RECOVERY OF RECORDS FROM CODE-REQUIRED ACCELEROGRAPHS AFTER THE NORTHRIDGE EARTHQUAKE

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ABSTRACT

The Northridge earthquake provided the first case since the 1971 San Fernando earthquake of effective recovery, processing, use and analysis of data from accelerographs installed in buildings to meet local code requirements. A large number of records were recovered from these accelerographs in an effort funded by the California Strong Motion Instrumentation Program and the National Science Foundation, with Agbabian Associates coordinating and managing field recovery. The records were valuable to assist post-earthquake structural evaluation and form an important complement to data from regular networks. Significant aspects of the code data recovery, processing and analysis are reviewed. Lessons learned from this experience with code instruments are reviewed to improve the success in future events. Recommendations include increasing the documentation of the location, orientation, and maintenance of code-required instruments, and shifting from film to digital recorders for new installations. Also, a goal of increased adoption of the Uniform Building Code (UBC) instrumentation code requirement by cities and counties is discussed. CSMIP will assist city and county code-instrument programs by providing technical and monitoring expertise.

INTRODUCTION

Recording the response of buildings during strong earthquake shaking is a key element in improving seismic design. There are two basic approaches used in instrumenting structures to record strong motion. One is the extensive-instrumentation approach used by the California Strong Motion Instrumentation Program (CSMIP) in the California Department of Conservation's Division of Mines and Geology (CDMG) in its normal instrumentation. In this approach, 10 to 20 or more single-direction or uniaxial acceleration sensors are strategically located in a building and their signals are cabled to a centrally-located recorder. CSMIP recorded the motions of nearly 60 buildings with this type of instrumentation during the Northridge earthquake (Shakal et al., 1994).

The second instrumentation approach is the much less extensive instrumentation required by the building code in many cities. In this approach, up to three accelerographs, each with 3 sensors, are located in a building at the top, base and approximate mid-height. Code-required instrumentation was the most common instrumentation in place at the time of the

1971 San Fernando earthquake. The experience with that earthquake made it clear that there were several needs not being met:

a) Much more instrumentation was needed, outside and inside buildings, and an additional program was needed to accomplish that;
b) The three points of recording in a building (bottom, middle and top) were not adequate to isolate torsion and other effects on drift; and
c) Centralized recording of the motion, with common timing, was critical to understanding details of the response of the building during earthquake shaking.

One result of the 1971 San Fernando earthquake experience was that CSMIP, a new state-wide program, was initiated, funded by a small fee on building permits. Another result was that new instruments were developed which had separable uniaxial sensors, and recorders were developed which recorded many channels side by side on the same medium, with common timing. The CSMIP program of extensively instrumenting a limited number of structures has been moving forward since then, and the large number of high-quality records obtained in Northridge is an example of the progress (Shakal et al., 1994). Nearly 200 structures, including 135 buildings, 20 dams and 35 bridges have been instrumented. In parallel with these extensive-instrumentation efforts, the code requirement for building accelerographs has continued in several cities.

CODE ACCELEROGRAPH REQUIREMENTS

The requirements for building accelerographs adopted by many cities follows the requirements in the Uniform Building Code, sometimes in a modified form. The requirement, as it appears in the Uniform Building Code (International Conference of Building Officials, 1994), Chapter 16 Appendix, is:

> Section 1646 - General. In Seismic Zones Nos. 3 and 4 every building over six stories in height with an aggregate floor area of 60,000 square feet or more, and every building over 10 stories in height regardless of floor area, shall be provided with not less than three approved recording accelerographs.
>
> Section 1647 - Location. The instruments shall be located in the basement, midportion, and near the top of the building. Each instrument shall be located so that access is maintained at all times and is unobstructed by room contents.
>
> Section 1648 - Maintenance. Maintenance and service of the instruments shall be provided by the owner of the building, subject to the approval of the building official. Data produced by the instruments shall be made available to the building official on request.

The City of Los Angeles modified this requirement and in recent years their city building code only requires a single instrument in buildings, at the roof level, but the City adopted a more stringent requirement to improve the monitoring of instrument maintenance. At the time of the Northridge earthquake there were nearly 500 buildings with code-required instruments in the Los Angeles area. Significant response data were recorded at many of these buildings during the earthquake.

Not all cities and counties require accelerographs in the large buildings in their jurisdiction. One CSMIP goal is to encourage cities to include the requirement for instruments in their code. This can be done as simply as by adopting the Appendix section of the UBC, or by developing a parallel requirement. CSMIP is available to assist cities and counties on technical aspects of instrumentation.

Another CSMIP goal is to help cities and counties deal with the instruments and with data from the instruments after a significant earthquake. Earthquakes are rare, and regardless of the good intentions of a city or county, institutional memory dims between earthquakes regarding what should be done with records after an earthquake and how to get early information from them. As a state-wide strong motion program with a focussed mission to extensively instrument sites and structures, CSMIP works with the instruments and data on a continuous basis, and can effectively help cities and counties administer and monitor the code-instrument program in their jurisdiction. CSMIP can more effectively help after an earthquake if it works with the city at some level during the period between the events.

This paper highlights key aspects of the data recovered from code-required instruments after the Northridge earthquake. Following the Northridge earthquake CSMIP worked extensively with the City of Los Angeles and other cities. This paper also discusses lessons learned about how the privately-maintained code-required instruments can more effectively contribute data and information important for the building owner and the city or county after future earthquakes.

THE CITY OF LOS ANGELES EXPERIENCE

The City of Los Angeles has a long history of addressing the need for instrumentation in buildings. When the state-wide CSMIP program began in 1972, the City already had a large enough program that it remained in place, separate from the new State program. After a few years Los Angeles decided that it would be more effective to join the State program, which occurred in the early 1980s.

At that time, the State and the City developed an agreement in which CDMG agreed to recover significant earthquake records from the code accelerographs that the City required in buildings. Since that time, Northridge is the first event that caused strong shaking throughout the Los Angeles area, and thus it was the first event which exercised the agreement. There had been earlier earthquakes which generated some strong motion records, most notably the 1987 Whittier earthquake, during which the shaking was recorded at a small number of buildings. The attempt to accomplish the provisions of the agreement after the Whittier event was an early lesson which influenced the approach CSMIP used for the Northridge earthquake.

Figure 1 illustrates, for the City of Los Angeles, the relationship between the City building department, the building owner, and the State. The City requires the accelerographs to be installed, and requires evidence of periodic maintenance by a company certified by the City. Periodic maintenance records are provided by the company to the City. If a significant earthquake occurs then CDMG is to recover the records and provide copies to the City and the building owners.

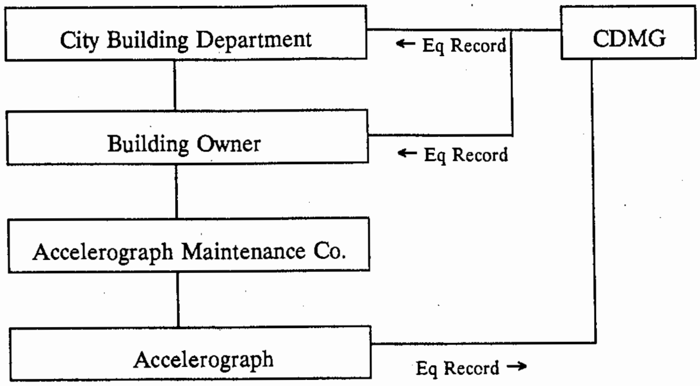


Figure 1. Relationship between the City of Los Angeles, building owner and CDMG for recovery of records from code-required accelerographs after significant earthquakes.

The experience of the Whittier earthquake suggested a modified approach, which was used in the Northridge earthquake. The key difference was to have the Accelerograph Maintenance vendor, already certified by the City, and with full knowledge of the locations and parameters of the instruments in the buildings because of their active contract with the building owner, to be the agent to do record recovery for the State. This leads to a slightly modified model, shown in Figure 2.

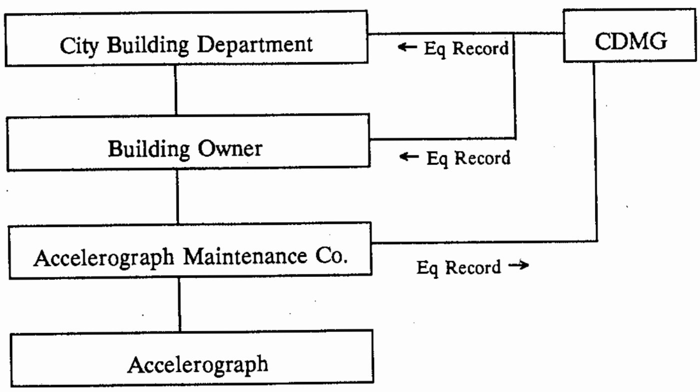


Figure 2. Relationship between the City of Los Angeles, the building owner, the accelerograph maintenance companies and CDMG for recovery of records from code-required instruments after the Northridge earthquake.

This model is much more effective. Of course, significant funding may be required for the State to contract for record recovery by the Maintenance Companies. After the Northridge earthquake, the National Science Foundation (NSF) shared this cost. To make the record recovery as effective as possible, NSF and CDMG jointly funded record recovery, in two separate contracts with Agbabian Associates to direct the activities of the individual Maintenance Companies, and to collect instrument and building information. This relationship is illustrated in Figure 3.

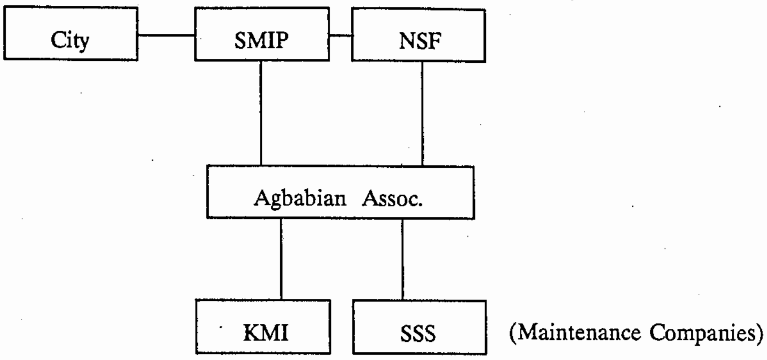


Figure 3. Relationships between The City of Los Angeles, CDMG, NSF, Agbabian Assoc. and accelerograph maintenance companies for the recovery of the Northridge accelerograms.

This framework was put into place rapidly after the Northridge earthquake, with effective and rapid work by Agbabian Associates and the Maintenance Companies, Kinemetrics, Inc. (KMI) and Seismic System Service (SSS), both certified by the City and having contracts with the building owners. A small amount of additional data was recovered by CSMIP staff working directly with building owners. With procedures in place from the Northridge experience, the approach shown in Figure 2 is a good model for how CSMIP can help cities recover data after significant earthquakes in the future.

CODE-RECORDS FROM THE NORTHRIDGE EARTHQUAKE

The Northridge earthquake yielded a large set of strong-motion recordings, including records from more than 250 ground-response stations, more than 400 buildings and 50 other structures. CSMIP recovered records from 116 ground-response stations and 77 extensively-instrumented structures, including 57 buildings (Shakal et al., 1994). The U.S. Geological Survey's National Strong Motion Instrumentation Project recovered records from more than 37 buildings (some with limited instrumentation), and more than 60 ground-response sites (Porcella et al., 1994). The University of Southern California's Los Angeles Strong Motion Accelerograph Network recovered records from 71 ground-response stations (Trifunac et al., 1994). Records were also obtained from 7 facilities of the Los Angeles Department of Water and Power (Lindvall Richter Benuska, 1994).

An even larger number of records were recovered from the privately-owned and maintained code-accelerographs. A total of 500 records from nearly 270 buildings in the Los

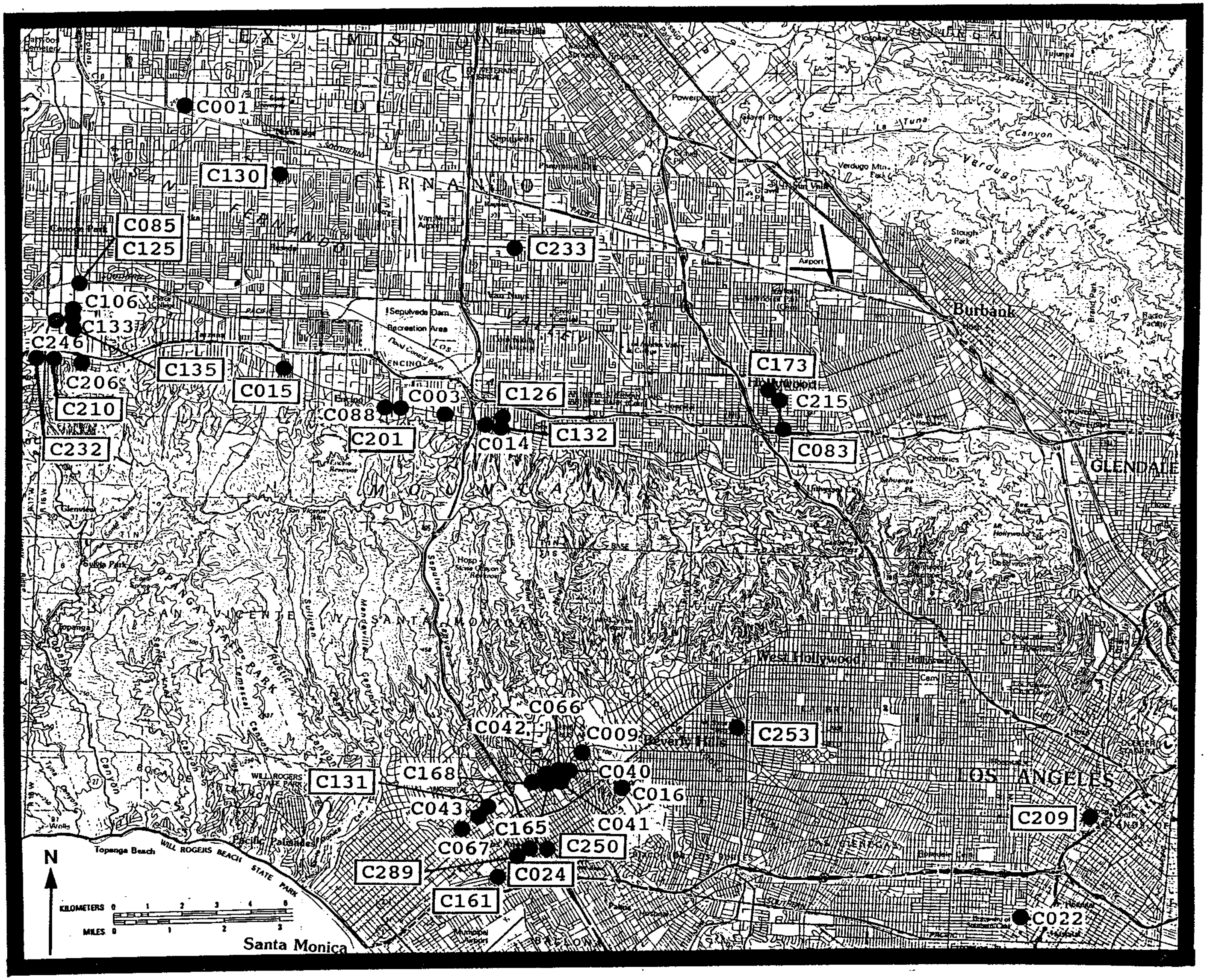


Figure 4. Index map showing 40 Code stations that recorded the Northridge earthquake for which data have been processed. The 20 stations in the first release are identified by a 4-character code. The 20 stations in the second release are identified by a 4-character code in a box. The code is cross-referenced to the station name in Table 1.

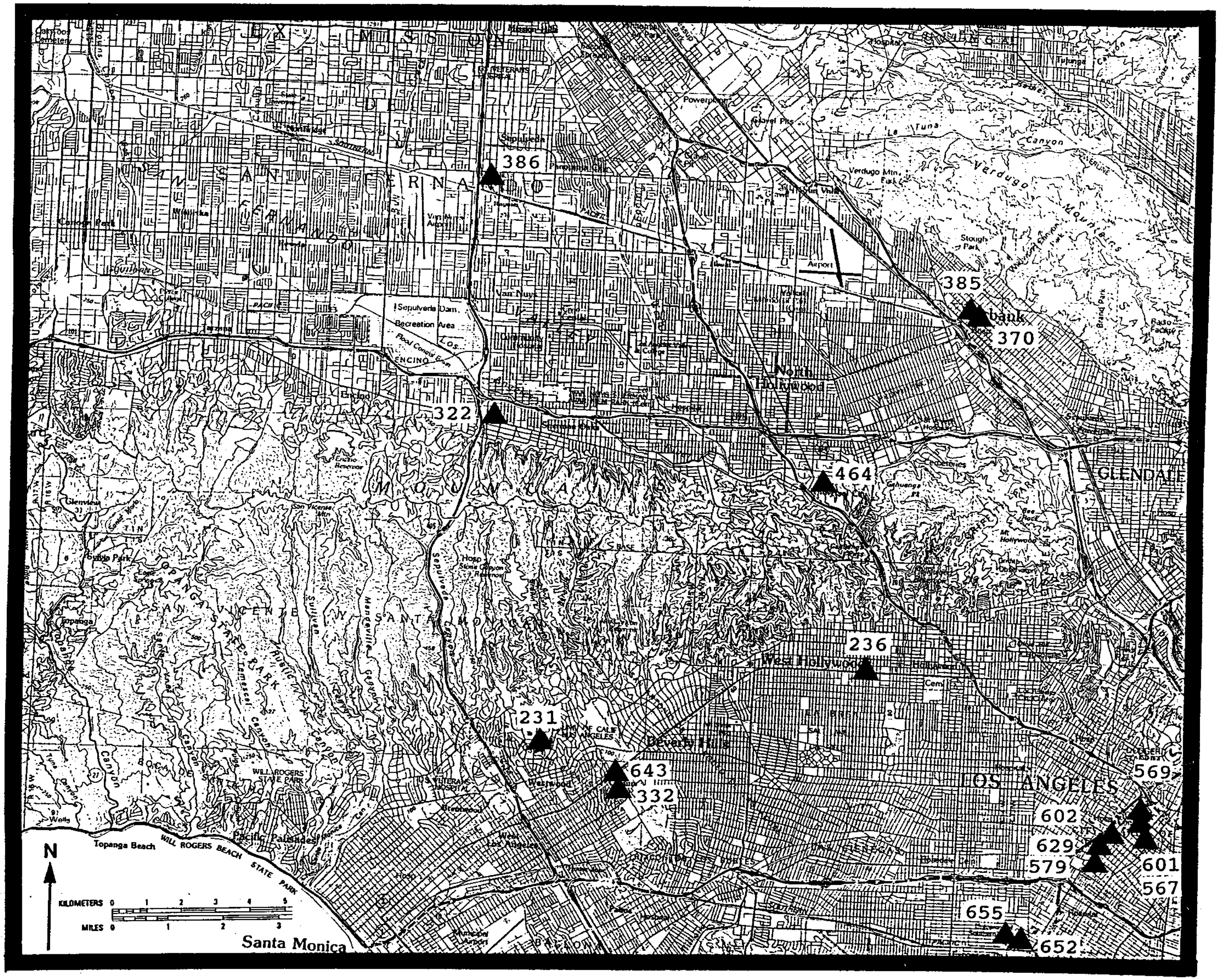


Figure 5. Index map showing the locations of the 17 CSMIP extensively-instrumented buildings in the San Fernando and Los Angeles areas. The stations are identified by a 3-character code that is cross-referenced to the station name in Table 2. The Northridge earthquake data for these buildings have been processed and released. Processed data are available from a total of 38 CSMIP buildings.

Angeles area were recovered and archived by CSMIP with recovery in the field by KMI and SSS under the coordination of Agbabian Associates. That effort is described in Nigbor and Madura (1996). A collected set of the records and locations of the buildings are presented in reports being prepared by CDMG and Agbabian Associates. The first records were digitized and processed rapidly by CSMIP at the request of the City of Los Angeles so that they could be studied by the Committees the City set up to study the steel-frame building problems after the earthquake. The first group of 20 buildings, provided in this manner during June though September, 1994 were collected to form the first code data report, released on September 20 (Darragh et al., 1994a). Additional records were processed according to a generalized priority of locations and building type, with additional specific requests from the City. The second release, with another 20 buildings, occurred in April, 1995 (Darragh et al., 1995). This release brought to 66 the number of code building records digitized and processed. Of course, during this time records from extensively-instrumented buildings of the CSMIP network were also being digitized and processed. The records from a total of 125 of these network stations, including 38 buildings, 79 freefield stations, and 8 other structures have been processed and released (Darragh et al., 1994b).

The 40 buildings included in the first two code-data releases are listed in Table 1. The buildings range in height from 7 stories to 36 stories. Both steel and concrete buildings are included. Only 1/3 of the buildings have more than one accelerograph. Some of the steel frame buildings were damaged, and four are discussed more in Huang et al. (1996). The locations of the buildings from which the code records have been processed and released are shown in Figure 4. Some records from some of the most important buildings could not be digitized because the accelerograph malfunctioned or the records were not readable.

The 38 CSMIP extensively-instrumented buildings for which the records have been processed and digitized are listed in Table 2, for comparison. The buildings range in height from 1 story to 54 stories, and include low-rise buildings not required to be instrumented under the code. Low-rise buildings were also damaged during the Northridge earthquake. Steel frame, concrete frame, concrete shear wall, base-isolated, and other building types are included. The damaged 7-story hotel located in Van Nuys is discussed in Huang et al. (1996). The locations of the 17 CSMIP buildings in the San Fernando and Los Angeles areas are shown in Figure 5.

Figure 6 shows the accelerogram from one of the code buildings as an example. The record is from the roof level of an 17-story building, Canoga Ave #2, in the western San Fernando valley. It shows that higher mode response is dominant in the acceleration record. After the record was digitized and processed, the first mode response with a period over 4 seconds was clear in the displacement record. The record also shows high frequency spikes in the records which may be associated with local damage or related effects near the recorder. The base-level motion is not known because there was only a roof instrument.

Examples of spectra are shown in Figure 7. This figure shows the spectral acceleration (5% damping) at the base of four buildings located in the epicentral area, Woodland Hills, Sherman Oaks and North Hollywood. The spectral acceleration for these areas is similar to or smaller than the UBC spectra. These spectra have been used in the Seismic Safety Commission Case Studies Project (SSC, 1996) as discussed in Turner (1996).

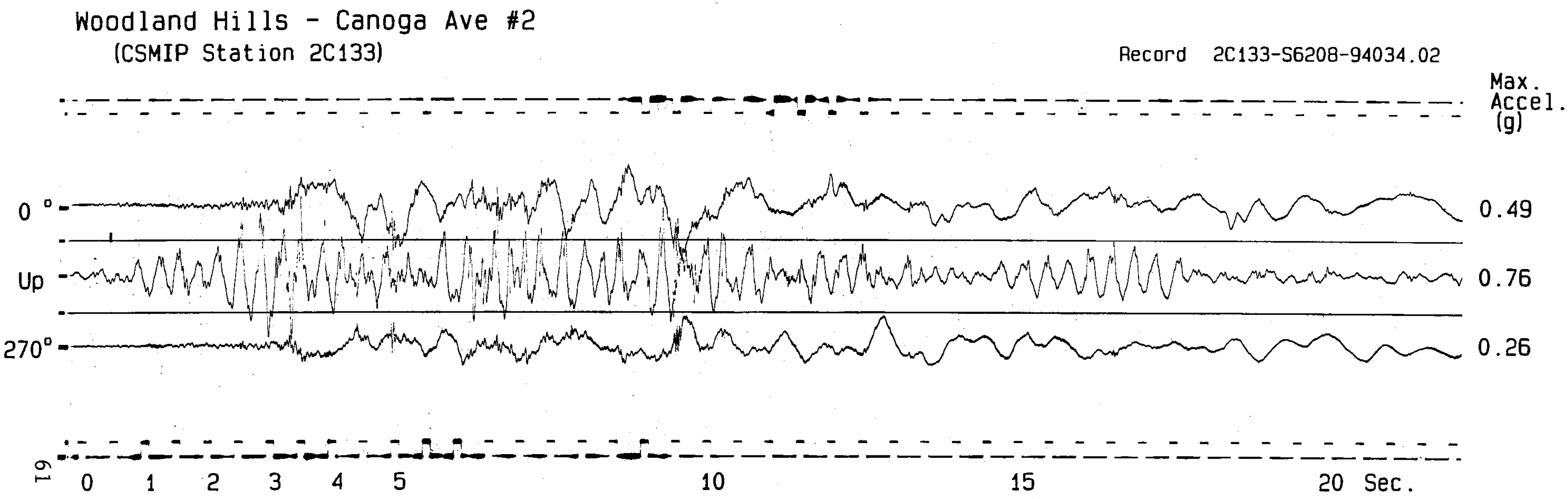
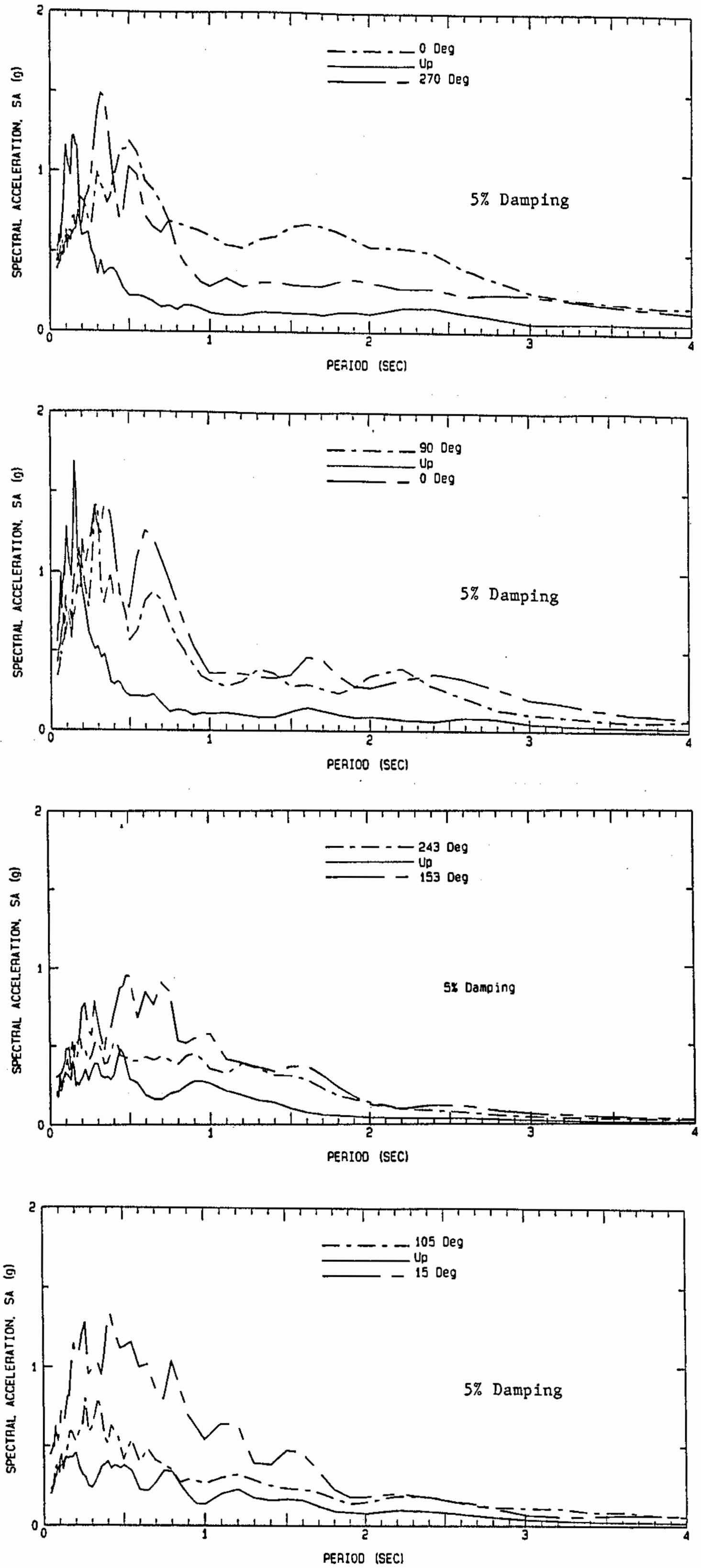


Figure 6. Acceleration record from a code instrument at the roof level of a 17-story building in Woodland Hills.



Epicentral Area

Northridge - Roscoe Blvd (CSMIP Sta. C130)
Ground Floor of 7-story Bldg.

Woodland Hills/Canoga Park

Woodland Hills - Oxnard Blvd. #4 (CSMIP Sta. C246)
Basement of 12-story Bldg.

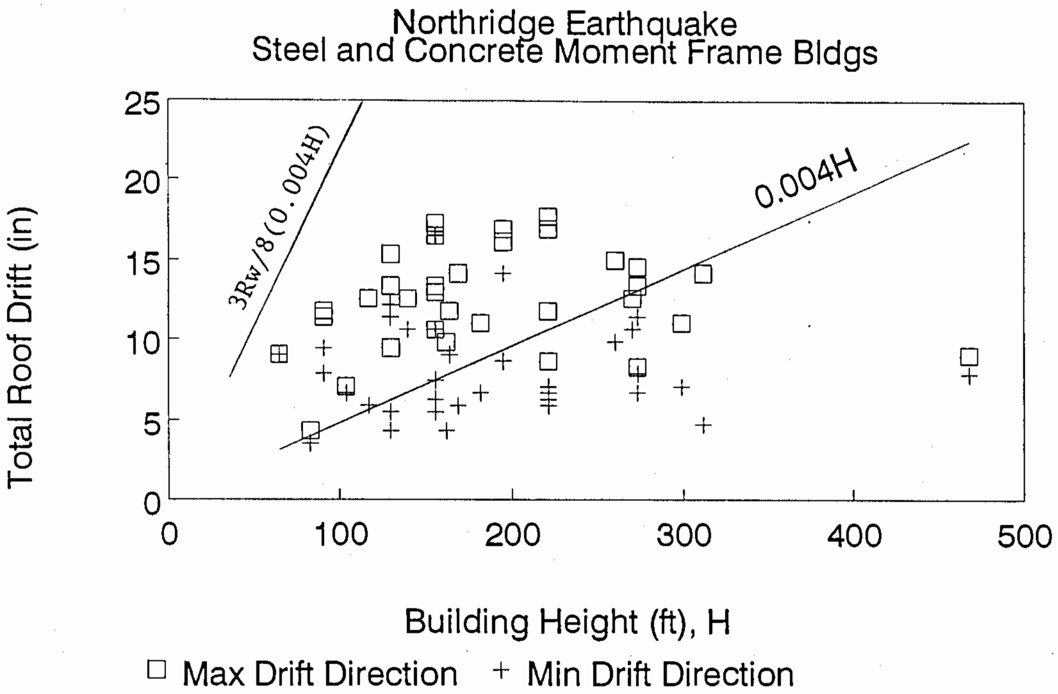
North Hollywood

North Hollywood - Lankershim Blvd. #2 (CSMIP Sta. C083)
Basement of 8-story Bldg.

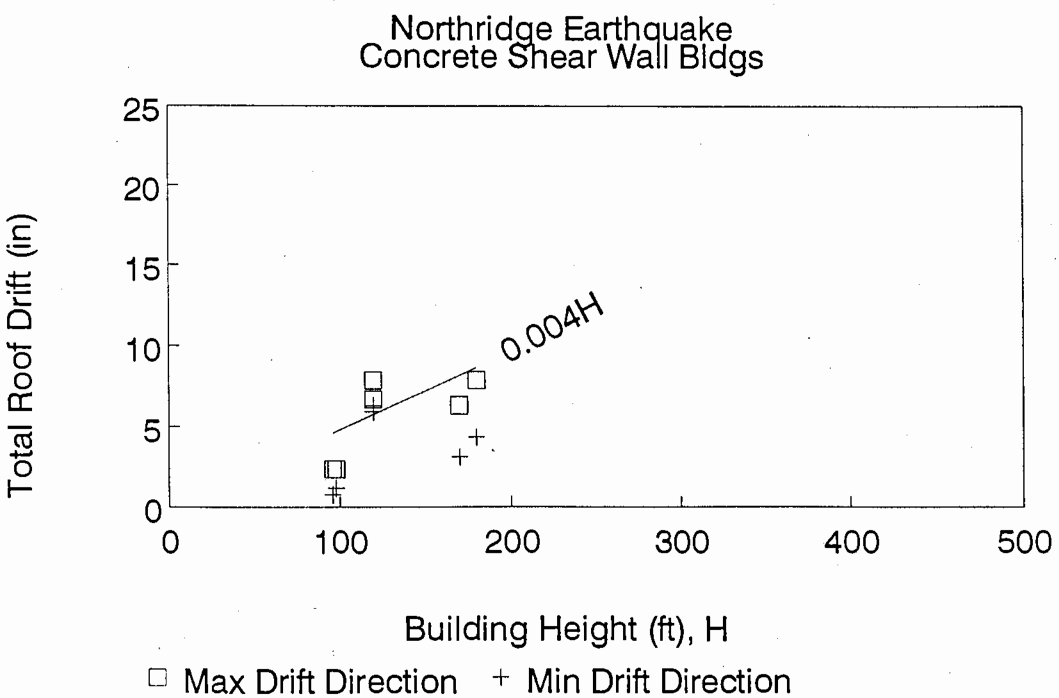
Sherman Oaks

Sherman Oaks - 13-story Commercial Bldg. (CSMIP Sta. 322)
Basement of 13-story Bldg.

Figure 7. Spectral acceleration (5% damped, all three components) from the accelerograph located at the base of four buildings, one located near the epicenter and three on the south side of San Fernando Valley. Records from the top three are from code-required accelerographs.



(a)



(b)

Figure 8. Total drifts at roof versus building height for (a) moment-frame buildings, and (b) concrete shear wall buildings in the Northridge earthquake. The line corresponding to the code drift limit of 0.004 H is also shown.

The records from code-accelerographs are important and have already been used in several important applications:

a) The records have been provided to the building owners who pass them to their structural engineers for post-earthquake evaluation of the building.
b) Data from 4 damaged steel buildings were included in the SAC (1995) project to evaluate analytical methods for identifying critical areas of damage in buildings.
c) The base-level records complement the smaller number of records from stations of the regular networks, and thus play an important role in providing information about the shaking in the building's vicinity. Although the base records will have some soil-structure interaction effects, they still provide very important data when there are no nearby stations of the regular networks.

Some studies focused on Northridge building damage include SAC (1995), SSC (1996), Turner (1996), Kariotis (1996) and Huang et al. (1996).

To get full value from a code-required accelerograph, the data should also be available rapidly enough to be useful in early post-earthquake response. The data can help the building owner and city to evaluate rapidly the response of the building, besides its usual application in longer term studies and computer modelling.

As an example of the value of strong motion data in the assessment of a building's response after an earthquake, Figure 8 shows a plot of total drift at the roof level calculated or estimated from the records for 23 moment-frame buildings of different heights (Huang and Shakal, 1995). The drift limit in the building code is about 0.004 H for these buildings. Total drift in many of the buildings was over this value. Since the designs of moment-frame buildings were mostly controlled by drift, structural members in some of these moment-frame buildings with large drifts may have yielded during the earthquake. If a building owner or response official knew, for example, that the total drift in a building was less than the code drift limit they may concern themselves first with other buildings, unless there are other symptoms of damage. Of course, to provide an accurate measurement of total drift, or allow the determination of base shear, there must be an instrument at the base of the building as well as at the roof level, rather than a single instrument at the roof.

RAPID DATA RECOVERY

For a rapid comparison to a code limit or other design parameter, the data needs to be available quickly after an earthquake. CSMIP has recently developed a near-real-time data recovery and processing facility that has important benefits in this regard. The system automatically recovers data from field instruments, using dial-up telephone lines, after they have been triggered by earthquake shaking. Once the data have been transmitted to a central bank of computers in Sacramento, the record is processed to yield acceleration, velocity and displacement time series, and response and Fourier spectra. The data can then be transmitted to people previously identified as recipients.

An example is provided by the Northridge aftershock of June 26, 1995 which occurred near Castaic, north of the Northridge mainshock. The magnitude 5 event occurred at 1:40 in the morning. Within 3 minutes the first CSMIP station had transmitted the recorded event to Sacramento, the record was processed, and designated people were notified. Within 30 minutes after the event, the records from all 13 near-real-time stations that recorded the event had been transmitted to Sacramento and the data had been processed. The data from the event and other aspects are documented in a short report released on the day of the event (CSMIP, 1995).

This capability can be applied to near-real-time recovery from any modern digital accelerograph with a modem and telephone communications. The addition of this capability greatly increases the value of the data in the early minutes, hours and days after the earthquake. All the code-accelerographs from which records were recovered after the Northridge earthquake were analog (film) instruments, so no rapid recovery or distribution was possible at that time.

LESSONS LEARNED REGARDING CODE INSTRUMENTS

Though record recovery was effective and quite successful after the Northridge earthquake, some aspects became clear during the course of these efforts. Addressing these aspects can make code data more useful, and recovery more rapid and effective after future earthquakes.

1) Documentation Earthquakes are rare events, from which data are desired rapidly once an event has occurred. Thus, in-depth research and historical investigation are not practical, and documentation must be readily available that is accurate and reliable, preferably on an automated basis.

a) Building Information: Key information is needed about a building to make the data useful after an earthquake. These include number of stories, construction data and structural system, among others. This information can be maintained by the City with assistance by the State as appropriate.

b) Instrument Location: A record from an instrument after an earthquake is almost useless, and possibly counterproductive, if it is not known where in a building the instrument is located. This means both floor (height in the building) and location on that floor. A very different record may be obtained on the same floor if the instrument is at an outer wall as opposed to being near the central elevator core. In terms of vertical motion, a very different record will be obtained if the instrument is near a column as opposed to the center of a span, where the vertical motion of the floor diaphragm can dominate the record (e.g., Canoga Ave #2 in Fig. 6). This vertical motion can be misinterpreted as the vertical vibration of the building. Unless there are special circumstances, the instrument should be placed near the central core of the building, near a column. This should probably be a recommendation or requirement in a future code revision.

c) Instrument Orientation: The orientation of an instrument seems a trivial issue, but the orientation is now often not recorded for code instruments. As a result, the record is difficult to use effectively, particularly if rapid usage is desired. A building could have very different motion in each direction, either because the structural system in each direction is different or because the input is different in the two directions. Also, a building in which the framing system has been damaged in one direction could have a very different response in that direction. The code now makes no mention of orientation. This should probably be addressed in a future revision, so that there is a specification for which way the instrument should be aligned relative to a chosen building direction.

2) Instrument Maintenance While the Northridge data suggests that the maintenance of instruments was generally adequate, improved and consistent maintenance standards are important. The certification of Maintenance Companies and the screening of periodic test records are important. Also, standardized acceptance levels should be established for test records. The State could provide help to city building departments so they can be as effective as possible without undue investment of staff time.

3) Instrument Upgrade The upgrade of code instrumentation from an analog film recorder to a digital recorder allows shaking data to be recovered, processed and analyzed quickly after an earthquake. Modern digital accelerographs have significantly better accuracy than the older analog units, and do not have significantly higher purchase or maintenance costs. New installations should probably be all digital, and upgrading would be effective in some cases. The State can again provide help to city building departments on digital instrumentation and communication equipment.

4) Extend Code Accelerograph Requirement Many cities require accelerographs in tall structures corresponding to the UBC instrumentation provision. However, a significant number of communities have not adopted such a requirement. Some jurisdictions had buildings with damage, but no measurement of the motion in the buildings. These communities should be encouraged to adopt an instrument requirement. Although modifying the UBC code language to require only two accelerographs at the top and base may be a reasonable step, requiring an instrument only at the top appears unwise after the Northridge earthquake, and in fact Los Angeles is modifying their regulation so that its calls for an instrument at the base as well as at the top (K. Deppe, personal communication).

ACKNOWLEDGEMENTS

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TABLE 1: SUMMARY OF PROCESSED DATA FROM CODE-REQUIRED ACCELEROGRAPHS IN BUILDINGS

Building Name	Sta. No.	No. Chns	Instrument Locations	No. of Stories	Max. Horiz. Accel.(g) Base	Roof
Encino - Ventura Blvd #1	2C003	3	Grnd (arcade)	17	0.54	*
Encino - Ventura Blvd #4	2C088	3	Roof	13	---	0.44
Encino - Ventura Blvd #9	2C201	9	Bsmt, 6th, roof	12	0.46	0.47
Los Angeles - Ave of the Stars #2	2C016	3	Roof	36	---	0.35
Los Angeles - Beverly Blvd #1	2C253	9	Grnd, 5th, roof	10	0.22	0.47
Los Angeles - McClintock Ave #2	2C022	9	Grnd, 6th, roof	10	0.31	0.28
Los Angeles - Olympic Blvd #1	2C024	3	Roof	9	---	0.70
Los Angeles - Olympic Blvd #2	2C289	3	Roof	11	---	1.07
Los Angeles - Olympic Blvd #3	2C250	3	Roof	10	---	0.71
Los Angeles - Olympic Blvd #4	2C161	3	Roof	12	---	0.56
Los Angeles - Wilshire Blvd #1	2C043	3	Roof	23	---	0.63
Los Angeles - Wilshire Blvd #2	2C040	3	Roof	17	---	0.54
Los Angeles - Wilshire Blvd #3	2C165	3	Roof	17	---	0.28
Los Angeles - Wilshire Blvd #4	2C168	3	Roof	21	---	0.37
Los Angeles - Wilshire Blvd #5	2C066	3	Roof	14	---	0.30
Los Angeles - Wilshire Blvd #6	2C042	3	Roof	17	---	0.29
Los Angeles - Wilshire Blvd #7	2C067	3	Roof	13	---	0.34
Los Angeles - Wilshire Blvd #8	2C041	9	Lobby, 9th, roof	18	0.19	0.33
Los Angeles - Wilshire Blvd #9	2C009	9	Bsmt, 11th, roof	21	0.24	0.20
Los Angeles - Wilshire Blvd #10	2C131	9	Bsmt, 12th, roof	24	0.27	0.35
Los Angeles - Wilshire Blvd #11	2C209	6	Grnd, roof	9	0.22	0.39
North Hollywood - Lankershim #1	2C173	3	Roof	8	---	0.35
North Hollywood - Lankershim #2	2C083	9	Bsmt, 5th, roof	8	0.31	0.36
North Hollywood - Magnolia #1	2C215	3	Roof	12	---	0.74
Northridge - Oakdale Ave #1	2C001	3	Roof	10	---	0.46
Northridge - Roscoe Blvd #1	2C130	7	1st, 4th, roof	7	0.42	0.59
Sherman Oaks - Ventura Blvd #6	2C014	9	Bsmt, 8th, roof	15	0.47	0.48
Sherman Oaks - Ventura Blvd #7	2C126	3	Roof	21	---	0.47
Sherman Oaks - Ventura Blvd #8	2C132	3	Roof	8	---	0.79
Tarzana - Ventura Blvd #10	2C015	9	Grnd, 5th, roof	10	0.47	0.52
Van Nuys - Sherman Way #1	2C233	9	1st, 6th, roof	12	0.37	0.66
Woodland Hills - Canoga Ave #1	2C135	3	Roof	17	---	0.39
Woodland Hills - Canoga Ave #2	2C133	3	Roof	17	---	0.49
Woodland Hills - Canoga Ave #3	2C106	3	Roof	15	---	1.04
Woodland Hills - Oxnard Blvd #2	2C210	3	Roof	21	---	0.31
Woodland Hills - Oxnard Blvd #3	2C232	3	Roof	17	---	0.72
Woodland Hills - Oxnard Blvd #4	2C246	9	Bsmt, 6th, roof	12	0.44	0.33
Woodland Hills - Ventura Blvd #5	2C206	6	6th, roof	12	*	0.55
Woodland Hills - Victory Blvd #1	2C085	3	Roof	12	---	0.57
Woodland Hills - Victory Blvd #2	2C125	3	Roof	8	---	0.79

--- No accelerograph.

* Accelerograph did not function.

TABLE 2: SUMMARY OF PROCESSED DATA FROM CSMIP EXTENSIVELY-INSTRUMENTED BUILDINGS

Building Name	Station Number	No. Chns	Sensor Locations	Max. Horiz. Accel.(g) Base	Max. Horiz. Accel.(g) Struct.
Burbank - 6-story Commercial	24370	13	Grnd, 2nd, 3rd, roof	0.35	0.49
Burbank - 10-story Residential	24385	16	1st, 4th, 8th, roof	0.35	0.79
Colton - 1-story School Gym	23540	13	Grnd, top walls, roof	0.04	0.23
El Segundo - 14-story Office	14654	16	1st, 4th, 9th, roof	0.13	0.25
Lancaster - 5-story Hospital	24609	12	1st, 4th, roof	0.07	0.28
Los Angeles - 2-story Fire Command	24580	16	Foundation, 1st, 2nd, roof	0.22	0.35
Los Angeles - 3-story Commercial	24332	15	Level B and mall, 2nd, roof	0.33	0.97
Los Angeles - 5-story Warehouse	24463	13	Bsmt, 2nd, 3rd, roof	0.26	0.29
Los Angeles - 6-story Parking Structure	24655	14	1st, 4th, roof	0.29	1.21
Los Angeles - 6-story Office	24652	14	Bsmt, 1st, 3rd, roof	0.24	0.59
Los Angeles - 7-story UCLA Math-Sci.	24231	12	1st, 3rd, 5th, roof	0.29	0.77
Los Angeles - 7-story Univ. Hospital	24605	24	Foundation, lower, 4, 6, roof	0.37	0.21
Los Angeles - 8-story CSULA Admin.	24468	16	Grnd, 2nd, roof	0.17	0.25
Los Angeles - 9-story Office	24579	18	Bsmt, 2nd, 5th, roof	0.18	0.34
Los Angeles - 13-story Office	24567	15	Bsmt, 2nd, 8th, roof	0.18	0.37
Los Angeles - 14-story Hollywood Str.	24236	12	Bsmt, 8th, 12th, roof	0.28	0.49
Los Angeles - 15-story Gov. Office	24569	15	B level, 2nd, 8th, roof	0.21	0.52
Los Angeles - 17-story Residential	24601	14	1st, 7th, 13th, roof	0.26	0.58
Los Angeles - 19-story Office	24643	15	Level D, 1st, 2nd, 8th, roof	0.32	0.65
Los Angeles - 52-story Office	24602	20	Lvl E, A, 14, 22, 35, 49, roof	0.15	0.41
Los Angeles - 54-story Office	24629	20	P4, grnd, 20, 36, 46, pent	0.14	0.19
Newport Beach - 11-story Hospital	13589	18	Service level, 3rd, 6th, roof	0.08	0.26
North Hollywood - 20-story Hotel	24464	16	Bsmt, 3rd, 9th, 16th, roof	0.33	0.66
Pasadena - 6-story Office	24541	16	Bsmt, 2nd, 6th, attic, roof	0.17	0.21
Pasadena - 9-story Commercial	24571	15	Bsmt, 2nd, 5th, roof	0.19	0.29
Pasadena - 12-story Commercial/Office	24546	15	2nd, 7th, 12th, roof	0.18	0.32
Pasadena - 12-story Office	24566	15	Grnd, 5th, 6th, roof	0.23	0.31
Pomona - 2-story Commercial	24511	10	Bsmt, 2nd, roof	0.06	0.22
Rancho Cucamonga - Law & Justice	23497	16	Foundation, bsmt, 2nd, roof	0.05	0.10
San Bernardino - 1-story Commercial	23622	10	Grnd, roof	0.08	0.15
San Bernardino - 5-story Hospital	23634	12	1st, 3rd, roof	0.08	0.35
San Bernardino - 5-story CSUSB Lib.	23285	10	Bsmt, 3rd, roof	0.04	0.21
San Bernardino - 6-story Hotel	23287	9	1st, 3rd, roof	0.07	0.23
Seal Beach - 8-story Office	14578	28	Bsmt, 1st, 2nd, 6th, roof	0.08	0.15
Sherman Oaks - 13-story Commercial	24322	15	2nd bsmt, grnd, 2nd, 8th, roof	0.46	0.90
Sylmar - 6-story County Hospital	24514	13	Grnd, 3rd, 4th, roof	0.80	1.70
Van Nuys - 7-story Hotel	24386	16	Grnd, 2nd, 3rd, 6th, roof	0.47	0.59
Whittier - 8-story Hotel	14606	12	1st, 5th, roof	0.19	0.49

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