Ground motion characteristics considering magnitude dependency and difference between surface and subsurface rupture earthquakes

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We have studied differences in ground motion according to fault rupture types and magnitude. We found the ground motion characteristics can be categorized by tree groups.

Somerville (2003) and Kagawa et al. (2004) studied difference of ground motion characteristics against empirical spectral attenuation [Abrahamson and Silva (1997)] between surface and subsurface rupture earthquakes. They found that the ground motion caused by subsurface rupture in the period range around one second is larger than the average for all earthquakes, but ground motion from earthquakes that rupture the surface is smaller in the same period range. The attached figure shows an example. We expand their study to smaller earthquakes and add several recent earthquakes. Used earthquakes are 24 including 7 earthquakes occurred in Japan.

We start to divide the earthquakes into four categories that are combination of two classifications, i.e. defined and undefined, surface and subsurface rupture earthquakes. Each category is divided for larger and smaller earthquakes (threshold about Mw 6.5). Finally, we classified the earthquakes with three groups as follows.

(a) Surface rupture type

Ground motion is smaller than average, especially period range around 1 second.

(b) Larger subsurface rupture type

Ground motion is larger than average, especially period range around 1 second.

(c) Smaller subsurface rupture type

Ground motion is larger than average, especially period range around 0.1 second.

As a reason that causes these characteristics, we can explain as follows. Subsurface rupture earthquakes with small magnitude occur at rather deep portion of seismogenic zone. Deep and high stress asperities generate large ground motion in short period range. Also pulse like ground motion does not generated, because the asperity is too small and deep to cause forward directivity effect. The larger subsurface rupture earthquake is, the wider fault rupture area spreads over seismogenic zone and it shall be a quadrate that has same fault length and width. The rupture area defines the magnitude around Mw 6.5, and asperity size shall be several kilo-meters square. Such asperity generates ground motions with predominant period of around 1 second. If magnitude is larger than around Mw 6.5, clear surface rupture can be detected. Kagawa et al. (2004) pointed out that the shallow asperity of surface rupture earthquake has small stress drop and long rupture duration. This causes smaller ground motion than average earthquake.

According to present procedure of strong ground motion evaluation, (a) Surface rupture type is considered to be a 'characteristic earthquake'. However, there should be cases that 'non-characteristic earthquake' generate larger ground motion than 'characteristic earthquake'. Therefore, we have to establish a fault rupture scenario of 'non-characteristic earthquake' (types (b) and (c))to estimate more dangerous ground motion than that of 'characteristic earthquake' (type (a)). The following is an example.

1) In case that large clear active fault is detected.

We should assume scenarios of surface rupture earthquake with total rupture of the target fault, and subsurface rupture earthquake with partial rupture, corresponding Mw around 6.5, of target fault.

2) In case that unclear active fault or active fold structure is detected.

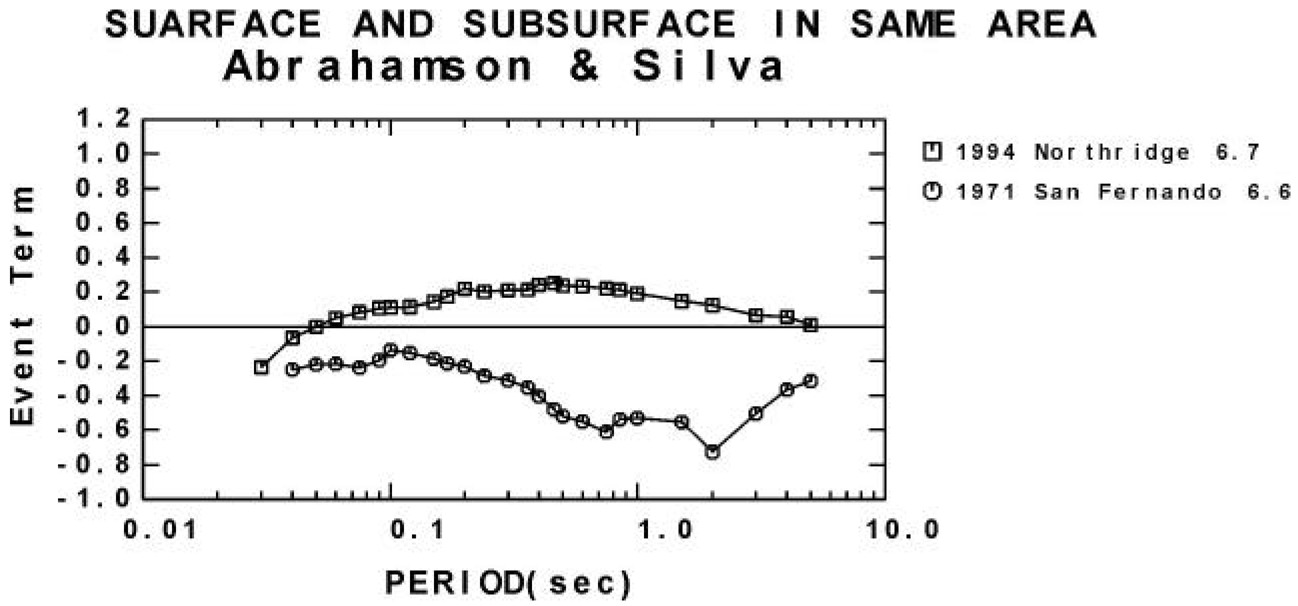
We should assume a scenario of subsurface rupture earthquake with total rupture of target fault or fold.

3) In case that no active fault or active fold structure is detected.

We should assume several scenarios of small subsurface rupture earthquakes with different magnitudes in seismogenic zone.

ACKNOWLEDGEMENT: A portion of this study is supported by JNES research subject 'Strong Ground Motion Evaluation Based on Dynamic Source Modeling' (Leadr: Kojiro Irikura).

REFERENCES: Abrahamson and Silva (1997), SRL, 68. Kagawa et al.(2004), EPS, 56. Somerville (2003), PEPI, 137.


SUARFACE AND SUBSURFACE IN SAME AREA
Abrahamson & Silva
Event Term
1.2
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
0.01
0.1
1.0
10.0
PERIOD(sec)
1994 Northridge 6.7
1971 San Fernando 6.6