Table of Contents

1 Strong-motion Database in the World

1.1 Center for Engineering Strong Motion Data (CESMD)

The Center for Engineering Strong Motion Data (CESMD)[1)] is a cooperative center established by the US Geological Survey (USGS) and the California Geological Survey (CGS) to integrate earthquake strong-motion data from the CGS California Strong Motion Instrumentation Program, the USGS National Strong Motion Project, and the Advanced National Seismic System (ANSS). The CESMD provides raw and uniformly processed strong-motion data for earthquake engineering applications.

Data files downloadable from the CESMD are compressed (zipped) files containing one or more data files in one of several standard simple text (ASCII) formats. The files are multi-channel, containing all the files recorded at the station (3 for a triaxial ground station, 6 to 100 or more for geotechnical arrays and structures). The channels are generally downloadable as individual channel files for structures. The data files in general have three sections for each channel: a text header, an integer-values header, a real-values header and the data values. There are three types of file, that is a raw acceleration data file (.v1), a processed acceleration, velocity and displacement data file (.v2), and a response spectrum file (.v3).

Strong motion data recorded in the United States since 1933 are available at the CESMD web site (http://www.strongmotioncenter.org/).

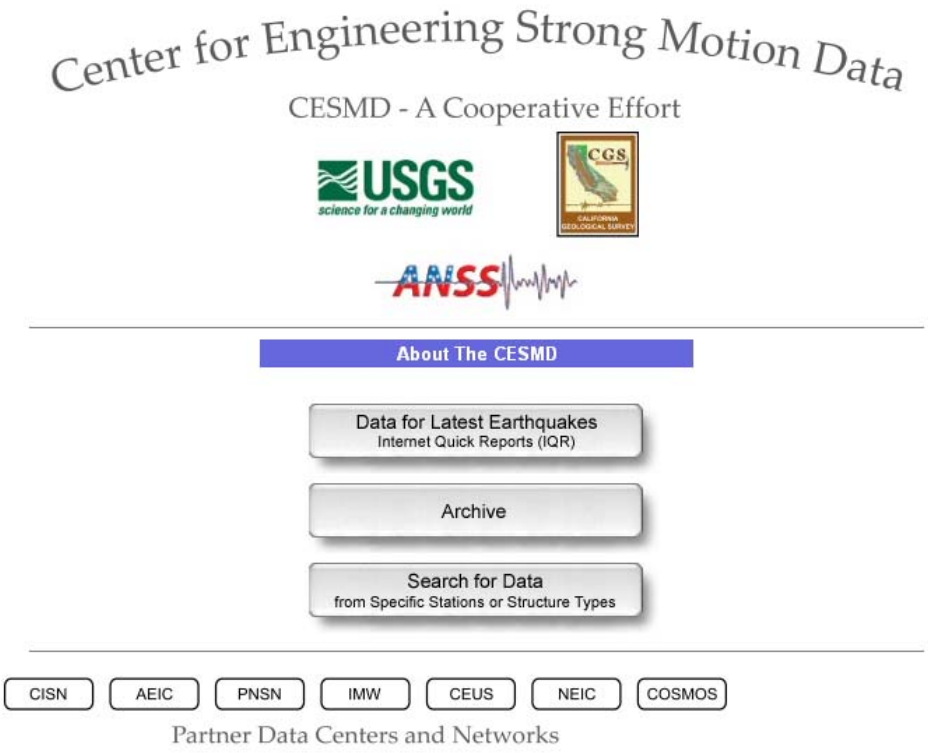

Figure 1.1 Screenshot at CESMD (http://www.strongmotioncenter.org/)

1.2 COSMOS Virtual Data Center

The Consortium of Organizations for Strong - Motion Observation Systems (COSMOS)[2] has been established with the support of the National Science Foundation (NSF) and charter endorsement by the California Division of Mines and Geology (CDMG), the U.S. Geological Survey (USGS), the U.S. Bureau of Reclamation, and the U.S. Army Corps of Engineers. As one of major activities of COSMOS, they are operating the virtual data center in the Internet.

The COSMOS Virtual Data Center[3] is providing worldwide strong motion data as well as in the United States.

Figure 1.2 Screenshot at the COSMOS Virtual Data Center (http://db.cosmos-eq.org/)

1.3 USGS National Strong-Motion Project (NSMP)

The U.S. Geological Survey (USGS) National Strong-Motion Project (NSMP)[4] has the primary Federal responsibility for recording each damaging earthquake in the United States on the ground and in man-made structures in densely urbanized areas to improve public earthquake safety. The Project maintains a national cooperative instrumentation network, a national data center, and a supporting strong-motion data analyses and research center in support of this responsibility. The NSMP currently operates over 900 strong-motion instruments at approximately 701 permanent stations located in 32 States and the Caribbean.

Strong motion data and related information from the project are available at the NSMP web site.

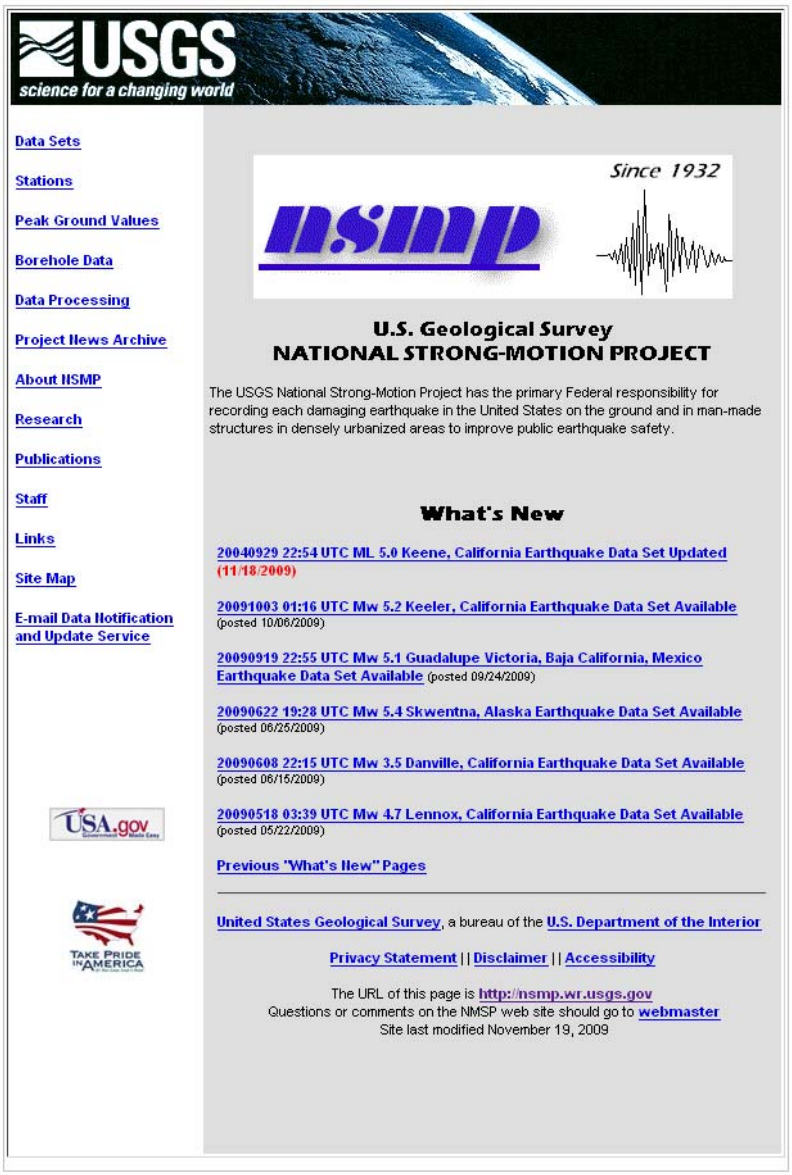

Figure 1.3 Screenshot at the USGS National Strong-Motion Project (NSMP) (http://nsmp.wr.usgs.gov/)

1.4 California Strong Motion Instrumentation Program (CSMIP)

The California Strong Motion Instrumentation Program (CSMIP)[5] was established in 1972 by California Legislation to obtain vital earthquake data for the engineering and scientific communities through a statewide network of strong motion instruments. When the planned network is completed, statewide coverage will ensure that strong ground motion for any moderate to larger size earthquake in the state will be recorded.

CSMIP installs state-of-the-art earthquake monitoring devices called “accelerographs” at various representative geologic foundation materials throughout California to measure the ground shaking. In addition, earthquake monitoring devices are installed in structures such as buildings, hospitals, bridges, dams, utilities and industrial facilities. Sites are selected by engineers and scientists representing industry, government, and universities. The program has installed more than 900 stations, including 650 ground-response stations, 170 buildings, 20 dams and 60 bridges.

Strong motion data from CSMIP are provided through the Center for Engineering Strong Motion Data (CESMD)[1].

1.5 PEER Strong Motion Database

The PEER (Pacific Earthquake Engineering Research Center, University of California at Berkeley) Strong Motion Database[6] contains 1557 records from 143 earthquakes from tectonically active regions in the world. The first publication contains strong motion data up to 1999. The database was updated to the PEER NGA database[7] as a part of the Next Generation Attenuation of Ground Motions (NGA) Project[8].

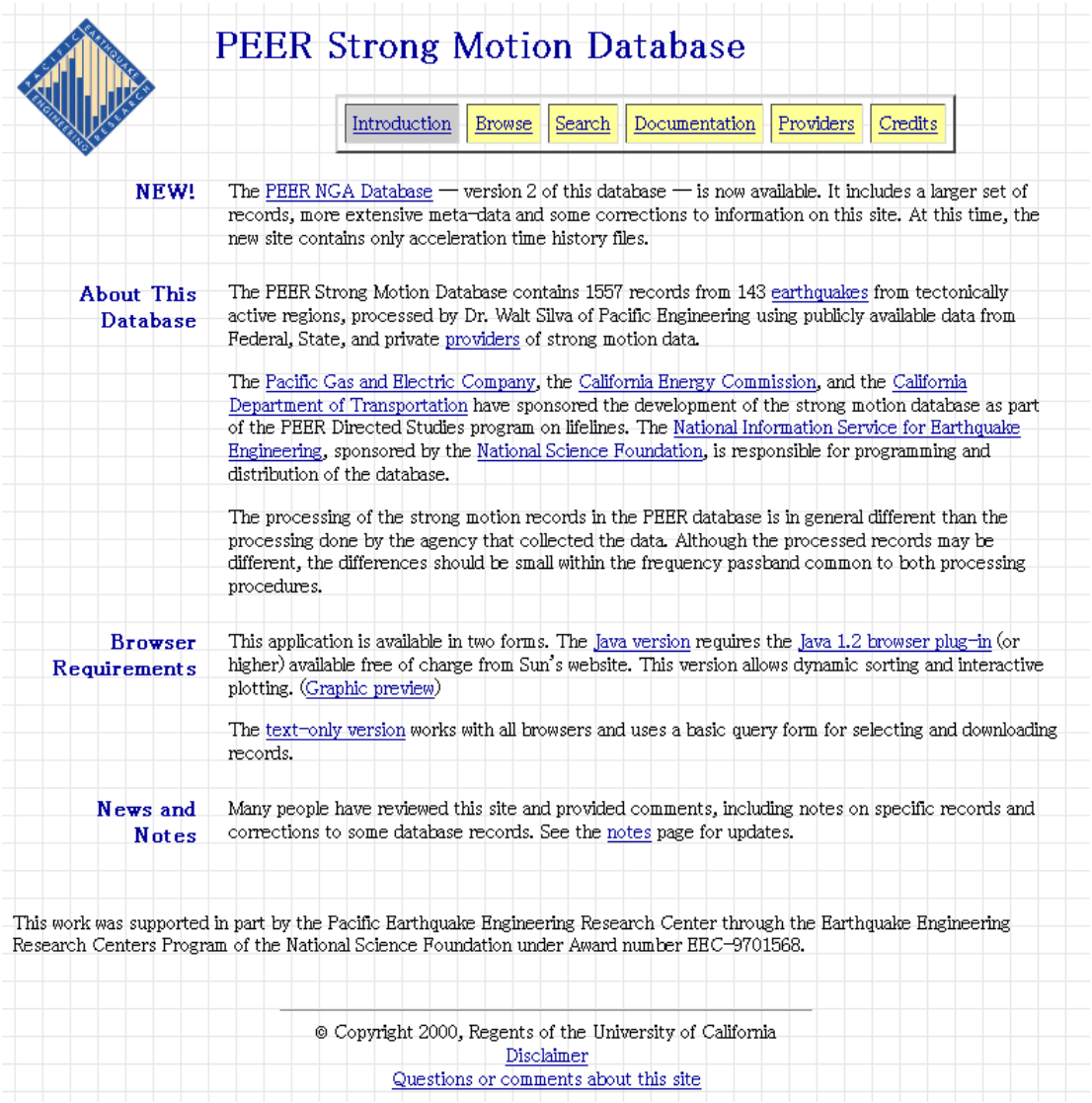

Figure 1.4 Screenshot at the PEER Strong Motion Database (http://peer.berkeley.edu/smcat/)

1.6 K-NET and KiK-net

The National Research Institute for Earth Science and Disaster Prevention (NIED) is operating some seismological and strong motion networks. The Kyoshin Net (K-NET) is the network of more than 1000 strong motion stations on the free field all over Japan. The KiK-net is the strong motion network installed with the high sensitivity seismograph network (Hi-net). Each station of KiK-net has two acceleration sensors on the ground and in the seismic bed rock. Strong motion data and station information from K-NET and KiK-net are provided by the respective web servers[10), 11)].

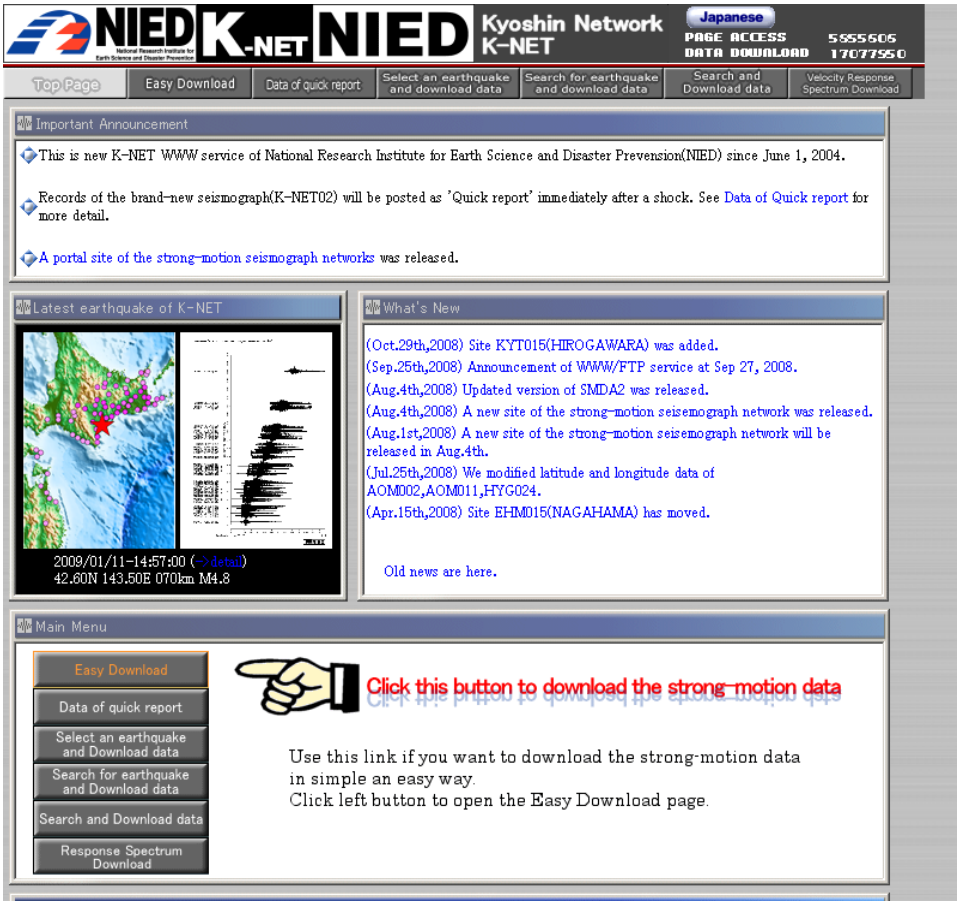

Figure 1.5 Screenshot at K-NET, NIED (http://www.k-net.bosai.go.jp/)

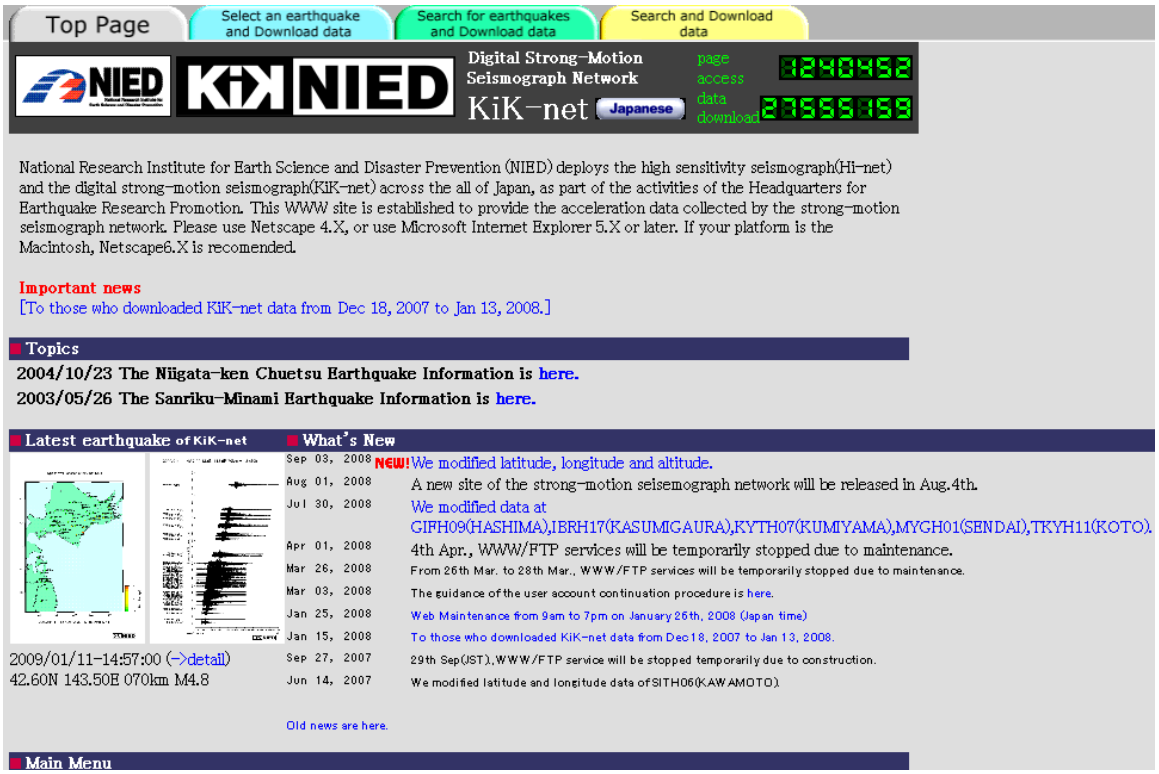

Figure 1.6 Screenshot at KiK-net, NIED (http://www.kik.bosai.go.jp/)

1.7 European Strong Motion Database

The European Strong Motion Database (ESD) was established in the frame of the 5th Framework Programme of the European Commission, Research-Directorate General, Environment and Climate Programme. This platform provides an interactive, fully relational database and databank with more than 3,000 uniformly processed and formatted European strong-motion records and associated earthquake-, station and waveform-parameters.

Figure 1.7 Screenshot at European Strong Motion Database (http://smbase.itsak.gr/)

1.8 BRI Strong Motion Database

The Building Research Institute (BRI), Japan, has renovated the strong motion web site and in 2009. The new web site provides the database containing the strong motion records observed in the BRI strong motion network.

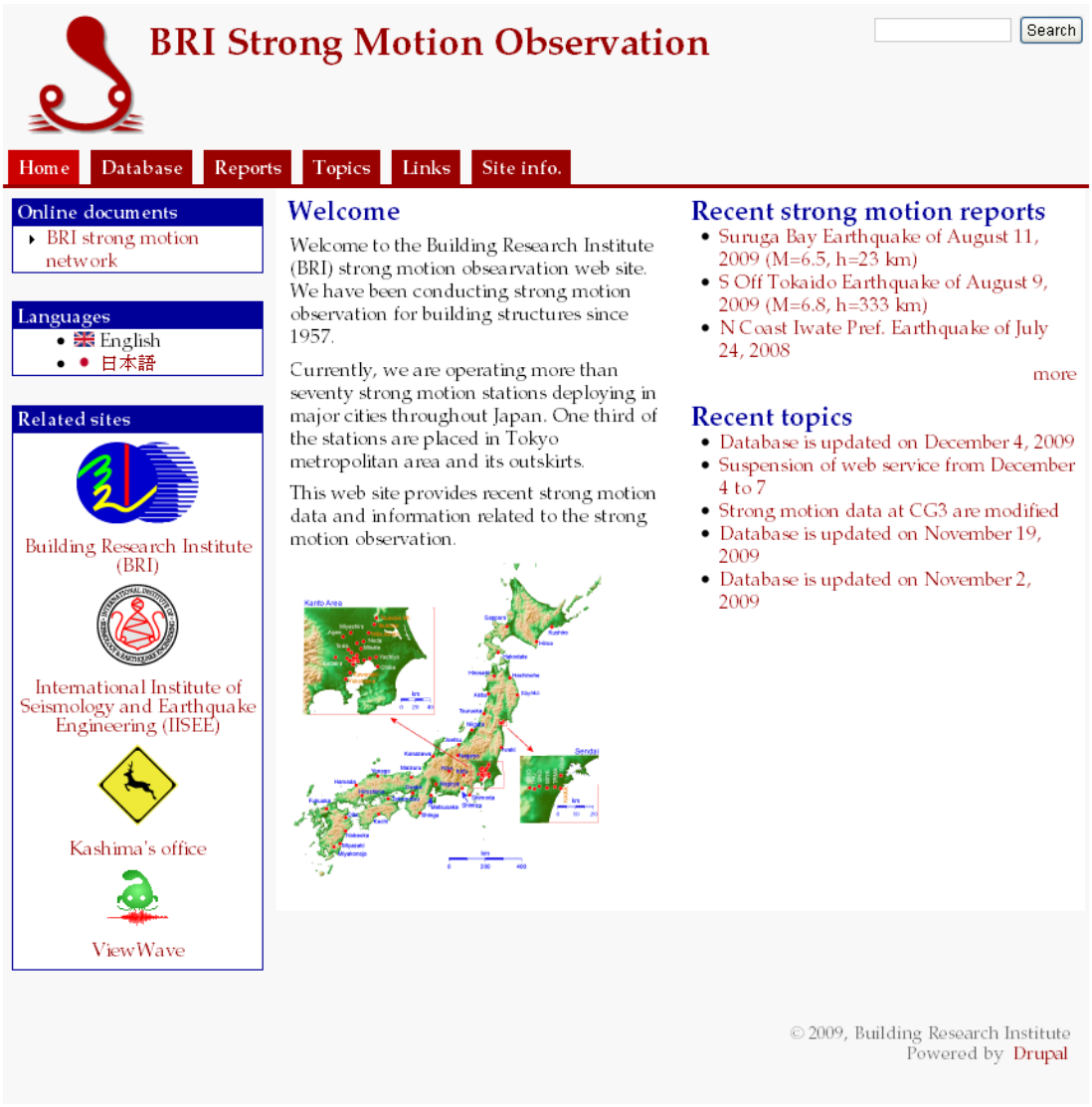

Figure 1.8 Screenshot at the BRI Strong Motion Database (http://smo.kenken.go.jp/)

2 Formats of Strong Motion Data

Most of strong motion data files are written in human-readable codes, such as the ASCII code. A data file contains necessary information as well as time series values of the strong motion data. Each strong motion network or database has a particular file format to store strong motion data and related information. Some typical formats are outlined in this chapter.

2.1 USGS (SMC) Format

The strong-motion time series data served out by the U.S. Geological Survey (USGS) National Strong-Motion Program (NSMP) are in one of two formats, SMC or BBF[13)]. The SMC format uses ASCII character codes and provides text headers, integer headers, real headers, and comments followed by digitized time-series, response spectra or Fourier amplitude spectra values. The header information is designed to provide the user with information about the earthquake and the recording instrument. The first line of each SMC-format file indicates type of contents, which is one of follows.

- "1 UNCORRECTED ACCELEROGRAM" (Also referred to as Volume 1 data)
- "2 CORRECTED ACCELEROGRAM" (Volume 2)
- "3 VELOCITY" (Volume 3)
- "4 DISPLACEMENT" (Volume 4)
- "5 RESPONSE SPECTRA" (Volume 5)
- "6 FOURIER AMPLITUDE SPECTRA " (Volume 6)

Files containing time series data, i.e. acceleration, velocity and displacement data, usually have a file extension ".smc".

```
2 CORRECTED ACCELEROGRAM
*
PSKIc
     2007  09  12    1110 SOUTHERN SUMATRA, INDONESIA
Moment Mag= 8.40     Ms=          Ml=
station = Sikuai Island, West Sumatra    component= 90
epicentral dist =    392.2       pk acc =  3.68E+1
inst type=K2         data source = CTO/USGS
*
*
*
    -32768      2007       255        11        11        46         0       590
         3    -32768    -32768     39768        90        90       128        10
     25800    -32768    -32768    -32768    -32768    -32768    -32768    -32768
    -32768    -32768    -32768    -32768    -32768    -32768         1     25800
    -32768    -32768    -32768    -32768    -32768    -32768    -32768    -32768
    -32768    -32768    -32768    -32768    -32768    -32768    -32768         3
  1.7000000E+38  2.0000000E+02 -4.5200000E+00  1.0137400E+02  3.4000000E+01
  8.3999996E+00  1.7000000E+38  1.7000000E+38  1.7000000E+38  5.0500000E+28
 -1.1247000E+00  1.0035340E+02  8.0000000E+01  1.7000000E+38  1.7000000E+38
  1.7000000E+38  3.9221179E+02  3.4315521E+02  3.3554430E+06  1.7000000E+38
  1.7000000E+38  5.0400002E+01  6.4999998E-01  1.2746450E-03  1.3051500E+02
  1.7000000E+38  1.7000000E+38  1.7000000E+38  5.7520000E+01  3.6847263E+01
  5.2119999E+01 -3.0702061E+01  1.2500000E-02 -2.0000000E+00  1.2000000E+01
  1.6000000E+01  1.7000000E+38  1.7000000E+38  1.7000000E+38  1.7000000E+38
  1.7000000E+38  1.7000000E+38  1.7000000E+38  1.7000000E+38  1.7000000E+38
  1.7000000E+38  1.7000000E+38  1.7000000E+38  1.7000000E+38  1.7000000E+38
|
| Converted using program evt2smc 2007/09/19 10:32:13
| Input file: BZ002_PSKI-00590.evt
```

```
| EventID: us2007hear
| Source: USGS NEIC (WDCS-D)
| GCMT Event: c200709121110A
| Original data acquired by Caltech Tectonics Observatory (CTO) with
| funding from USAID for the Indian Ocean Tsunami Warning System (IOTWS)
| provided to CTO through USGS Cooperative Agreement award #06WRAG0013.
| Processing by USGS NSMP.
 3.4204E-1 3.9491E-1 4.2996E-1 4.4627E-1 4.4497E-1 4.2882E-1 4.0160E-1 3.6736E-1
 3.2987E-1 2.9224E-1 2.5673E-1 2.2485E-1 1.9760E-1 1.7577E-1 1.6020E-1 1.5186E-1
 1.5178E-1 1.6077E-1 1.7904E-1 2.0575E-1 2.3877E-1 2.7458E-1 3.0852E-1 3.3525E-1
  :
  :
  :
```

Figure 2.1 Corrected acceleration data file in USGS (SMC) format

2.2 CISMIP Format

The California Strong Motion Instrumentation Program (CSMIP) provides three formats of strong motion data[14], which is called volumes 1 to 3.

A volume 1 file contains raw (uncorrected) acceleration time series data. No instrument correction or filtering has been applied to Volume 1 data, so it has all the noise in the original recording still present. A file has a text header, integer values header and real values header followed by acceleration data. Volume 1 files are generally named with a file extension ".v1".

Volume 2 files contain the processed acceleration, velocity and displacement time series data obtained by integrating and filtering the raw acceleration. The bandwidth of the filter is generally given in the file header for contemporarily produced files. The files have a format similar to the Volume 1 format. The files are generally named with a ".v2" suffix.

Volume 3 files contain the response and/or Fourier spectra. Several response spectra are usually given, including Sa, Sv, Sd and FS.

```
CORRECTED ACCELEROGRAM   24436-S1614-94017.02       CHAN  1:  90 DEG     FROM
UNCORRECTED ACCELEROGRAM DATA              PROCESSED: 09/09/94, CDMG QN94A436
NORTHRIDGE EARTHQUAKE OF JAN 17, 1994
CSMIP PRELIMINARY PROCESSING           (ORIGIN(CIT): 01/17/94, 12:30:55.4 GMT)
24436-S1614-94017.02               TRIGGER TIME: 01/17/94, 12:30:59.8 UTC
STATION NO. 24436   34.160N, 118.534W     SMA-1  S/N 1614
TARZANA - CEDAR HILL NURSERY A
CHAN  1:  90 DEG
NORTHRIDGE EARTHQUAKE OF JAN 17, 1994     CSMIP PRELIMINARY PROCESSING
HYPOCENTER(CIT): 34.215N, 118.538W, H=18KM. ML=6.6, MW=6.7(CIT); MS=6.7(NEIC)
INSTR PERIOD =  .0396 SEC,  DAMPING =  .583,  SENSITIVITY = 1.86 CM/G.
                        RECORD LENGTH = 60.000 SEC.
                                    UNCOR MAX  =  1.927 G, AT   8.352 SEC.
RMS ACCEL OF (UNCOR) RECORD  =  .160 G.
ACCELEROGRAM BANDPASS FILTERED WITH RAMPS AT  .050- .100 AND 23.00-25.00 CYC/SEC
  3001 POINTS OF INSTRUMENT- AND BASELINE-CORRECTED ACCEL, VELOC AND DISPL DATA
AT EQUALLY-SPACED INTERVALS OF    .020  SEC.
PEAK ACCELERATION =  1744.533    CM/SEC/SEC  AT    8.360   SEC.
PEAK   VELOCITY   =  -110.159      CM/SEC    AT    8.340   SEC.
PEAK DISPLACEMENT =    29.153        CM      AT    7.920   SEC.
INITIAL VELOCITY  =     1.702   CM/SEC;   INITIAL DISPLACEMENT =    4.395   CM
NORTHRIDGE EARTHQUAKE OF JAN 17, 1994     CSMIP PRELIMINARY PROCESSING

24436-S1614-94017.02      TARZANA - CEDAR HILL NURSERY A    CHAN  1:  90 DEG

    1    1    1    3    3    0    1    1    1 2048    0    0    0    0    0    0
    0    0    0    0    0    0    0    0    0    0   9012107   37   30   70    0
    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
    0    01210712107 3001    4   10   10    0    0   70   76   10   10    0 3001
    0 3001    0    0    0    0    0    0    0    0    0    0    0    0    0    0
    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
```

```
    0    0    0    0
      .040       .583    60.000       .160       .100     1.859     1.927     8.352
    25.250     50.000     2.690     50.000     4.956      .101     4.716     9.546
      .000       .000      .000       .000       .000      .000      .000      .000
      .000       .000      .000       .000       .000      .000      .000      .000
      .000       .000      .000       .000       .000      .000      .000      .000
      .000       .000      .000       .000       .000      .000      .000      .000
      .000       .000      .000     98.066       .005    60.000   158.650      .000
      .000     25.000     2.000     60.000       .020      .100      .050      .000
     8.360   1744.533     8.340   -110.159     7.920    29.153     1.702      .100
    23.000       .020      .020      4.395       .000      .000      .000      .000
      .000       .000      .000       .000       .000      .000      .000      .000
      .000       .000      .000       .000       .000      .000      .000      .000
      .000       .000      .000       .000
 3001 POINTS OF ACCEL DATA EQUALLY SPACED AT  .020 SEC.  (UNITS: CM/SEC/SEC)
      .364     -3.004    -3.425     -5.664     -5.234    -4.409    -2.501     -.315
    -6.206     -6.961    -1.645       .432     -3.208    -4.252    -1.044      .726
    -4.383     -4.509     2.699      3.470     -5.572   -12.333   -13.562      .783
 :
 :
 :
```

Figure 2.2 Corrected acceleration data file in CISMIP (DMG) format

2.3 COSMOS Format

The Consortium of Organizations for Strong Motion Observation Systems (COSMOS) defined a new format of strong motion data for their database[15]. The COSMOS format is based on the CSMIP format and improved some portions. The COSMOS format has four file types, volume 0 to volume 3. File extensions ".v0c", ".v1c", ".v2c" and ".v3c" are generally used for respective file names.

```
Corrected acceleration    (Format v01.20 with 13 text lines) Src:   ce57200f
Record of Thu Jun 15, 2006 05:24:46 PDT
Hypocenter: To be determined    H=   km       ML=     Mw=
Origin: To be determined
Statn No: 05- 57200 Code:CE-       CGS  Gilroy - 2-story Hospital
Coords: 37.037  -121.571   Site geology:
Recorder: K2     s/n 1329 (10 Chns of  10 at Sta) Sensor: FBA
Rcrd start time: 6/15/2006, 12:24:46.0 UTC (Q= )   RcrdId: 57200-K1329-06166.01
Sta Chan  1:  Up     (Rcrdr Chan  1) Location:Ground Floor
Raw record length =  50.000 sec, Uncor max =    .015 g, at    7.385 sec.
Processed:06/15/2006,12:24:46 UTC, CGS . Max =    15.133 cm/sec2 at    7.380 sec
Record filtered below   .30Hz , and above                          40.00 Hz
Values used when parameter or data value is unknown/unspecified:   -999, -999.0
 100 Integer-header values follow on  10 lines, Format= (10I8)
       2       1       3     120       1    -999    -999   57200    -999    -999
       5       5    -999       5    -999       1    -999    -999      10    -999
     338       1      10    -999    -999    -999    -999    -999    -999     108
       3    1329      10      10      24      18    -999       1       1    2006
     166       6      15      12      24       5       5    -999    -999       1
       1       4    -999    -999     500    -999    -999    -999    -999       1
       5       5    -999       0       0    -999    -999    -999    -999    -999
    -999    -999    -999    -999       1       0    -999    -999    -999       0
     500       0       0       0       1       0       0       0     333       3
       0     200    -999    -999    -999    -999    -999    -999    -999    -999
 100 Real-header values follow on  17 lines, Format= (6F13.6)
    37.037000  -121.571000    65.000000  -999.000000  -999.000000  -999.000000
  -999.000000  -999.000000  -999.000000  -999.000000  -999.000000  -999.000000
  -999.000000  -999.000000  -999.000000  -999.000000  -999.000000  -999.000000
  -999.000000  -999.000000  -999.000000      .298020     2.500000     9.000000
    30.000000  -999.000000  -999.000000  -999.000000  -999.000000    46.000000
  -999.000000     7.000000  -999.000000      .005000    50.000000  -999.000000
  -999.000000  -999.000000  -999.000000    50.000000      .700000      .625000
     2.500000     4.000000  -999.000000  -999.000000     1.000000  -999.000000
  -999.000000  -999.000000  -999.000000  -999.000000  -999.000000      .303030
  -999.000000      .000000    40.000000  -999.000000      .000000  -999.000000
  -999.000000    10.000000    50.000000    15.132740     7.380000    33.769290
  -999.000000     -.000024      .000021  -999.000000  -999.000000  -999.000000
```

```
  -999.000000  -999.000000  -999.000000  -999.000000  -999.000000  -999.000000
  -999.000000      .010000  -999.000000      .001630      .030583  -999.000000
      .000000  -999.000000  -999.000000   980.665000  -999.000000      .000000
     -.001813   980.690000  -999.000000  -999.000000  -999.000000  -999.000000
  -999.000000  -999.000000  -999.000000  -999.000000
   1 Comment line(s) follow, each starting with a "|":
|
|
    5000 acceleration pts, approx   50 secs, units= cm/sec2 (04), Format=(8f10.6)
  -.000058  -.000226  -.000082  -.000212  -.000063  -.000262  -.000065  -.000206
  -.000120  -.000261  -.000034  -.000162  -.000107  -.000584  -.000449   .000583
   .000239  -.001743  -.001019   .000271   .000653  -.000128  -.000689  -.000066
 :
 :
 :
```

Figure 2.3 Corrected acceleration data file in COSMOS format

A file can contain multi-channel data in the COSMOS format by putting an “End-of-data” line between data blocks of channels.

```
 :
 :
End-of-data for Chan  1 acceleration
Corrected acceleration    (Format v01.20 with 13 text lines) Src:   ce57200f
 :
 :
```

Figure 2.4 Boundary of channels in COSMOS format

2.4 PEER Format

Data files provided by the PEER strong motion database have more simple data structure. A file can have a single acceleration time series. Each file has four header lines in which minimum information is described. Data files of the PEER database usually have a file extension “.at2”.

```
PEER STRONG MOTION DATABASE RECORD. PROCESSING BY CDMG.
NORTHRIDGE 01/17/94 1231, TARZANA - CEDAR HILL NURSERY A, 090 (CDMG STATION
24436)
ACCELERATION TIME HISTORY IN UNITS OF G. FILTER POINTS: HP=0.1 Hz LP=23.0 Hz
NPTS=  2000, DT= .02000 SEC
   .5445240E-03  -.2892047E-02  -.3322675E-02  -.5607659E-02  -.5170258E-02
  -.4329955E-02  -.2384987E-02  -.1564558E-03  -.6166460E-02  -.6937741E-02
  -.1516599E-02   .6007679E-03  -.3113202E-02  -.4179247E-02  -.9082497E-03
 :
 :
 :
```

Figure 2.5 Acceleration data in PEER format

2.5 K-NET Format

K-NET furnishes strong motion data in their original format. A file contains a single channel acceleration data. Each data file has a 17-line header followed by acceleration data. The acceleration data is written as raw data values in digital counts and scaling factor is given in the header. Each K-NET station has tri-axial accelerograph orienting to North-South, East-West and Up-Down directions, therefore a strong motion record consists of three files with file extensions “.ns”, “.ew” and “ud”.

KiK-net adopted the compatible format with K-NET. They provide six-channel data from a station, so file extensions are ".ns1", ".ew1" "ud1" ".ns2", ".ew2" and "ud2". Suffixes "1" and "2" indicate sensors in the bedrock and on the ground, respectively.

```
Origin Time       2008/06/14 08:43:00
Lat.              39.0
Long.             140.9
Depth. (km)       10
Mag.              7.0
Station Code      NIG001
Station Lat.      38.2584
Station Long.     138.4337
Station Height(m) 6
Record Time       2008/06/14 08:44:28
Sampling Freq(Hz) 100Hz
Duration Time(s)  104
Dir.              E-W
Scale Factor      3920(gal)/6182761
Max. Acc. (gal)   13.059
Last Correction   2008/06/14 08:44:13
Memo.
  -19357   -19313   -19279   -19263   -19271   -19372   -19438   -19342
  -19253   -19270   -19285   -19305   -19354   -19342   -19298   -19300
  -19289   -19281   -19345   -19366   -19317   -19319   -19320   -19291
  -19326   -19353   -19308   -19297   -19326   -19317   -19310   -19322
  -19301   -19287   -19302   -19292   -19308   -19368   -19334   -19249
  -19292   -19374   -19341   -19320   -19379   -19361   -19277   -19277
   :
   :
   :
```

Figure 2.6 Acceleration data in K-NET format

3 References

1) Center for Engineering Strong Motion Data (CESMD): http://www.strongmotioncenter.org/

2) Consortium of Organizations for Strong - Motion Observation Systems (COSMOS): http://www.cosmos-eq.org/

3) COSMOS Virtual Data Center: http://db.cosmos-eq.org/

4) USGS National Strong-Motion Project (NSMP): http://nsmp.wr.usgs.gov/

5) California Strong Motion Instrumentation Program (CSMIP): http://www.conservation.ca.gov/cgs/smip/

6) PEER Strong Motion Database: http://peer.berkeley.edu/smcat/

7) PEER NGA database: http://peer.berkeley.edu/nga/

8) PEAR Next Generation of Ground-Motion Attenuation Models (NGA) project: http://peer.berkeley.edu/products/nga_project.html

9) National Research Institute for Earth Science and Disaster Prevention (NIED): http://www.bosai.go.jp/

10) K-NET, NIED: http://www.k-net.bosai.go.jp/

11) KiK-net, NIED: http://www.kik.bosai.go.jp/

12) European Strong Motion Database: http://smbase.itsak.gr/

13) SMC-format Data Files: http://nsmp.wr.usgs.gov/smcfmt.html

14) Shakal, A. P. and M. J. Huang: Standard Tape Format for CSMIP Strong-motion Data Tapes, California Strong Motion Instrumentation Program Report OSMS 85-03, California Department of Conservation, Division of Mines and Geology, December 1985

15) COSMOS Strong Motion Programs Board: COSMOS Strong Motion Data Format, Consortium of Organizations for Strong-Motion Observation Systems, August 2001