TriNet Engineering Strong Motion Data Center

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Abstract

The TriNet project greatly increases the number of strong motion recordings available after significant earthquakes. A means of communicating that data to the earthquake engineering community in the aftermath of major earthquakes is described, which can be viewed as an Internet based evolution of the customary Quick Reports and full data reports produced after significant earthquakes. A second evolution is that the post-earthquake data collection will be multi-agency. In parallel, the low-amplitude records obtained at modern strong motion stations will routinely be made available through the seismological data center of the Southern California Earthquake Center for seismological analysis.

Introduction

Effective means for disseminating strong motion data for engineering application after major earthquakes is an important goal of the TriNet project. Traditional methods of disseminating data in the aftermath of damaging earthquakes include Quick Reports and similar means. These methods can be significantly advanced by utilization of modern Internet technology, and by combining the data from several networks into one product that is convenient to the user while adequately crediting the source of the data. The data of the TriNet project is a central aspect of this effort, and as the consortium extends statewide, as presently projected, this product can be of even greater convenience for the engineering user of consortium data.

TriNet Project

TriNet is a cooperative effort of three agencies, the California Division of Mines and Geology, the California Institute of Technology and the Pasadena Office of the U.S. Geological Survey. The project was initiated after the 1994 Northridge earthquake with support by the Federal Emergency Management Agency through the Governor's Office of Emergency Service, with additional funds provided by the USGS, CDMG, and Caltech.

The initial station deployment period of the TriNet project will be completed at the end of 2001. By that time a total of 600 stations capable of recording strong motion will be installed in southern California, 200 of which will have real-time, broad-band recording capability, installed by Caltech/USGS Pasadena. The remaining 400 will be classic strong motion stations with near-real-time communication (i.e., communication-on-demand via conventional phone lines and similar means) installed by CDMG. Some additional strong motion stations will have been installed and/or upgraded by the USGS strong motion program.

After all earthquakes in southern California, small or large, the records recovered by the source networks will be transmitted to and made available through the Southern California Earthquake Center (SCEC) data center of Caltech, at http://www.scecdc.scec.org/, to allow seismological analysis. This includes the low amplitude records recorded by strong motion instruments, which will be passed to the SCEC data center and made available for seismological research through that data center. This requires conversion of conventional strong motion data files to the SEED format used in seismological research.

After major earthquakes, up to 600 strong motion recordings may be obtained from the TriNet network. These records, as well as being available through the SCEC data center, will also be available through the TriNet Engineering Strong Motion Data Center, described here, for earthquake engineering utilization and analysis. Use of records from the seismic networks in engineering applications requires conversion of the data from SEED to traditional strong motion formats. Software packages have been developed for the two conversions.

Dual Use of Ground Motion Recordings

A basic bridging concept in bringing together data from the classic seismic networks and strong motion networks is convenient use of the pooled data by both the seismological and the earthquake engineering data-user communities. These two communities customarily access and utilize the data in very different manners. To obtain the full benefit of the recorded data, it must be available to these two user communities in the manner to which they are accustomed.

In the dual-use model, the same ground motion recording is made available through two separate but linked Internet sites – one with products and data in formats customarily used in seismological research, the other with products and data in formats customarily used in earthquake engineering. A key feature of the TriNet inter-agency agreement that makes this practical is that the source agencies will still be credited as the original source of the data. Under this model, the user's task is much simpler, since it is no longer necessary to visit the web site of each agency to perform the needed searches. This paper describes one half of this parallel data-distribution structure.

Engineering Strong Motion Data Center

The TriNet Engineering Strong Motion Data center will share features of the seismological data centers and the COSMOS data center. The COSMOS data center (Archuleta, 2000; this volume) is a virtual data center, which is a key reason for its success. As Archuleta discusses in greater detail, the data center is virtual in that the actual records generally remain on the server of the agency that recorded the data and which is responsible for quality control of the data. This allows that agency to make any necessary corrections as the ongoing process of quality control continues after an earthquake, and relieves the data center of that responsibility. It also helps to ensure that the source agency receives appropriate credit, and is able to describe data usage and customer satisfaction during internal strategic planning and program reviews by the agency.

In a similar way, the TriNet engineering strong motion data center will provide a virtual data dissemination channel for data that resides at the three agencies, and provide appropriate source-agency credit. In addition, this vehicle will serve as an evolutionary electronic version of the "Quick Reports" often produced after major networks.

Northern California Outlook

Although TriNet is limited to southern California, a similar TriNet-like project has been under discussion for northern California for several years, the corresponding partners being the USGS at Menlo Park, UC Berkeley, and CDMG. In the absence of significant funding only limited progress has been possible. A current proposal is that TriNet and its developing northern California counterpart be drawn together into a single statewide network consortium, to be known as the California Integrated Seismic Network (CISN). Once this occurs, an Engineering Strong Motion Data Center would be part of the effort. That data center, like the seismological data centers, would be expanded to include statewide recordings, again with appropriate credit to the source networks. Thus, although the discussion here is focused on TriNet, because it is an element of that project, it is intended that northern California be included in the near future.

Relationship to Quick Reports

It has been customary in the last 15 years for CDMG and some other strong motion networks to produce what are known as Quick Reports after significant earthquakes. These brief reports are rapidly produced and distributed. They contain a tabulation of the peak acceleration values known up to that point and reproductions of images of the most important records, or the most important records that had been recovered since the previous Quick Report. For a major earthquake like Northridge, a series of Quick Reports would be produced, the earliest on the day of the earthquake and the last perhaps 10 days later (e.g., CSMIP, 1994a; 1994b). These reports are then followed by a comprehensive Full Report, containing all data, about 30 days after the earthquake (e.g., CSMIP, 1994c).

SMIP2000 Seminar Proceedings

Quick Reports serve the information needs of the earthquake engineering community well in the immediate aftermath of an earthquake, and many users give high marks to the effectiveness of this approach. However, they have presented some drawbacks:

Distribution: It is somewhat difficult to distribute even brief reports rapidly to a large number of people (e.g., several hundred). Fax machines can be very slow, and reproduce copies of records poorly. Surface mailings provide good quality images but may take several days to reach a user. Distribution via email is effective, but transmitting a significant number of record images as attachments can present problems for some Internet providers and servers; in addition, delivery time for the email messages can be quite unpredictable.

Independence of Information Packets: Quick Reports are largely independent, in order to be kept small, and are not cumulative – the 4th Quick Report does not contain the records which were in the 3rd, and so forth. Until the Full Report, the information is therefore piecemeal, and users may have difficulty keeping a clear understanding of the earthquake unless they keep each Quick Report at hand.

The data center discussed here addresses these issues and takes the Quick Report concept forward into the electronic Internet world.

Description of Data Center

The main user interface page to the Data Center on the Internet is illustrated in Figure 1. This page will be linked from the TriNet/CISN web pages, and the "Latest Earthquake" link will lead to the electronic analog of the Quick Reports, in a manner similar to the way the most recent TriNet ShakeMap is accessed (e.g., see http://www.trinet.org/shake).

A central feature of Quick Reports, and Full Reports, is a table of peak acceleration values. The parallel to this table is shown in Figure 2 (for which the Hector Mine earthquake is used as an example). The key feature of the table is that it can be cumulative, and updated continuously. If users check the table on the 2nd day after an earthquake, the table will show all data recovered and quality-controlled as of that time. If they check later, they can see from the update time if new information has been added in the intervening time.

The graphic images available in Quick Reports are available from links on the main table in Figure 2. For example, a record image will be received if the user clicks on the "View" under Time Series, and spectra can similarly be requested in the next column. In the case of an analog record, just the image of the accelerogram would appear until the record has been digitized and processed.

Another advance beyond the previous means of releasing data is the ability to present more information about the station, including geology, site conditions, recording housing, etc. Figure 3 illustrates station information for a ground response station; more information could easily be added. Figure 4 illustrates that, for structures, a photo of the structure will be available as well as an image of the sensor layout and details of the design, so that an engineer can study the location of the sensor relative to key elements of the structure, to analyze the drift, torsion and other aspects of the structural response. For bridges and dams, the sensor layout will similarly show the locations of the sensors on the abutments, bents, deck, crest, etc.

Multi-agency Quick Report through TriNet/CISN

Beyond changes in the means of report delivery through the use of new technology, a major change from previous Quick Reports is that this continuously-updated quick report will be multi-agency. Instead of CDMG reports or USGS reports, there will be a single joint report, which will be electronic. Caltech has for some years deployed strong motion sensors, and more in recent years under TriNet, and that data will be available through this channel. Similarly, UC Berkeley has recently deployed strong motion sensors, and that data can also be included as CISN becomes established.

Link to COSMOS Virtual Data Center

A major focus of TriNet/CISN is rapid information after an earthquake, ranging from the ShakeMap to dual distribution of the data. In contrast, the COSMOS Virtual Data Center has a library of strong motion data extending back to the first records obtained in 1933, and includes data from around the world. The COSMOS data center will link to, and build necessary database tables for, the data in the TriNet/CISN data centers during the days and weeks after the event; it will virtually link to that data as it links to the data maintained by its other contributing agencies (Archuleta, 2000). The COSMOS and TriNet sites will be linked to, and complement, each other. The extensive information needed to do structural analysis of records will not be available in the COSMOS data center, while the extensive search engine and world wide database will not be available in the TriNet data center.

Summary

The TriNet Engineering Strong Motion Data Center is an important product of the TriNet project and is an evolutionary step in several ways. The Data Center:

- Provides access by the earthquake engineering user community to strong motion records of engineering importance recorded by all three agencies in TriNet (CDMG, USGS, Caltech). In a corresponding way, CDMG records for all events will be available through the seismological data center at SCEC.
- Provides an evolutionary path for the Quick Report product to transition into the electronic web environment, providing greater user convenience and more rapid access. This electronic Quick Report product will be continuously updated, so it

is always comprehensive at the time accessed; the user need only download the specific graphic images needed.

- Provides a smooth transitional path for access to records through the long-term COSMOS data center, which has a powerful search engine capability and comprehensive data set from around the world.

- Provides a complete presentation of structural records, including structure descriptions, sensor layouts, and structural design information.

References

Archuleta, R. (2000). "COSMOS Virtual Data Center"; this volume.

CSMIP (1994a). "First Quick Report on CSMIP Strong-Motion Data from the San Fernando Valley Earthquake of January 17, 1994," *Report OSMS 94-01*, Calif. Div. Mines and Geology, Strong Motion Instr. Program, January 17, 1994, 10 pp.

CSMIP (1994b). "Fifth Quick Report on CSMIP Strong-Motion Data from the Northridge/San Fernando Valley Earthquake of January 17, 1994," *Report OSMS 94-05,* Calif. Div. Mines and Geology, Strong Motion Instr. Program, January 25, 1994, 8 pp.

CSMIP (1994c). "CSMIP Strong-Motion Records from the Northridge, California Earthquake of January 17, 1994," *Report OSMS 94-07*, Calif. Div. Mines and Geology, Strong Motion Instr. Program, February 18, 1994, 308 pp.

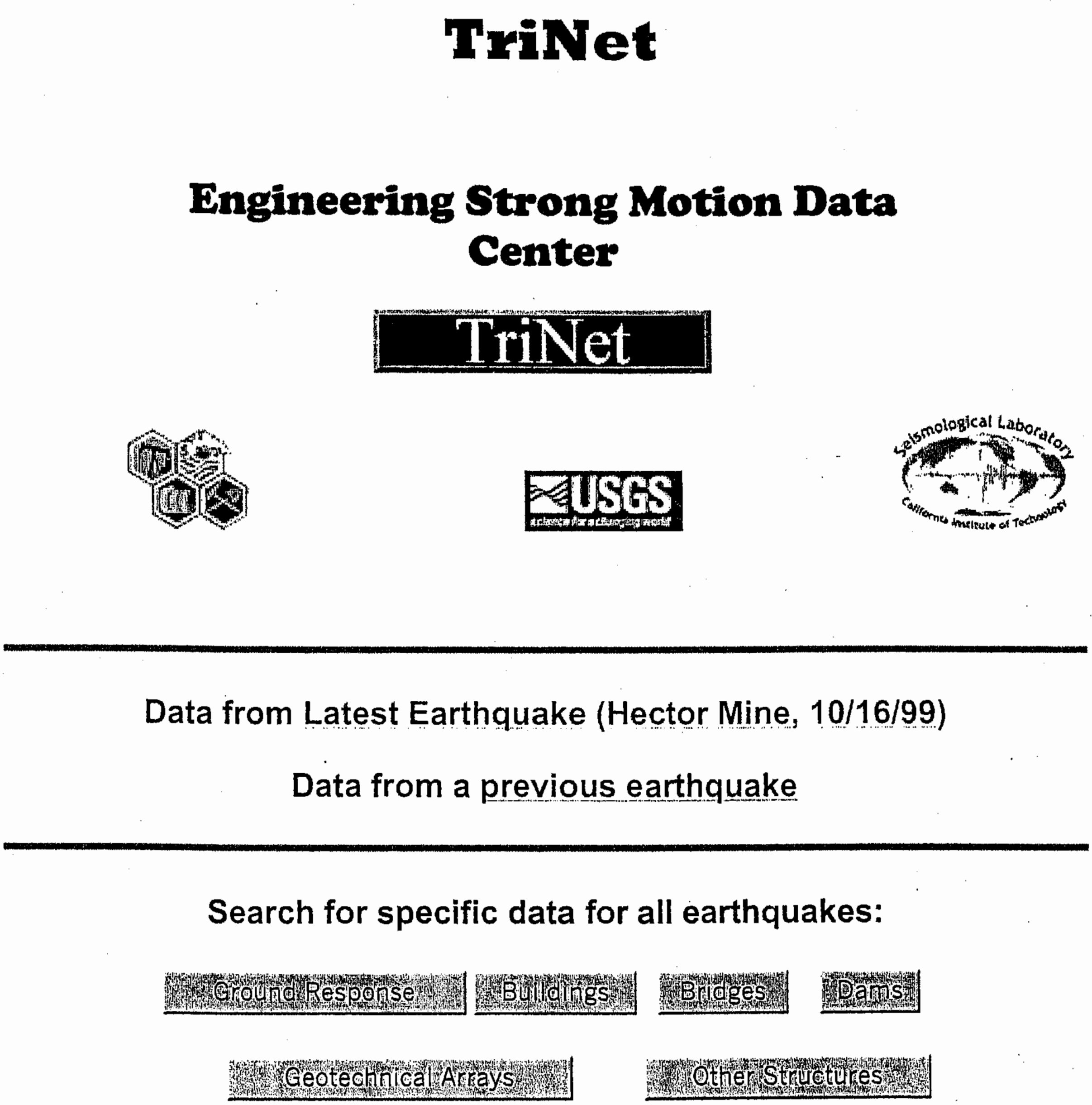


Figure 1. Illustration of main interface to the TriNet Engineering Strong Motion Fata Center, linked from the TriNet home page.

Pooled TriNet Strong-Motion Data Set

-- Data from stations of CDMG, USGS, and Caltech--

(SCSN is a cooperative network of Caltech and the USGS)

M7.1 Hector Earthquake of Oct 16, 1999

For information on Hector Earthquake: Location, magnitude and TriNet ShakeMap

Stations listed in **Increasing Epicentral Distance** (Alternatively, select alphabetical listing)

Stations <100km *100-185km* *185-230km*	Station No./ID	Network	Site Type	Dist. (km)	Horiz Apk (g)		Time Series	Spectra	Down-load
					Ground	Struct.			
HEC, Hector	HEC	SCSN		26.1	0.328	--	View	View	Download
Amboy	21081	CDMG	1-story	48.6	0.185	--	View	View	Download
Joshua Tree - Fire Station	22170	CDMG	1-story	52.3	0.191	--	View	View	Download
Morongo Valley - Fire Sta	5071	USGS		66.8	0.086	--	View	View	Download
Big Bear Lake - Fire Station	22791	CDMG	1-story	68.2	0.174	--	View	View	Download
Twentynine Palms - Joshua Tree N.M.	22161	CDMG	1-story	68.6	0.072	--	View	View	Download
Heart Bar State Park	22T04	CDMG	T-hut	68.8	0.082	--	View	View	Download
Los Angeles - 52-story Office Bldg	24602	CDMG	52-story	70.0	0.20	0.71	View	View	Download
Desert Hot Springs - Fire Station	12149	CDMG	1-story	74.1	0.082	--	View	View	Download
Fun Valley - Reservoir	5069	USGS		75.0	0.088	--	View	View	Download
Joshua Tree N.M. - Keys View	12647	CDMG	T-hut	75.4	0.088	--	View	View	Download
Whitewater Canyon	5072	USGS		75.8	0.057	--	View	View	Download
Baker - Fire Station	32075	CDMG		76.7	0.131	--	View	View	Download
Barstow - Vineyard & H St.	23559	CDMG		78.0	0.082	--	View	View	Download
Whitewater Canyon	5295	USGS		79.0	0.063	--	View	View	Download
DAN, Danby	DAN	SCSN		81.6	0.132	--	View	View	Download
Forest Falls - Post Office	5075	USGS		82.0	0.061	--	View	View	Download
Fort Irwin	32577	CDMG		83.2	0.127	--	View	View	Download
Snow Creek	12630	CDMG		87.7	0.029	--	View	View	Download
Cabazon - Post Office	5073	USGS		89.0	0.040	--	View	View	Download

Figure 2. Peak acceleration table, analogous to the acceleration tables in paper reports (e.g., CSMIP 1194a,c). Besides listing peak acceleration the table allows the user to obtain more information about the station (linked through the first column), or view the time series or spectra, or download a zipped file of the data (right columns). Note that the source network is clearly indicated (second column).

Big Bear Lake - Fire Station	Sta.No. 22791
Network:	CDMG/CSMIP

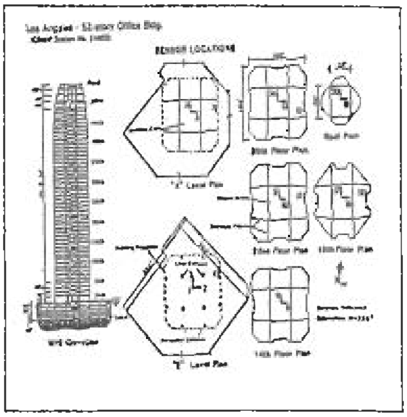
Latitude	34.241N
Longitude	116.872W
Elevation	2100 m
Site Geology	Shallow alluvium over granite bedrock

Return

Figure 3. Example of station information for a ground station, obtained through a link from Fig. 2, for Big Bear station.

Los Angeles - 52-story Office Building, No. 24602

Instrumented by: CDMG/SMIP



(Sensor Layout - click to enlarge)

Los Angeles - 52-story Office Building **(CSMIP Station No. 24602)**

No. of Stories above/below ground	52 / 5
Plan Shape	Square with clipped corners
Base Dimensions	274 x 263 ft (83.5 x 80.2 m)
Typical Floor Dimensions	156 x 156 ft (47.5 x 47.5 m)
Design Date	1988-90
Instrumentation	20 accelerometers, on 7 levels

Vertical Load Carrying System	3 - 7 in. (7.6 -17.8 cm) concrete slabs on steel deck supported by steel frames.
Lateral Force Resisting System	Concentrically braced steel frame at the core with moment resisting connections and outrigger moment frames in both directions.
Foundation Type	Concrete spread footings, 9 to 11 ft (2.7 - 3.3 m) thick.

Return to Home Page

Figure 4. Example of station information for an instrumented building. The sensor layout can be enlarged for study and printing.