Strong Motion Observation System and Project Plan in China

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Contents

1. China Digital Strong Motion Observation Network
2. Demonstrative Earthquake Early Warning System under Construction
3. Development Program in the Next 10 Years
4. Strong Motion Records from the M8.0 Wenchuan Earthquake
Contents

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Distribution of Strong Motion Network Stations in China

About 3,000 stations and arrays under the management of CEA
More than 1,000 stations under the management of other institute and enterprise
Most of these stations were built in the “Strong Motion Network Project in China” (2003-2008)

Distance between 2 stations:
  about 25 – 50 km in most regions
And about 5 km in Beijing area

Different instrument houses for the stations

Instruments in the station
Because of the large differences between China and some countries, USA, Japan in G-M-O before 2000

CEA proposed a big project plan to build a digital strong motion observation network system

The project was approved by China government in 2002

For the project, total investment amount is about 370 million RMB (about 60 million USD)

How to arrange the project? must consider an effective distribution of the observation points
Consider the Background of Earthquakes in China

Strong earthquake distribution in China (M>= 6.0)
Background of Earthquakes in China

Earthquakes occurred were non-uniform in space.

Recorded earthquake distribution (including $M \leq 4.7$)
Based on the analysis results of seismic tendency, 21 main monitoring areas of strong earthquakes were divided in mainland (1995-2005)

8 first level and 13 second level

First level: bigger magnitude, higher probability
Second level: smaller magnitude, low probability
Target of the project was to control the density of stations in different areas. Space between 2 stations is:
1. about 25km in 8 first level monitoring areas
2. about 40km in 13 second level monitoring areas
3. less than 10 km in 5 main cities for intensity rapid reporting
National Strong Motion Observation Network System

- National network center
- 3 regional network centers
  - 5 city network centers
    - 370 intensity rapid reporting stations
    - 1160 permanent stations
- 12 special arrays
  - 1 active fault array
  - 2 attenuation arrays
  - 2 site effect arrays
  - 1 topography effect array
  - 4 typical building arrays
  - 1 bridge array
  - 1 dam array
- 10 relative software compiling
1 national center and 4 regional centers for the network management
Intensity Rapid Reporting Network for 5 Cities

- Beijing: 80 stations
- Tianjing: 80 stations
- Lanzhou: 50 stations
- Urumuqi: 50 stations
- Kunming: 50 stations
Beijing Intensity Rapid Reporting Network

80 stations
Mobile observation centers

- Beijing: 80 sets
- Nanjing: 40 sets
- Lanzhou: 40 sets
- Kunming: 40 sets
Near Fault Ground Motion Observation Array

30+20 stations
space: 5-10km
Ground Motion Attenuation Observation Array

50 stations in each array
space: 5-10km

East one

West one
Site Effect Observation Array (east and west)

west array in Yunan
East array in Tangshan
8 points (3 comp.) for each
Topography Effect Observation Array

In Sichuan
8 points (3 comp.)
Bridge Response Observation Array

Dangshi bridge in Santou
bridge Length is 3467m
main span is 512m
23 points (3 comp.)
Dam Response Observation Array

Ertan arch dam in Sichuan
height is 240m
22 points (3 comp.)
High-rise Building Response Observation Array

Shanghai Huanqiu Finance Center
104-storey (3 underground)
The height is 492m
46 points (3 comp.)
Multi-storey and Base Isolated Building Response Observation Array
Large Span Building Response Observation Array

A sport hall for 2008 Beijing Olympic games

46 points (3 comp.)
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• Considering the benefit of earthquake early warning system in Japan and other countries, CEA proposed a new project plan to build demonstrative earthquake early warning system

• The project would be carried out from 2008 to 2012

• For the project, total investment amount: about 70 million RMB (about 10 million USD)
Earthquake Early Warning System in Construction (2008-2012)

In this project

• Two earthquake early warning system arrays
• and some free-field stations
Earthquake Early Warning System in Construction

Stations on the 5 circles

one earthquake early warning system array in Capital area
Earthquake Early Warning System in Construction

Stations on the several circles

Other earthquake early warning system array in Lanzhou area
Distribution of Strong Motion Network Stations in Mainland of China After 2012
Distribution of Strong Motion Network Stations in Beijing-Tianjin area After 2012

About 500 stations (2006-2012)
space: less than 5km
Contents

1. China Digital Strong Motion Observation Network
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China  Earthquake Intensity Rapid Reporting and Earthquake Early Warning System (2013-2020)

• After the construction of the digital strong motion observation network system (2003-2008) and the demonstrative earthquake early warning system (2008-2012), the next great project is proposed
• An earthquake Intensity Rapid Reporting and Earthquake Early Warning System will be constructed
• In the system, about 9,000 stations will spread all over mainland of China.
• For the project, the estimated investment amount is about 3.0 billion RMB (about 0.45 billion USD)
Distribution of about 9,000 Stations in the planned system
Contents

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Records from the earthquakes before 2000

- The strong motion observation in China began in 1962
- In 1962, the first strong motion record in mainland of China was obtained at the Xinfengjiang reservoir site in the south China after the Xinfengjiang reservoir-induced earthquake M6.1 in 1962
- But only about 3000 useful records had been obtained from only 283 stations and arrays until 2000
Records from the earthquakes during 2000 to 2008

• From 2000 to 2008 before M8.0 Wenchuan earthquake, over 6,000 records were obtained from earthquakes M<6.5
  
  Most of them was recorded by the New digital strong motion observation system in construction at that time

• But only about 1,000 records with PGA>10 gal
Large numbers of records were obtained from the main shock and aftershocks of Wenchuan Earthquake.

1. 460 stations and 3 arrays obtained 1,350 records from the main shock.

Topography Effect Observation Array
2. 15,903 components of records were obtained from 949 aftershocks
   Most of them were recorded by the mobile stations

After main shock, quickly deployed mobile stations at more than 70 points
There were about 4000 components of strong motion records obtained from 510 earthquakes except the M8.0 Wenchuan earthquake and aftershocks in 2008~2009.

And also some records were obtained in this 2 years.
In the records from the main shock:
239 Stations with PGA $\geq 10$ gal
In the records from the main shock:

- The largest PGA: 958 gal at Wolong station
- in the hanging wall area with a rupture distance of 23 km
The interesting result:

- the largest PGA of aftershock records was 966 gal from Qingchuan Eq. M4.2 (2008.08.10)
- but M4.2, and epicentral distance is 1.4 km
Strong rupture directivity effect and multi-segment rupture effect
Different shapes of time-histories from records in different locations
Strong rupture directivity effect and multi-segment rupture effect

Different shapes of time-histories from records in different locations
Earthquake Early Warning in Wenchuan Earthquake?

From the Wenchuan earthquake, we can understand the effect of earthquake early warning system.
the effect of earthquake early warning system?
Thanks!