SCEC/ROSRINE Workshop on Borehole Array Data Utilization

Riviera Resort, Palm Springs, CA - Thursday November 16, 2000 (following the 6ICSZ)

Workshop Organizers: Jamie Steidl & Bob Nigbor

Executive Summary:

The SCEC/ROSRINE borehole data utilization workshop was held on Thursday November 16, 2000 at the Riviera Resort in Palm Springs, CA. More than 30 people participated; Table 1 is a list of participants. The purpose of the workshop was to bring the user community together and focus on the current status and use of borehole array data, and discuss the future directions for integration and operations of the borehole array programs. The number of existing borehole arrays is growing at a rapid pace, supported by multiple agencies which often have very different goals and needs. The workshop was convened to educate the many diverse users and providers as to what is the existing infrastructure, and to discuss ways to integrate this growing research infrastructure to provide dissemination of the array data to all user groups.

The workshop was organized into three sessions (see agenda below). The first session, several brief presentations were made on the background and current status of the various borehole programs in California. The second session focused on the current use and analysis of the borehole array data. The third session was a discussion session to answer specific questions related to the future directions for the borehole programs.

The existing borehole array programs from the California Division of Mines and Geology strong motion instrumentation program (CSMIP), the Southern California Earthquake Center (SCEC), the US Geological Survey (USGS), the University of California at Berkeley (UCB), and the University of California at Santa Barbara (UCSB) were described. In addition, site characterization programs under the USGS and the ROSRINE program were discussed, as these data are critical to analyses of strong motion data. We also were given an update on the dynamic testing of samples for laboratory estimates of large strain soil behavior, and an update on the techniques for *in situ* pore pressure measurement used in liquefaction studies.

Several presentations on the current use of borehole data were given. Analysis of data from the existing arrays for both small and large strain levels was presented using state-of-the-art numerical modeling techniques for the simulation of dynamic soil behavior. The focus in this

part of the workshop was on the use of the array data for the validation and calibration of out physical and numerical models of soil behavior. These presentations are provided in the workshop proceedings that are being compiled and will be made available in March of 2001.

By the end of workshop it was clear that there is a great deal of effort in terms of funding and manpower directed at earthquake engineering borehole array studies, yet there was no common underlying thread to tie the diverse efforts together into a coherent program. There are some recent efforts to compile a list of borehole arrays and gather the data (Table 1- modified from W. Silva, written communication). There was consensus within the user group that the community should mobilize a working group to address the data compilation, dissemination, and future array installation priorities. As a result of this workshop a proposal has been submitted to NSF Engineering to support a working group to organize this collaborative effort.

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Workshop Participants:

Name	Organization	E-Mail
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Workshop Agenda:

8:00am	Registration & Continental Breakfast	
8:45am	Introduction & Workshop Objectives	**Steidl/Nigbor**
	<u>Background & Current Status Reports</u>	
9:00am	SCEC/Other Vertical array update	**Steidl**
9:20am	USGS Vertical array update	**Borcherdt**
9:40am	CSMIP Vertical array update	**Graizer**
10:00am	ROSRINE Field Investigations update	**Nigbor**
10:20am	Coffee Break	
10:40am	USGS Field Investigations update	**Boore**
11:00am	Laboratory Studies update-U of Texas	**Stokoe**
11:20am	Pore Pressure array experiments	**Steidl**
11:40am	Pore Pressure Measurement	**de Alba**
12:00pm	Lunch Break	
	<u>Current Use of Borehole Data</u>	
1:00pm	Results from past borehole arrays – Lotung	**Elgamal**
1:15pm	Recent results from vertical array data in Japan	**Idriss**
1:30pm	Recent results from Caltrans/CSMIP vertical arrays	**Graizer**
1:45pm	Site Response at Rock Sites from Borehole Data	**Nigbor/Steidl**
2:00pm	Small and large strain modeling at SCEC/ROSRINE sites	**Steidl/Bonilla**
2:15pm	Modeling vertical array data using system identification	**Glaser**
2:30pm	Bay area borehole network	**Baise**
2:45pm	The use of vertical array data	**Silva**
3:00pm	Coffee Break	

3:15-5:00 **<u>Discussion Questions-Future of Borehole Studies</u>**

- Blind prediction for low-strain data from one or more vertical arrays: a good idea?
- Are the laboratory studies providing what is needed for the numerical modeling?
- Vertical array ground motion data dissemination: How should we link geotechnical site characterization data with the ground motion time histories
- What are possible funding strategies for maintenance of existing vertical arrays
- Future vertical array installation priorities?

5:00	Summary and conclusions
5:30pm	Adjourn

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Table 1. Draft Summary Table of Downhole Arrays

Array	Location	Site Geology	Sensor Depths	Data
1.	*Anza, Southern CA	Shallow Soil, Hard Rock	0, 150, 300m 2 arrays, Keenwild and Pinon Flat	Regional & Local Earthquakes, 1.4<**M**<5.5
2.	*Ashigara Valley Sw of Tokyo	Alluvium	0, 30, 97.6m	4 Local Earthquakes, 2.9<Mj<5.1
3.	**Baldwin Hills Los Angeles, Ca	Alluvium	0, 420, 1500m	1 Earthquake, **M** = 2.8, Dist=0.9 Km
4	**Borrego Valley Southern CA	Alluvium over rock	0, 9, 19, 139, 238m + Surface array & nearby rock outcrop	200+ Earthquakes, Regional and local, 2.0<**M**<7.3
5.	**Cajon Pass Southern CA	Soft Rock	0, 300, 1500, 2500, 2900m	109 Earthquakes, 0<**M**<5
6.	*Chiba Chiba, Japan	Soil & Loam	1, 5, 10, 20, 40m	>160 Earthquakes, 4<**M**<8
7.	Chikura South of Tokyo	Mudstone, Siltstone	0, 732m	20 Earthquakes, 1.9<Ml<4.2
8.	Dahan Taiwan	Gravel & Sand	0, 50, 100, 200m	8 Earthquakes, 3.8<Ml<5.2
9.	DWR Sacramento Delta 4 arrays	Peat, alluvium	0, 4, 10, 120m	2 Earthquakes, 3<**M**<5.0
10.	Etchujima Tokyo	Silty Sand	0, 40, 100m	23 Earthquakes, 5.1<Mj<6.8
11.	**Euro-Seistest Macedonia, Greece	Alluvium	0, 17, 72m 2D array	32 Earthquakes, 3<**M**<7.5
12.	*Garner Valley Southern CA	20m Soil	0, 6, 15, 22, 50, 220, 500m + Surface array & nearby rock outcrop	>1000 Earthquakes, 1.5<Ml<7.1
13.	**Garni Garni, Armenia	Rock		Teleseismic, Regional, and Local Eqs

* Data acquired

** Data requested

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Array	Location	Site Geology	Sensor Depths	Data
14.	Griffith Park, Southern CA	Fractured Rock	0, 100m	Local & Regional Earthquakes, 1.8<**M**<7.1
15.	**Hollister Hollister, CA	Alluvium over rock	0, 10, 20, 50, 110, 192m + nearby rock outcrop	>100 Earthquakes, Regional and local, 2.5<M<7.3
16.	*Hwalien Taiwan	Coarse Gravel		9 Earthquakes, 3.5<M_L<6.8
17.	Iwaki Ne of Tokyo	Sandstone	0, 20, 70, 130, 200, 330m	20 Earthquakes, 5.2<**M**<7.7
18.	Jensen Filtration Plant, Los Angeles, CA	Alluvium	0, 90m at Two Sites, Admin and Generator buildings	Local and Regional Earthquakes
19.	Joaquim North Parkfield, CA	Rock	0,198m	59 Earthquakes, 0.5<Mcoda<2.4
20.	K-Site East of Tokyo	Alluvium	1, 4, 10, 17, 25, 36, 50, 158, 502m	25 Earthquakes, M<6.0
21.	KBU Kobe University	rock	0, 70m	2 Earthquakes, **M**<5
22.	*1Kainn	Soil	0, 25, 100m	1 Earthquake, **M** 6.9
23.	*LaCienega Los Angeles, CA	Alluivium	0, 18.3, 101.2m	9 Earthquakes, 3.0 <**M**<5.1
24.	*LSST_Lotung Taiwan	Alluvium	0, 6, 11, 17, 47m	9 Earthquakes, 4.3<Ml<6.5
25.	*Mcgee Creek Mammoth, CA	Glacial till	0, 35, 166.5m	8 Earthquakes, 1.14<Md<3.0
26.	Meloland El Centro, CA	Alluvium	0, 30, 100, 195m	5 Earthquake 3.9<<M<7.1
27.	Mexico City Mexico	Lake Bed Alluvium	0, 30m	4 Earthquakes
28.	Mira Catalina Palos Verdes, CA	Soft Rock	0, 30m	Local & Regional Earthquakes, 3.0<**M**<7.1
29.	*Narimasu Tokyo	Alluvium	1, 5, 8, 22, 55m	Horizontal Components Only
30.	Ngendei SW Pacific	Sediments	54, 124m below Seafloor	2 Regional Earthquakes

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31.	Ohrid Ohrid, FYROM (Macedonia)	Silts, Clays	0, 9, 9.5, 13, 21.5, 22, 22.9, 99.6, 101, 125m	6 Earthquakes, 4<**M**<6
32.	Oroville Oroville, CA	Fractured Rock	0, 34, 118, 208, 297, 375, 475m	12 Earthquakes, 0.3<**M**<0.8
33.	*Port Island Kobe, Japan	Alluvium	0, 16, 32, 83m	8 Earthquakes, 4.0 <**M**<6.9
34.	Pwri Tokyo	Alluvium	0, 2, 46, 50m	21 Earthquakes, 3.0<Mjma<6.7
35.	*Richmond Field Station, CA	Alluvium, Bay Mud	0, 15, 40m	6 Earthquakes, 2.8<**M**<6.2
36.	**Samoa Eureka, Ca	Alluvium	0, 19, 33, 56, 136, 165m	3 Earthquakes
37.	Sendai-Shiogama Sendai, Japan	Clay,Graval		32 Earthquakes, 4<**M**<8
38.	*SF Marina San Francisco	Fill	0, 88m	12 Earthquakes, 2.8<Ml<5.7
39.	Shiroyama, West of Tokyo	Rock	0, 164, 201, 215.7, 229, 239m	71 Earthquakes, 2.9<**M**<7.4
40.	Stone Canyon Southern CA	Rock	0, 100m	Local & Regional Earthquakes, 1.8<**M**<7.1
41.	*Takasago	Alluvium	0, 25, 100m	1 Earthquake, **M** 6.9
42.	Tarzana Southern CA	Alluvium	0, 60m	12 Earthquakes, 2.5<M<7.1
43.	*Techcent	Alluvium	0, 25, 100m	1 Earthquakes, **M** 6.9
44.	Tokyo Airport	Alluvium	0, 49.6, 67.2m	32 Earthquakes
45.	Tomioka NE of Tokyo	Tuff, Sandstone	0, 6, 100, 251, 660, 950m	16 Earthquakes, 5.0<Mj<7.7
46.	*Treasure Island, CA	Hydraulic Fill Bay Mud	0, 7, 16, 31, 44, 104m	7 Earthquakes, 4.0<M<5.4
47.	*Varian Parkfield, CA	Great Valley Sediments	0, 23.5, 298, 572, 938m	28 Local Earthquakes, 0.96<**M**<3.70
48.	Vincent Thomas Bridge, Southern CA	3 Vertical arrays	0-91m	Local & Regional Earthquakes
49.	Vineyard Canyon, Parkfield, CA	Rock	0, 198m	98 Earthquakes, 0.5<Mcoda<2.4
50.	*Waseda Tokyo	Alluvium	1, 17, 67, 123m	Horizontal Components Only

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51.	*Wildlife Imperial Valley, CA	Silt,sand,clay	0, 7.5m	4 Local Earthquakes, 4.0<**M**<6.6
52.	***Whitshell Pinarig, Monitoba	Granite	0, 420m	30 Earthquakes, **M** small
53.	Wonderland Ave. School, Southern, CA	Granite	0, 65m	Local & Regional Earthquakes, 1.8<**M**<7.1
54.	Yerba Buena CA	Weathered Rock	0, 61m	18 Earthquakes, 2.1<**M**<5.0

* Data acquired

** Data requested