Fault-fling Effect from the Near-source Strong-Motion Records of the Great 2008 Wenchuan Earthquake

Ming LU[1] John X. ZHAO[2] Ya Min ZHAO[1]

1. Institute of Crustal Dynamics,
China Earthquake Administration, Beijing, China
2. GNS Science, Lower Hutt, New Zealand

Introduction

- The largest horizontal permanent ground displacement is 5.3m and the largest vertical displacement is 6.2m.
- Both the main fault (Longmenshan fault) and the secondary fault (Hanwang-Bailu fault) have a relatively shallow dipping angle towards to the north-west.

- Wenchuan earthquake strong-motion records：
- 2 records within 15km
- 5 records within 30km

- Two types of velocity pulse:
- forward-directivity pulse (Somerville et al. 1997)
- and fault-fling pulse (Abrahamson 2006).

- The forward-directivity effect occurs only at stations on the receiving side of the fault-rupture propagation. This velocity pulse is typically in two directions (positive and negative) and the ground surface displacement due to the velocity pulse reaches nearly zero after the velocity pulse passes the recording station.

- The fault-fling pulse is a result of permanent fault displacement and this velocity pulse usually occurs in one direction. The ground surface displacement is almost constant after the fault-fling pulse passes the recording site.

- In practice, a near-source record may contain both types of velocity pulses.

Figure 1 presents a classical example of these two types of velocity pulse – a near-source record obtained at Lucerne recording station from the 1992 Landers earthquake (M_w=7.3, California, USA) at a source distance of just over 2km. This earthquake has a strike-slip focal mechanism and the fault rupture initiated at one end of the fault and propagated towards to the Lucerne station which is located at the other end of the fault.

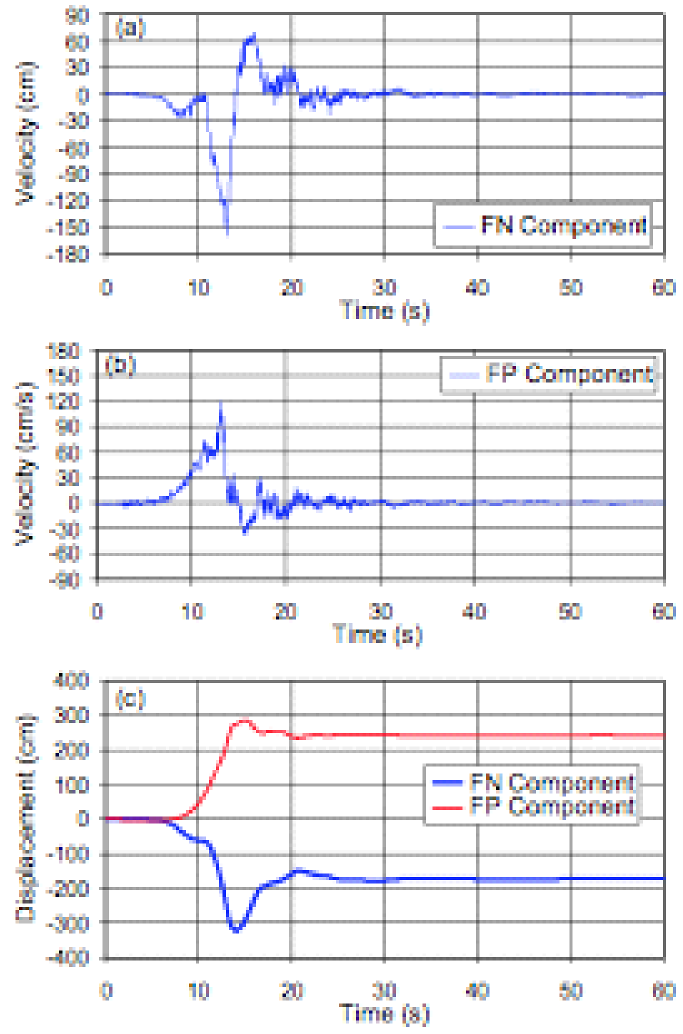
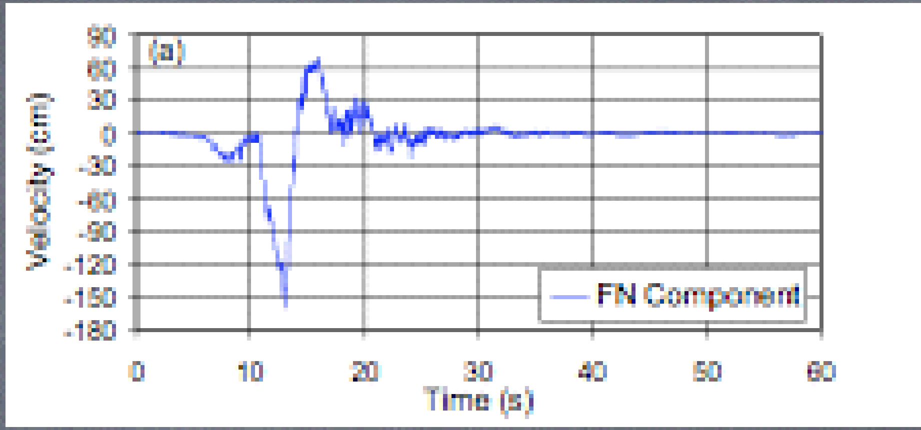
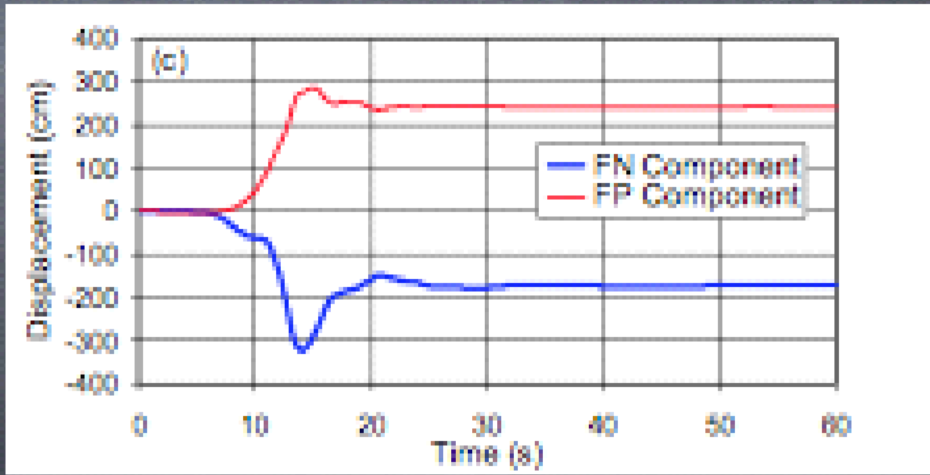


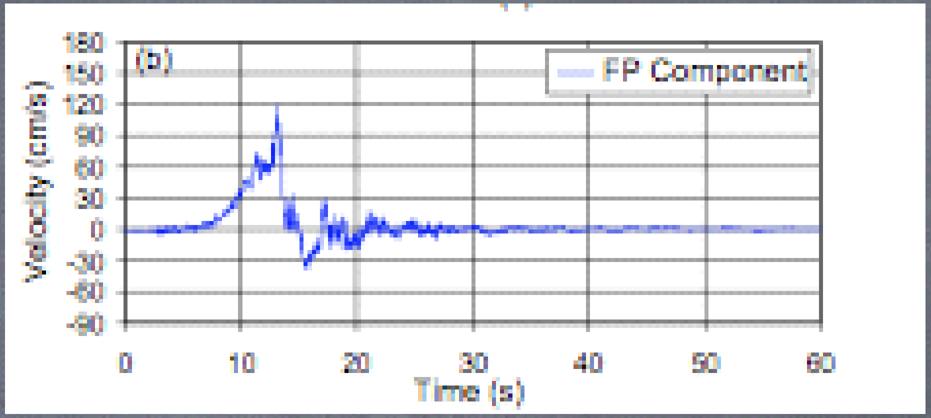
Figure 1 The velocity and displacement time histories of the Lucerne record obtained from the 1992 Landers earthquake, (a) velocity time histories for the fault-normal component; (b) velocity time histories for the fault parallel component; and (c) the displacement time histories for both fault-normal and fault-parallel components

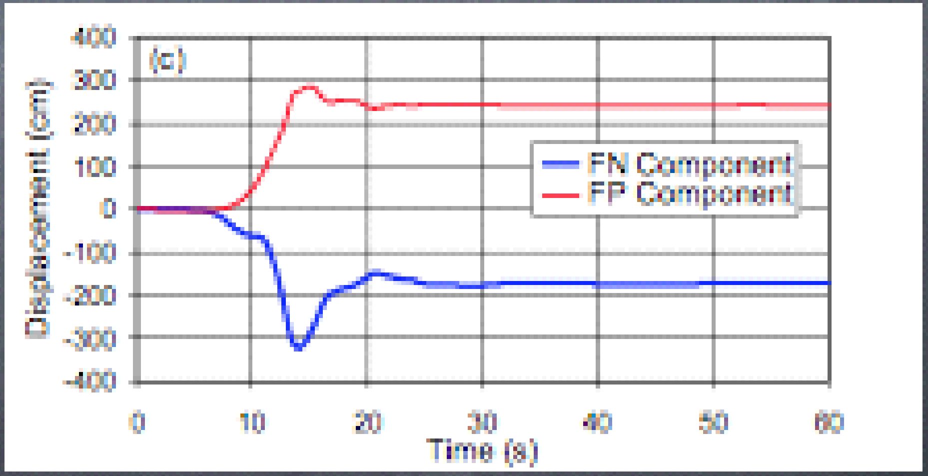
- The fault-normal (FN) component for this record contains the forward-directivity velocity pulse as shown in Figure 1(a) and also contains fault-fling effect (see the permanent ground displacement just over 170cm, the thick line in Figure 1(c)). The difference between the peak ground displacement (PGD) (just over 300cm) and the ground permanent displacement is due to the positive velocities in the time window of 14-22s.



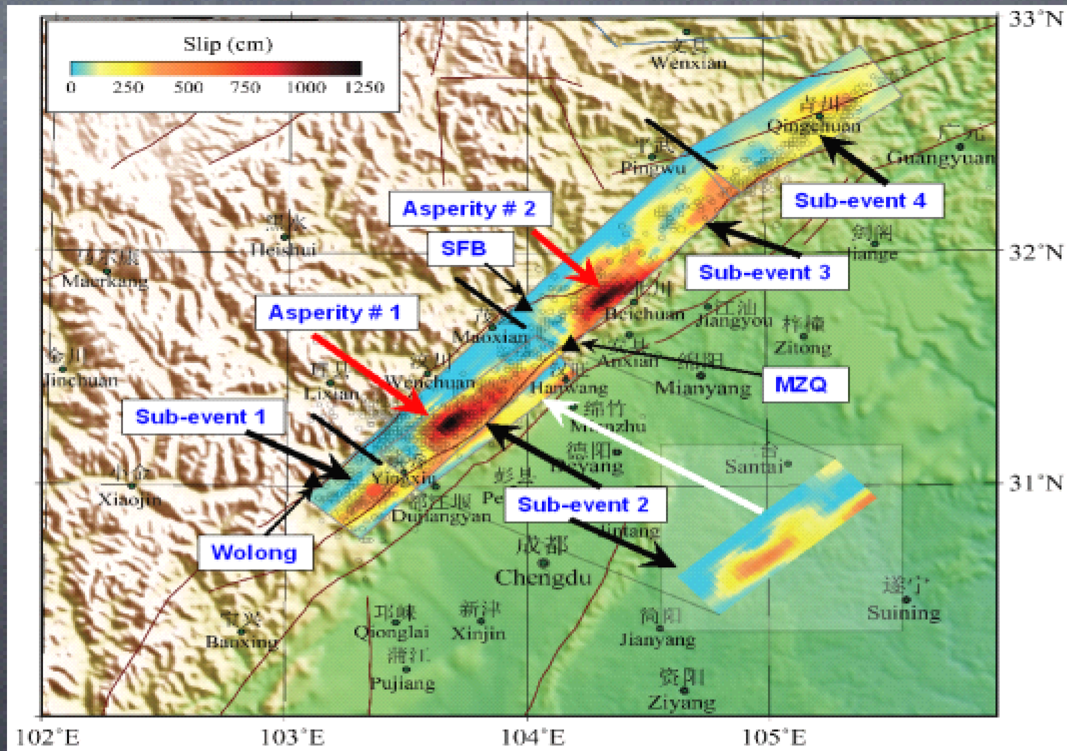


- The fault-parallel component contains a fault-fling velocity pulse as shown in Figure 1(b). The velocity pulse is largely in the positive direction which leads to a permanent ground displacement of just over 240cm as shown in Figure 1(c).



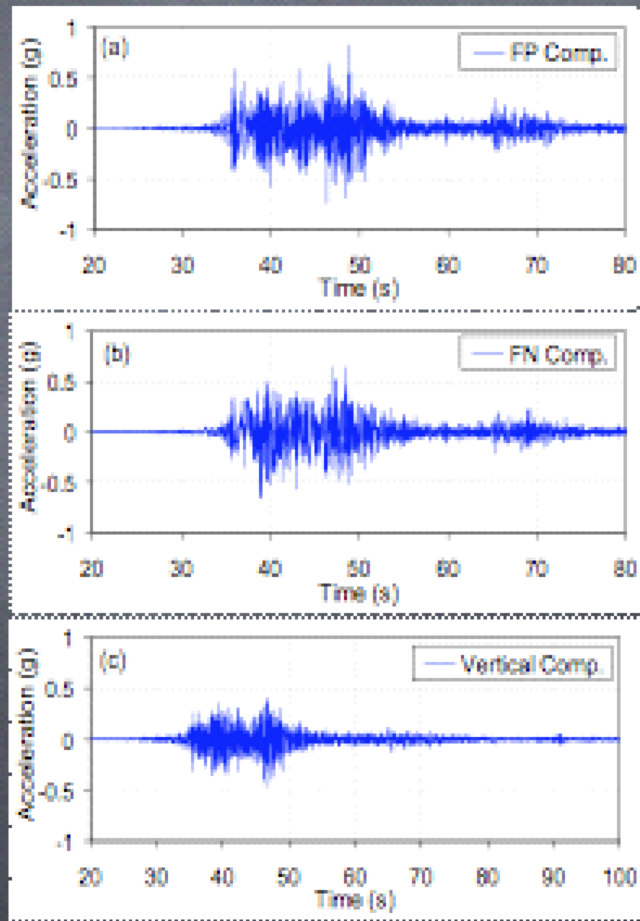


In the present study, we present the characteristics of two strong-motion records that have obvious fault-fling effect and we compare the near-source records from the Wenchuan 2008 earthquake with those from the 1992 Landers earthquake (California, USA) and the 1999 Chichi, Taiwan earthquake.



A. Fault-fling effect from the MZQ record

- Figures 3-5 show the "corrected" time histories from the MZQ site with a source distance less than 2km.
- PGA, PGV and PGD for this record are presented in Table 1. The processing technique is from Boore (2001).



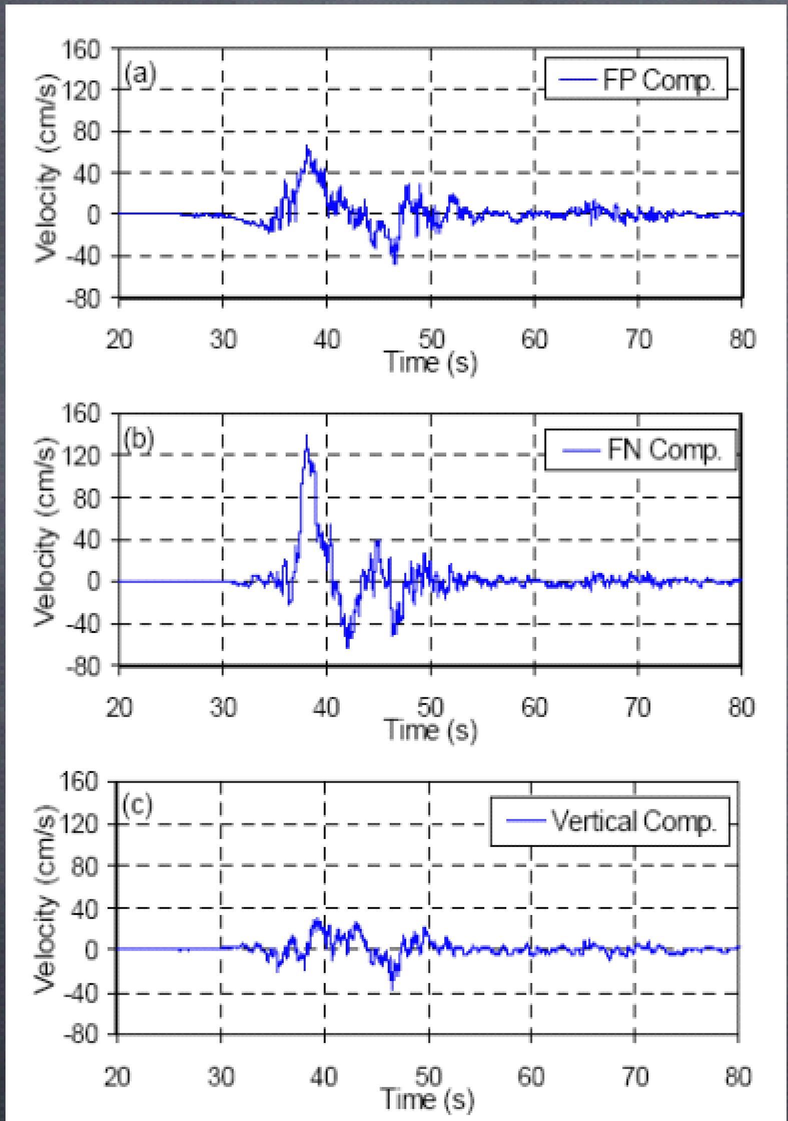


Figure 4　Corrected velocity time histories of the MZQ strong-motion record

(a) fault-parallel Component

(b) fault-normal component

(c) the vertical component

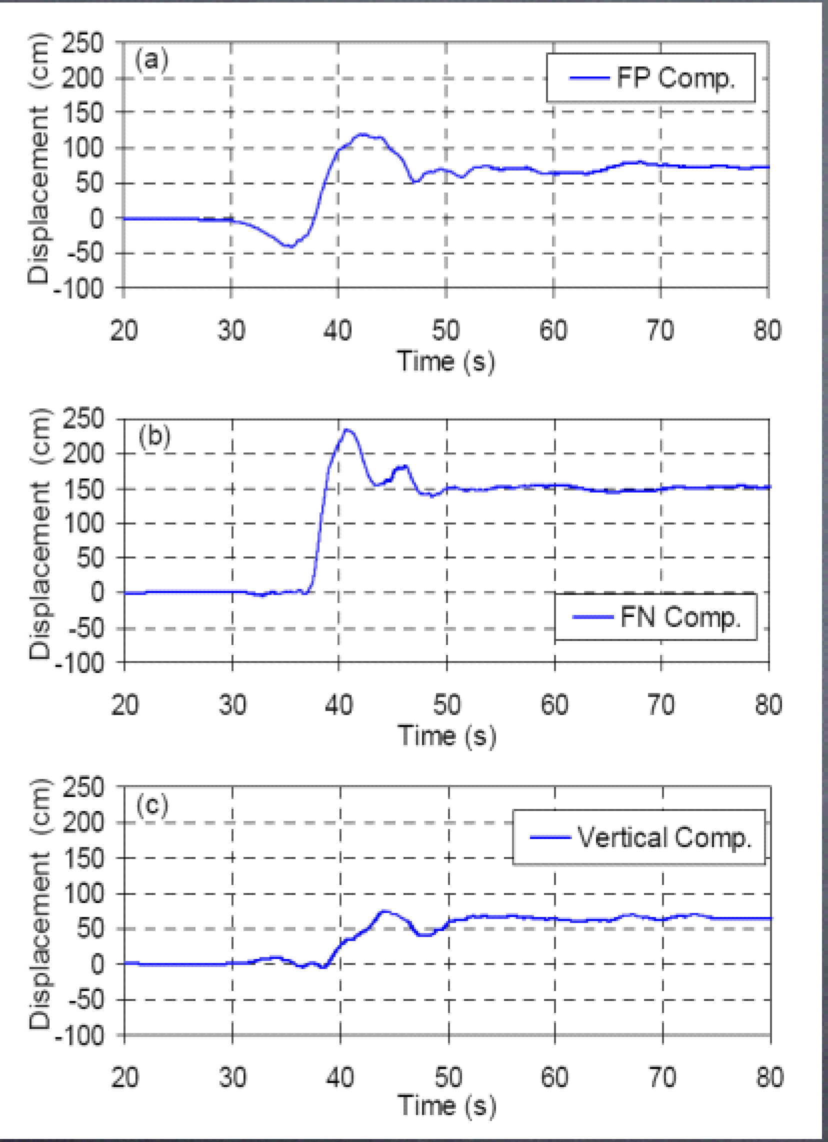


Figure 5 Corrected displacement time histories of the MZQ strong-motion record

(a) fault-parallel component

(b) fault-normal component

(c) The vertical component

2 绵竹青平MZQ强震记录断层残余位移效应

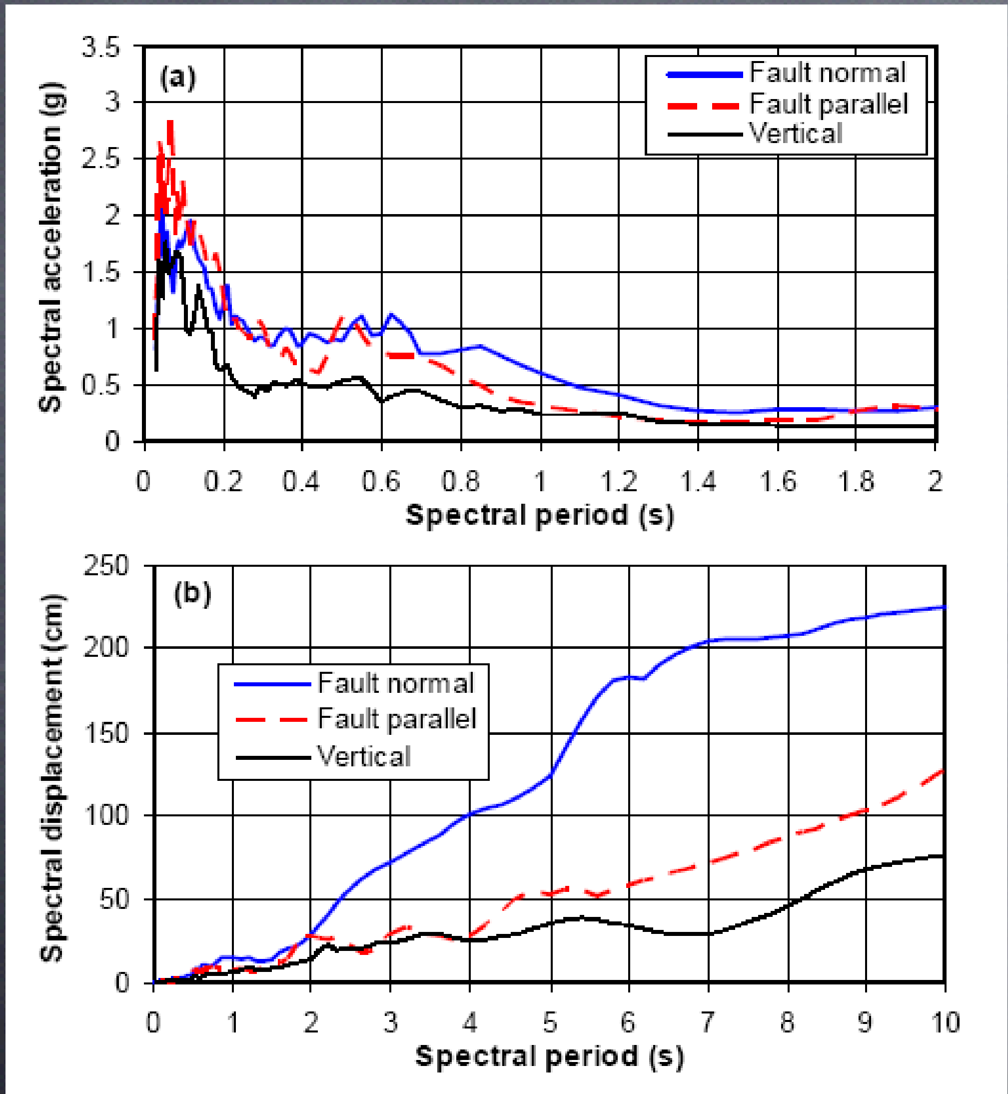


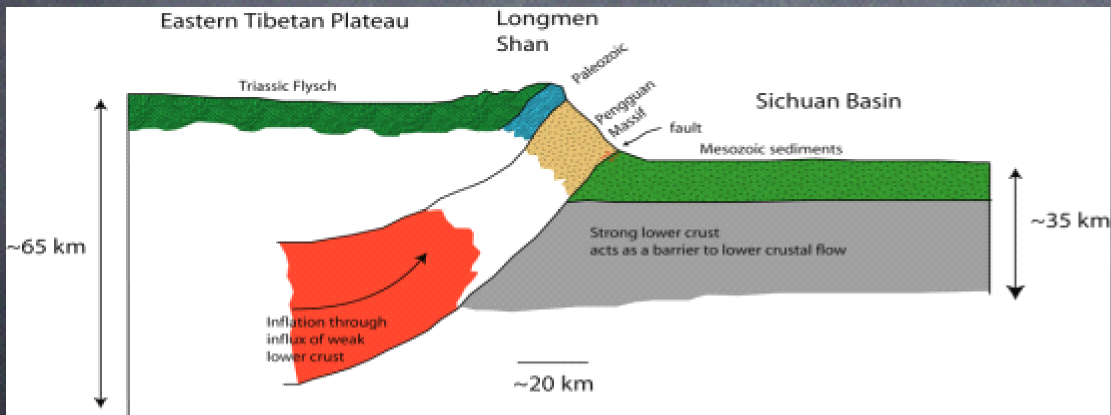
Figure 6
Response spectra of the MZQ strong-motion Record
(a) acceleration spectra
(b) displacement spectra

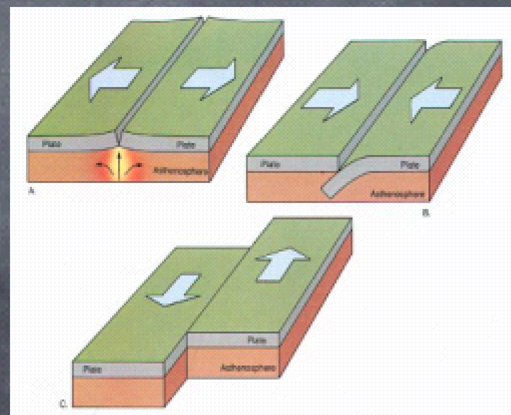
Table 1 Peak ground acceleration, velocity and displacement for 2 near-source records of the Wenchuan earthquake

	PGA (g)	PGV (cm/s)	PGD (cm)
	MZQ (Soil)		
Fault-normal	0.669	139	235
Fault-parallel	0.827	66	119
Vertical	0.471	38	75
	SFB (Soil)		
Fault-normal	0.490	79	76
Fault-parallel	0.512	38	52
Vertical	0.563	85	376

A thrust earthquake fault inside a continent

Both the main fault (Longmenshan fault) and the secondary fault (Hanwang-Bailu fault) have a relatively shallow dipping angle towards the north-west.

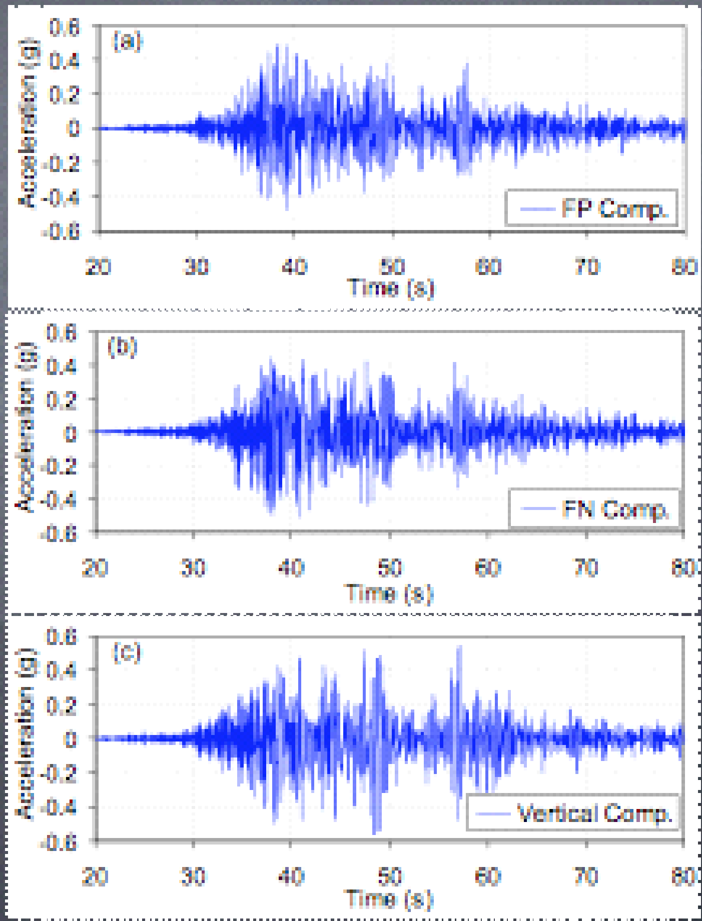




B. Fault-fling effect from the SFB record

- Figure 7 shows the acceleration time histories of the SFB record at a source distance of 14 kilometres.

- The duration of strong shaking (over 0.3g) is nearly 30s and is about 60s for accelerations over 0.2g. The PGA in the fault-normal and fault-parallel direction is moderate, only about 0.5g, and the vertical PGA is 0.56g, as shown in Table 1.



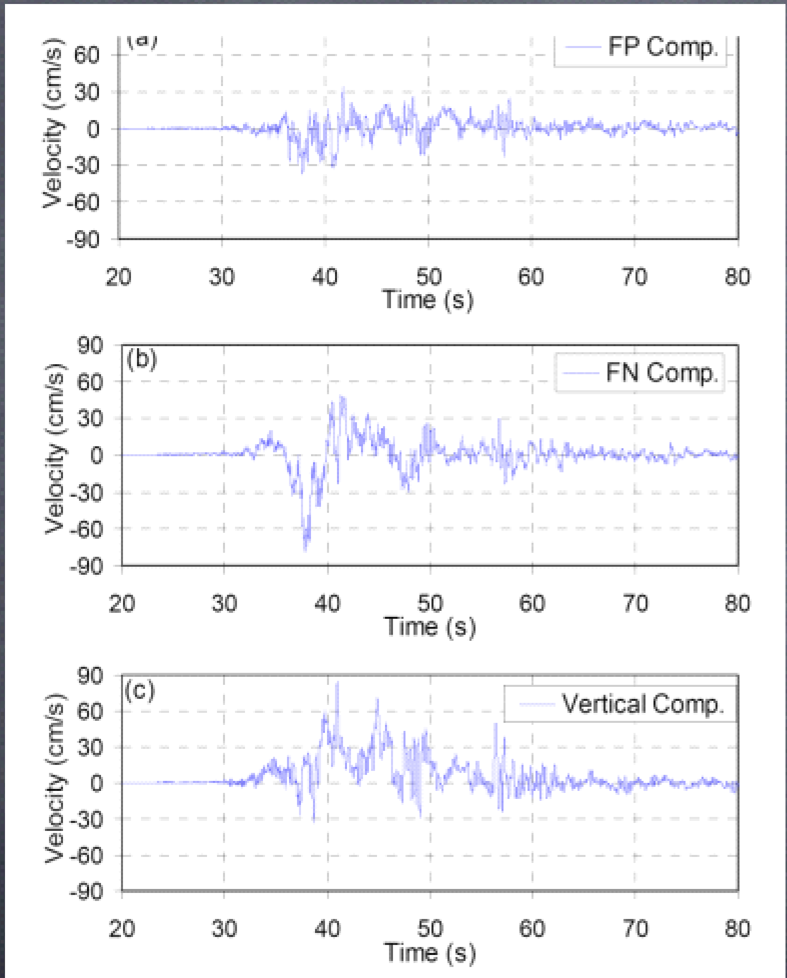


Figure 8
Corrected velocity time histories of the SFB strong-motion record

- fault-parallel component
- fault-normal component
- vertical component

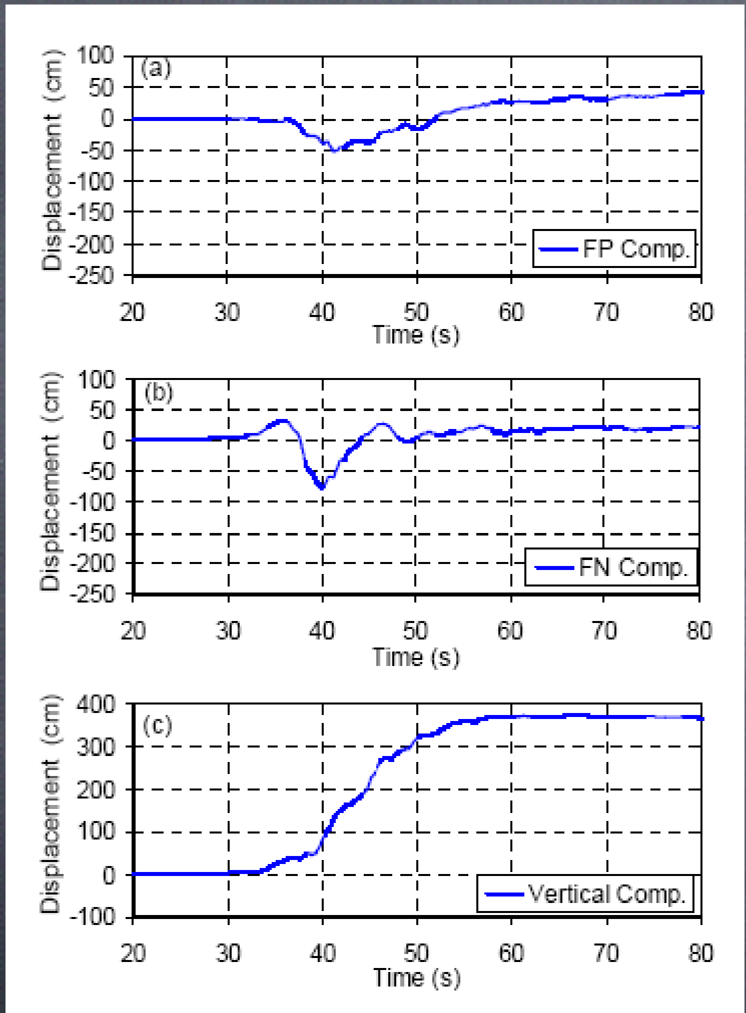


Figure 9 Corrected displacement time histories of the SFB strong-motion record

(a) fault-parallel component

(b) fault-normal component

(c) vertical component

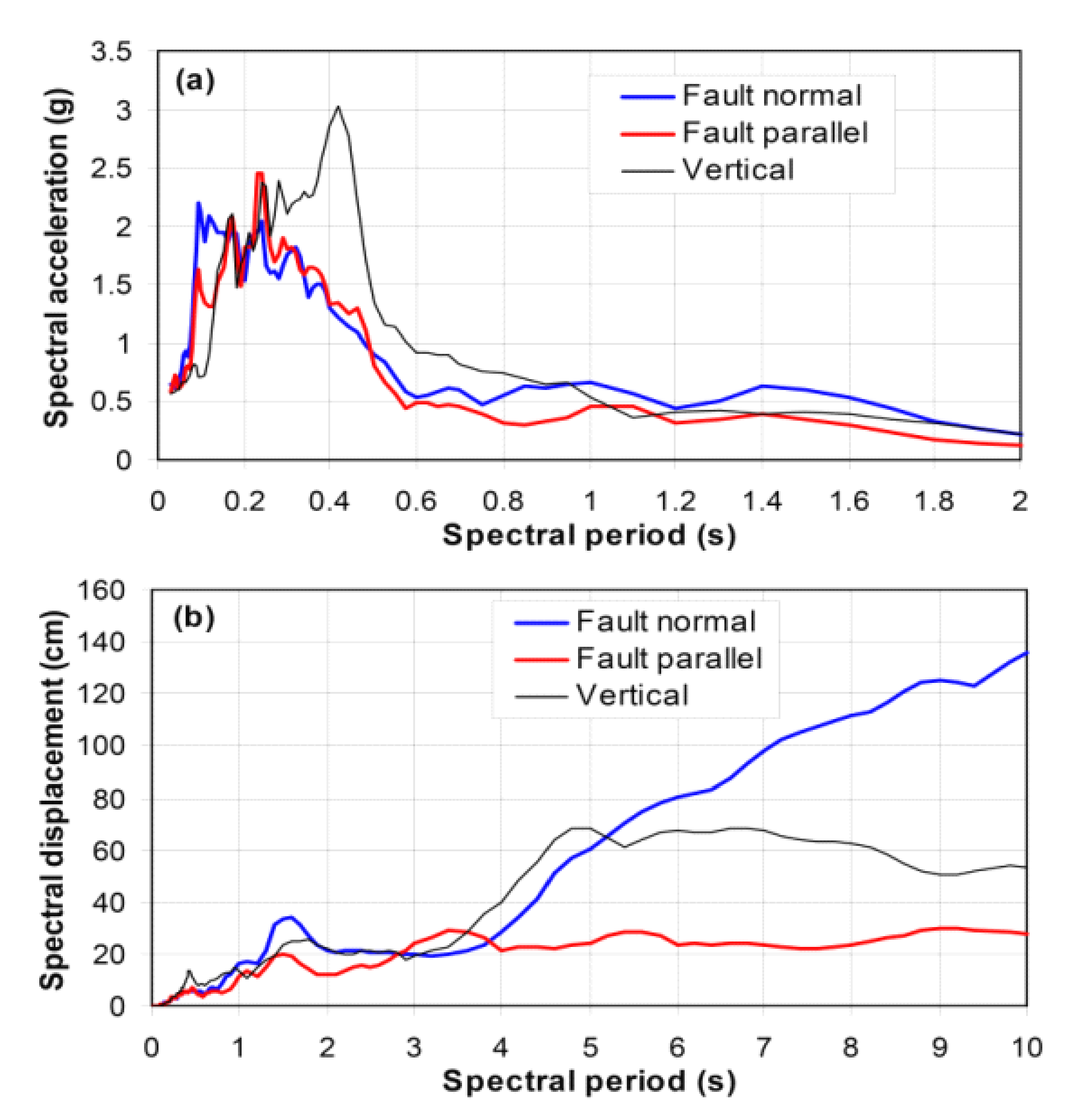

(a)
Fault normal
Fault parallel
Vertical
Spectral acceleration (g)
Spectral period (s)
(b)
Fault normal
Fault parallel
Vertical
Spectral displacement (cm)
Spectral period (s)

Table 1 Peak ground acceleration, velocity and displacement for 2 near-source records of the Wenchuan earthquake

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c. Comparison with the large fault-fling effect of near-source records from the 1999 Chichi, Taiwan and the 1992 Landers, California, USA, earthquakes

The 1999 Chichi, Taiwan earthquake has a magnitude of 7.6 with a reverse focal mechanism and the TCU052 and TCU068 records are obtained from the northern end of the Chelongpu fault on the hanging wall.

The two Chichi earthquake records selected here have the largest PGV and PGD among the strong-motion records in the dataset of the next generation of attenuation models (NGA).

The Chichi earthquake has very similar seismological characteristics to those of the 2008 Wenchun earthquake.

Table 2 Ground-motion parameters of large near-source records from two surface-rupture earthquakes

	Fault-normal			Fault-parallel			Vertical		
Station Name	PGA (g)	PGV (cm/s)	PGD (cm)	PGA (g)	PGV (cm/s)	PGD (cm)	PGA (g)	PGV (cm/s)	PGD (cm)
TCU052	0.36	182	502	0.45	221	722	0.20	169	409
TCU068	0.51	281	710	0.37	291	856	0.53	229	451
Lucerne	0.73	159	324	0.70	119	285			

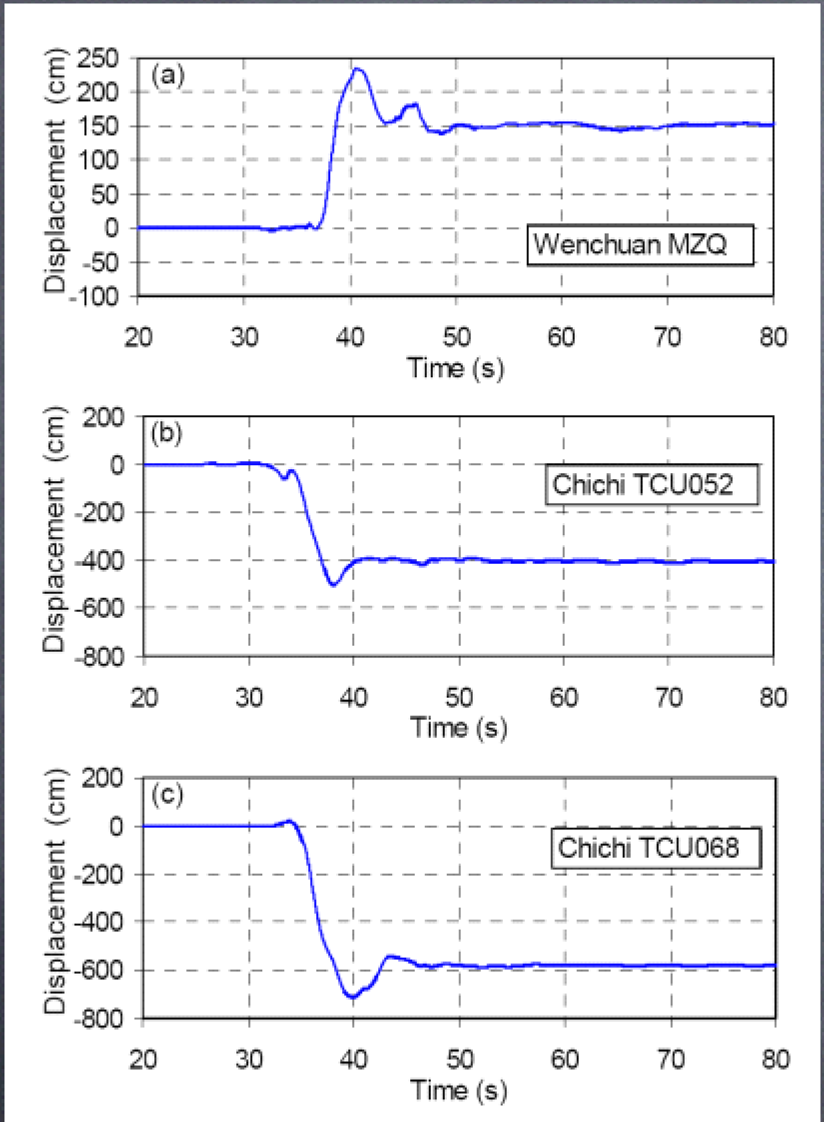

Figure 11

Comparison of the fault normal displacement time history

MZQ fault normal component in (a)

TCU052 (EW component) record in (b)

TCU068 record in (c)

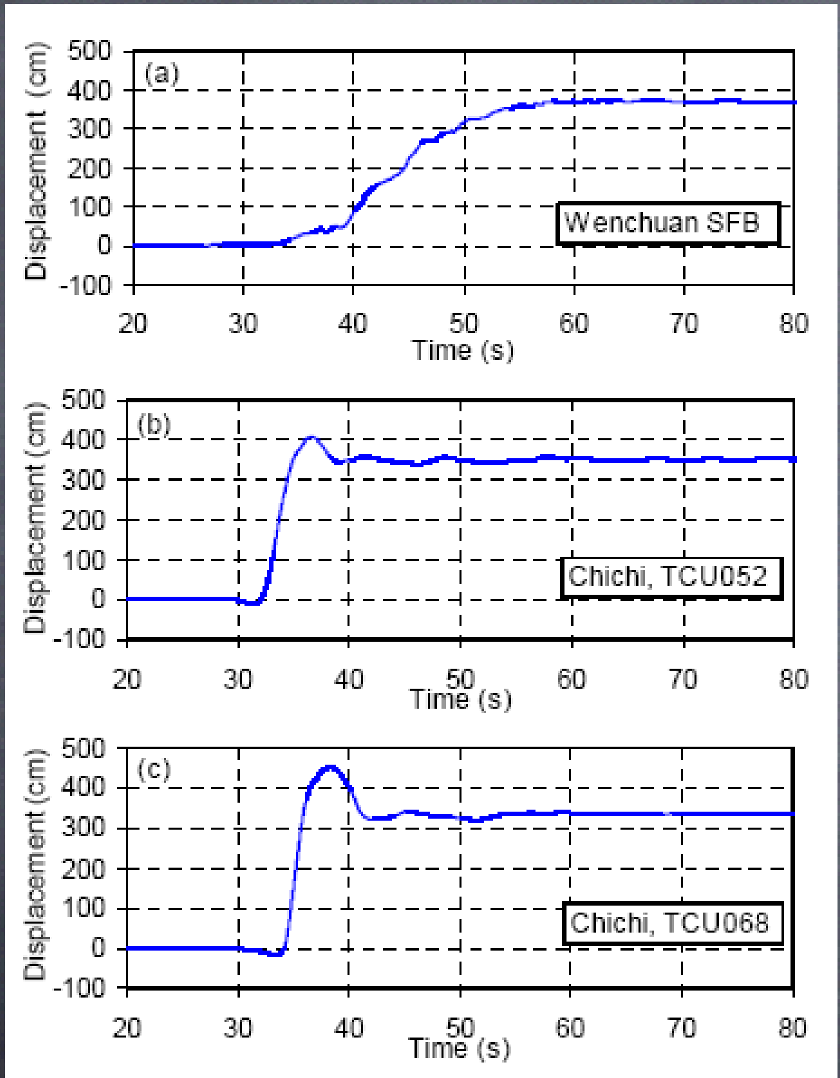

Figure 13

Comparison of the vertical component displacement time history

SFB fault vertical component in (a)

TCU052 (vertical component) record in (b)

TCU068 record in (c)


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Thanks for your attention

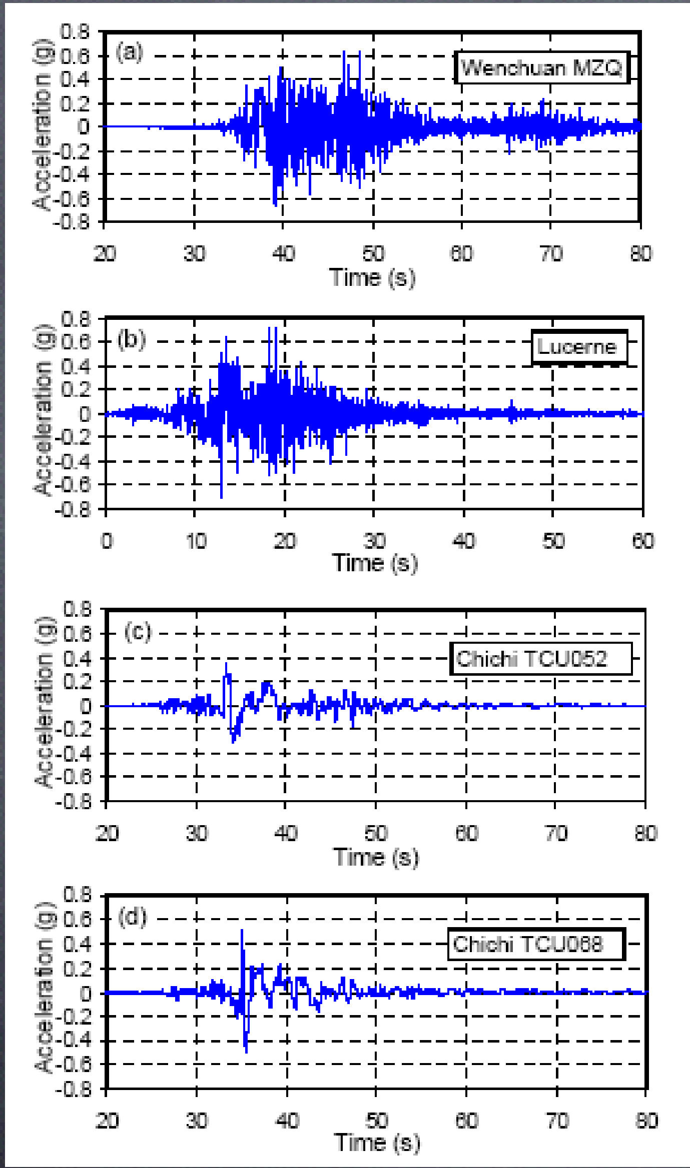

Figure 12 Comparison of the fault-normal component acceleration time history

MZQ fault-normal component record in (a)

Lucerne record in (b);

TCUO52 record in (c);

TCUO68 in (d)

This means that the damage potential of the MZQ record for short period structures is similar to that of the Lucerne record but is much larger than those of the TCUO52 and TCUO68 records.

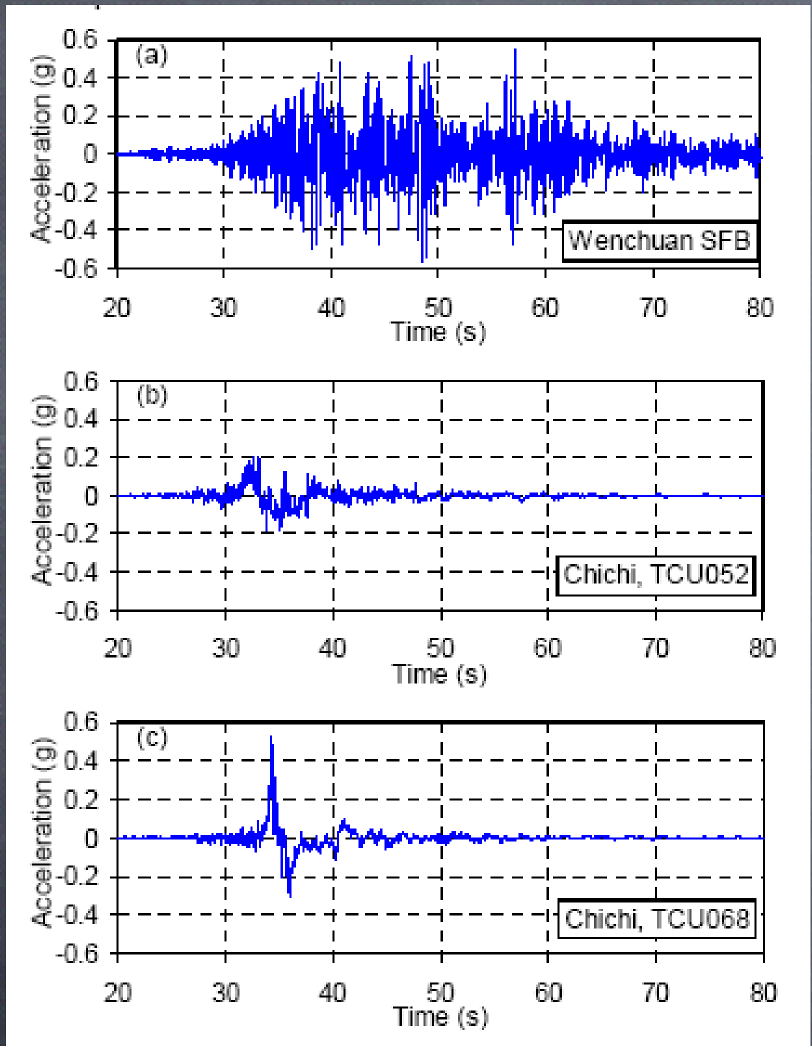

Figure 14

Comparison of the SFB vertical acceleration time history

SFB vertical component record in (a)

TCUO52 record in (b);

TCUO68 record in (c)

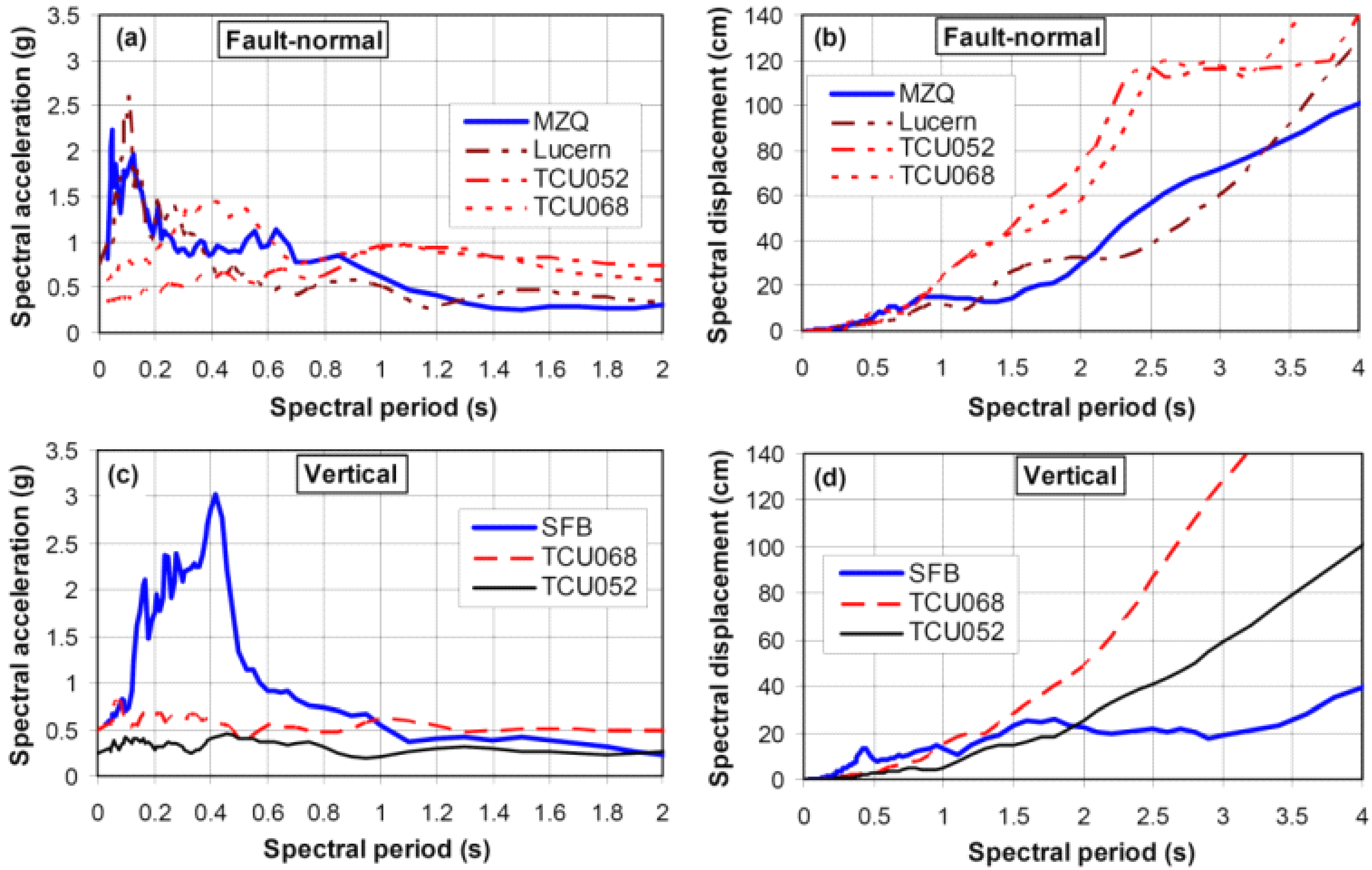

Figure 15 Comparison of the near-source record spectra from the Great 2008 Wenchuan earthquake with those from surface-rupture earthquakes, (a) acceleration spectra; (b) displacement spectra of the fault normal component; (c) acceleration spectra; and (d) displacement spectra of the vertical component