊雄)						
Proponent Taiwan GMMs: Median	11:00 ~ 12:00	Median Ground Motion Models for Taiwan Crustal and Subduction Events	60	B. Chiou (丘士正) V.B. Phung (馮文龐) S.H. Chao (趙書賢)	R. Archuleta N. Kuehn A. Sandikkaya J. Zhao (趙興權) H. Si (司宏俊) Y.H. Chen (程毅豪) K.S. Liu (劉坤松) Y.J. Wang (王郁如) T.Y. Chang (張翠玉)	● Summarize the procedure of GMPE development/adjustment methodology and demonstration. ● Confirm the model is median center and unbiased with appropriate variance term.
	12:00 ~ 12:30	*Discussion*				
12:30 ~ 13:30		*Lunch (Rm1401, 1402)*				

<table>
<tr><td colspan="7">13:30 ~ 15:00 Chaired by Y.N. Huang (黃尹男)</td></tr>
<tr><td rowspan="3">Proponent Taiwan GMMs: Tau and Phi_ss</td><td>13:30 ~ 14:00</td><td rowspan="2">Tau and Phi_ss Models for Taiwan Crustal and Subduction Events</td><td rowspan="2">60</td><td rowspan="2">S.H. Chao
(趙書賢)
B. Chiou
(丘士正)</td><td rowspan="3">R. Archuleta
N. Kuehn
A. Sandikkaya
J. Zhao
(趙興權)
H. Si
(司宏俊)
Y.H. Chen
(程毅豪)
K.S. Liu
(劉坤松)
Y.J. Wang
(王郁如)
T.Y. Chang
(張翠玉)</td><td rowspan="2">● Summarize the procedure of developing Taiwan Tau and Phi_ss models for crustal and subduction events
● Check the magnitude dependence of Taiwan Tau and Phi_ss models.</td></tr>
<tr><td>14:00 ~ 14:30</td></tr>
<tr><td>14:30 ~ 15:00</td><td colspan="3">Discussion</td><td></td></tr>
<tr><td colspan="2">15:00 ~ 15:20</td><td colspan="5">Break</td></tr>
<tr><td colspan="7">15:20 ~ 16:50 Chaired by Y.N. Huang (黃尹男)</td></tr>
<tr><td rowspan="3">Available Tau and Phi_ss Models</td><td>15:20 ~ 15:50</td><td>Available Tau and Phi_ss Models for Shallow Crustal Earthquakes</td><td>30</td><td>N. Abrahamson</td><td rowspan="3">R. Archuleta
N. Kuehn
A. Sandikkaya
J. Zhao
(趙興權)
H. Si
(司宏俊)
Y.H. Chen
(程毅豪)
K.S. Liu
(劉坤松)
Y.J. Wang
(王郁如)
T.Y. Chang
(張翠玉)</td><td rowspan="2">● Summarize Tau and Phi_ss models for crustal and subduction events.
● Summarize the magnitude range of data and discuss the merits of magnitude dependence (or independence) in each model.
● Discuss the upper tail of residual distribution and the need to use a mixture model to represent the heavy tailed distribution.</td></tr>
<tr><td>15:50 ~ 16:20</td><td>Available Tau and Phi_ss Models for Subduction Zone Earthquakes</td><td>30</td><td>N. Abrahamson</td></tr>
<tr><td>16:20 ~ 16:50</td><td colspan="3">Discussion</td><td></td></tr>
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<tr><td colspan="2">17:40 ~ 18:00</td><td colspan="5">Comments and Questions from Observers (Chaired by PM)</td></tr>
<tr><td colspan="2">18:00</td><td colspan="5">Adjourn</td></tr>
<tr><td colspan="2">18:00 ~ 19:00</td><td colspan="5">Closed Meeting: PPRP, Sponsor, PM, PTI and TI Lead</td></tr>
</table>

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