Strong Motion Instrumentation on Wharves and Piers in California

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California Strong Motion Instrumentation Program

California Geological Survey

Department of Conservation

Sacramento, California

Prevention First 2002 Symposium

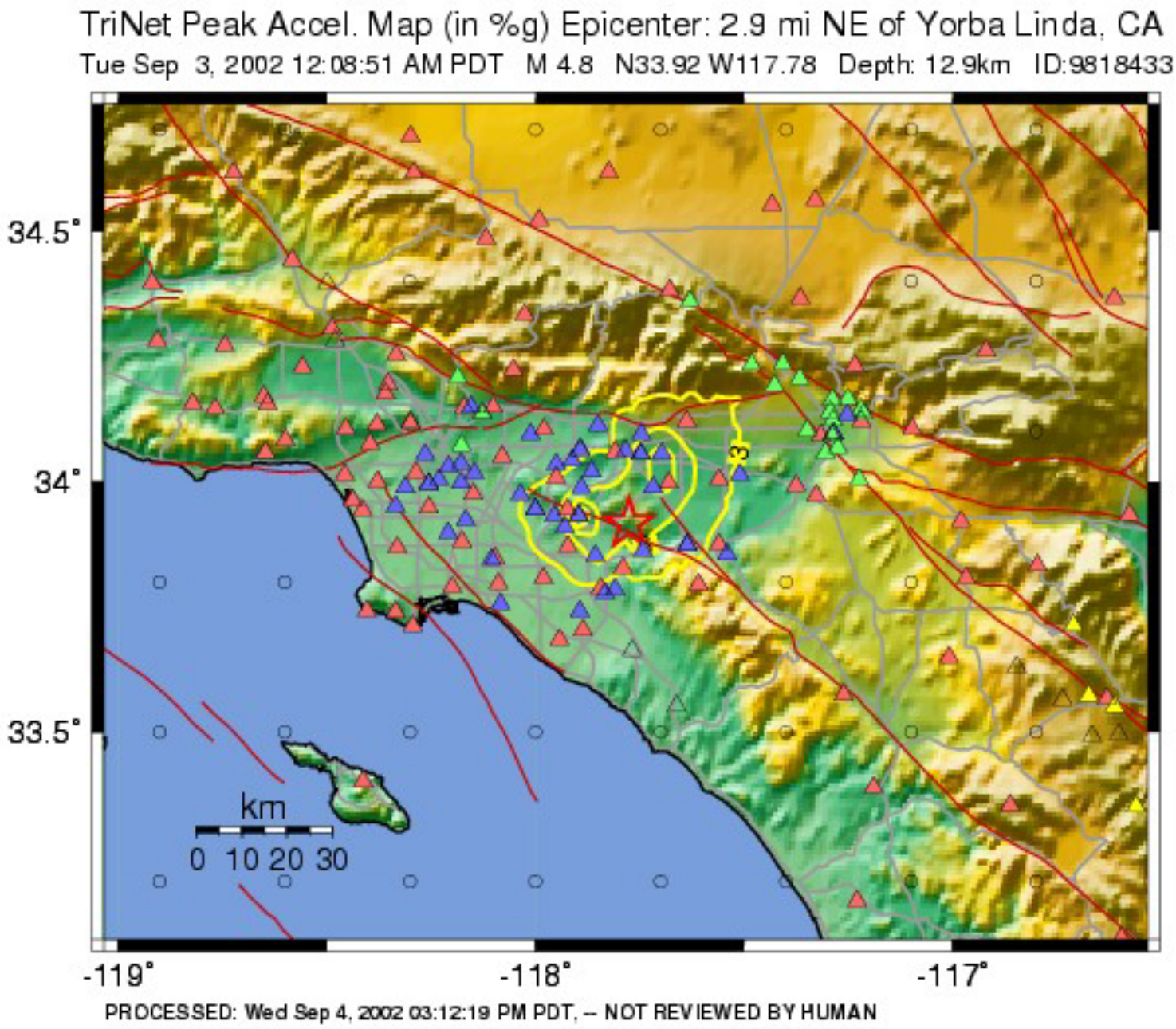
California State Lands Commission

September 10-11, 2002

California Strong Motion Instrumentation Program

- **Installation**
  - Ground Sites (700)
  - Buildings (171)
  - Bridges (65)
  - Dames (21)
  - Wharves/Lifelines (6)
  - Geotechnical Arrays (13)
- **Network Maintenance**
  - Personal Visit
  - via Telephone
- **Data Recovery and Dissemination**
  - Near-Real-Time Data
  - Data Distribution via e-mail
  - Internet Quick Report
  - Data Center on Internet
- **Data Interpretation**
  - Fund Research Projects
  - Data Interpretation Reports
  - Annual Seminar

TRINET SEISMIC STATIONS


TriNet Peak Accel. Map (in %g) Epicenter: 2.9 mi NE of Yorba Linda, CA
Tue Sep 3, 2002 12:08:51 AM PDT M 4.8 N33.92 W117.78 Depth: 12.9km ID:9818433
34.5°
34°
33.5°
km
0 10 20 30
-119°
-118°
-117°
PROCESSED: Wed Sep 4, 2002 03:12:19 PM PDT, -- NOT REVIEWED BY HUMAN

ShakeMap

TriNet ShakeMap: Estimated Instrumental Intensity - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Back Search Favorites History

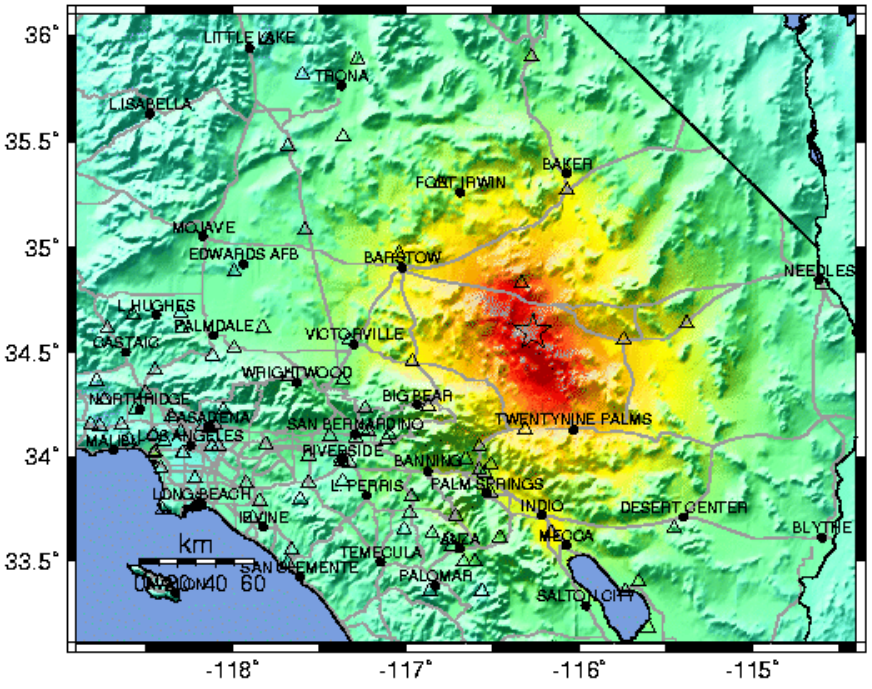
Address http://www.trinet.org/shake/9108645/intensity.html

Home | Map Archive | Event 9108645 | Related Links | Scientific Background | Disclaimer | Comment

EVENT: Hector Mine | Instrumental Intensity | Peak Ground Acceleration | Peak Ground Velocity | Spectral Response | Focal Mechanism | Download

TriNet Rapid Instrumental Intensity Map for Hector Mine Earthquake

Sat Oct 16, 1999 02:46:45 AM PDT M 7.1 N34.60 W116.27 ID:9108645



PROCESSED: Mon Jan 28, 2002 02:19:43 PM PST,

PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<.17	.17-1.4	1.4-3.9	3.9-9.2	9.2-18	18-34	34-65	65-124	>124
PEAK VEL.(cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	8.1-16	16-31	31-60	60-116	>116
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

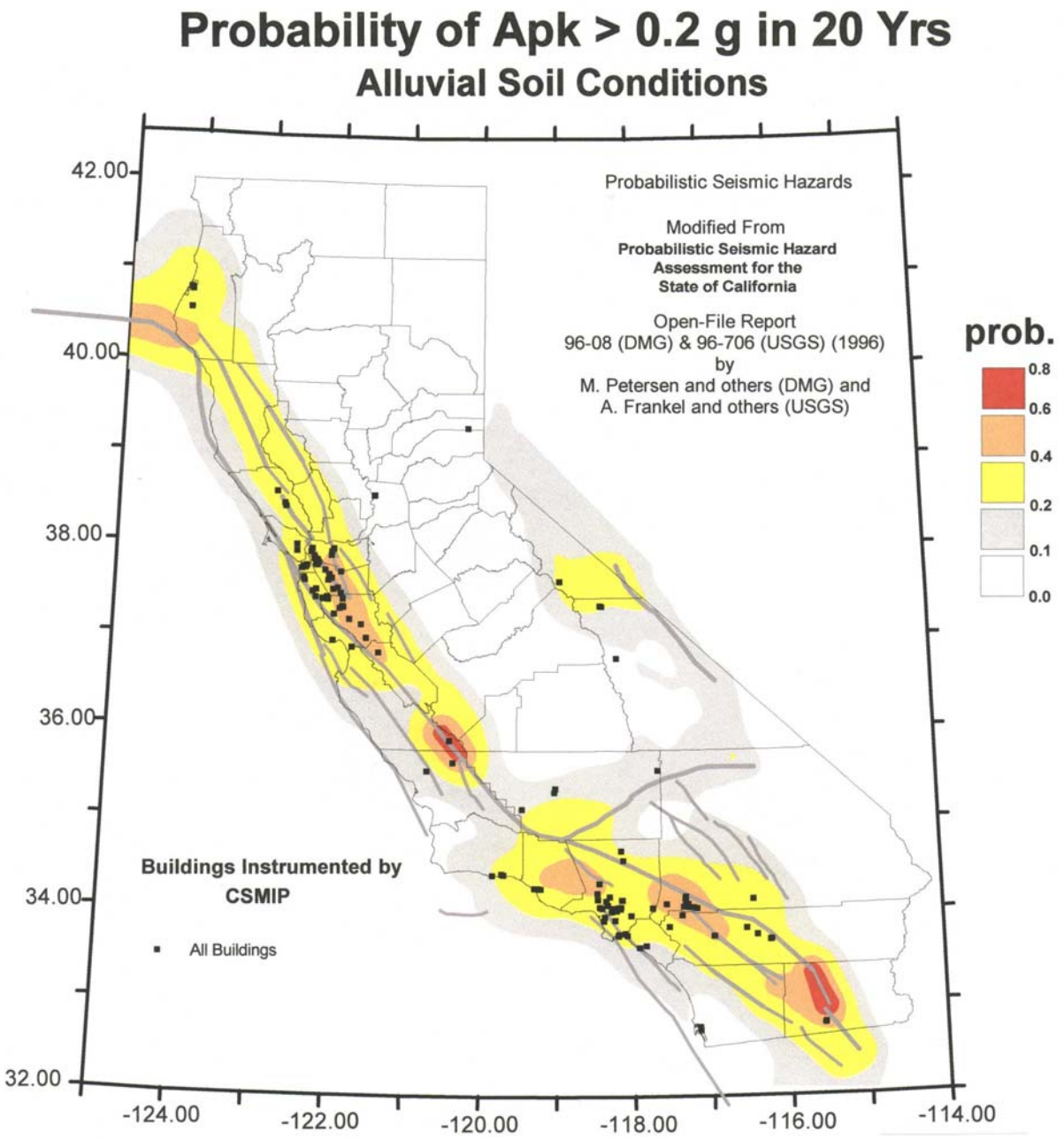
TriNet Instrumental Intensity Map

1999 Hector Mine Earthquake

About Intensities

Internet

Locations of 171 Buildings in California Extensively Instrumented by CSMIP



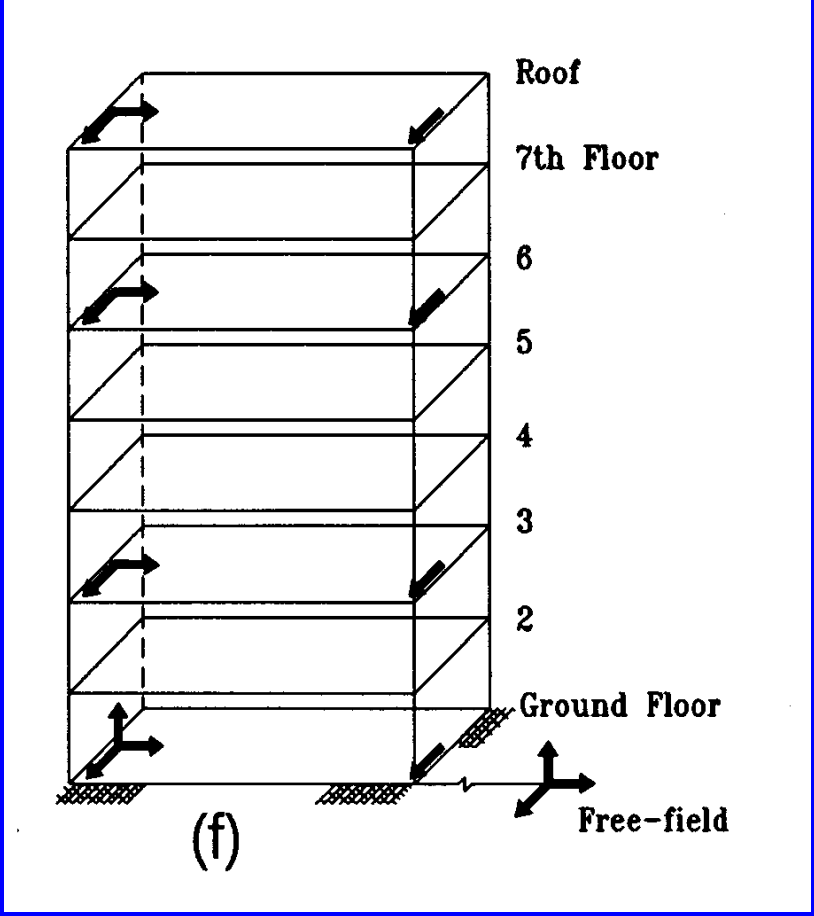
CSMIP Instrumented Buildings 171

1. Wood	**9**
2. Steel a. Moment Frames b. Braced Frames c. Light Frames d. Frames with Concrete Shear Walls e. Frames with Infill Masonry Walls	**66**
3. Concrete a. Moment Frames b. Shear Walls c. Frames with Infill Masonry Walls d. Precast/Tilt-Up Shear Walls e. Precast Frames	**71**
4. Masonry a. Reinf. Walls with Flexible Diaphragms b. Reinf. Walls with Stiff Diaphragms c. Unreinforced Bearing Walls	**15**
5. Isolated w/ or w/o Dampers	**10**

Long Beach City Hall

Free-Field

Sensor Locations in Extensively Instrumented Buildings



Sensors

-Accelerometer

-Relative Displ. Sensor


Accelerometer
SMIP
Accelerometer
JUL 25 '90

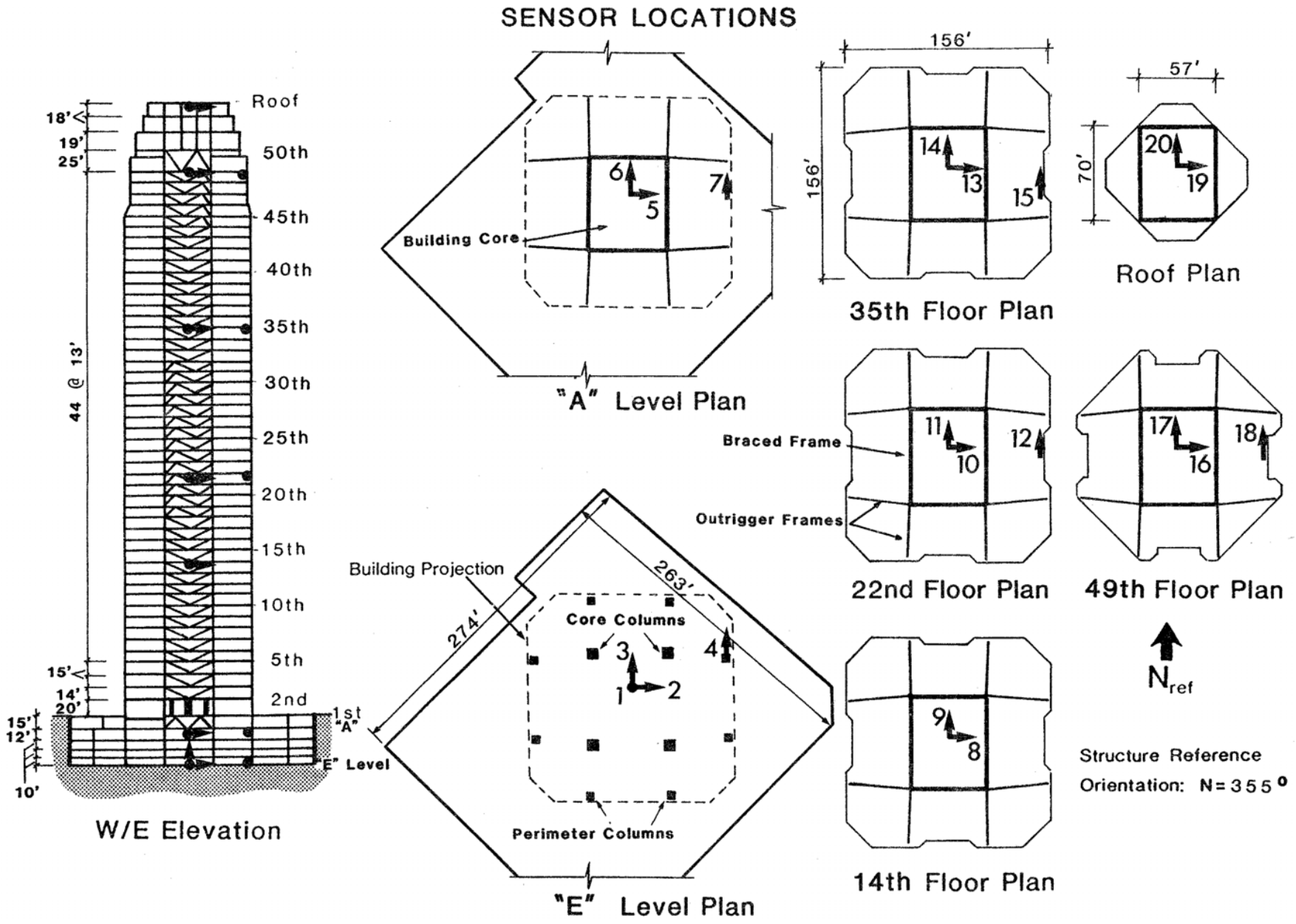
Recorder

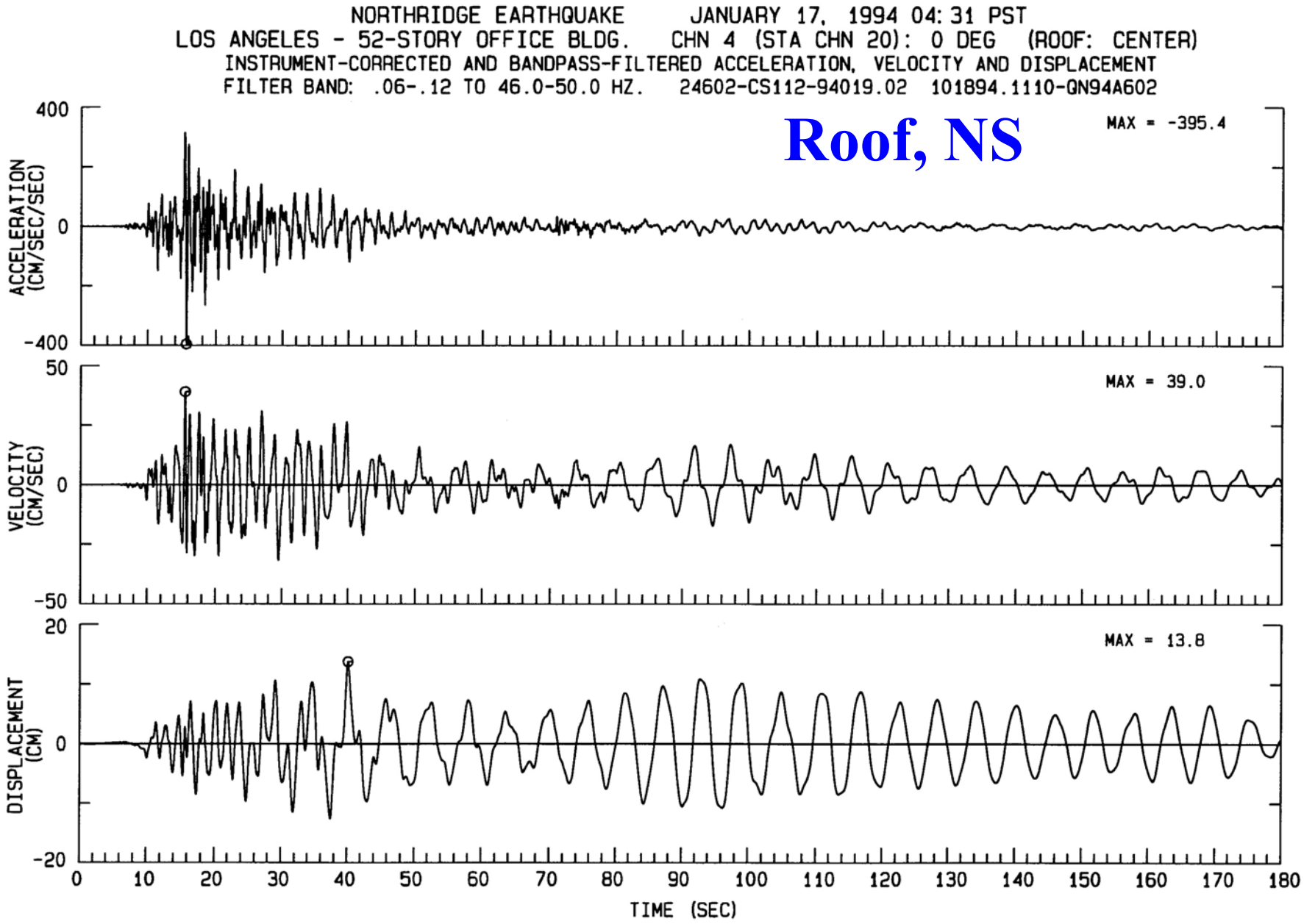
- cable to each sensor
- memory
- communications
- battery
- timing

Los Angeles – 52-story Office Building

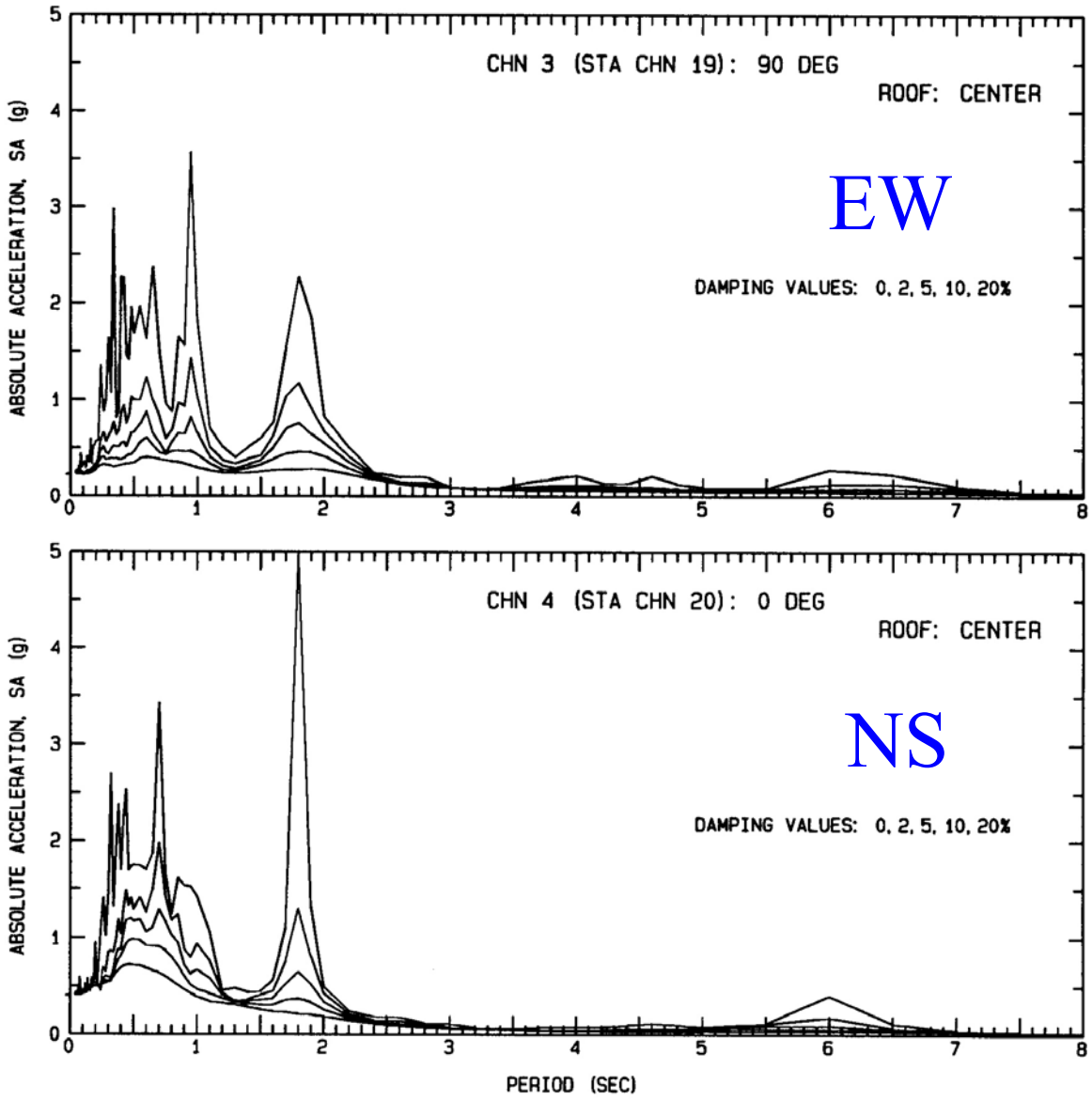
Los Angeles - 52-story Office Bldg.

(CSMIP Station No. 24602)

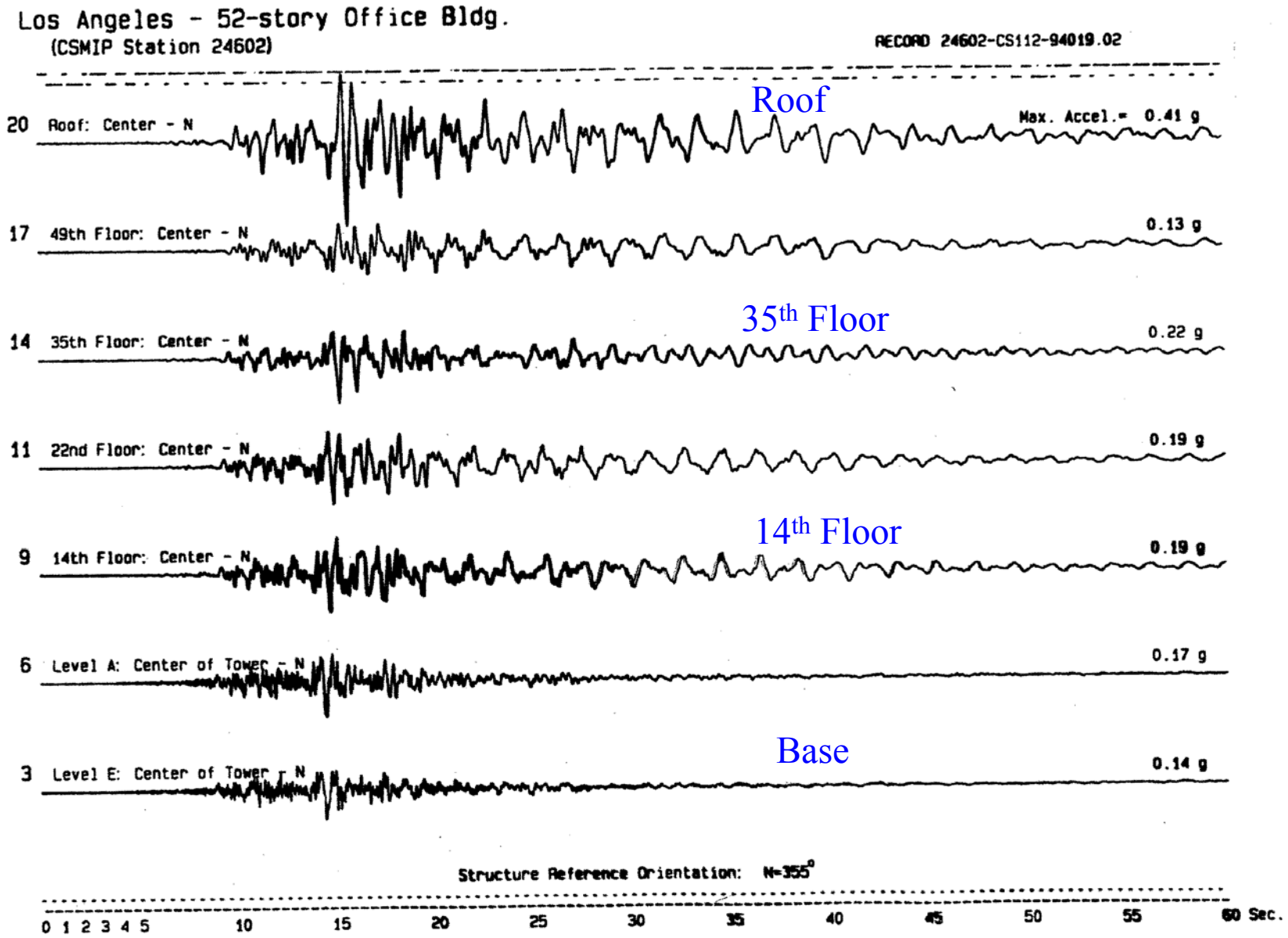



NORTHRIDGE EARTHQUAKE JANUARY 17, 1994 04:31 PST
LOS ANGELES - 52-STORY OFFICE BLDG. CHN 4 (STA CHN 20): 0 DEG (ROOF: CENTER)
INSTRUMENT-CORRECTED AND BANDPASS-FILTERED ACCELERATION, VELOCITY AND DISPLACEMENT
FILTER BAND: .06-.12 TO 46.0-50.0 HZ. 24602-CS112-94019.02 101894.1110-QN94A602
Roof, NS
MAX = -395.4
MAX = 39.0
MAX = 13.8
ACCELERATION (CM/SEC/SEC)
VELOCITY (CM/SEC)
DISPLACEMENT (CM)
400
0
-400
50
-50
20
-20
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180
TIME (SEC)

NORTHRIDGE EARTHQUAKE JANUARY 17, 1994 04:31 PST
LOS ANGELES - 52-STORY OFFICE BLDG.
ACCELEROGRAM BANDPASS-FILTERED WITH RAMPS AT .06-.12 TO 46.0-50.0 HZ.
24602-E0337-94019.02 021795.0832-QN94A602



1994 Northridge Earthquake



Wharf and Pier Instrumentation

VS Building Instrumentation

1) more hostile environment (salt water, etc.)
2) moving cranes and trucks
3) input ground motions hard to be defined
4) complicated soil-structure-pile interactions
5) instrumentation of underground piles
6) recorded data are more difficult to analyze

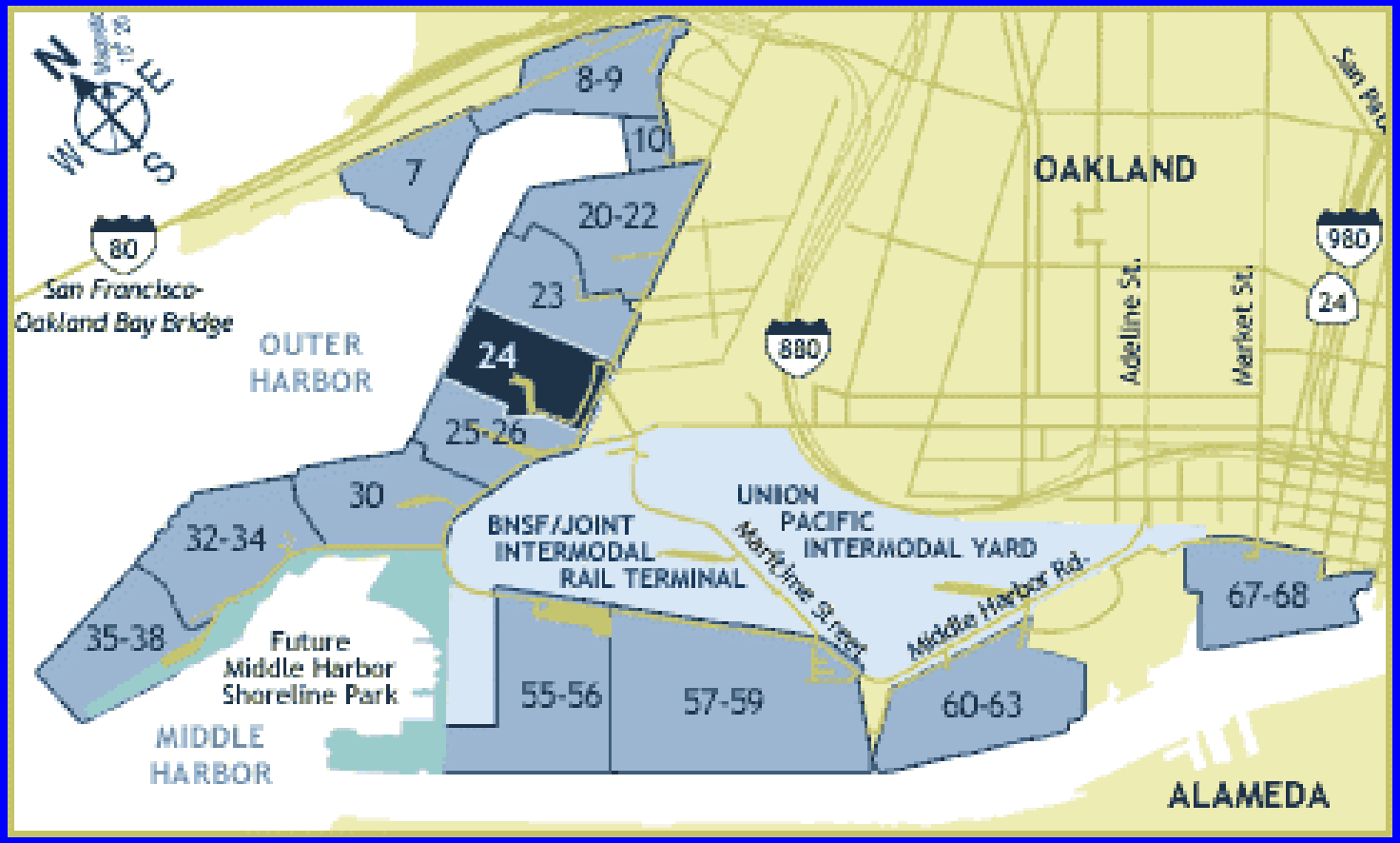
List of Wharves and Piers for Instrumentation by CSMIP

Port	Structure	Length, Width	No. of Sensors
Port of Oakland	Outer Harbor Wharf	1616', 65'	12
Port of Oakland	Berths 55 and 56	2400', 124'	18
Port of Oakland	Berths 57 - 59		6
Richmond	Long Wharf	3419'	6
Port of Long Angeles	Pier 300	1671', 124'	6
Port of Long Angeles	Pier 400, Phase II	1200', 124'	18
Port of Long Beach	Pier T, Phase II	900', 100'	18
Port of Long Beach	Pier J		tbd

Wharf and Pier Instrumentation
Instrumentation Objectives

1) measure ground motion at inland surface
2) estimate seismic force on the deck
3) measure motion (translational & torsional) of the deck
4) measure motion at the bottom of pile
5) obtain deformation of the pile
6) measure motion of energy dissipation devices if used

Port of Oakland

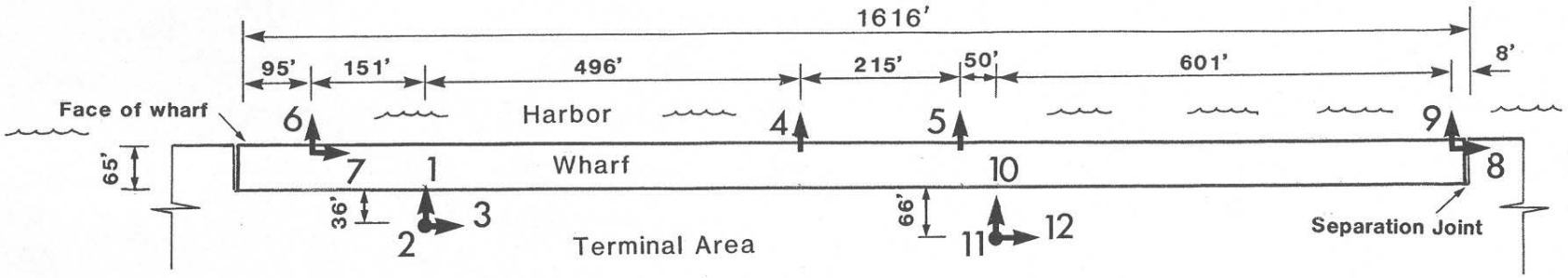


Port of Oakland – Outer Harbor Wharf (Berth 24)

Oakland – Outer Harbor Wharf

(CSMIP Station No. 58472)

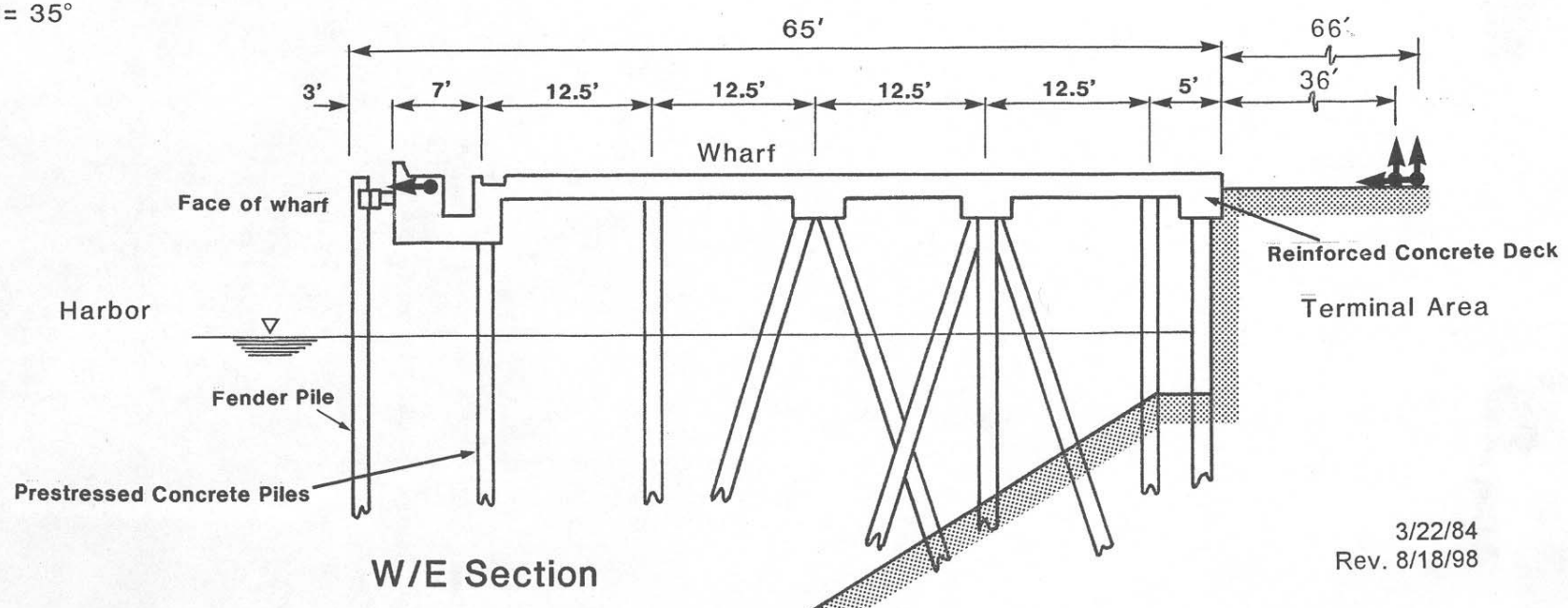
SENSOR LOCATIONS



Plan

N_{ref}

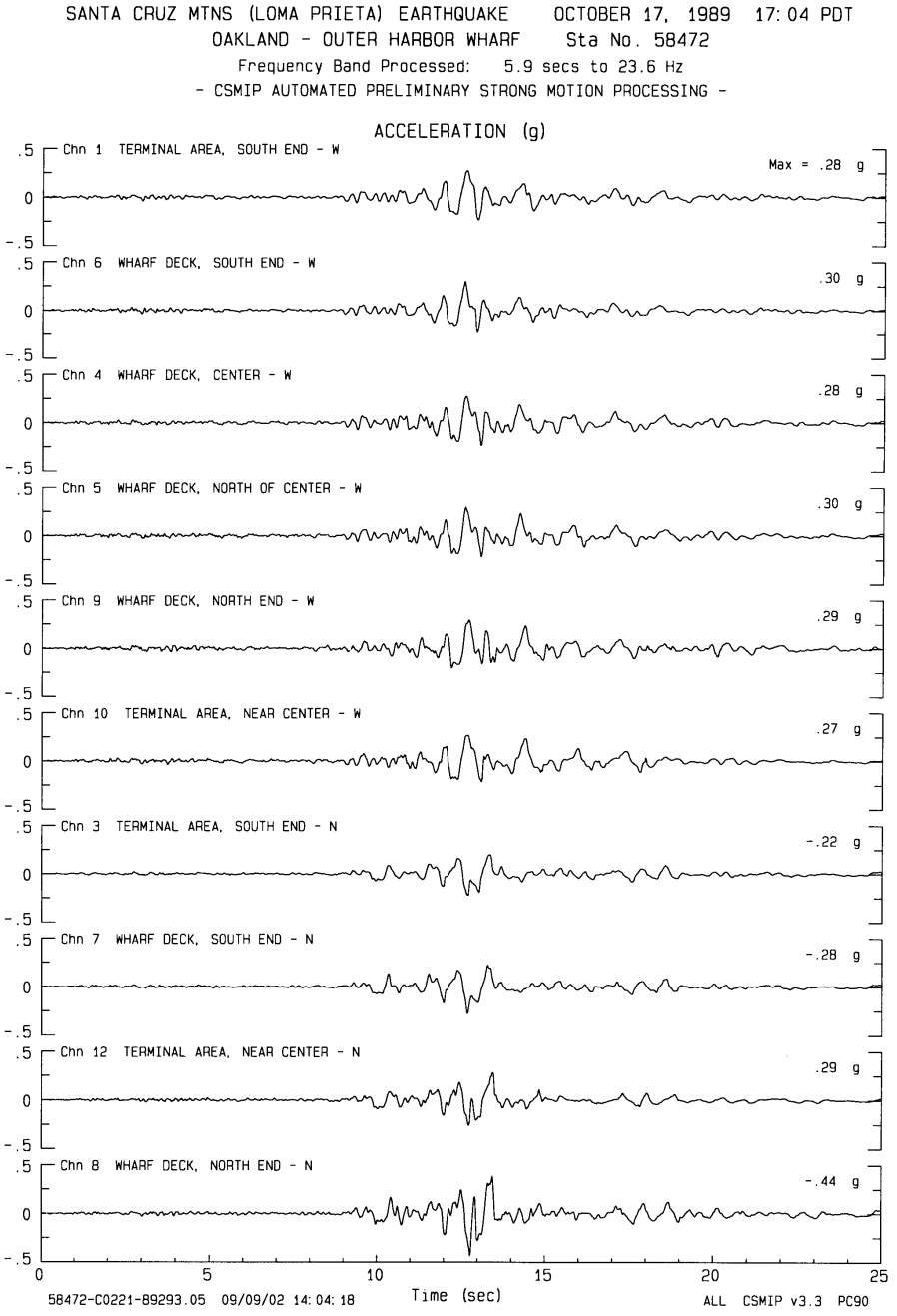
Structure Reference
Orientation: N= 35°



W/E Section

3/22/84
Rev. 8/18/98

Acceleration Records from the 1989 Loma Prieta Earthquake

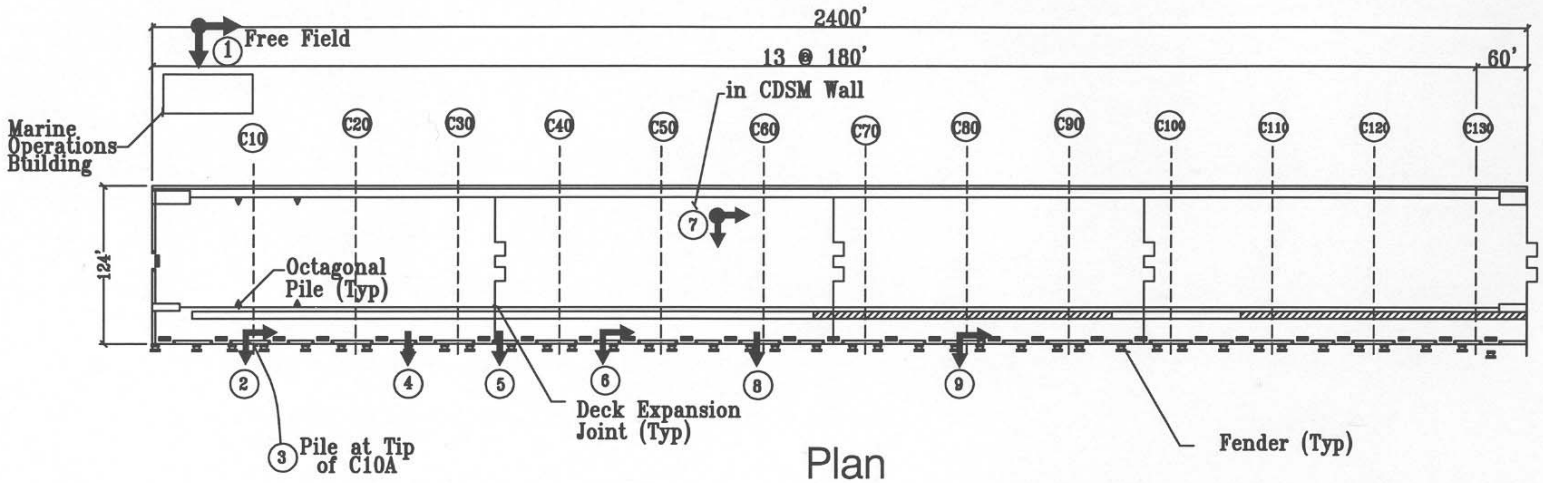


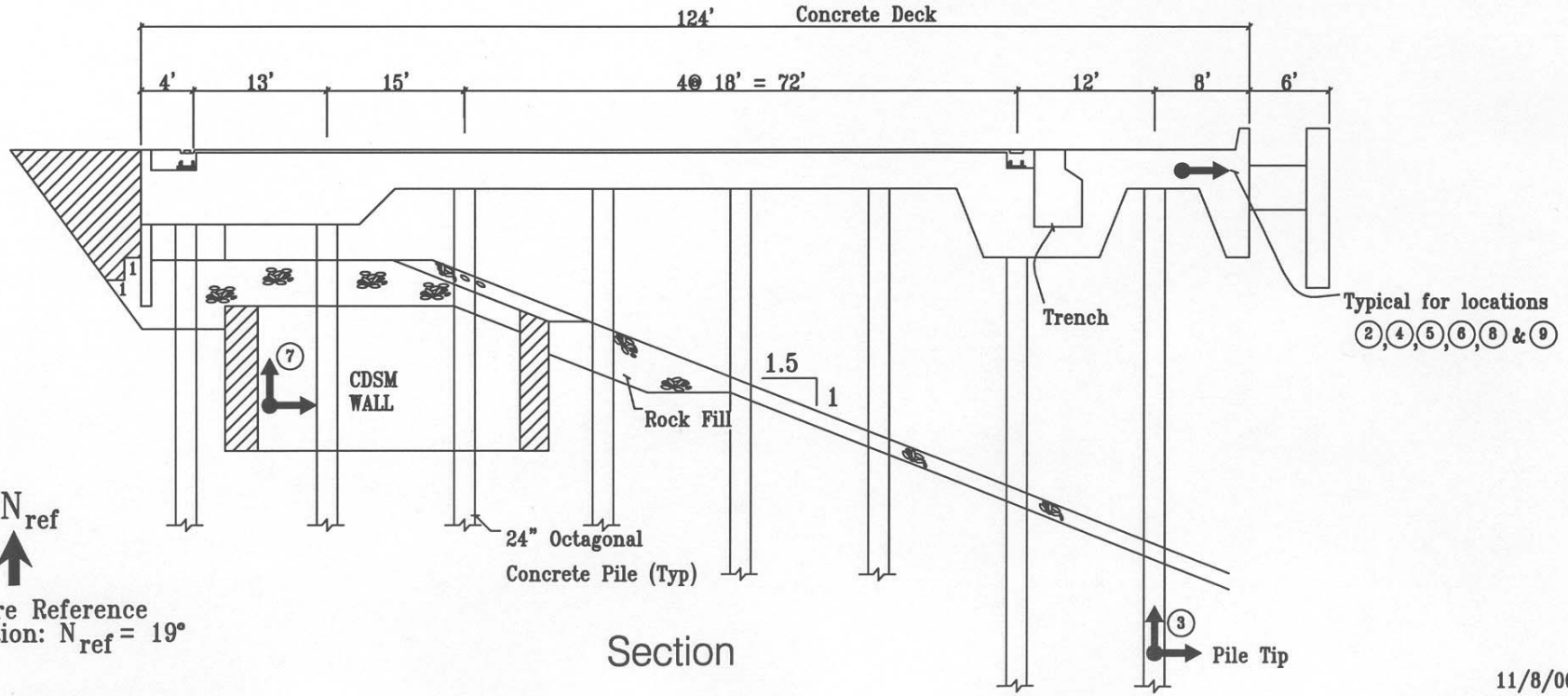
Port of Oakland – Berths 55 and 56

SENSOR LOCATIONS

Oakland- Berths 55 and 56

CSMIP Station





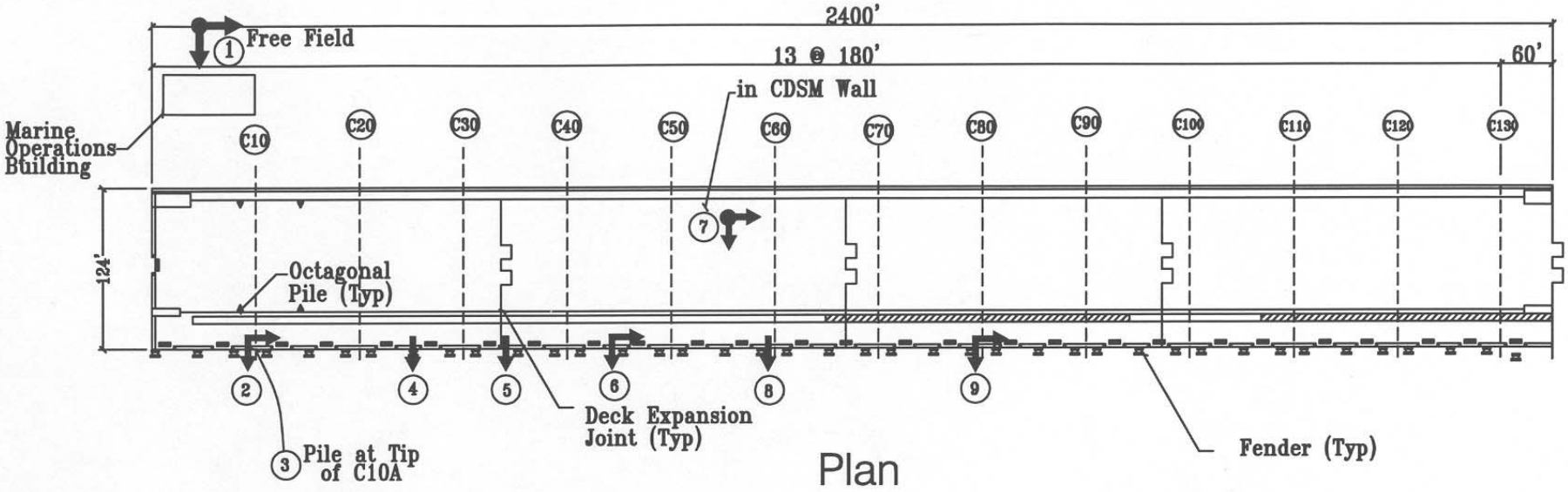
N_{ref}

Structure Reference Orientation: N_{ref} = 19°

11/8/00

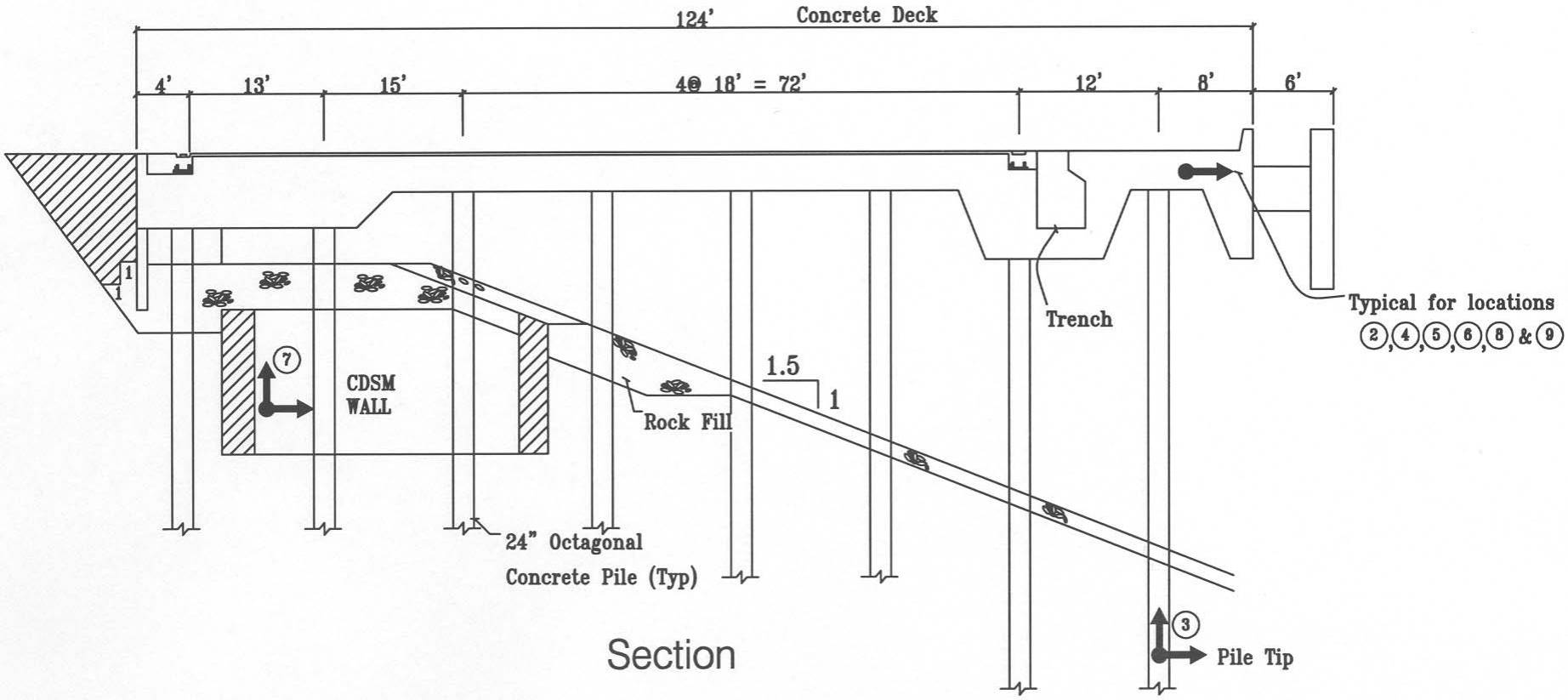
Oakland- Berths 55 and 56

CSMIP Station



Oakland- Berths 55 and 56

CSMIP Station



Section

Port of Oakland – Berths 55 and 56

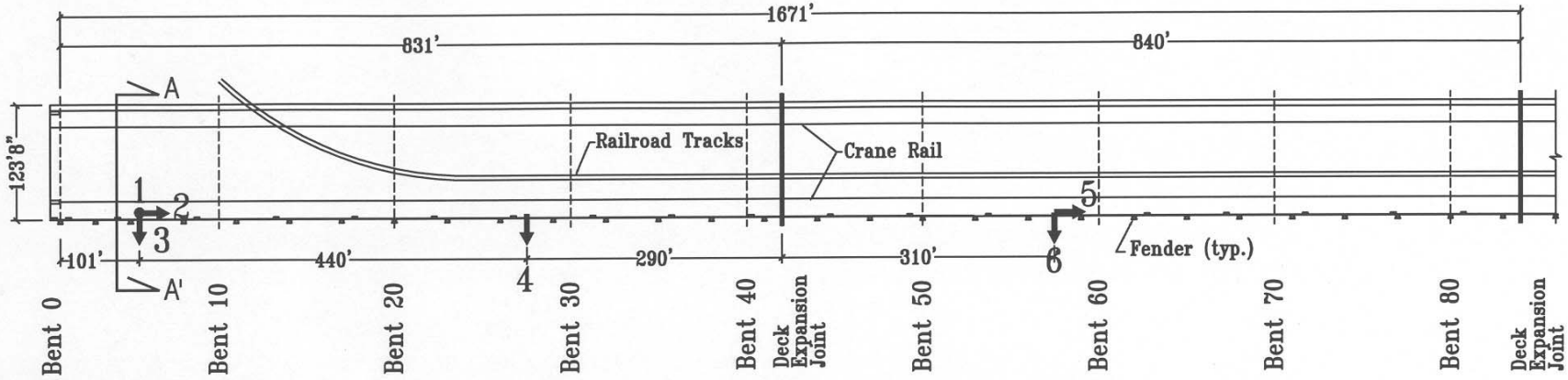
Port of Los Angeles

Port of Los Angeles - Pier 300

Los Angeles - Port of LA Pier 300

CSMIP Station No.14187

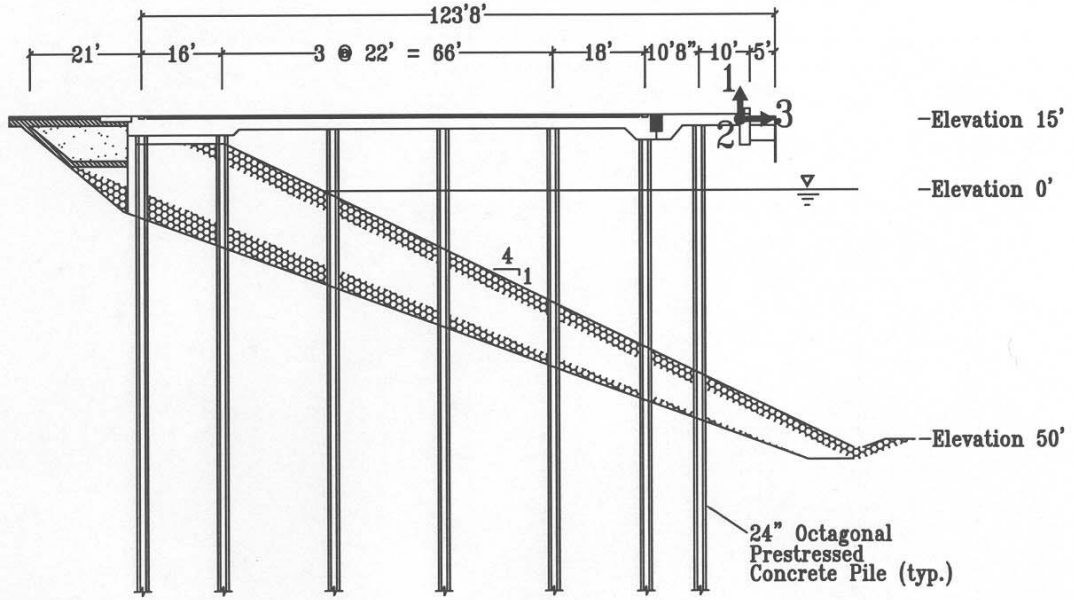
SENSOR LOCATIONS



Plan

N_{ref}

Structure Reference Orientation: N_{ref} = °



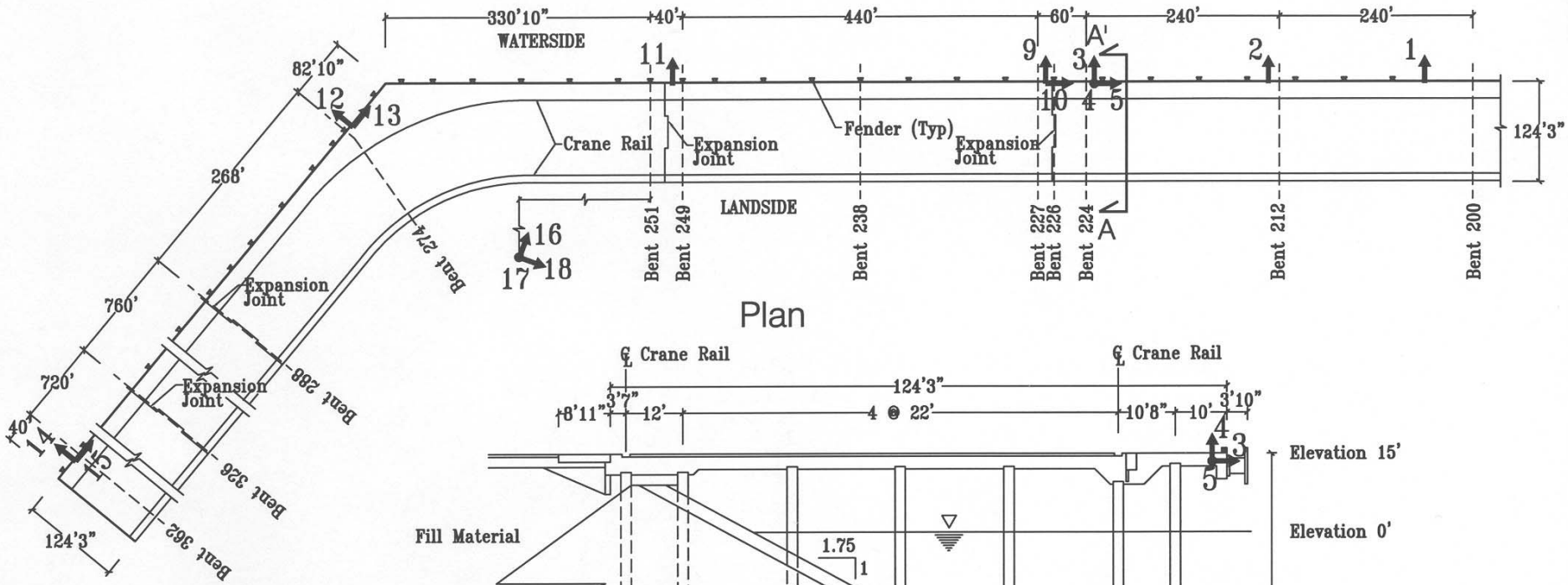
Section A-A'

12/12/01

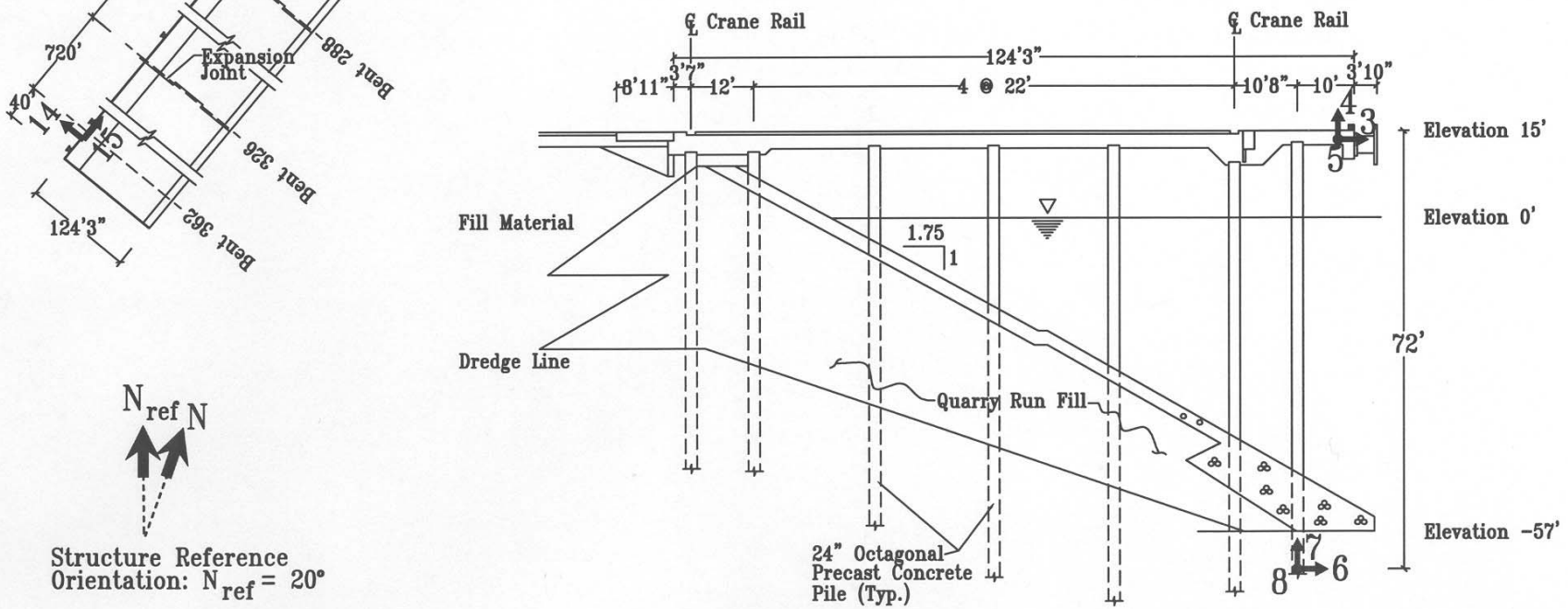
Los Angeles - Port of LA Pier 400

CSMIP Station

SENSOR LOCATIONS



Plan



Section A - A' @ Bent 224

N_{ref} N

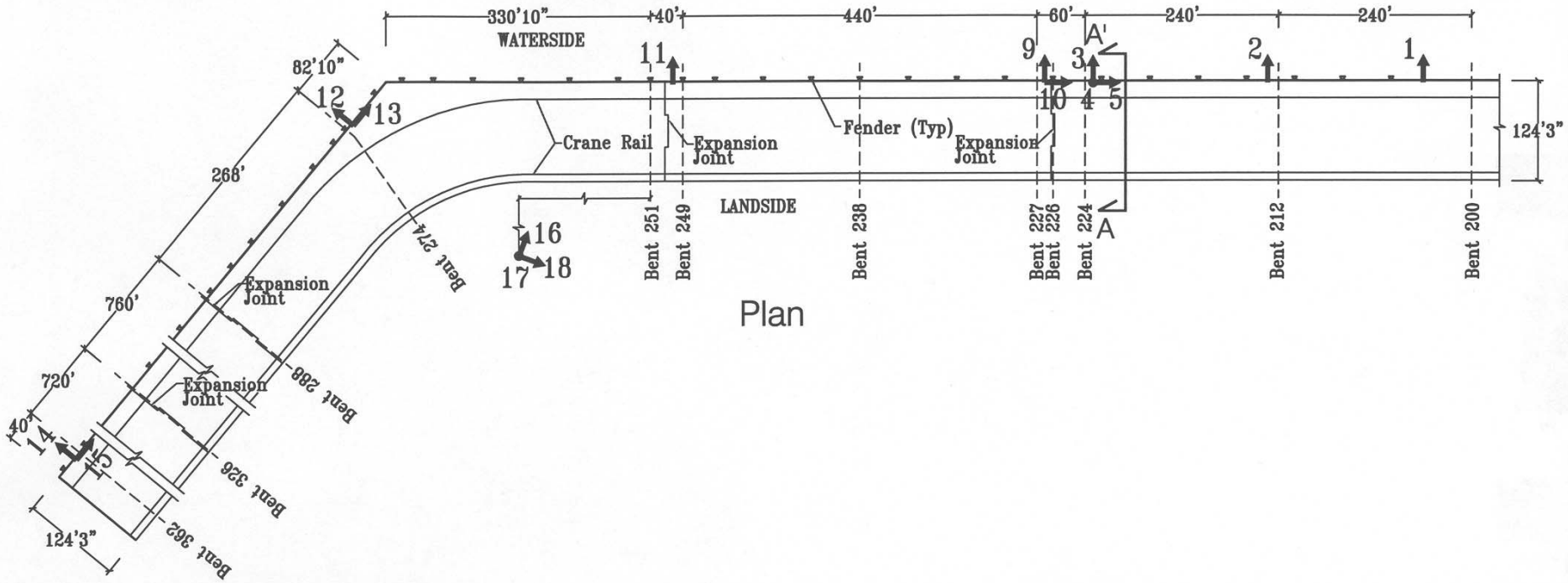
Structure Reference Orientation: N_{ref} = 20°

05/08/02

Los Angeles - Port of LA Pier 400

CSMIP Station

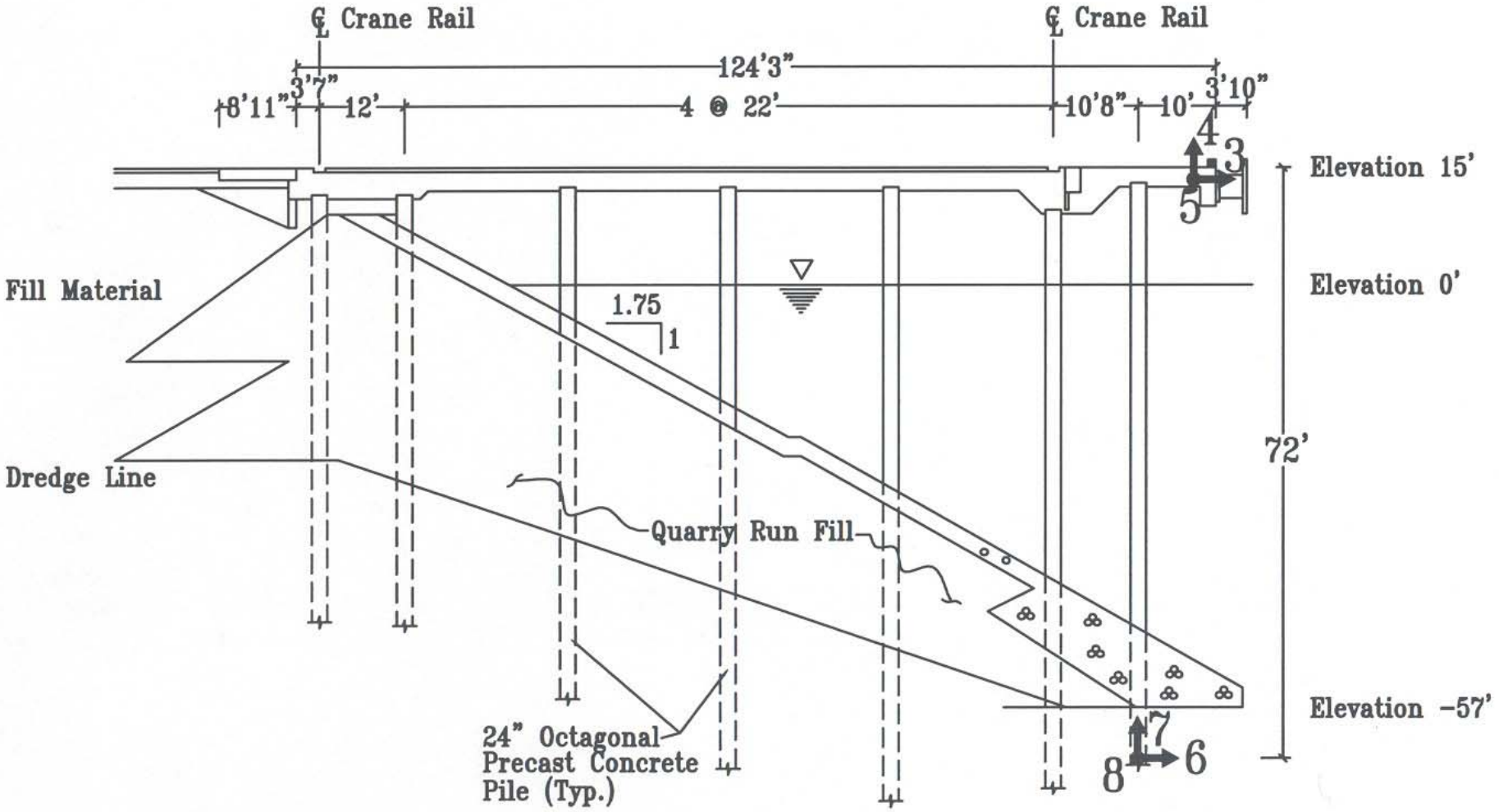
SENSOR LOCATIONS



Plan

Los Angeles - Port of LA Pier 400

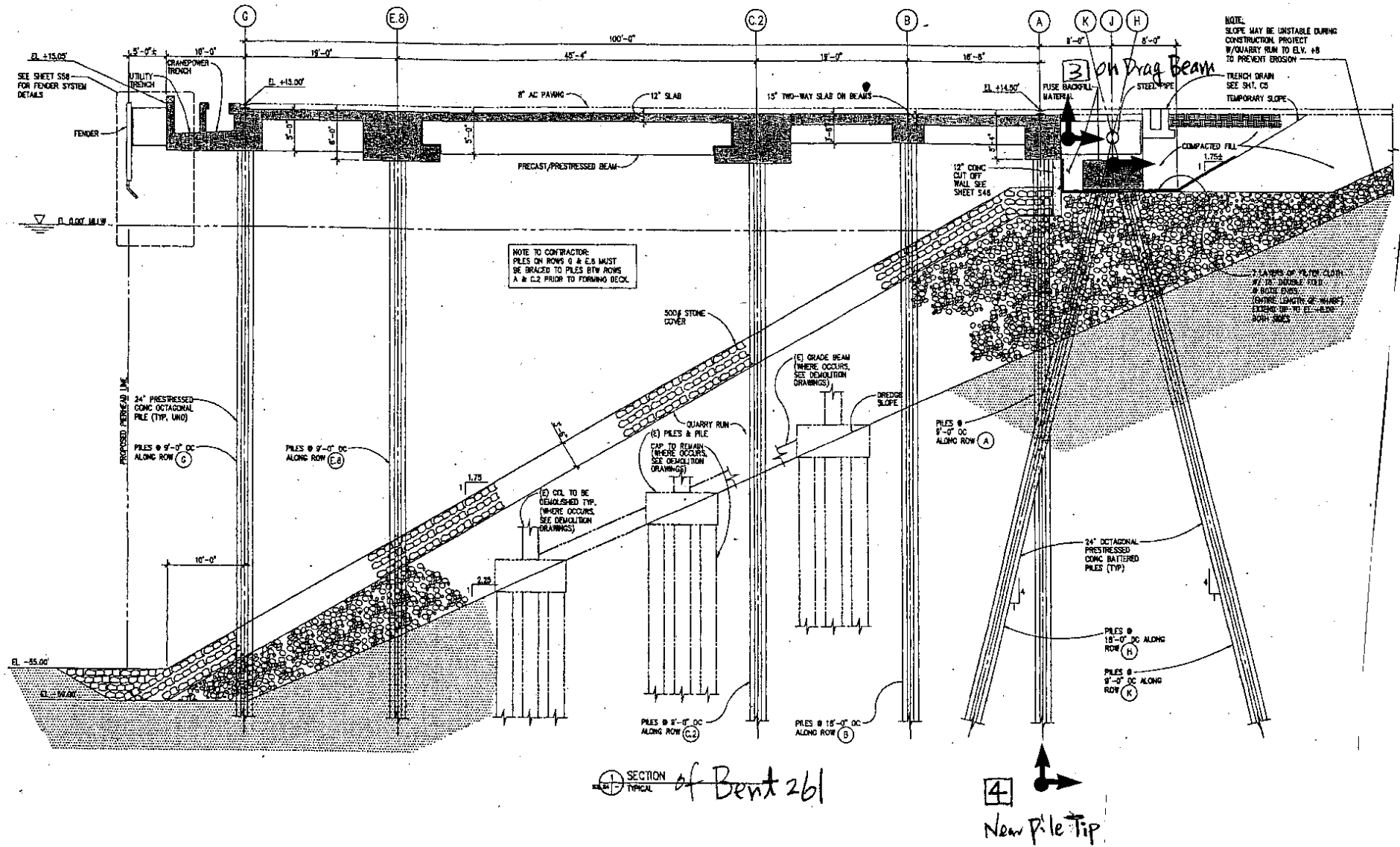
CSMIP Station



Section A - A' @ Bent 224

Port of Long Beach

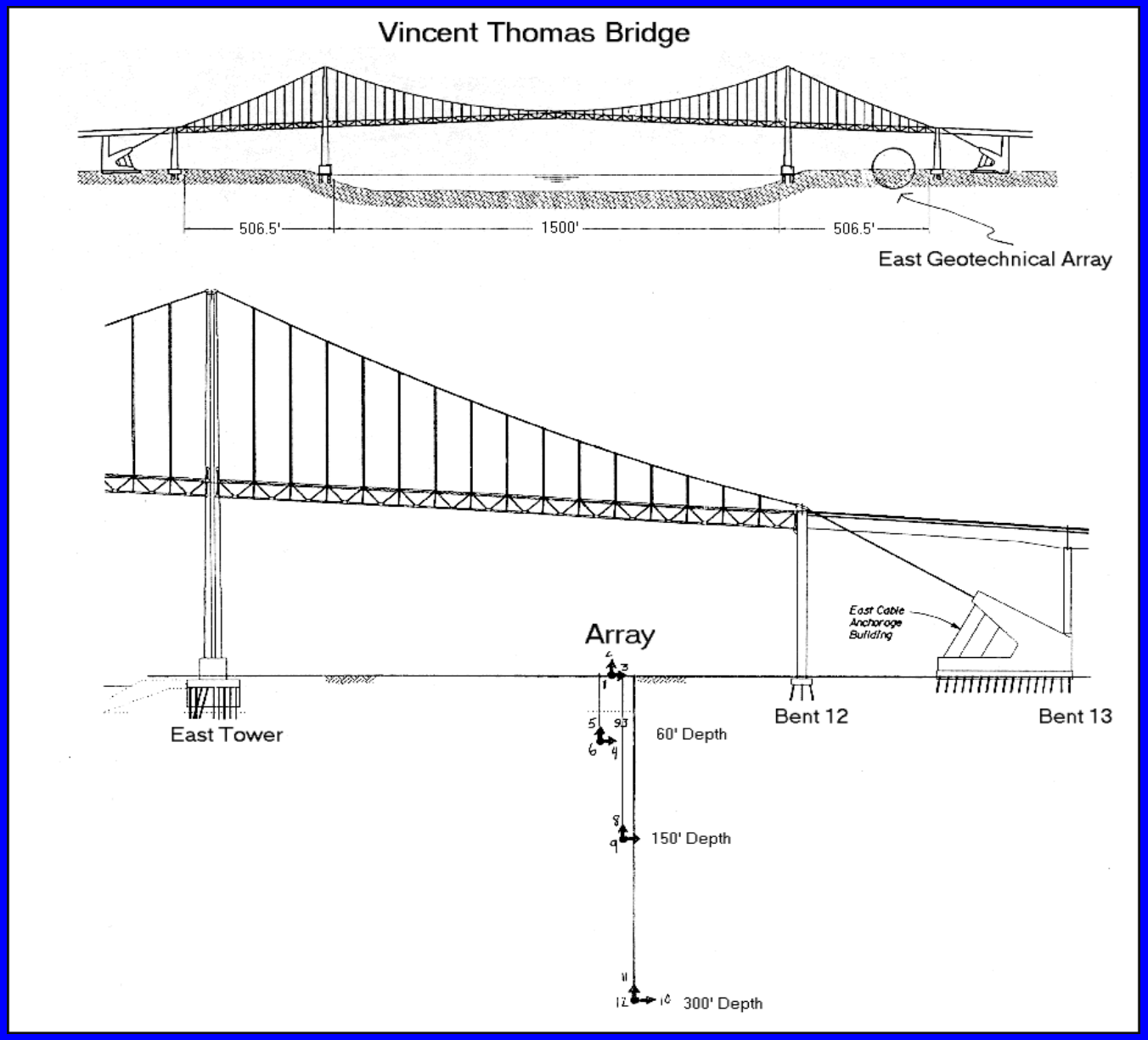
Port of Long Beach – Pier T, Phase II



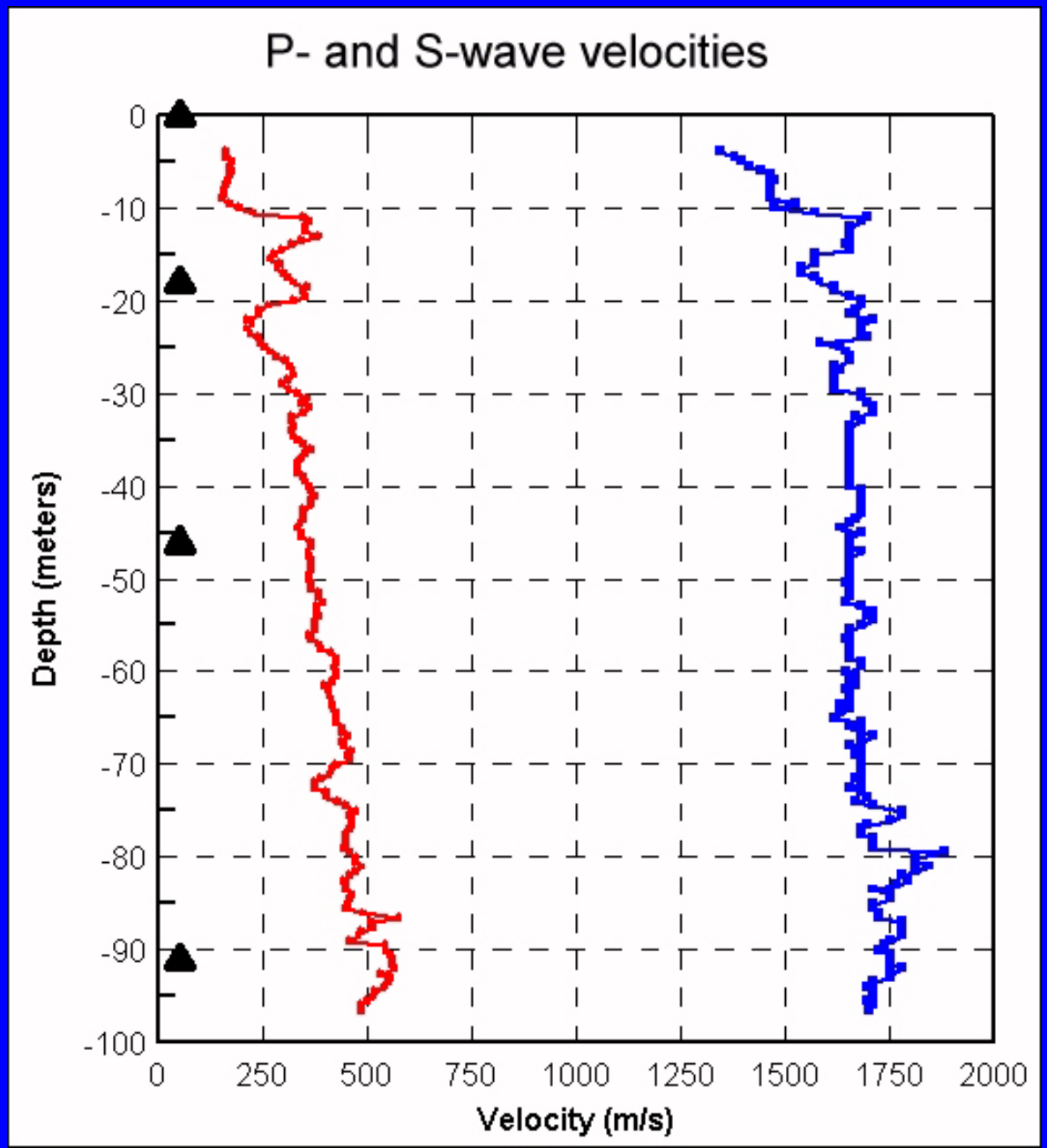
Geotechnical (Downhole) Arrays Instrumented by the Caltrans/CSMIP Project

	Station No.	Station Name	Lat.	Long.	No. of Depths	No. of Sen-sors	Sensor Depths, m	Geology
1	24703	Los Angeles - La Cienega Geotech Array	34.036	118.378	4	12	Surface, 18, 100, 252	Deep Soft Alluvium
2	89734	Eureka - Geotechnical Array	40.819	124.164	5	15	Surface, 19, 33, 56, 136	Deep Soft Alluvium
3	14785	Los Angeles - Vincent Thomas Geotech Array East	33.750	118.270	4	12	Surface, 18, 46, 91	Deep Soft Alluvium
4	14786	Los Angeles - Vincent Thomas Geotech Array West (Anchorage)	33.750	118.280	4	12	Surface, 30, 91, 189	Deep Soft Alluvium
5	14786	Los Angeles - Vincent Thomas Geotech Array West (Approach)	33.750	118.280	3	9	Surface, 15, 30	Deep Soft Alluvium
6	01794	El Centro - Meloland Geotechnical Array	32.773	115.447	4	12	Surface, 30, 100, 195	Deep Alluvium
7	58798	Hayward - San Mateo Br Geotech Array	37.617	122.153	5	15	Surface, 10, 23, 46, 91	Deep Alluvium
8	58964	Half Moon Bay – Tunitas Geotech Array	37.360	122.395	4	12	Surface, 5, 12, 45	Alluvium, Soft Rock

Vincent Thomas Bridge East Geotechnical Array

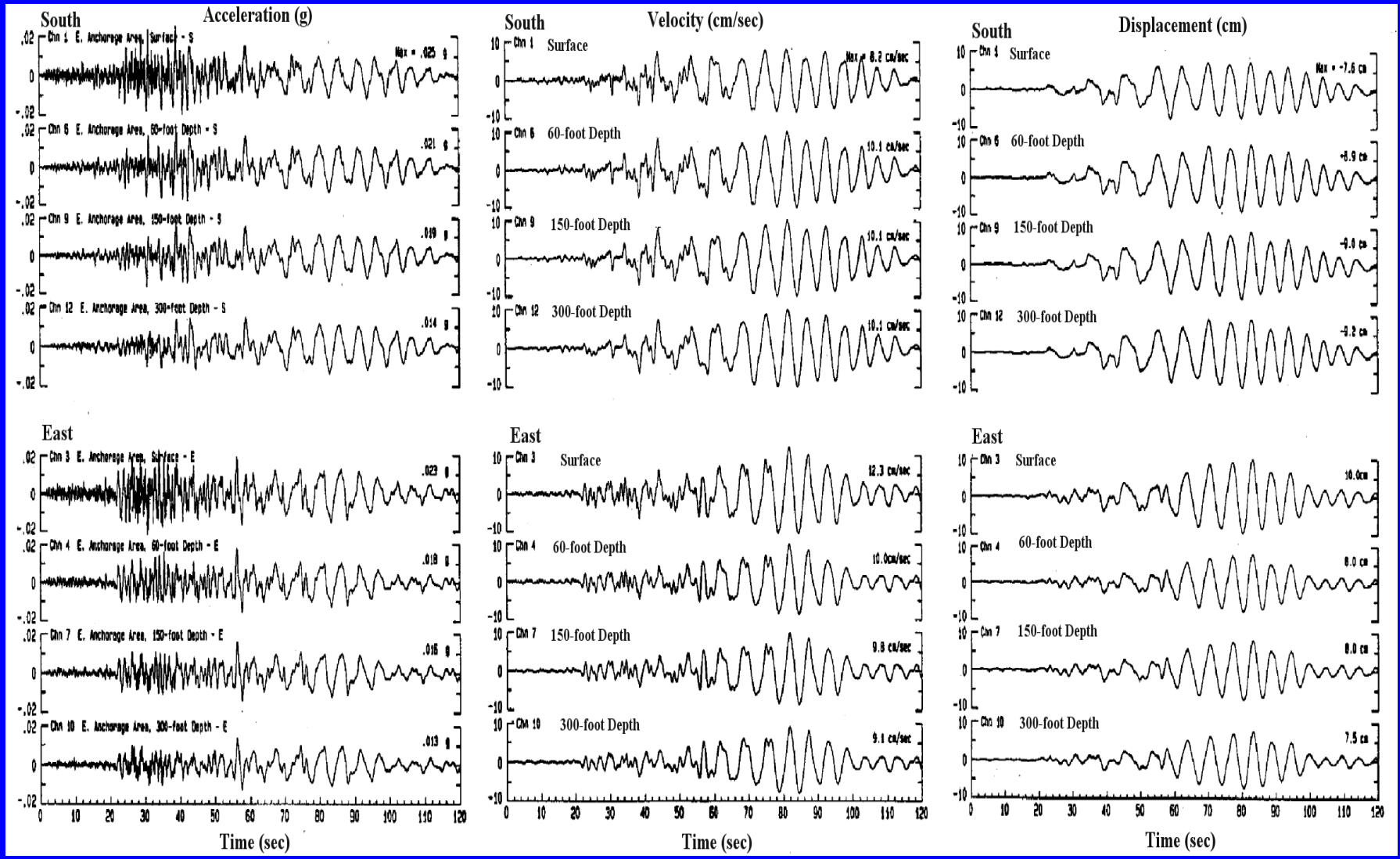


Vincent Thomas East Geotechnical Array



Downhole Instrumentation

Acceleration, Velocity and Displacement at the Vincent Thomas Array for 7.1M Hector Mine event at the Surface and Depths of 18, 46 & 91 m



Summary

- CSMIP is working with Port of Oakland, Port of Los Angels and Port of Long Beach to instrument their wharves and piers, advised by the Lifelines Subcommittee of the Strong Motion Instrumentation Advisory Committee (SMIAC).
- CSMIP has installed 13 geotechnical arrays; many funded by Caltrans, The data recorded at these arrays will provide valuable information for understanding the site response and soil liquefaction, and for improving seismic analysis procedures.
- Near-real-time recovery of recorded data will be useful for post-earthquake assessments of structural integrity of the wharf structures.