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Study on Technology and Data of the Strong Motion Data Share Sub-center

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Abstract

As part of China's earthquake science data share project, the strong motion data share sub-center is mainly composed of strong motion observation database and engineering damage database. It provides data retrieval and data download service of strong motion observation database and engineering damage database through the website. The main implementation technologies of strong motion data share sub-center include WebGIS technology, database technology, web technology, and storage technology. The national strong motion observation network system is also briefly introduced. As of December, 31, 2013, the strong motion data share sub-center has published 18 volumes of the "China Strong Motion Record Assembly Report". The strong motion data share sub-center have assembled and processed 47 sets of strong motion records from 1968 to 2013. 28419 pieces of strong motion records are assembled in the strong motion database. The statistical data for strong motion database sorted by different index are also provided. The aims of this work are to provide significant support for researchers and engineers to make better use of the strong motion data share sub-center, and to promote its use to play a more important role in related research fields.

Keywords: data share; acceleration time series; strong motion database; strong motion observation;

1. Introduction

The Earthquake Science Data Share Project is one of the data share projects started by the Ministry of Science and Technology, People's Republic of China, in 2002 [1].It is under the planning and management of the National Scientific Basic Platform, in order to implement standardization data acquisition, data processing, and data storage. This project aims to integrate earthquake science data resource and build up data share service platform based on modern information technology. The strong motion data share sub-center is developed from the strong motion database and engineering damage database [2].First, strong motion data assemble and processing system was constructed by of Institute of Engineering Mechanics, China Earthquake Administration funded by the National Basic Research Special Fund of the Ministry of Science and Technology, People's Republic of China. Since then it has served as the strong motion data share sub-center of the national earthquake science data share center. The strong motion data share sub-center was improved by collecting and processing more strong motion data step-by-step and year-by-year. The strong motion data share sub-center has provided strong motion data and engineering damage data service for all scientists and engineers since 2002. It has become widely used in China, with a large number of registered users.

2. System Framework

The technical systems of the strong motion data share sub-center mainly include the data storage and backup system, the data management system and the data dissemination system. In order to the implement the process, management, and share of data effectively, support platforms, including internet communication platform, internet security platform and power supply platforms have also been constructed.

2.1 Storage Backup Technology

The storage and backup system includes two main components. The first is the tape backup system, mainly used for data backup of the data acquisition server, webpage server, and file transfer protocol server. The second is the SAN (Storage Area Network) data storage system, mainly used for the online data service. The SAN is built from two EMC Ds4400M fiber switches. The storage device, and the server are both attached to the SAN, creating a double-redundant backup, high-availability SAN system.

2.2 Database Technology

In order to improve the availability of the database, the database of strong motion data share sub-center adopted dual-computer hot-backup technology, the specific workflow is showed as follows: to ensure the platform can be used continuously, the database server is configured as a cluster system, with two servers configured to share one database. Thus, if one server cannot function normally due to a hardware or software fault, the other server in the cluster will take over the application and the database from the failed server. The database system can switch servers successfully within tens of seconds to a few minutes.

2.3WebGIS Technology

The key technology of the strong motion data dissemination system is supported by the ArcGIS server platform. This system includes a database server, spatial data engine, online analysis and calculation system (Fig. 1). The system was developed mainly by ASP (Active Server Pages), JSP (Java Server Pages), ArcGIS Engine and other tools. The online analysis and calculation system consists of the DLL components developed by Visual Basic and FORTRAN, and the ASP pages then call these components to complete the corresponding calculations [3]. The strong motion data of the data dissemination system are divided into spatial data and attribute data. The attribute data stored in the Oracle database management system are published through a web server and middleware system. The release of the spatial data is divided into two steps: First, ArcGIS server drives the ArcSDE spatial data engine, which is directly connected to the Oracle database, to access all kind of spatial vector data. Then, the ArcGIS server converts the spatial vector data to a raster map and performs spatial indexing, and data compression of the raster data.

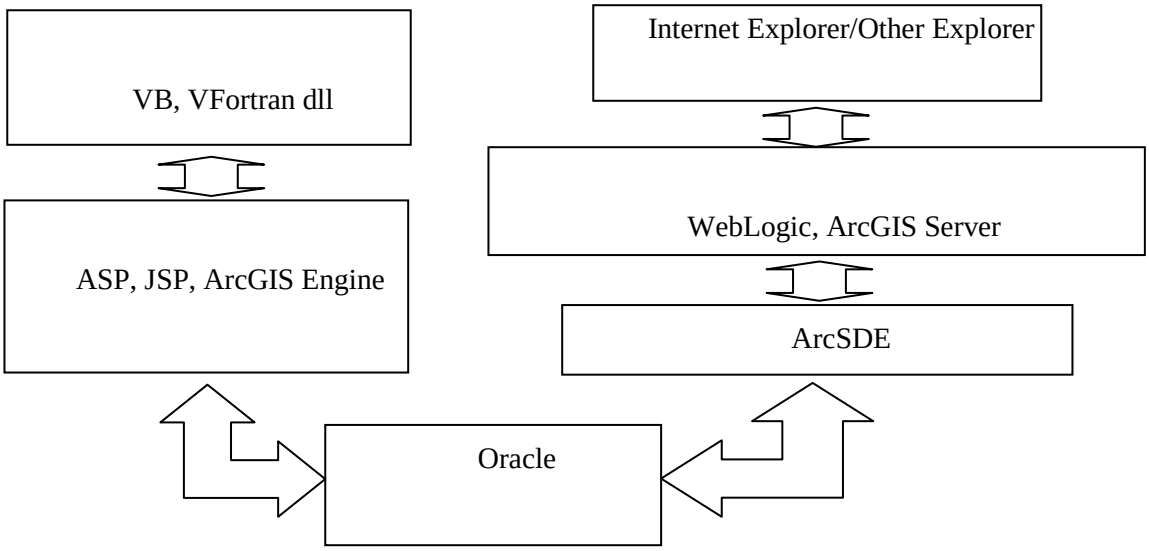

Fig.1 Schematic of the strong motion data dissemination system

2.4 Web Technology

ASP and JSP technology are used to publish data and information that can be accessed through the web browser. ASP is mainly used to build the whole webpage framework, while JSP is mainly used for user registration, data retrieval, and data downloading from the data share services. The strong motion data share sub-center provides data share services to network users mainly through web services. Registered users can use the browser to retrieve various data resources that have been stored in the strong motion database and damage database. Users can download the strong motion data, images of earthquake damage, and related information.

2.5 Information Security Technology

The firewall system of the strong motion data share service system between the intranet and extranet works as an effective barrier to protect the network boundaries and to prevent hacking. All packets in and out of the network are checked here. At the same time, an intrusion detection system is also deployed to detect network attacks, to update the operating system and network vulnerabilities, and to improve the information security of the service system. All servers providing internet services are equipped with anti-virus software, with regular automatic updates of the virus library, to ensure that the virus software on the network can deal with newly emerging viruses.

3. Data Share

3.1 Data Assembly

China's strong motion observation project was launched in 1962, with the development of fifty years, the National Strong Motion Observation Network System (NSMONS) is composed of 1154 free-field fixed stations, 310 seismic intensity fast-reporting stations, 12 special arrays, and 200 temporary stations since 2007 (Fig. 2).The 1154 fixed stations are deployed in the 21 national key earthquake monitoring areas. The average distance between stations is approximately 25 km, which is close to the international standard. When earthquakes with magnitude lager than 4.0 occur in these key monitoring areas, many strong motion station of

NSMONS can obtain strong motion records. In the second level earthquake monitoring areas, the average distance between stations is approximately 40 km. When earthquake with magnitude larger than 4.0 occur in these monitoring areas, at least one station can obtain strong motion record. The 310 fixed stations for the fast reporting of seismic intensity are also deployed. They are deployed in the earthquake zones located around Beijing, Tianjin, Lanzhou, and Urumqi. The 12 special strong motion observation arrays are deployed according to different research objectives. These arrays include one active fault effect array consisting of 30 fixed free-field observation stations, two ground motion attenuation arrays composed of 50 fixed free-field observation stations, two site influence arrays consisting of eight surface observation points and eight borehole observation points, one topography array consisting of eight surface observation points, four arrays of structural seismic response observation stations located in high-rise, multi-stores, large-span and base isolation buildings, composed of 46, 23, 46, and 14 observation points respectively, one large bridge array composed of 23 observation points, and one large dam array composed of 21 observation points. The 200 sets temporary equipment for strong motion observation are also equipped. To ensure the effective maintenance and operation of NSMONS, the effective strong motion data collection, processing, storage, and management, and the provision of fast and effective online data services, the national strong motion network management system has also been established. The system include 1 national strong motion network center, 3 regional strong motion network centers, 5 seismic intensity fast-reporting network centers, and 31 provincial strong motion network centers [4].

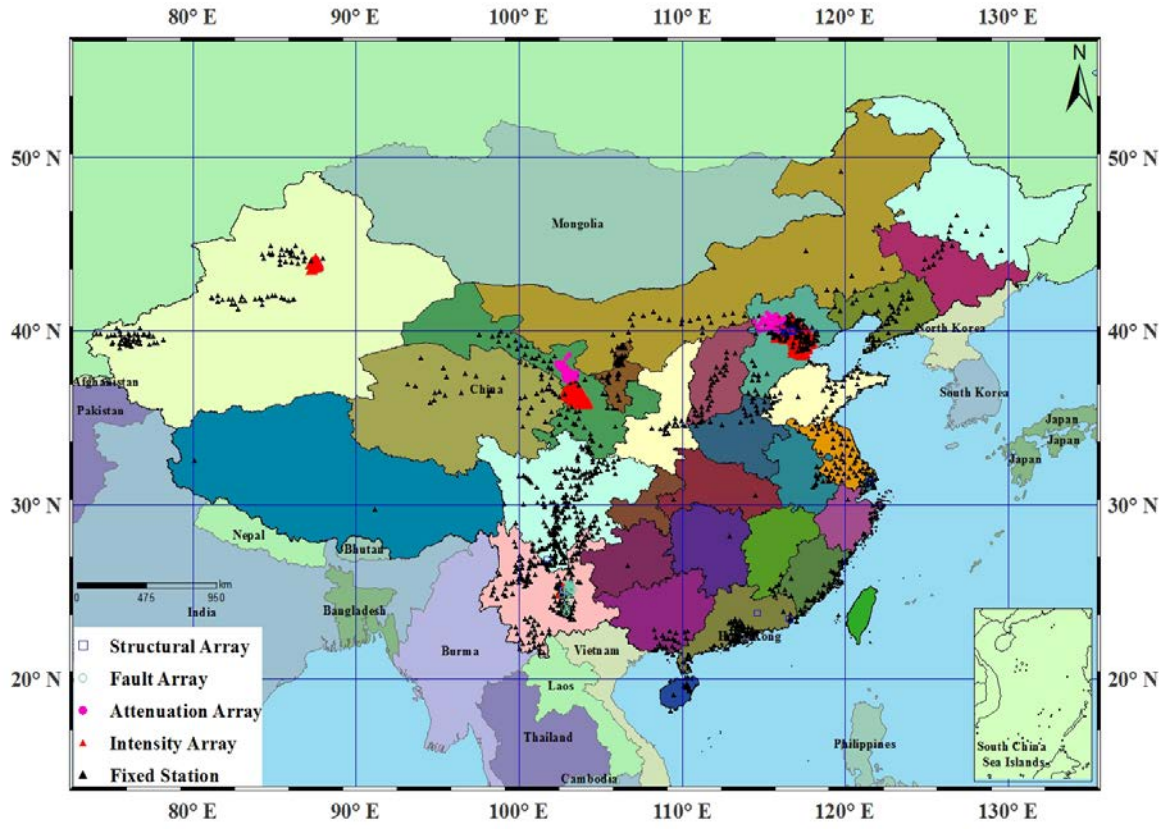

Fig. 2 China's digital strong motion observation network

After completing the "Ten Five Plan" Project of the China Earthquake Administration, the strong motion data share sub-center published 7 volumes of the "China Strong Motion Record Assembly Report" [5~11]. Because the strong motion data recorded during the earthquakes that occurred in 2014 and 2015 are still in processing. Exact statistical data are only available up to the end of 2013.As of December, 31 of 2013, the strong motion data share sub-center has published 18 volumes of the "China Strong Motion Record Assembly Report", and assembled and processed 47 strong motion data sets. The data set of strong motion records includes a total of 28419 entries, with a time span covering from 1968 to the present. These strong motion data were recorded from 2956 earthquakes with magnitudes from 0.6 to 8 (Table 1). The numbers of entries in the strong motion database cataloged by six consecutive time periods are shown in Fig. 3. Before the establishment of NSMONS, only 5184 data entries from strong motion records had been collected and processed for data share. A statistical distribution map of the database cataloged by peak ground acceleration is shown in Fig.4.The number of entries corresponding to a peak ground acceleration larger than 10 cm/s/s is 11777. The strong motion data share sub-center has developed into the most authoritative database in China.

Table 1 Strong motion data sets collected and processed by the strong motion data share sub-center

No.	Earthquake (Array)Name	Date of Earthquake	Magnitude	Number of Events	Number of Accelerograms
1	Tangshan 1	1976.07.28-1976.11.15	3.5-7.8	38	267
2	Haicheng	1975.02.08-1975.02.28	3.0-5.4	24	366
3	Longling	1976.06.05-1976.06.29	2.3-6.2	11	87
4	Gengma	1988.11.06-1988.12.06	2.3-7.6	92	403
5	Tonghai	1970.01.14-1970.09.04	2.6-5.7	11	87
6	Xinfengjiang Reservoir Arrays 1	1968.10.21-1978.09.02	2.6-4.7	17	231
		1989.11.26	4.5	1	11
7	WuQia 1	1985.08.28-1985.09.20	3.2-6.3	18	52
8	XinJiang	1985.09.01-1990.10.25	1.9-6.4	32	55
9	Tangshan Arrays 1	1982.07-1984.12.11	2.3-5.7	52	555
10	Datong	1989.10.18-1989.10.25	3.2-5.3	7	24
11	Xinfengjiang Reservoir Arrays 2	1970.11.26-1973.03.11	2.5-3.7	7	103
12	Wusu	1995.05.02-1996.03.22	3.3-6.9	7	24
13	Shidian 1	2001.04.10-2001.04.16	3.5-5.9	6	27
14	Yaoan	2000.01.15-2000.01.31	2.7-6.5	9	38
15	Shidian 2	2001.04.22-2001.05.19	1.5-3.9	32	105
16	Jiji	1999.09.21	7.6	1	567
17	Yongsheng	2001.10.27	6	1	6
18	Gonghe	1994.02.16-1994.09.24	5.2-5.6	3	8

No.	Earthquake (Array)Name	Date of Earthquake	Magnitude	Number of Events	Number of Accelerograms
19	Sunan	1976.08.16-1992.01.12	2.7-7.5	19	84
20	Wuding	1995.10.25-1995.10.27	4.1-5.3	8	24
21	Lijiang	1995.01.31-1996.02.09	3.7-7.0	12	54
22	Atushi	1995.09.26-1996.03.22	3.3-6.9	6	21
23	Huangbizhuang Reservoir Arrays	1968.07.25-1974.06.06	2.4-5.2	6	65
24	Guanting Reservoir Arrays	1976.11.15-1994.12.23	3.8-6.9	2	17
25	Liujiaxia Reservoir Arrays	1995.07.22	5.8	1	19
26	Douhe Reservoir Arrays	1979.08.25-1980.04.16	3.6-4.7	3	25
27	Longyangxia Reservoir Array	1990.04.26-1994.10.10	1.9-6.9	3	47
28	Jiashi	1997.01.21-2003.03.31	3.2-6.8	139	459
29	WuQia 2	2002.12.25-2003.02.14	4.2-5.7	5	21
30	Yunnan	2000.08.21-2003.05.27	2.7-5.3	7	33
31	Tangshan Arrays 2	1994.09.03-1999.12.21	1.4-5.9	50	417
32	Bachu	2001.03.22-2003.03.31	3.9-5.8	3	12
33	Tangshan Arrays 3	1998.01.03-2004.01.20	0.6-7.2	159	621
34	Dayao	2003.07.24-2003.08.18	3.1-4.7	18	54
35	Shidian 3	2001.04.08-2001.10.11	3.2-4.2	1	15
36	Tangshan 2	2004.01.20-2004.12.04	2.4-5.0	20	102
37	Sichuan	2006.08.24-2007.11.11	2.0-4.3	25	114
38	Gansu	2001.07.07-2008.03.30	3.1-6.1	31	150
39	Xinjiang 2	2007.04.16-2008.10.05	4.1-6.8	8	147
40	Puer	2007.06.03-2007.06.05	4-6.4	2	120
41	Wenchuan Mainshock	2008.05.12	8.0	1	1260
42	Wenchuan Aftershock(fixed station)	2008.05.12-2008.12.31	4.0-6.4	383	6078
43	Wenchuan Aftershock (temporary station)	2008.05.12-2008.12.31	2.0-6.9	949	2745
44	2007-2009 (excluding Wenchuan Earthquake)	2007.01.01-2009.12.31	2.6-6.7	185	2499
45	2010-2011	2010.01.01-2011.12.31	2.0-7.1	86	2046
46	Lushan Earthquake	2013.4.20-2013.7.20	2.5-7.0	177	3729

No.	Earthquake (Array)Name	Date of Earthquake	Magnitude	Number of Events	Number of Accelerograms
47	2012-2013(excluding Lushan Earthquake)	2012.1.3-2013.12.29	1.3-6.7	278	4425
Sum		1968.07.25-2013.12.31	0.6-8.0	2956	28419

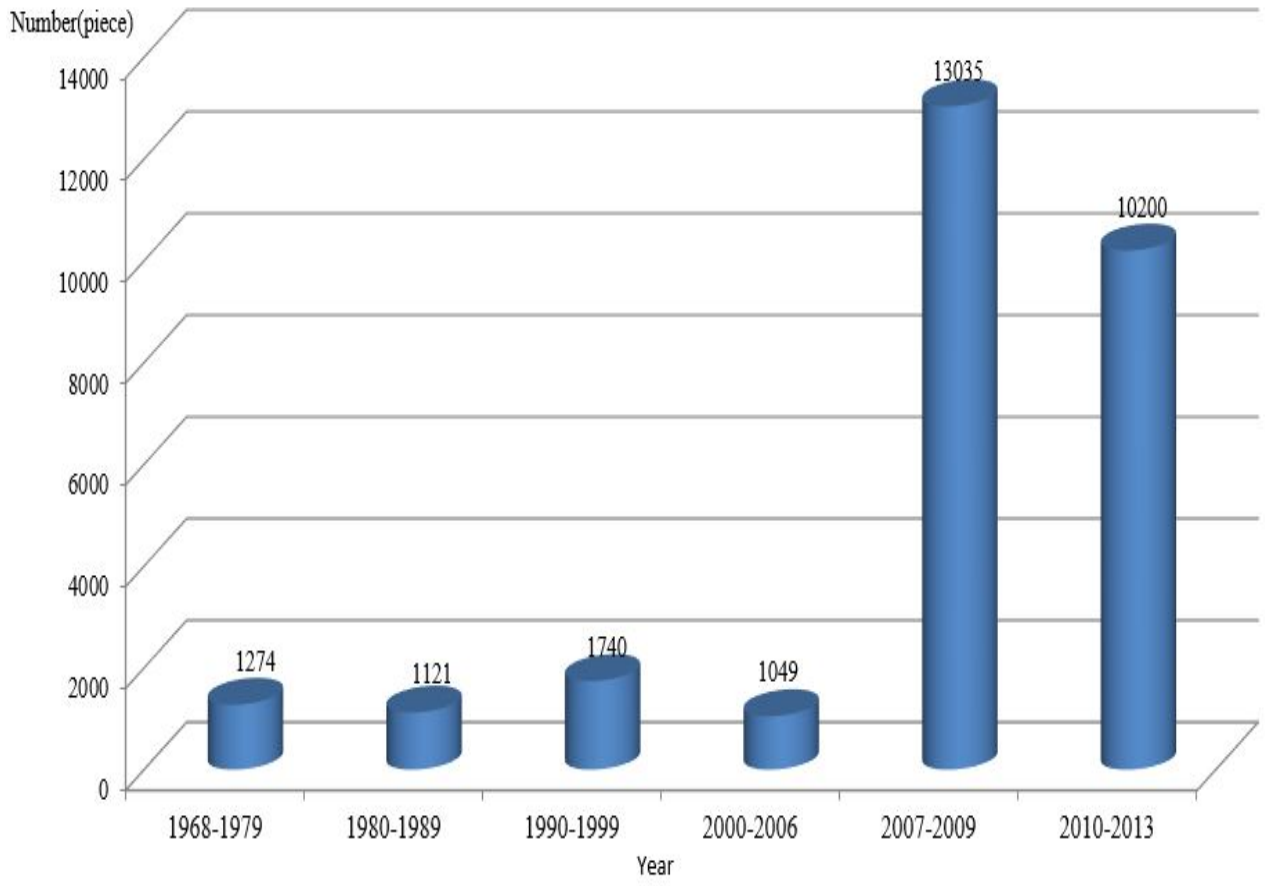

Fig. 3 Distribution map of strong motion records cataloged by year

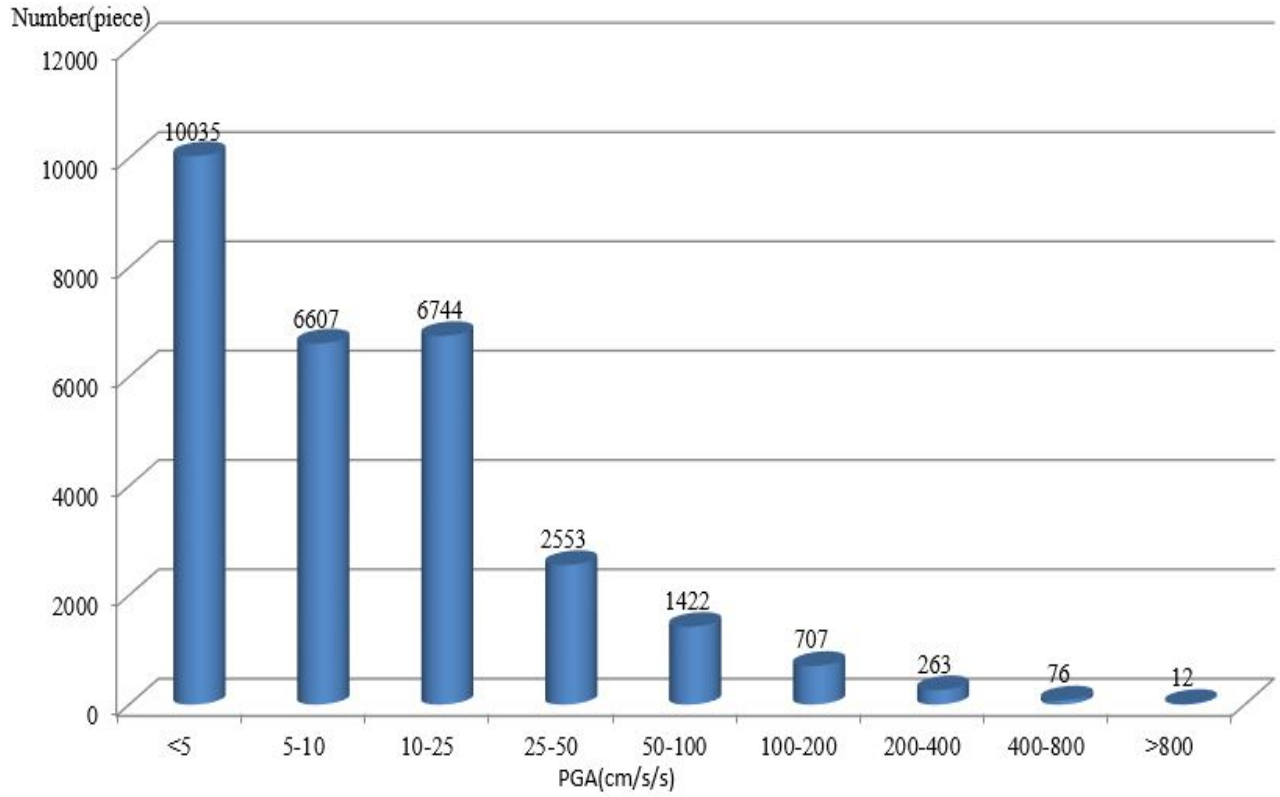

Fig. 4 Distribution map of strong motion records cataloged by peak ground acceleration

An overview of the strong motion data trigged by significant earthquakes is briefly presented. During the Ms 8.0 Wenchuan Earthquake, a total of 420 stations distributed among 19 provinces(e.g.,Sichuan,Yunnan,Gansu,Shaanxi…)and municipalities(i.e., Beijing,Tian,and Shanghai)[12] were trigged, and 1260 strong motion acceleration time histories were recorded. Among them, the greatest peak ground acceleration was 957.8 cm/s/s, recorded by Wolong station, and more than 118 peak ground accelerations greater than 100 cm/s/s [5]. During the strong motion observation of the Wenchuan aftershocks, 76 strong motion stations deployed in Sichuan province and Gansu province were triggered by 383 aftershocks [6].1915 strong motion records were recorded by 62 stations deployed in Sichuan province and 111 groups of strong motion records were recorded by 14 stations deployed in Gansu province. More than 701 groups of peak ground acceleration greater than 10 cm/s/s. It is rare in such a large district to obtain such abundant acceleration records during the major aftershocks in strong motion observation history of the world. During the Ms 7.0 Lushan Earthquake, more than 80 stations located in Sichuan province and Yunnan province were triggered, 15 pieces of strong motion records greater than 200cm/s/s, 12 pieces of strong motion records between 100 and 200 cm/s/s.The biggest strong motion record is obtained by 51BXD [10]. After baseline correction, the peak ground acceleration of the east-west component of 51BXD was greater than 1000 cm/s/s, it is the first record that exceed 1g in mainland China (Fig. 5).

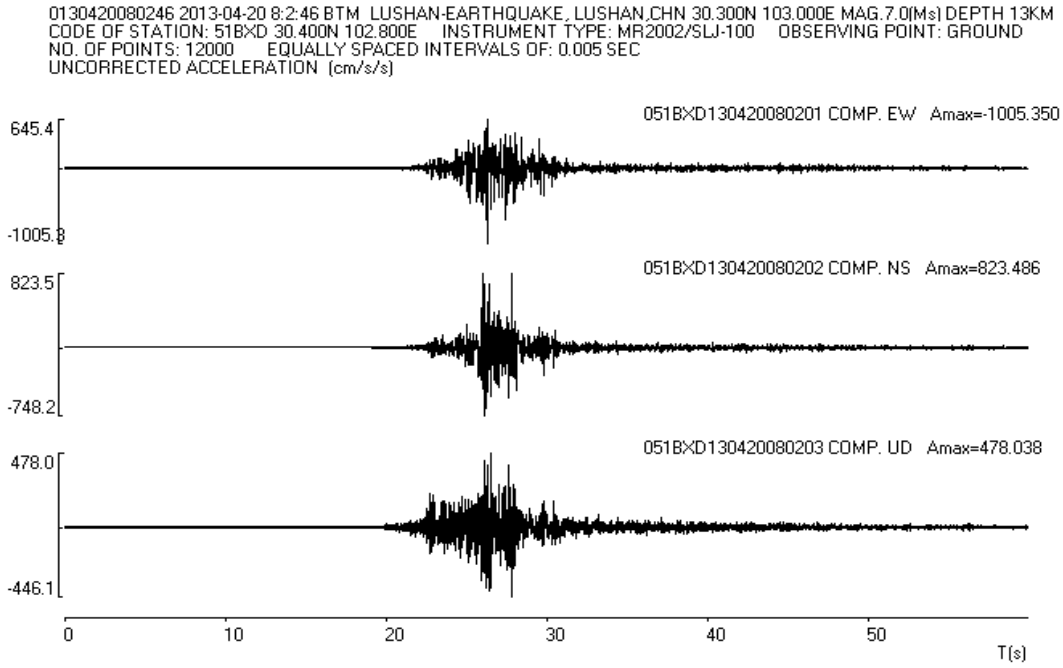

Fig. 5 The greatest strong motion recorded in mainland China, recorded by 51BXD station, triggered by the Lushan Earthquake

3.2 Data Share Service

The strong motion data-share sub-center takes the main responsibility for data assembly, data processing, data storage, and data share. The homepage of the sub-center presents the main modules, namely, the strong motion database module, engineering damage database, strong motion station retrieval system based on WebGIS technology, user registration module, and information download module [13]. The data-share service includes both online and offline data share. For online data share, new users can register with the sub-center by filling in some personal information from webpage http://www.smsd-iem.net.cn:8080/smsd/user/regist.jsp.Then the staff will check the information and grant the registered user data download permission. The registered user can log into the database from webpage http://www.smsd-iem.net.cn:8080/smsd/user/login.jsp. Users then can freely search the strong motion records according to their requirements and download data from http://www.smsd-iem.net.cn:8080/smsd/eqkview.jsp. It provided basic research and advanced research. In webpage http://www.smsd-iem.net.cn:8080/smsd/eqkview/basic.jsp. Registered users can search the data by earthquake name, station name, magnitude, peak ground acceleration, site condition and epicenter distance. The result will show in the webpage http://www.smsd-iem.net.cn:8080/smsd/eqkview/basic_sub.jsp. Then you can download not only data on acceleration, velocity, displacement, Fourier spectra, response spectra, and related waveform pictures freely. The users can also visit http://www.smsd-iem.net.cn:8080/smsd/eqkview/eqkshow.jsp by click on the map to select the data you want to download. The engineering damage database include the engineering damaged images assembled from spot scientific investigation when a damaged earthquake occur and exchanged with other countries. Registered users can visit the engineering damage database from http://www.smsd-iem.net.cn:8080/smsd/eqk.jsp. The engineering database can be searched by earthquake name, and it can also be visited by different engineering damage object such as buildings, components, lifeline system, site and others. Registered users can download the images of engineering damage freely according to their requirement.

Offline data share is also applicable, for example, if users want to obtain large data sets, such as the complete strong motion data of the Wenchuan Earthquake. In this case, users must download the data application form from the information download module on the homepage, fill in the blanks as required, provide a personal

signature, and post the application form to the strong motion data-share sub-center. The staff will check the information and then provide the applicant with an FTP account, allowing them to freely download the specified large data set. According to the strong motion data application protocol and the data-share procedure, the sub-center will publish related information on the homepage whenever a new strong motion data set is processed. As of December 31, 2013, more than 200 researchers had applied to obtain the strong motion data of the Wenchuan Earthquake, totaling more than 128 GB of data transferred. Most are associated with universities and research institutes, governments, and businesses in China, Japan, and the United States. Registered users can search and download not only data on acceleration, velocity, displacement, Fourier spectra, response spectra, and related waveform pictures from the strong motion database, but also images of engineering damage affecting all kinds of structures and components from the engineering damage database. Users can also retrieve information on the strong motion stations through the strong motion station information inquiry system [14].

4. Conclusion

The technologies used to construct the strong motion data-share sub-center are described in this paper, and the national strong motion observation management system is also briefly introduced. As of December 31, 2013, the strong motion data-sharing sub-center had published 18 volumes of the "China Strong Motion Record Assembly Report," and assembled and processed 47 sets of strong motion records from 1968 to 2013. A list of the strong motion data sets, including key data, is tabulated in this paper. In total, 28419 entries are assembled in the strong motion database. Statistical data sorted by various indices are also provided. The aims of this work are to provide significant support for researchers and engineers to make better use of the strong motion data-share sub-center platform, and to promote the use of the sub-center to play a more important role in related research fields.

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6. Copyrights

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