Friday, April 30th, 2021

To: Technical Advisory Committee, David Stevens – Research Project Manager, Utah Department of Transportation

From: Steven Bartlett

Subject: Task 7 – Completion Memo for Database Population, TPF-5(350) NGL Lateral Spread study

International Project Participants

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Background

The Next-Generation Liquefaction (NGL) project was launched to (1) substantially improve the quality, transparency, and accessibility of case history data related to ground failure; (2) provide a coordinated framework for supporting studies to augment case history data for conditions important for applications but poorly represented in empirical databases; and (3) provide an open, collaborative process for model development in which developer teams have access to common resources and share ideas and results during model development, to reduce the potential for mistakes and to benefit from best practices mutually. This approach is motivated in part by the success of the Next-Generation of Attenuation (NGA) models for ground motion prediction, which has followed this approach and has had substantial global buy-in and broad application.

The principal investigators for the lateral spread databasing efforts are Drs. Steven Bartlett (U. of Utah) and Dr. Kevin Franke (Brigham Young University). The technical advisory committee (TAC) currently includes representatives from Utah, California, Oregon, Washington State DOTs, and Dominion Energy. The MPC has also provided additional funding for the study.

The primary outcome of this research is a vetted and community database of seismic, topographical, geotechnical, and horizontal displacement measurements about case histories of liquefaction-induced lateral spread for further research and model development by other researchers and investigators under the auspices of the Pacific Earthquake Engineering Research (PEER) Center (<u>http://peer.berkeley.edu/</u>). Secondary outcomes are software development and support required to host and disseminate this database and supporting information.

Students from the University of Utah and Brigham Young University have gathered information about case histories of liquefaction-induced lateral spread. This effort has the following research objectives: (1) develop peer-reviewed and consistent methodology for data documentation and archiving of lateral spread case histories, (2) develop quality assurance protocols for assessing and documenting data quality, (3) develop methods and protocols to quantify uncertainties associated with the collected data, (4) populate the case history database with well-documented examples of liquefaction-induced lateral spread, (5) explore methods of integrating SPT and CPT data into analyses and evaluations, (6) disseminate this database for general use using web-based software tools.

Project Tasks

The following is a list of tasks assigned to Phase I of the project: Project Initiation, Database Screening, Structuring, and Population.

Tasks

- 1. Kickoff meeting and procurement of software
- 2. Development of data quality indicators/metrics, quality assurance, and database population protocols
- 3. Defining methods for quantifying the uncertainty of key inputs
- 4. Development and structuring of database
- 5. Selection of case histories
- 6. Obtaining and screening of case history information
- 7. Population of case history database (addressed by this memo)
- 8. Database dissemination

9. Screening criteria for lateral spread potential

10. Phase I Reporting

Table 1 shows those case histories that have been selected for inclusion in the NGL lateral spread database. These case histories are being populated and checked by students of the University of Utah and Brigham Young University under the supervision of Drs. Bartlett and Franke, respectively. The database consists of the earthquake, seismological, topographic, geology, and geotechnical information, which has been structured in the relational database.

Table 2 shows the number of data records that have been compiled for the various data types (e.g., displacement vectors, boreholes, soil information, topology, etc.) by the University of Utah.

Table 3 shows the same information for the data records compiled by Brigham Young University.

1906 San Francisco, California	Coyote Creek Bridge near Milpitas California
Earthquake	
	Mission Creek Zone in San Francisco
	Salinas River Bridge, Salinas California
	South of Market Street Zone in San Francisco
1964 Alaska Earthquake	Bridges 141.1, 147.4, 147.5, 148.3 on Matanuska
	River, Alaska
	Bridges 63.0, 63.5 on Portage Creek Alaska
	Highway Bridge 629 Placer River, Alaska
	Bridge 605A, Snow River, Alaska
	Bridges, 3.0, 3.2, 3.3, Resurrection River, Alaska
1964 Niigata, Japan	Numerous lateral spreads within Niigata City
Earthquake	
1971 San Fernando	Jensen Filtration Plant, San Fernando, California
Earthquake	Juvenile Hall, San Fernando, California
1979 Imperial Valley	Heber Road near El Centro, California
Earthquake	River Park near Brawley, California
1983 Borah Peak, Idaho	Whiskey Springs near Mackay, Idaho
Earthquake	Pence Ranch near Mackay, Idaho
1983 Nihonkai-Chubu, Japan	Numerous lateral spreads within Noshiro City
Earthquake	
1987 Superstition Hills,	Wildlife Instrumentation Array near Brawley,
California Earthquake	California
1989 Loma Prieta, California	Pajaro River
Earthquake	Moss Landing, Monterey
	Marina District, San Francisco
1990 Luzon Philippines	Dagupan City
Earthquake	
1991 Costa Rica Earthquake	Railroad and Highway Bridge sites
1994 Northridge, California	King Harbor, Redondo Beach
Earthquake	Balboa Blvd., San Fernando Valley
	Malden Street, San Fernando Valley
	Wynne Avenue, San Fernando Valley
	Potrero Canyon, San Fernando Valley
1995 Kobe, Japan Earthquake	Lateral Spreads on Port Island
	Lateral Spreads on Roko Island
1999 Kocaeli, Turkey	Cark Canal Site
Earthquake	
	Yakin Street Site

Table 1 – List of Case Histories for Databasing as part of Task 7

1999 Kocaeli, Turkey	Cumhuriyet Avenue Site						
Earthquake (continued)	Sapanca Hotel Site						
	Police Station Site, East Izmit Bay						
	Soccer Field Site. East Izmit Bay						
	Degirmendere Nose Site						
	Yalova Harbor Site						
1999 Chi-Chi,	Wufeng Site C						
Taiwan	Wufeng Site C1						
Earthquake	Wufeng Site B						
	Wufeng Site M						
	Nantou Site N						
	Leuw Mei Bridge						
2010 Maule, Chile	Port Coronel						
Earthquake	Valparaiso						
	Llacolen Bridge						
	Juan Pablo II Bridge, Concepcion						
	La Mochita Bridge, Concepcion						
	Tubul Bridge, Tubul						
	Mataquito Bridge, Iloca						
2011 Tohoku, Japan	Several lateral spreads						
Earthquake							
2010 Darfield, New Zealand	Several lateral spreads in and around Christchurch						
Earthquake							
2011 Christchurch, New	Several lateral spreads in and around Christchurch						
Zealand Earthquake							

Table 1 - List of case histories selected for databasing as part of Task 7 (continued)

Case history	Site	Displacement vectors	Boreholes	Subsurface data rows	Topology points	Cross- checked
	F10	179	24	359	429	Completed
	G10	654	68	1574	256	Completed
1064 Niigoto	Н9	155	4	92	235	Completed
1964 Niigata	19	442	45	192	297	Completed
	К8	285	4	62	302	
	Total	1715	145	2279	1519	Completed
1983 Noshiro	South	266	128	462	176	
1983 NOSHITO	North	147	59	848	348	
	Total	413	187	1310	524	Completed
1971 San	Jensen water plant	69	33	494	flat file	
Fernando	Juvenile hall	79	6	121	flat file	
	Total	148	39	615		Completed
1964 Alaska	Total	14	20	411		Completed
	Heber road	29	7	135	flat file	
1979 Imperial Valley	River park site	NA	4	62	NA	
	Total	29	11	197		Completed
1983 Borah	Whiskey springs	3	3	54	flat file	
peak, Idaho	Pence Ranch	3	6	69	flat file	
	Total	6	3	54		Completed
	Mission creek zone	9	8	92	flat file	
1906 San Francisco	South of Market area	7	7	80	N.A.	
Tuncisco	Foot of market area	3			NA	
	Total	19	15	172		Completed
1987 Superstition Hills, California		7	2	53	flat files	

Table 2. Data Records Compiled by the University of Utah

Case history	Site	Displacement vectors	Boreholes	Subsurface data rows	Topology points	Cross- checked
1989 Loma Prieta, California		3	15	236	flat files	
1999 ChiChi Taiwan	Site C	20	15			
	Site C1	4	2			
	Site B	4	6		flat files	
	Site M	4	2			
	Site N	4	3			
	Total	34	23	2806		Completed
2010 Chile	Lo Rojas port		8			Completed
	North and South Pier		7			
	Juan Pablo II Bridge		8	2494	in progress	Completed
	La Mochita Bridge					Completed
	Llacolen Bridge		6			
	Mataquito Bridge		6			

Table 2. Data Records Compiled by the University of Utah

	Mataquito Bridge		6			
	Tubul Bridge		6			
	Raqui 1 and Raqui 2 Tubul		1			
	Total	0	21	2494		
1990 Luzon Philippines	11	13	233			Completed
1994 Northridge, California						
1995 Kobe, Japan		3168	156	3273		Completed
1999 Kocaeli, Turkey		4				
Total:		5564	627	14018	2043	

Case history	Site	Displacement vectors	Boreholes	Subsurface data rows	Cross-checked		
	Port Coronel	37	11				
	Lo Rojas	13	б		Cross Checked		
2010 Maule,	Juan Pablo	1	7	6412			
Chile	La Mochita	3	2	6413	Waiting in NGL Queue for Data Entry		
	Mataquito	2	6]			
	Tubul Bridge	2	6				
	Tubul Raqui	2	1				
	Llacolen	18	5				
	Hitachinaka	11	2				
	Isobe	17	3]			
2011 Tohoku,	Tone River	Tone River 1 3 856		856	Cross Checked Waiting in NGL Queue for		
Japan	Sodegaura	1	3		Data Entry		
	Hokota City	1	2				
	Avonside Loop	195	11				
	Dallington Loop (Point Bar)	90	10				
2010	Bend at Locksley Avenue	58	7				
Darfield,	Avon Park	23	3	53404+	Cross Checked Waiting in NGL Queue for		
New Zealand	Avondale	106	7		Data Entry		
	Bexley	120	4				
	Pleasant Point Yacht Club	3	4				
	St.Martins	68	13]			
	Dallington Loop (Cut Bank)	46	3				

Table 3. Data Records Compiled by Brigham Young University

Case history	Site	Displacement vectors	Boreholes	Subsurface data rows	Cross-checked			
	Avonside Loop	202	11					
	Dallington Loop (Point Bar)	127	10					
	Bend at Locksley Avenue	63	7					
	Avon Park	22	3		Cross Checked Waiting in NGL Queue for			
2010	Avondale	108	7					
Darfield, New	Bexley	122	4	53404+				
Zealand	Pleasant Point Yacht Club	3	4		Data Entry			
	St.Martins	68	13					
	Beckenham	86	6					
	Anzac Bridge	66	5					
	Avon Loop	173	44					
	Central Business District	136	74					

Table 3. Data Records Compiled by Brigham Young University

Database Structure



The following items are needed to make a case history, event, site, and observations.

The database is accessed using a structured query language (SQL). It is the common language use to access relational database management systems. The database structure (i.e., schema) is shown in Figure 2. The relational databases (also called tables) have unique data fields to the specific table and other shared fields used to related or access information in different tables. The schema was the outcome of a broad community effort involving review by the NGL database working group and other attendees. A two-day workshop was held in July 2017 at UC Berkeley involving 50 participants where the schema was presented and modified.

The schema for the general table (i.e., the highest most table in the database structure) is shown in Figure 2. This overview database is used to access the event, site, and observation information for each case history. In this schema, there are primary keys and foreign keys. A **primary key** is a field or a set of fields in a table whose values uniquely identify a record in the table. In contrast, a **foreign key** is a field or a set of fields in a table whose values correspond to the primary key values in another table. The schemas for the site, observation, and event databases are shown in Figures 3 through 5, respectively.

Figure 1 Definition of a case history

	Users (USER)		Sites (SITE)		Tests (TEST)		Files (FILE)
<mark>0</mark> 7	USER_ID	<mark>0</mark> 7	SITE_ID	<mark>0</mark> 7	TEST_ID	<u></u>	FILE_ID
	user_name		SITE_NAME	õ	SITE_ID		FILE_NAME
	first_name		SITE_LAT		TEST_NAME		FILE_TYPE
	last_name		SITE_LON		TEST_TYPE		FILE_SIZE
	email		SITE_GEOL		TEST_LAT		FILE_FILE
	reg_date		SITE_REM		TEST_LON		
	organ		SITE_STAT		TEST_ELEV		
	country		SITE_REVW		TEST_REM		
	region			, 	TEST_STAT		O Primary key
	zip				TEST_REVW		
	user_pass						O Foreign key
	num_visit	S	Site Files (SITF)	Т	est Files (TESF)		
	num_download	<mark>0</mark> 7	SITF_ID	0F	TESF_ID		
	num_upload	Ō	SITE_ID	õ	TEST_ID		
		07	FILE_ID	õ	FILE_ID		
			SITF_DESC		TESF_DESC		

Figure 2 General Schema for NGL Database

Completion Memo

	BORHOLES (BORH) BORH ID TEST ID BORH TYPE BORH RIG BORH DIA BORH CREW BORH MECH BORH METH BORH STAR		ample Files (SAMF)		ndex Tests (INDX) INDX ID SPEC ID INDX BDEN INDX DDEN INDX GS INDX WC INDX FINE INDX FINE INDX REM			OT OT	CPT (SCPG) SCPG ID TEST ID SCPG CSA SCPG RATE SCPG CREW SCPG METH SCPG STAR SCPG ENDD SCPG PWP SCPG REM	<mark>o</mark> , O,	CPT Data (SCPT) SCPT ID SCPG ID SCPT DPTH SCPT RES SCPT FRES SCPT FRES SCPT PWP				
	BORH_ENDD BORH_REM		SAMF_ID SAMP_ID		icle-Size Dist. (GRAG)		Size Dist. data (GRAT)	Invasi	ive Geophysical (GINV)	Vel.Pr	of, from Invasive (GIND)				
		07	FILE_ID	07	GRAG_ID	07	GRAT_ID	07	GINV ID	07					
	Samples (SAMP)		SAMF_DESC	07	SPEC ID GRAG METH	07	GRAG_ID GRAT_SIZE	07	TEST ID	07	GINV ID				
0=	SAMP ID		Specimens (SPEC)		GRAG METH		GRAT PERP		GINV TYPE		GIND DPTH				
0a	TEST ID	07	SPEC ID		ONAG_NEM				GINV CONF GINV CREW		GIND VS GIND VP				
	SAMP NAME	07	SAMP ID						GINV STAR		GIND VP				
	SAMP_TYPE		SPEC_REF		erberg Limits (PLAS)				GINV ENDD						
	SAMP_TOP		SPEC_TOP					- C	rface Wave (GSWG)	SIM	disp. curves (GSWD)	V -V	■ profiles info (SWVG)	Vol. or	ofiles from SW (SWVD)
	SAMP BASE		SPEC BASE	07					GSWV ID			0,	SWVG ID		SWVD ID
	SAMP SDIA		SPEC_CREW		PLAS_LL			0A	GSWD ID	Ŏ,	GSWG ID	05	GSWG ID	1 OF 1	SWVG ID
	SAMP_DATE SAMP_REC		SPEC_REM		PLAS_PL PLAS_METH			0.	GSWV TOP	0.	GSWD FREQ	0.	SWVG NAME	1	SWVD TOP
	SAMP DESC		SPT Data (ISPT)		PLAS WETH				GSWV BTTM		GSWD PHVL		SWVG DESC		SWVD BTTM
	SAMP REM	07	ISPT ID		FLAJ NEIVI				GSWV VS					' I	SWVD VS
		Ŏ,	SAMP ID	Rel	ative Density (RDEN)				GSWV VP						SWVD VP
5	Stratigraphy (STRA)		ISPT_TOP	0-	RDEN_ID				GSWV RHO						SWVD RHO
07	STRA_ID		ISPT_RODL	07				Wit	hin-Layer info (DETL)						
07	TEST_ID		ISPT_TPEN		RDEN_EMIN			0 7	DETL ID						
	STRA TOP		ISPT_NVAL		RDEN_EMAX			07	TEST ID						
	STRA_BASE		ISPT_ERAT ISPT_REM		RDEN_METH				DETL DPTH						Primary key
	STRA USCS STRA COL		ISPT_REIM		RDEN_REM				DETL DESC						
	STRA DESC			Oth	er Lab. Tests (OTHR)				Test Pits (TEPT)		er Field Tests (OTHF)				E analana kaud
	01101_0200			07	OTHR ID			<u>9</u> -	TEPT ID	2	OTHF ID			U.S.	Foreign key
v	Vater Table (WATR)			<u></u>	SPEC ID			07	TEST ID TEPT BASE	<u>O</u> a	TEST ID OTHF NAME				
<u>o</u> a	WATR_ID			07	FILE_ID				TEPT BASE		OTHE NAME				
0A	TEST_ID				OTHR NAME				TEPT CREW		OTHF DESC				
	WATR_DPTH				OTHR_TYPE				TEPT STAR		OTHE STAR				
	WATR DATE WATR REM				OTHR_DESC				TEPT_ENDD		OTHF_ENDD				
	WAIN_NEW			-					TEPT REM						

Figure 3 Schema for the Site Database

Completion Memo

Observations (FLDO)		Ground Motion at site (GMIM)			servation Files (FLDF)	Liquefa	ction Manifestations (FLDM)	Disp. Vectors (FLDD)		
<mark>0</mark> ,	FLDO_ID	<mark>0</mark> 7	GMIM_ID	<u></u>	FLDF_ID	07	FLDM_ID	<u></u>	FLDD_ID	
07	EVNT_ID	07	FLDO_ID	07	FLDO_ID	07	FLDO_ID	07	FLDO_ID	
07	SITE_ID		GMIM_LAT	07	FILE_ID		FLDM_LAT		FLDD_LAT	
	FLDO_DESC		GMIM_LON		FLDF_LAT		FLDM_LON		FLDD_LON	
	FLDO_STAT		GMIM_TYPE		FLDF_LON		FLDM_ELEV		FLDD_AZIM	
	FLDO_REVW		GMIM_VALUE		FLDF_DESC		FLDM_SFEV		FLDD_HDIS	
ſ		1	GMIM_STDDEV			-	FLDM_SNBL		FLDD_VDIS	
	O Primary key		GMIM_UNIT				FLDM_LTSP		FLDD_METH	
	<u> </u>		GMIM_METHOD				FLDM_STTL			
	O Foreign key						FLDM_STDM			
. I		J					FLDM_DESC			

Figure 4 Schema for the Observation Database

Completion Memo

Ear	thquake Event (EVNT)	Rec	ording Station (STAT)	Fa	ult Segment (SEGM)		Recorded IMs (RCIM)
07	EVNT_ID	07		0-	SEGM_ID		RCIM_ID
	EVNT_ID		STAT_NAME	07	EVNT_ID	07	EVNT_ID
	EVNT_EQID		STAT_SEQN		SEGM_NAME	07	STAT_ID
	EVNT_NM		STAT_NET		SEGM_LENGTH		IM_RJB
	EVNT_YR		STAT_LAT		SEGM_WIDTH		IM_EPI
	EVNT_MD		STAT_LON		SEGM_STRIKE		IM_HYPO
	EVNT_HM		STAT_HOUSE		SEGM_DIP		IM_R_DIST
	HYPO_LAT		STAT_ELE		SEGM_RAKE		IM_RMS
	HYPO_LON		STAT_VS30		ULC_LAT		IM_CLST
	HYPO_DT		STAT_SIGVS30		ULC_LON		IM_RX
	EVNT_MAG		STAT_NEHRP		ULC_DEPTH		IM_AZIMUTH
	MAG_TY		STAT_REG				PGA
	MAG_UNCK		STAT_DEPTH				PGV
	MAG_UNCST		STAT_GEOL		Or Primary key		PGD
	EVNT_MO						T0.010S
	EVNT_MECH						T0.020S
	EVNT_RUP				O Foreign key		T S
	EVNT_FFMOD						
	EVNT_STRIKE						T20.000S
	EVNT_RAKE						
	EVNT_DIP						

Figure 5 Schema for the Event Database

Accessing the Database

The database can be accessed using the following link http://www.nextgenerationliquefaction.org/

Status of the Lateral Spread Case Histories

The database information gathered by the University of Utah and BYU students has been cross-checked and sent to UCLA for further vetting. NGL will determine the timeline for their review and the public dissemination of the collected dataset. On February 3rd, 2021, we reported information to the TAC regarding Tasks 7, 8 and, 9. The delay of NGL in reviewing and publishing our dataset was discussed. Some TAC members (e.g., Tom Shantz, CALTRANS) expressed the Universities have met the TAC expectations in terms of populating the NGL dataset.

I would be happy to discuss this subject further if there are any questions.

Respectfully,

Ativen Bastlett

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