ON THE DEVELOPMENT OF "USER-FRIENDLY" INTERFACES FOR THE USE OF STRONG-MOTION DATA ON THE INTERNET

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ABSTRACT

Public earthquake safety must necessarily be based on measurements in and of the built environment to damaging earthquake ground motions. Development of procedures for data archival and dissemination, based on rapidly evolving modern computer technology, can significantly improve data accessibility and usability for purposes of improving construction of an earthquake resistant environment. An essential component of such procedures is a flexible data format structure that will facilitate data archival and dissemination to a wide variety of research and practicing communities focused on improving public earthquake safety. It must be a structure that provides a standard for archive and exchange of data with other data centers, yet a structure that will permit the data to be retrieved and analyzed in a variety of "user-friendly" forms on the Web. Examples illustrating possible future "user-friendly" interfaces for presentation and analysis of strong-motion data are presented. The examples presented are intended to suggest a direction for development of "user-friendly" interfaces to facilitate dissemination and use of strong-motion measurements of the built environment for purposes of public safety. Pursuit of this objective, taking advantage of advances in computer technology and the Internet is an important goal of COSMOS.

INTRODUCTION

Recent earthquakes especially those effecting the United States, Japan, and Turkey emphasize the urgent need to improve public safety through improved design, retrofit and construction practice. Public earthquake safety must necessarily be based on measurements in and of the built environment to damaging earthquake ground motions. Strong-motion recordings provide the essential quantitative in-situ measurements needed to improve design and construction practice. Consequently, development of improved capabilities to acquire, disseminate and interpret strong-motion recordings of the built environment is crucial for improvements in public safety.

Recent advances in computer technology and the Internet offer dramatic new opportunities to facilitate the use of strong motion recordings for purposes of improving public safety. Concepts for a "Virtual Data Center" are presented by Archuleta and others (this volume). An essential component of such a Data Center is a modern data format standard that will facilitate data archival and dissemination to a wide variety of research and practicing communities, as discussed by Shakal and Borcherdt (this volume). In addition, the standard needs to permit the rapid transfer of the data to "user-friendly" formats developed to facilitate its use for improvements in public safety.

Attributes for a format standard for use in the context of a Virtual Data Center focussed on improved public earthquake safety are discussed by Shakal and Borcherdt (this volume). The format structure must include formats presently being used by contributing strong-motion agencies. It must include a general format standard appropriate for future data archival and exchange with other data centers, such as the IRIS DMC. Inclusion of a variety of "user-friendly" procedures for interactive data retrieval and interpretation via the Internet can significantly improve data accessibility by the practicing communities. Because strong-motion data is the basis for modern design and construction codes, examples are chosen to emphasize aspects considered important for facilitating the use of the data by the practicing community.

EXAMPLES OF "USER-FRIENDLY" INTERFACE ON INTERNET

An important aspect of the "Virtual Data Center" being developed for consideration by COSMOS is the concept that the actual data will be maintained in linked databases maintained by contributing agencies. This aspect is important for maintaining data quality, for accomplishing agency mission, providing appropriate agency credit, and maintaining agency responsibility for data quality. Presently data stored at the centers is stored in different formats. Consequently, an important aspect of facilitating the use of strong-motion data is the development of a format structure to accommodate these differences. It must provide a standard for exchange of data with other centers and for the dissemination of "processed" data to the practicing community. It also must permit the data to be presented in a variety of "user-friendly" forms to simplify and facilitate its use by a wide variety of communities concerned with public safety.

Modern software tools and Internet capabilities offer significant opportunities to improve capabilities to use and interpret strong motion data. Examples are provided to illustrate the nature of "user-friendly" environments that have been developed. If space permitted, a number of additional examples also could be shown. Examples are chosen to illustrate possible future "user-friendly" interfaces that might be implemented as part of the capabilities of the COSMOS Virtual Data center to facilitate use of the data for public safety.

A relatively recent data search and retrieval system for the Internet developed exclusively for a strong-motion network is that developed for the Kyoshin strong-motion network following the 1995 tragic earthquake affecting Kobe, Japan. This system provides a "user-friendly" environment for accessing both strong-motion data and associated geotechnical metadata describing site response and station information at each site. Linked strong-motion data and associated geotechnical metadata is suggested as an important capability for future incorporation into capabilities of the COSMOS Virtual Data Center.

The Home page for the Kyoshin Net suggests a straightforward procedure for retrieving data recorded on the strong-motion network and associated borehole data collected at each site (Figure 1). Presentation of the data in this "user-friendly" form has significantly improved data use and accessibility to a wide range of communities concerned with public safety in Japan.

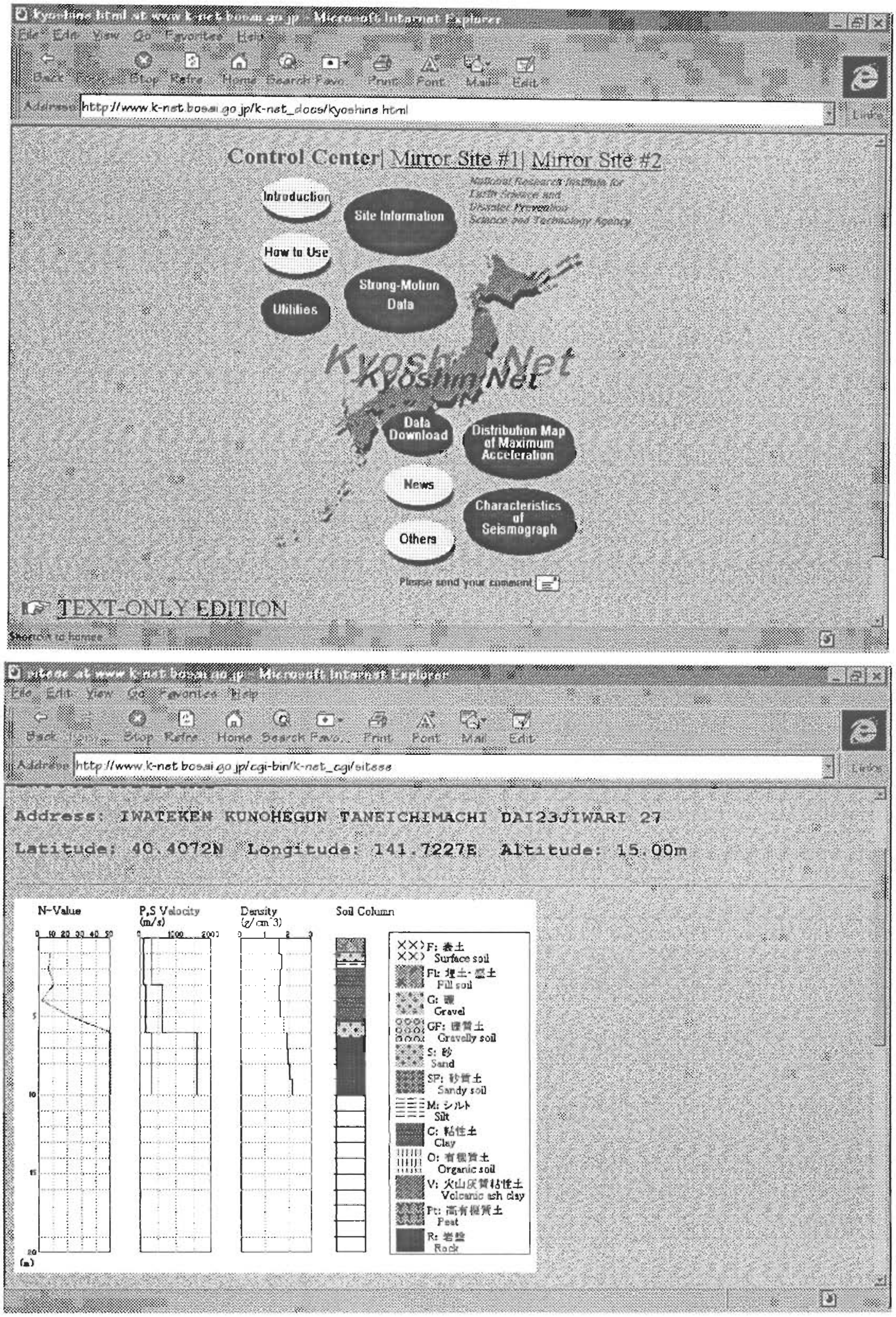


Figure 1. (a) Home page for Kyoshin strong-motion network (http://www.k-net.bosai.go.jp/k-net_docs/kyoshin.html), b) Geotechnical logs for a site in the Kyoshin net.

A principal objective of strong-motion networks is the measurement of the response of the built environment to damaging levels of ground motion. As a result, a major portion of databases maintained by conventional strong-motion programs in the United States is that recorded on buildings, bridges, hospitals, dams, and various other lifelines. As this information is the basis for site-specific design and corresponding design and retrofit codes, efforts to improve its communication to the engineering community are an especially important objective of the COSMOS. An especially useful "user-friendly" environment developed to interactively analyze and retrieve information on the response of the built environment is that developed with support of CDMG by Naeim (1997). The user-friendly database includes strong-motion response data and associated metadata for 20 buildings as recorded during the Northridge earthquake. The database is currently available via CD-ROM. It provides an excellent illustration of the nature of an interactive, "user-friendly" data analysis and retrieval capability for possible future inclusion in capabilities of the COSMOS Virtual Data Center.

Maps (Figure 2a) showing the location of cultural features as well as locations of well-instrumented buildings provide a simple and straightforward "user-friendly" format for selecting buildings of interest.

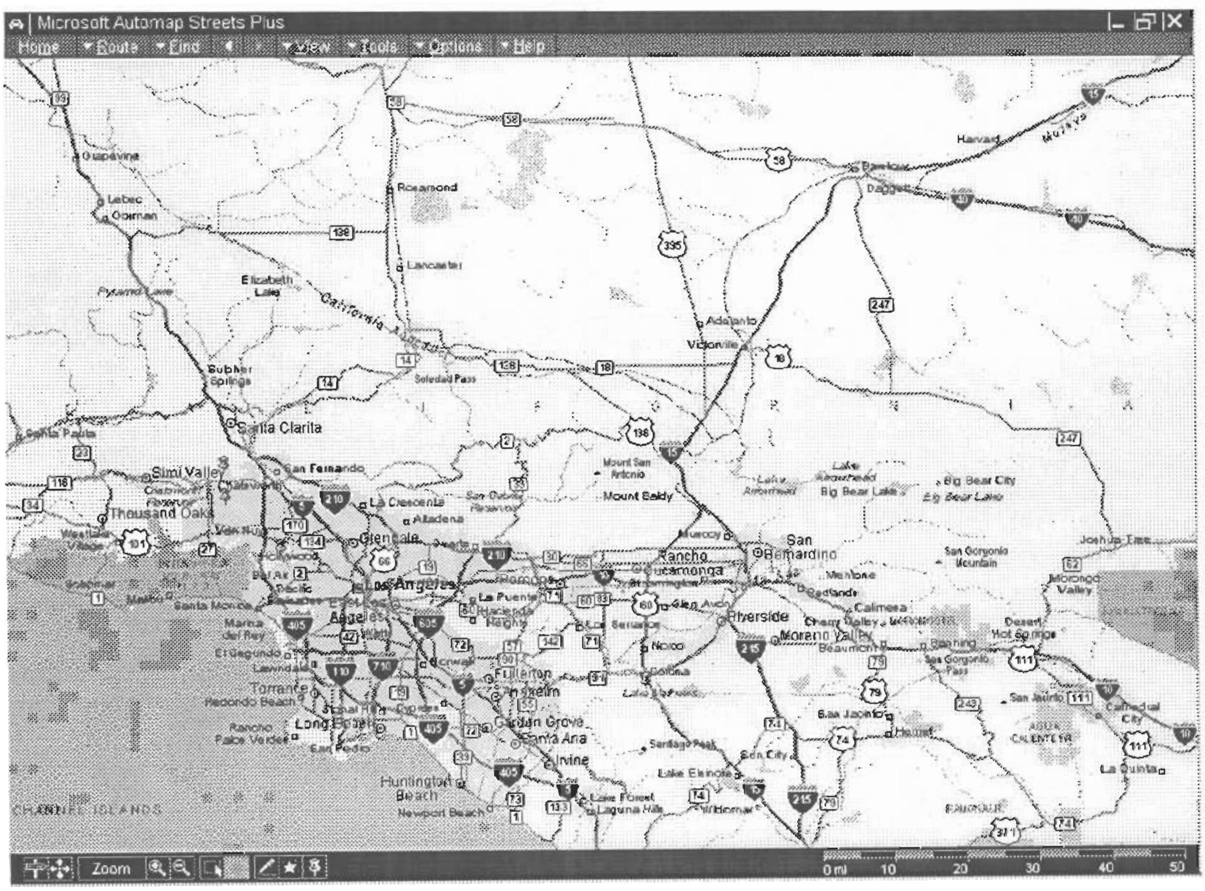


Figure 2a. Map showing locations of cultural features and well-instrument buildings included in the Northridge database (from Naeim, 1997).

A folder format developed for the recorded building data and associated metadata provides a convenient means of accessing the data (Figure 2b). The metadata accessible via folders includes information on the design and construction characteristics of the building, corresponding model building types, photos, and results of detailed damage evaluation following the Northridge earthquake, (see folders in Figure 2b). The metadata includes detailed and readily accessible tabular information about the recorded time histories (see Figure 3a) and an associated instrumentation array schematic (Figure 3b).

Time histories processed according to established "strong-motion" standards are illustrated in a convenient format showing acceleration, velocity and displacement (Figure 4a). These time series can be both easily retrieved in a tabular digital format or interactively analyzed via the CD ROM or in the future on the Internet. Capabilities illustrated here are readily transferable to borehole and ground motion measurements.

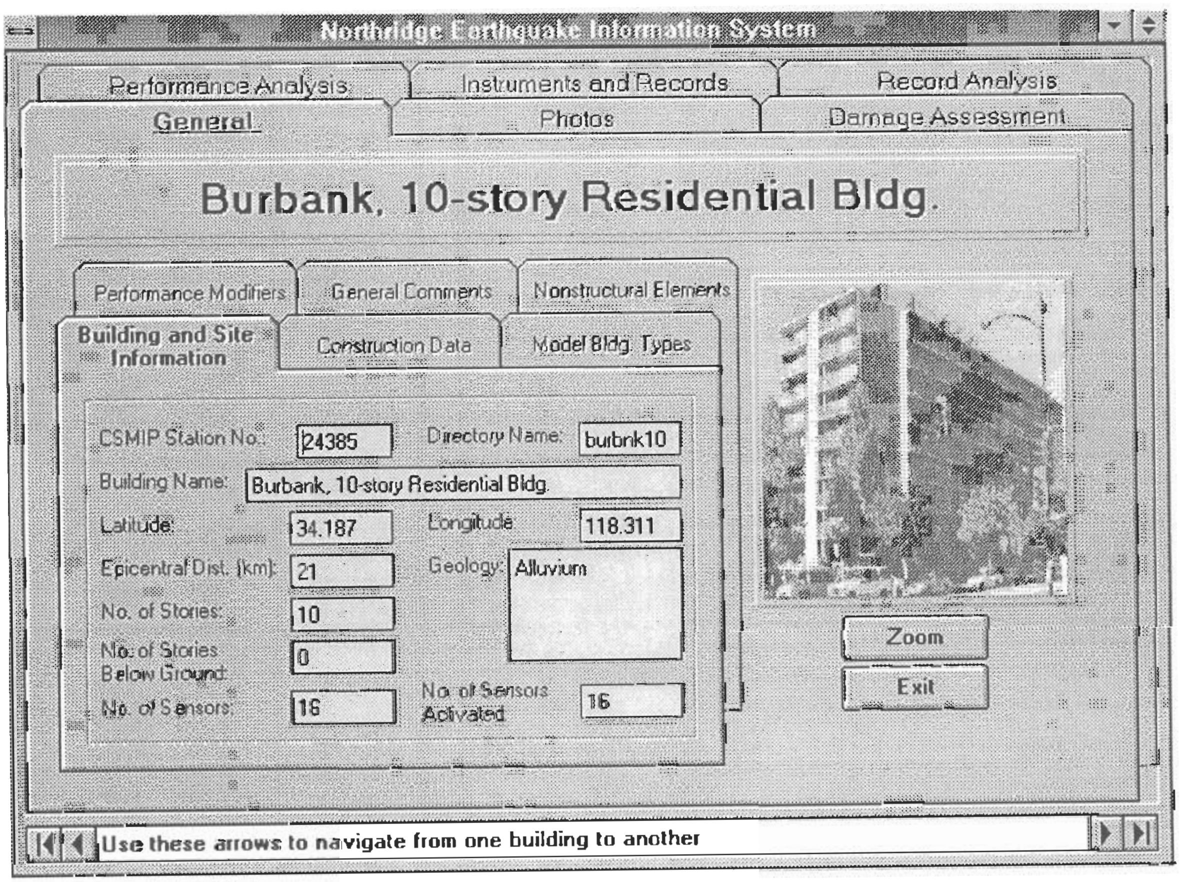
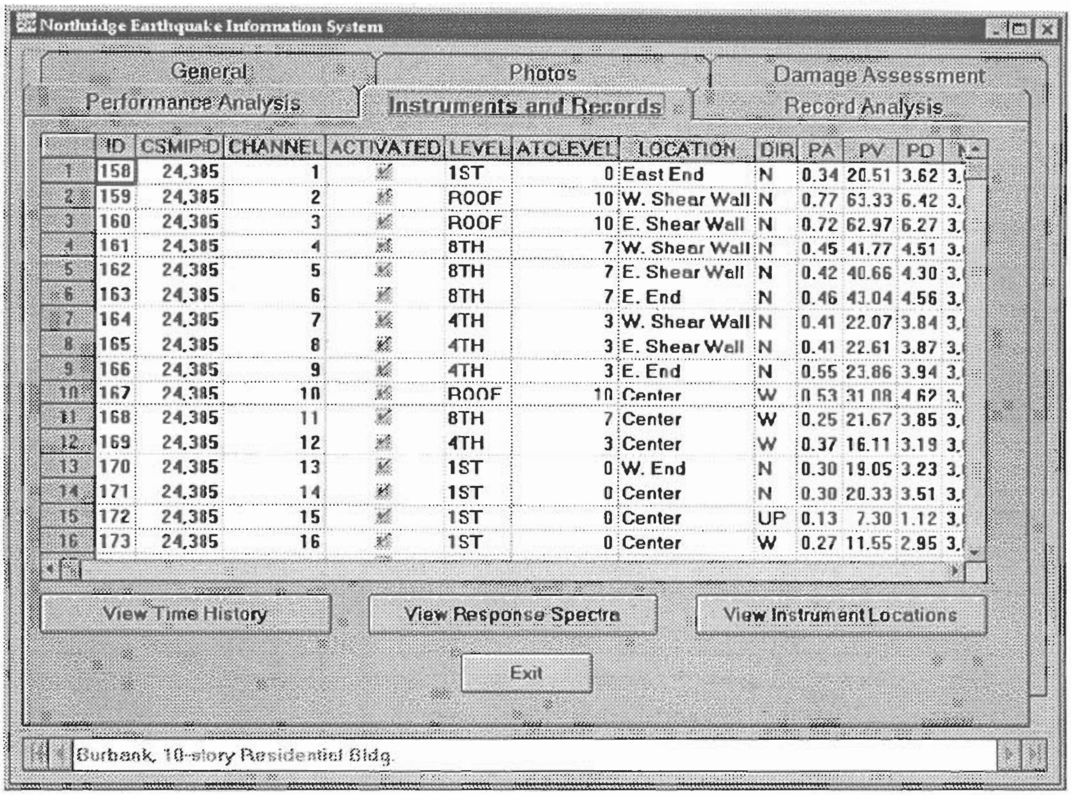


Figure 2b. A "User-Friendly" folder format for retrieval and interactive analysis of strong-motion data and associated metadata for buildings instrumented by the CDMG (from Naeim 1997).



	ID	CSMIPID	CHANNEL	ACTIVATED	LEVEL	ATCLEVEL	LOCATION	DIR	PA	PV	PD	
1	158	24,385	1	x	1ST	0	East End	N	0.34	20.51	3.62	3.
2	159	24,385	2	x	ROOF	10	W. Shear Wall	N	0.77	63.33	6.42	3.
3	160	24,385	3	x	ROOF	10	E. Shear Wall	N	0.72	62.97	6.27	3.
4	161	24,385	4	x	8TH	7	W. Shear Wall	N	0.45	41.77	4.51	3.
5	162	24,385	5	x	8TH	7	E. Shear Wall	N	0.42	40.66	4.30	3.
6	163	24,385	6	x	8TH	7	E. End	N	0.46	43.04	4.56	3.
7	164	24,385	7	x	4TH	3	W. Shear Wall	N	0.41	22.07	3.84	3.
8	165	24,385	8	x	4TH	3	E. Shear Wall	N	0.41	22.61	3.87	3.
9	166	24,385	9	x	4TH	3	E. End	N	0.55	23.86	3.94	3.
10	167	24,385	10	x	ROOF	10	Center	W	0.53	31.08	4.62	3.
11	168	24,385	11	x	8TH	7	Center	W	0.25	21.67	3.85	3.
12	169	24,385	12	x	4TH	3	Center	W	0.37	16.11	3.19	3.
13	170	24,385	13	x	1ST	0	W. End	N	0.30	19.05	3.23	3.
14	171	24,385	14	x	1ST	0	Center	N	0.30	20.33	3.51	3.
15	172	24,385	15	x	1ST	0	Center	UP	0.13	7.30	1.12	3.
16	173	24,385	16	x	1ST	0	Center	W	0.27	11.55	2.95	3.

Figure 3a. Tabular header data for strong-motion building response measurements recorded on a well-instrumented building by the CSMIP during the Northridge earthquake (from Naeim 1997).

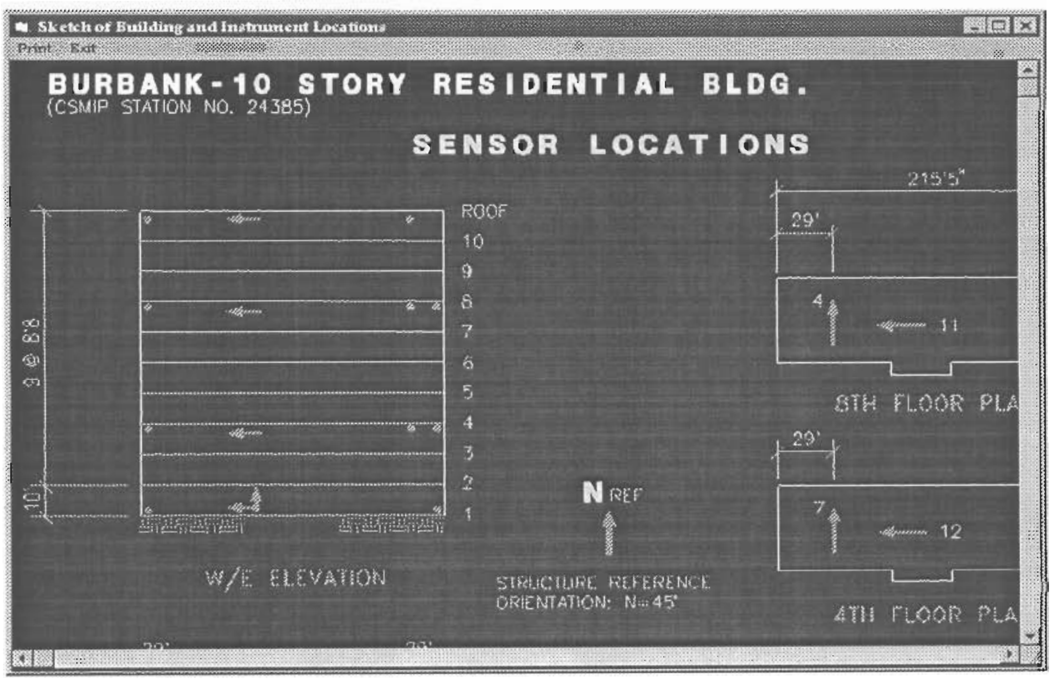


Figure 3b. Structural instrumentation array schematic for a "well-instrumented" structure maintained by the CSMIP (from Naeim 1997).

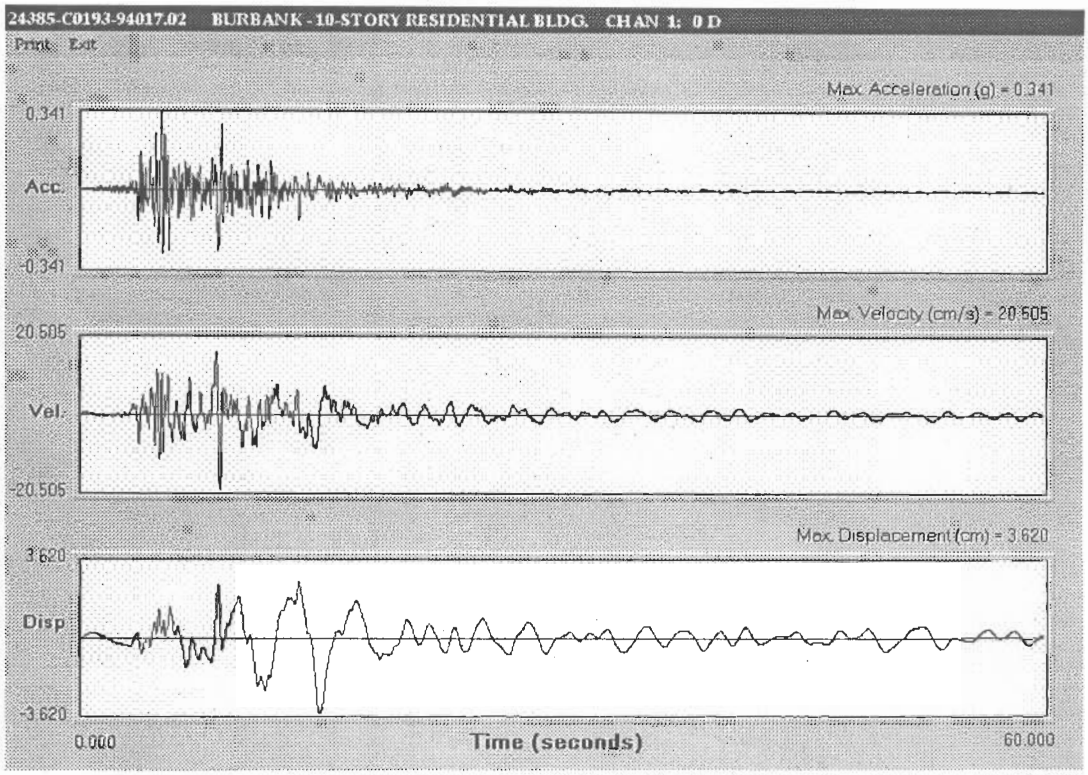


Figure 4a. Example of processed acceleration, velocity, and acceleration for strong-motion data recorded on a well-instrumented building by the CSMIP during the Northridge earthquake (from Naeim 1997).

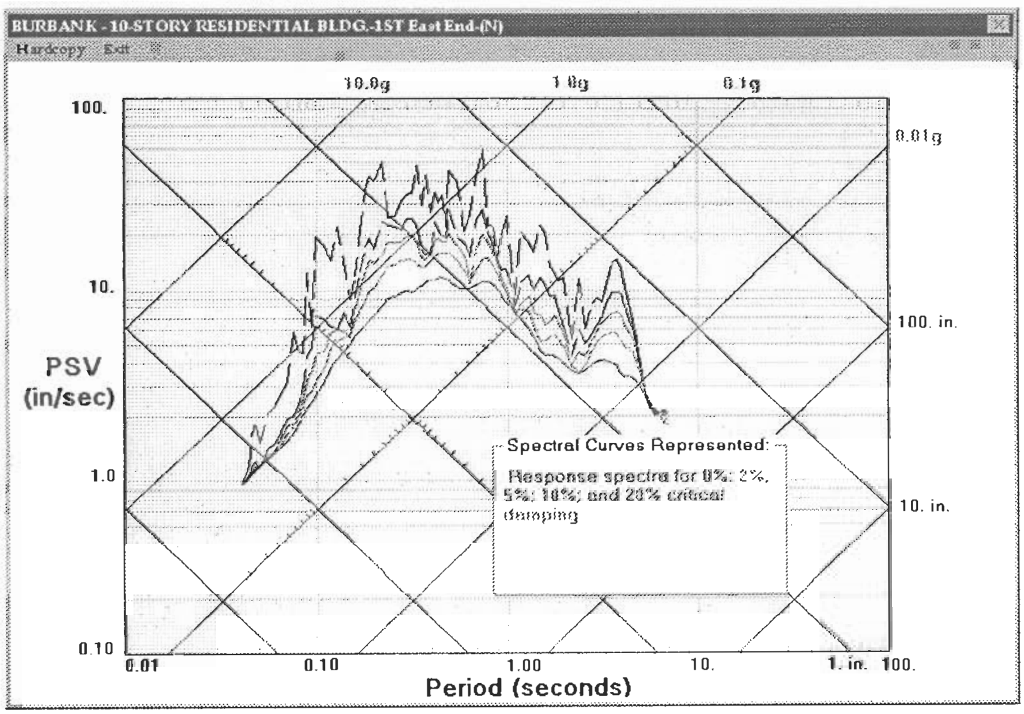


Figure 4b. Examples of pseudo-velocity response spectra inferred from strong-motion recordings obtained on a well-instrumented building by the CSMIP during the Northridge earthquake (from Naeim 1997).

Modern computer technology and the Internet provide an environment not only for rapid access to strong-motion data and associated Metadata, but also for rapid interactive analysis needed to interpret strong-motion recordings. An example illustrating building performance analysis is provided on the CD-ROM developed by Naeim (1997). The example (Figure 5) shows story shears inferred at the time of maximum base shear in the north-south direction. Such interactive capabilities can significantly enhance the usefulness of strong-motion data for the practicing engineering community.

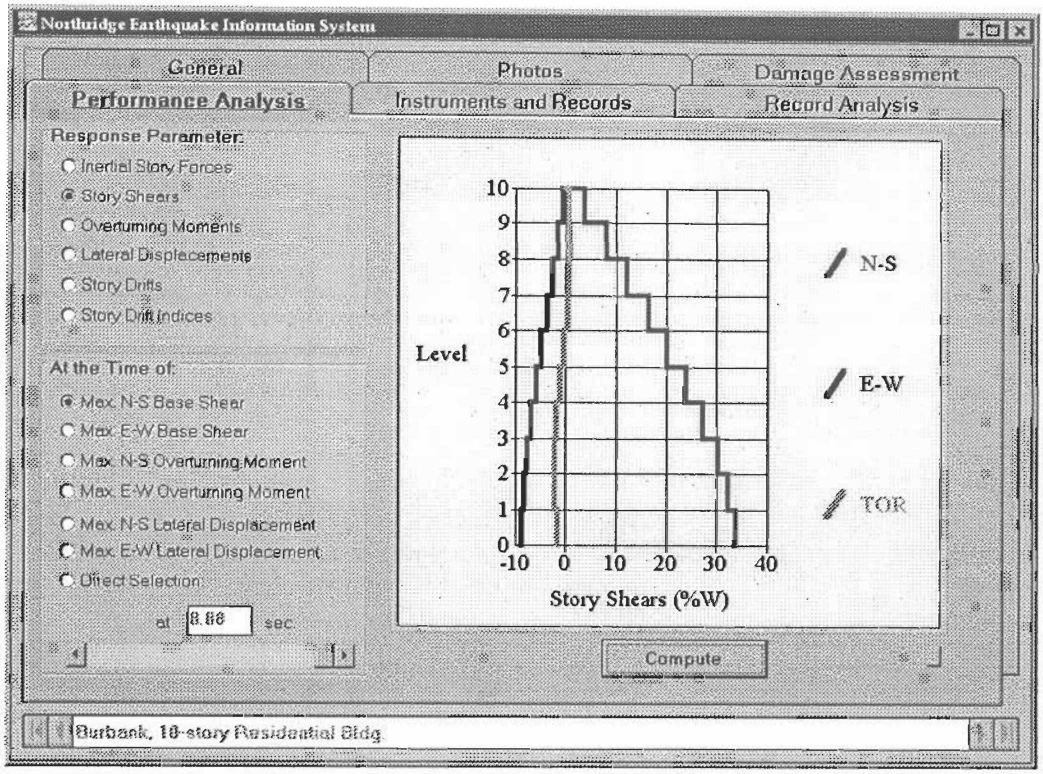


Figure 5. Results illustrating building response characteristics inferred interactively using capabilities developed by Naeim (1997). Structural response is inferred for a "well-instrumented" building (CSMIP) using standard analysis techniques prepared by Naeim (1997).

Another example illustrating interactive capabilities for analysis of strong-motion metadata is provided by the ROSRINE Web site. This site provides geotechnical borehole data recovered at strong-motion sites following the Northridge earthquake. The borehole seismic velocity logs are presented in tabular EXCEL spreadsheet format. This format permits interactive analysis of the tabular data on the Internet as well as rapid download for use on the users own computer. An EXCEL spreadsheet that summarizes the P and S velocity profiles for a strong-motion site is shown in Figures 6. Corresponding graphs of these data also available via the Internet are shown in Figure 7. User-friendly interactive analysis capabilities available on the Web can significantly simplify the problems associated with access and interpretation of strong-motion data by the engineering community.

Resolution of Site Response Issues
in Northridge Earthquake (ROSRINE) Project
P- & S-Wave Velocities Using Suspension Logging Method
Baldwin Hills
Data Collectd March 20, 1997

Depth (meters)	Vs (meters/sec)	Vp (meters/sec)
1.5	161.3	333.3
2.0	186.0	416.7
2.5	189.0	350.9
3.0	189.8	452.5
3.5	197.2	409.8
4.0	206.6	448.4
4.5	246.3	534.8
5.0	265.3	546.4
5.5	253.8	469.5
6.0	249.4	543.5
6.5	254.5	552.5
7.0	255.1	571.4
7.5	295.9	657.9
8.0	296.7	621.1
8.5	273.2	529.1
9.0	267.4	595.2
9.5	306.7	565.0
10.0	314.5	584.8
10.5	341.3	613.5
11.0	369.0	757.6
11.5	339.0	666.7
12.0	310.6	606.1
12.5	305.8	526.3
13.0	303.0	568.2
13.5	301.2	709.2
14.0	309.6	775.2
14.5	324.7	649.4
15.0	319.5	704.2
15.5	309.6	729.9
16.0	310.6	657.9
16.5	306.7	621.1
17.0	330.0	684.9
17.5	355.9	775.2
18.0	374.5	578.0
18.5	346.0	680.3
19.0	348.4	699.3
19.5	349.7	806.5
20.0	361.0	763.4
20.5	362.3	746.3
21.0	380.2	757.6
21.5	361.0	925.9
22.0	359.7	854.7
22.5	367.6	990.1
23.0	354.6	952.4
23.5	355.9	925.9

Figure 7. EXCEL format for P and S velocity profile data measured at a strong-motion site under the ROSRINE program (http://rccg03.usc.edu/rosrine). This format permits interactive analysis and retrieval of the data in EXCEL format via the Internet.

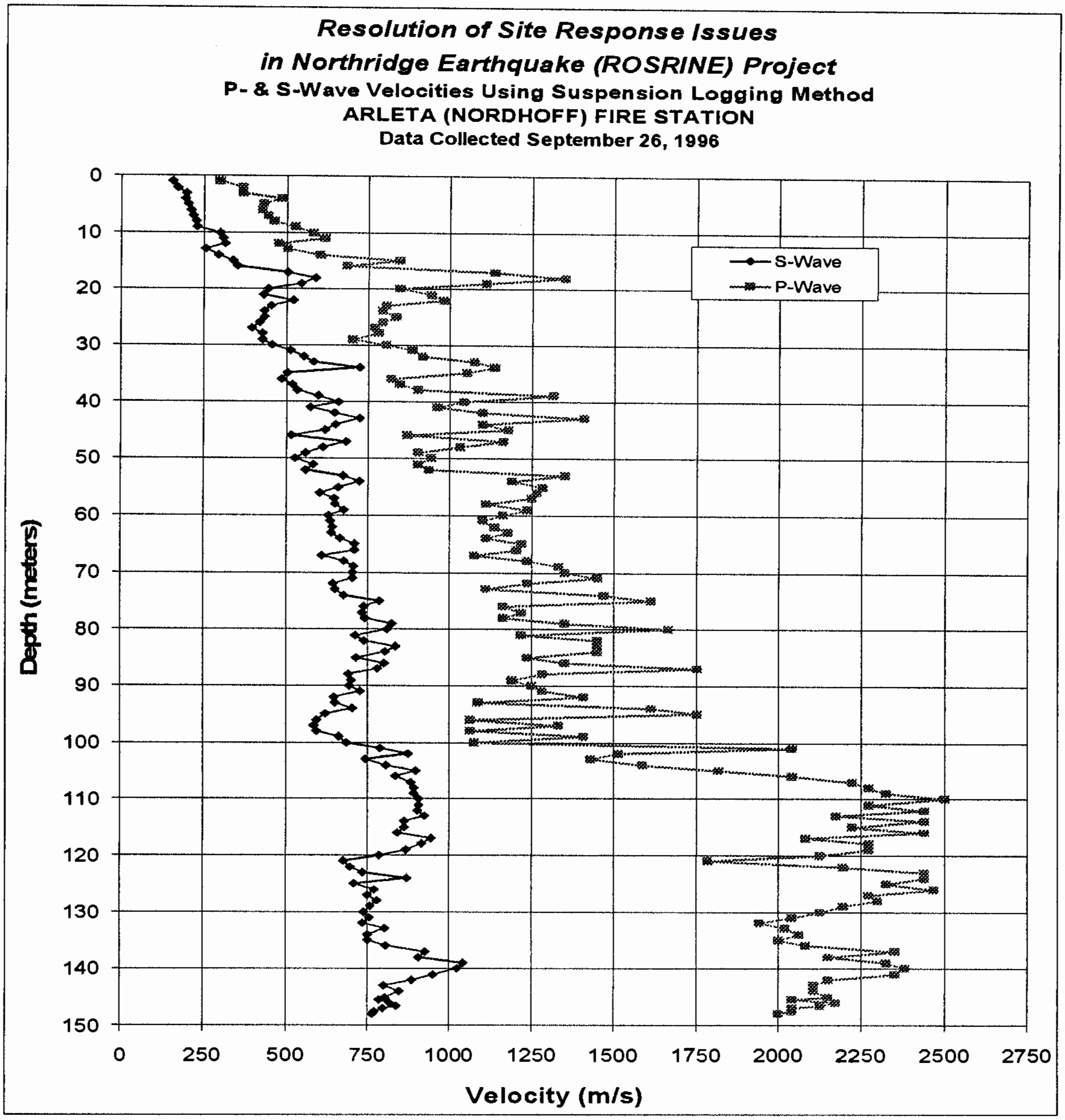


Figure 8. EXCEL chart format of P and S velocity profiles measured at a strong-motion site under the ROSRINE program (http://rccg03.usc.edu/rosrine).

ACKNOWLEDGEMENTS

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REFERENCES

Naeim, F., 1997, Response of Instrumented Buildings to the 1994 Northridge Earthquake -- An Interactive Information System, John A. Martin, Assoc., CD-ROM, also in SMIP96 Proceedings, CDMG.