STUDY ON LONG PERIOD DESIGN SPECTRUM And ATTENUATION RELATIONSHIP

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Along with the number of long period structures increasing rapidly, such as skyscraper, super-large bridge etc, the seismic design of long period buildings has become a problem that needs urgent solution. The period of those structures is longer than 8s， and react violently with long period ground motion. It's seismic design needs parameters of long period ground motion.

The period of design response spectrum in current chinese seismic design codes is only several seconds, which can't satisfy the need of long period stuctures' seismic design. For example, the longest period of design response spectrum is 6s in the Code for Seismic Design of Building (GBJ50011-2010)and is 7s in the Code for Seismic Design of Structure (GBJ0191-93).

On the whole, the study of long period ground motion just still is in an abecedarian phase. For lacking abservation data, it is difficult to creat the attenuation relationship of long period ground motion.

322 horizontal component acceleration records are collected from the digital accelerograph records, which have long beforehand record and basic site material. Those data is recorded in the Taiwan Chi-chi Earthquake 1999, the 1985 Mexico Ms8.1 Earthquake and Ms7.5 aftershock, the 1995, the 1994 Northridge Earthquake, Tangshan aftershock records and the Taiwan SMART-1 Array records (table 1).

Because the sites information isn't collected enough, the sites are divided into 3 types: bedrock, general soil and soft soil.

Table 1 Digital Accelerograph Record

Earthquake	Bedrock	General soil	Soft soil
Chi-Chi Earthquake	8	105	46
Earthquake	38	2	6
Earthquake	4	16	2
Northridge Earthquake	14	24	8
aftershock		5	
SMART-1 Array		44	

For the long period spectrum attenuation part, use two methods.

1、single-stage method

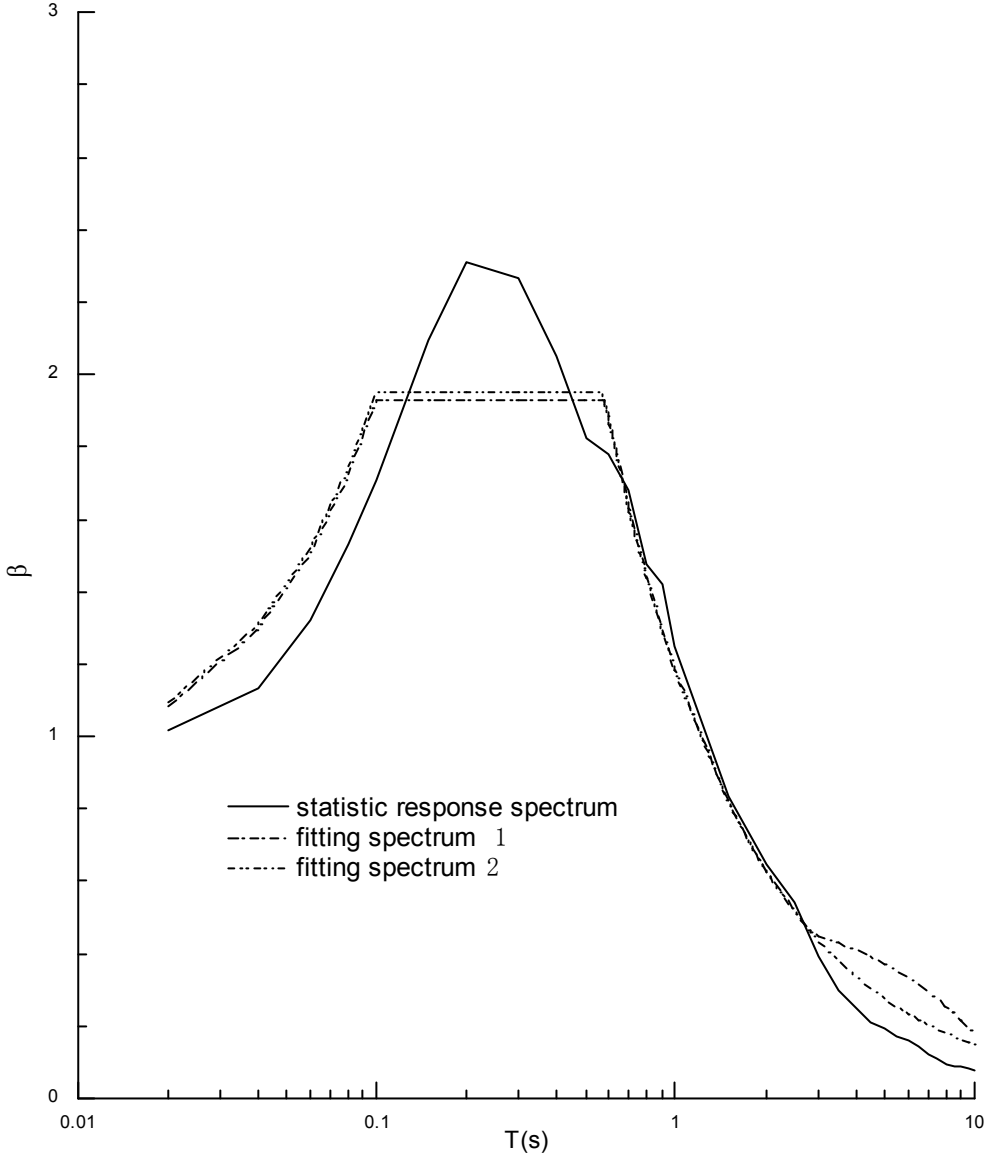
$$S_i = \begin{cases} 1+(C-1)\dfrac{T_i}{T_1} & 0 \le \mathrm{T_i} < T_1 \\ C & \mathrm{T_1} \le T_i < T_g \\ \left(\dfrac{T_g}{T_i}\right)^{0.9} C & \mathrm{T_g} \le T_i \end{cases}$$

2、two stage method

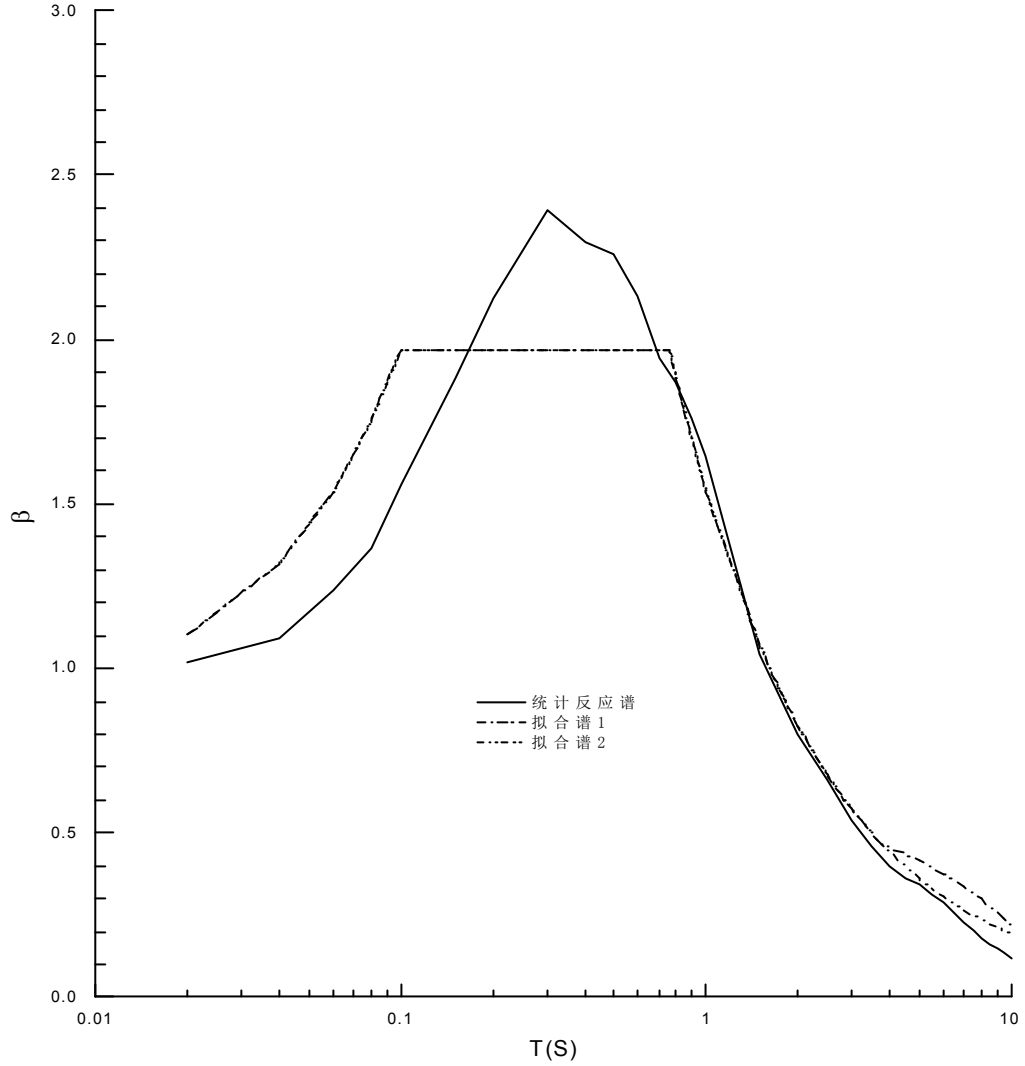
$$\mathrm{S_i} = \begin{cases} 1+(\mathrm{C}-1)\dfrac{\mathrm{T_i}}{\mathrm{T_1}} & 0 \le \mathrm{T_i} < \mathrm{T_1} \\ \mathrm{C} & \mathrm{T_1} \le \mathrm{T_i} < \mathrm{T_g} \\ \left(\dfrac{\mathrm{T_g}}{\mathrm{T_i}}\right)^{0.9} \mathrm{C} & \mathrm{T_g} \le \mathrm{T_i} < 5\mathrm{T_g} \\ \left(0.2^{0.9} - 0.02(\mathrm{T_i} - 5\mathrm{T_g})\right)\mathrm{C} & 5\mathrm{T_g} \le \mathrm{T_i} \end{cases}$$

Fitting result:

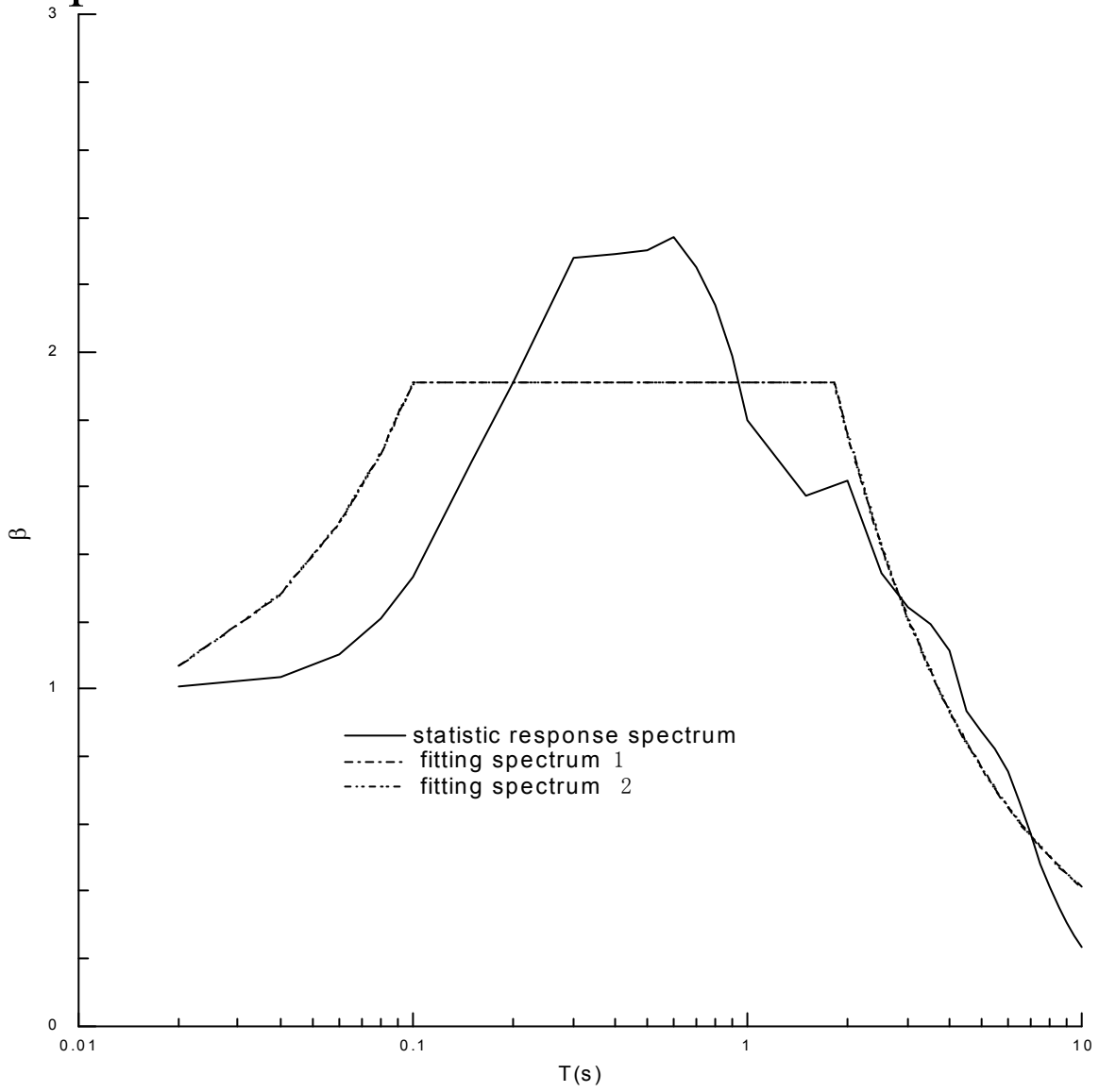
1、 Average acceleration response spectrum and fitting response spectrum of bedrock.



2、Average acceleration response spectrum and fitting response spectrum of general soil.



3、 average acceleration response spectrum and fitting response spectrum of soft soil.



Characteristic value of fitting curves

Type of site	characteristic value of fitting curves			
	decrease part use two-stage		decrease part use single-stage	
	Tg	Bmax	Tg	Bmax
Bed rock	0.58	1.93	0.57	1.95
General soil	0.76	1.97	0.76	1.97
Soft soil	1.81	1.91	1.81	1.91

The fitting results of the two methods are almost same, and the single-stage fitting result is better than the two-stage fitting result. The characteristic period in fitting results is much bigger than it in the current criterion. Response spectrum platform values are around 2.0 for different the sites and are lower than the current criterion's.

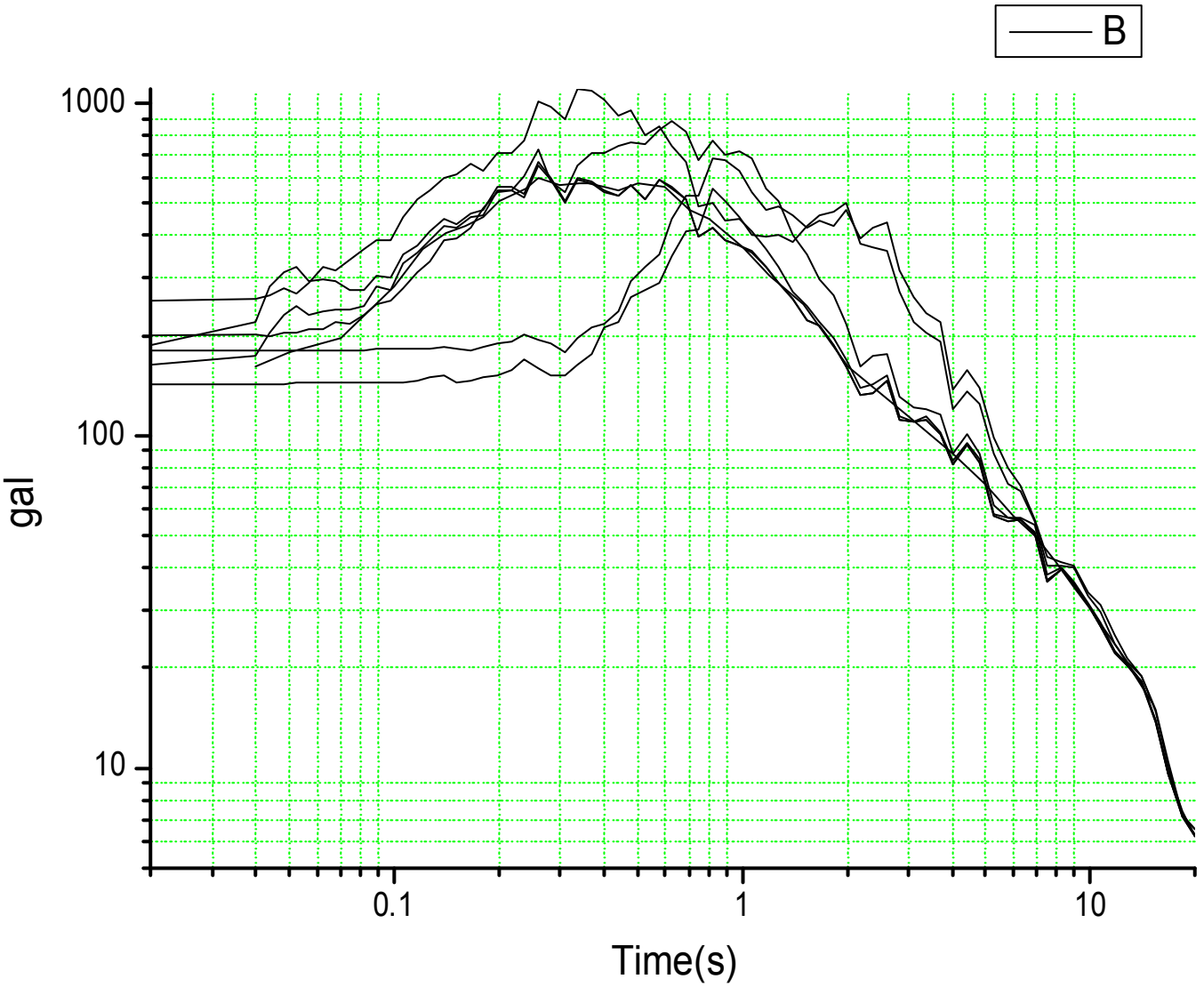
- The problem how to evaluate the long period ground motion longer than 8s is a hot subject in current earthquake engineering field. This study is to evaluate the long period ground motion based on the attenuation relationship.

The Numerical Simulation

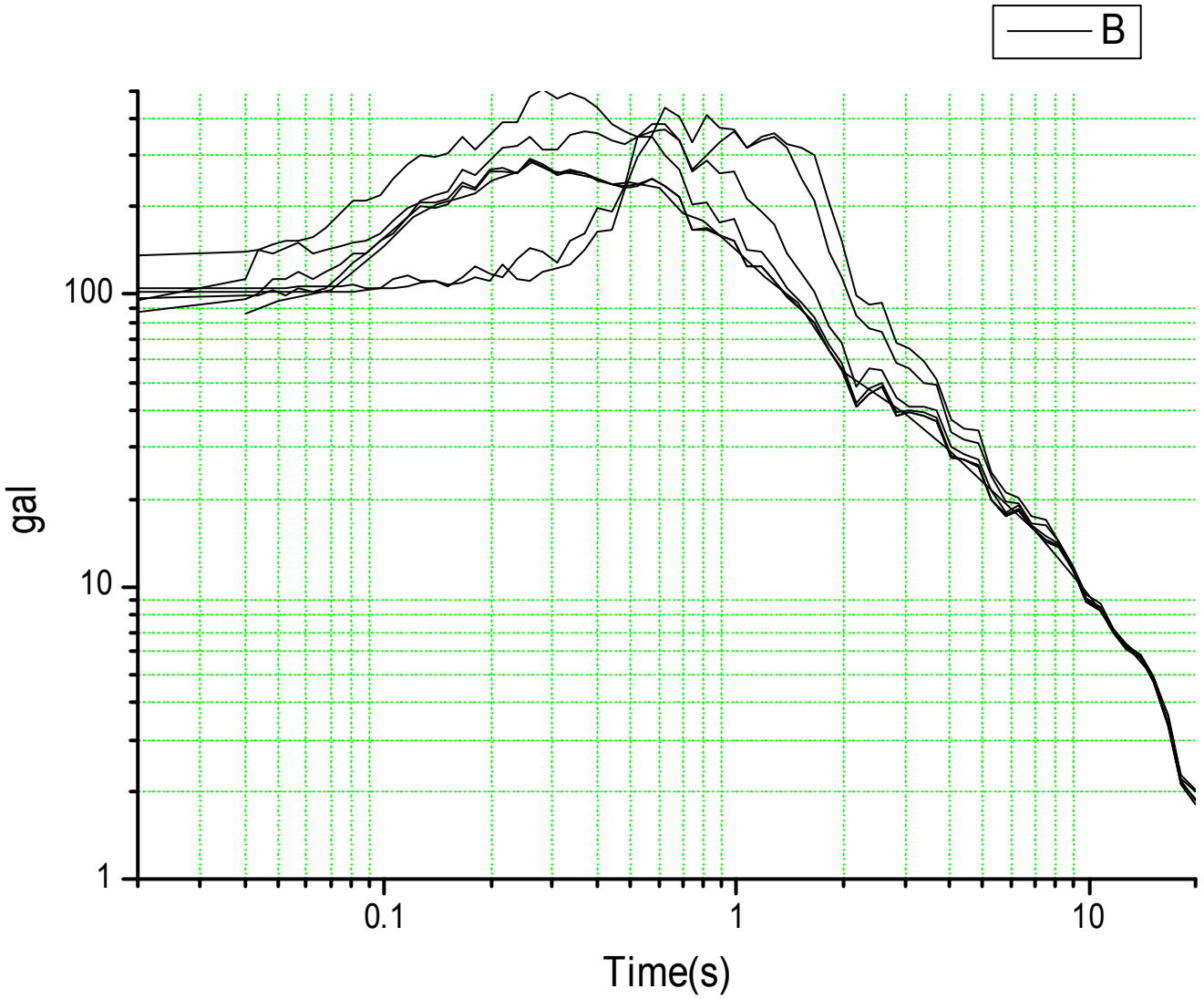
- a larger number of earthquake records is needed for studing attenuation relationship of long period groud motion. But for the lacking earthquake area, we attempt to use one type site's attenuation relationship to stand for other sites.
- Because of lacking the bedrock earthquake records, the records of overburden layer is used to stand for the bedrock earthquake records. The thickness of overburden layer is the primary effact factor to the ground motion.

- Choose the seven site model: bedrock , hard soil (5m, 15m), moderately hard soil (25m, 40m), soft soil (60m, 80m).
- Use three artificial ground motion : large (601 gal), medium (283 gal) and small (119 gal), to calculate every sites' response spectrum.

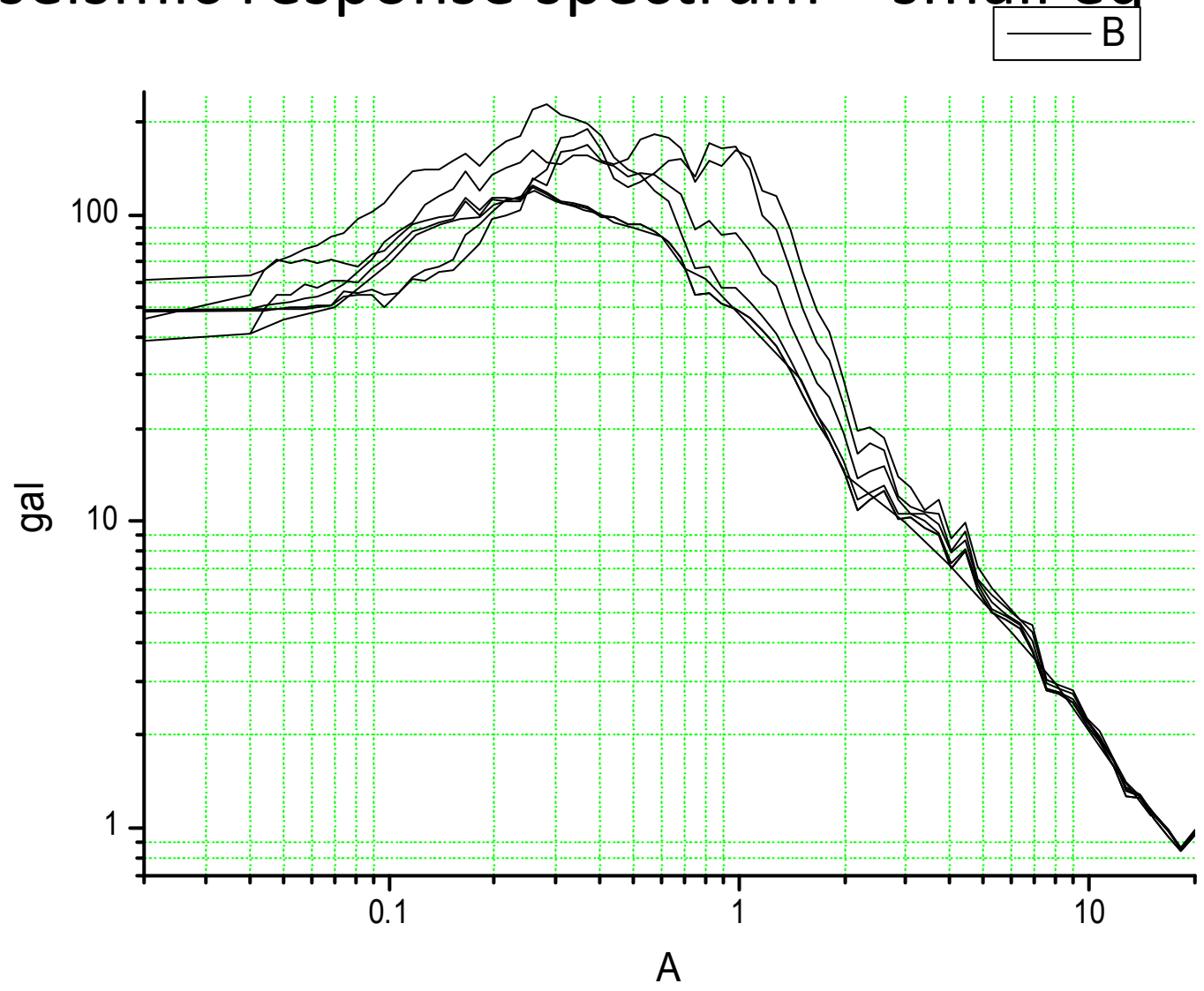
1、seismic response spectrum – large eq



2、seismic response spectrum – medium eq



3、seismic response spectrum – small eq

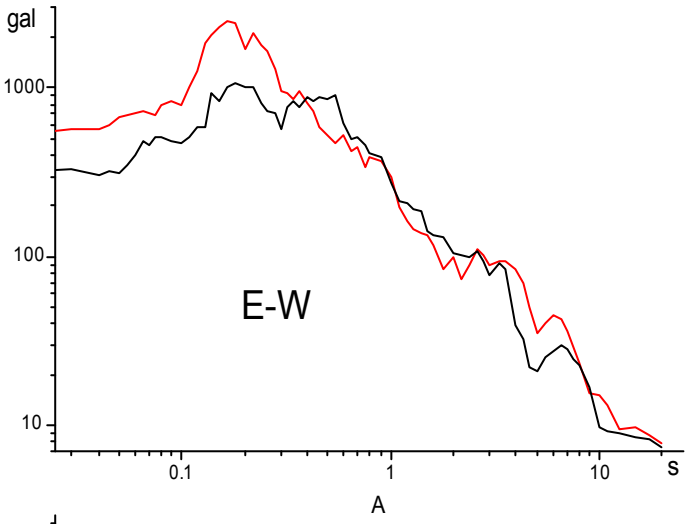


- From the point of view of the numerical simulation we can see, the difference at long period seismic spectrum part is very small.

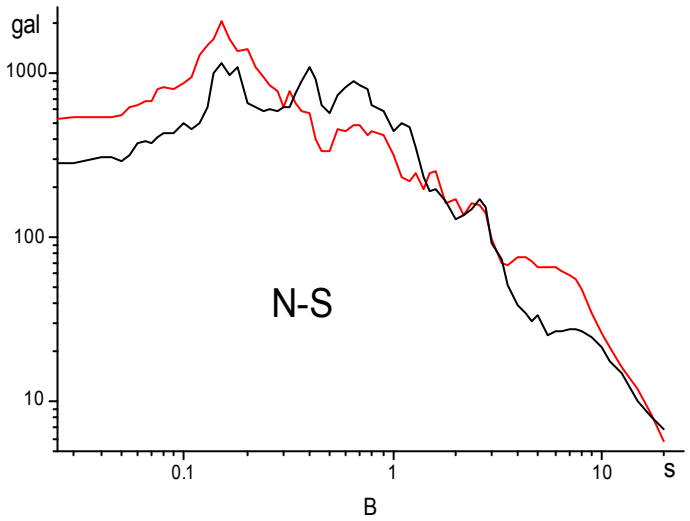
Verify the result of numerical simulation

- To prove the result of numerical simulation, use three group earthquake records to compare their long period seismic response spectrum.

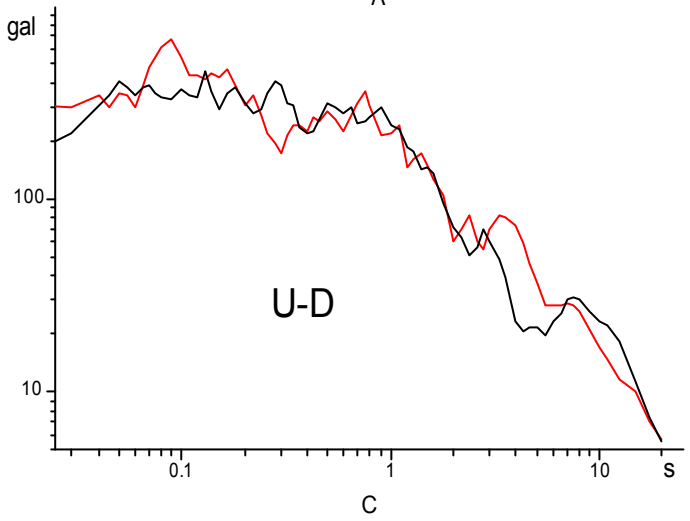
1、江油地震台和江油重华



A



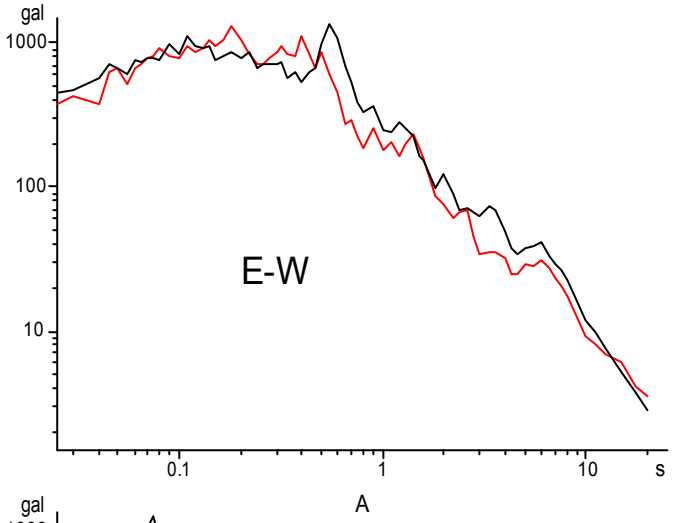
B

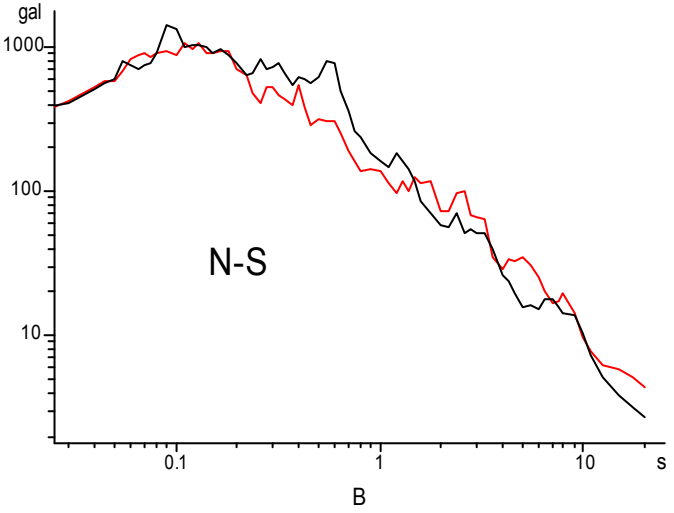


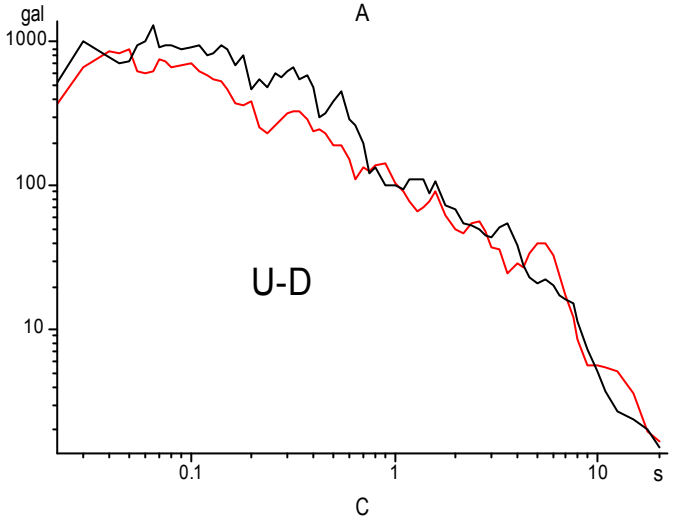
C

红色为江油地震台
黑色为江油重华

2、茂县地办和茂县南新



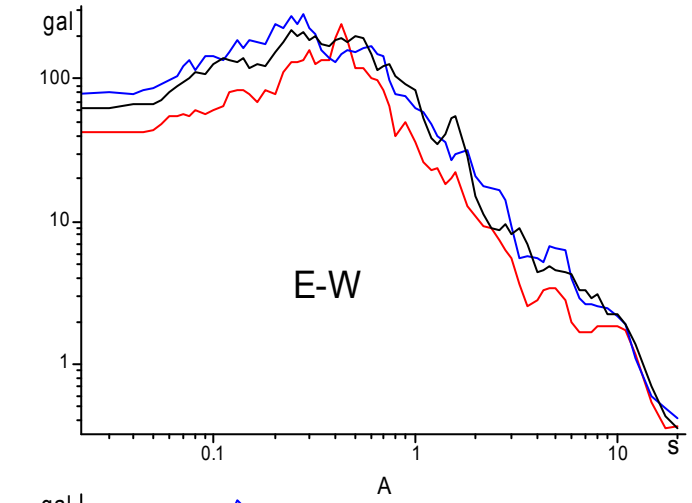


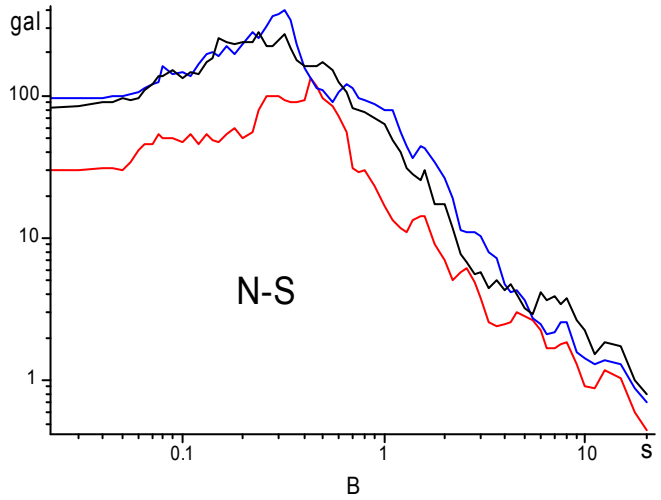


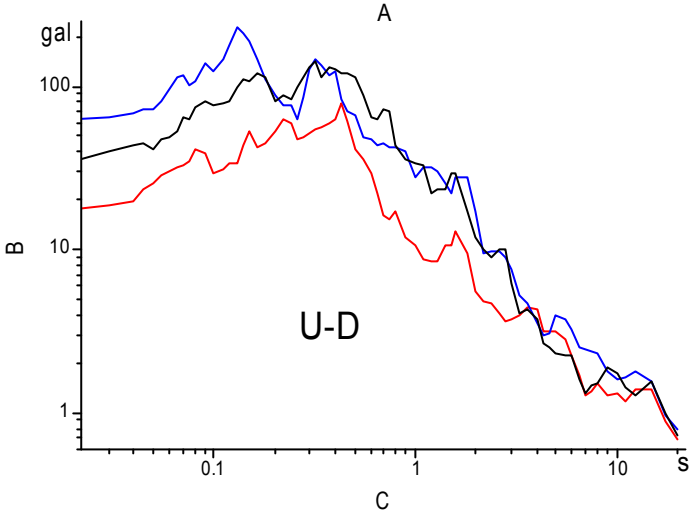
红色为茂县地办

黑色为茂县南新

3、石棉草科、挖角和先锋







红色为石棉草科

蓝色为挖角

黑色为先锋

Thank you !