Taiki Saito

STERA_WAVE Ver. 1.0

User Manual

1. Introduction

STERA_WAVE is a program to generate an artificial ground motion which acceleration response spectrum is compatible with the target acceleration response spectrum.

2. Method to generate artificial ground motion

Given the Fourier spectrum F_k and the phase spectrum ϕ_k $\left(k = 0,1,2,\cdots,N/2\right)$, the Fourier coefficients are calculated as

$$C_k = \left|C_k\right| e^{i\phi_k} = \left(F_k/T\right)\left(\cos\phi_k + i\sin\phi_k\right), \quad k = 0,1,2,\cdots,N/2 \tag{1}$$

$$C_{N-k} = C_k^{\ *} \tag{2}$$

Where N is the number of data, $T = N \cdot \Delta t$ is the duration of wave and Δt is the time interval.

The artificial ground motion is obtained from the inverse Fourier transform as

$$x_m = \sum_{k=0}^{N-1} C_k e^{i\left(\frac{2\pi km}{N}\right)}, \quad m = 0,1,2,\cdots,N-1 \tag{3}$$

The Fourier spectrum F_k is created based on the target acceleration response spectrum. There are two options to create the phase spectrum; one option is to use uniform random numbers and an envelope function, and another option is to use the phase spectrum of real ground motion record. The detail of the theory is described in the "**STERA_WAVE Technical Manual.pdf**".

3. Input data

Please prepare the following files:

1) data_wave.txt

Input data	comment
1	(0: random phase (60s), 1: random phase (120s), 2: real earthquake phase)
0.05	(damping factor to calculate acceleration response spectrum)
5	(iteration number until convergence)
Artificial_wave.txt	(name of the generated artifitial ground acceleration data)
ElCentro1940_NS.txt	(earthquake record for phase information – not necessary for random phase)

2) ElCentro1940_NS.txt

The file of an earthquake ground acceleration record for phase information.

2688	Number of data
0.02	time interval
-1.400	acceleration data (cm/s^2) separated by blank or comma
-10.800	(continue)
…	

3) tareget_spectrum.txt

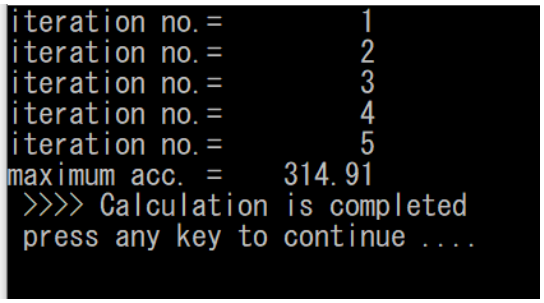
The file of a target acceleration response spectrum (gal=cm/s^2) with the specified damping factor.

T(sec)	Sa(gal)	comment
0.01	350	period, acceleration response spectrum
0.02	380	(continue)
…		
10	51.2	(end of data)

For the natural period outside the range of the minimum natural period and the maximum natural period, the value of the spectrum is zero. In this example, the spectrum at the period less than 0.01sec (or more than 100Hz) and that at the period more than 10sec (or less than 0.1Hz) are zero. It is equivalent to adopt high-cut and low-cut filters.

4. Execute program

When you double click “STERA_Wave.exe”, the following message will appear on the console window.



5. Output data

After executing the program, the following files will be created in the same folder of the program.

1) out_data.txt

repeat of input data

2) out_spectrum.txt

output of spectrum

F(Hz)	T(s)	Phase	Spec(cm/s)	Sv(cm/s)	Sv(target)	Sa(cm/s/s)	Sa(target)
0.0061	163.8400	1.5712	2.4579	49.3166	0.0000	0.2162	0.0000
0.0122	81.9200	1.5715	1.2290	48.7236	0.0000	0.4330	0.0000
0.0183	54.6133	1.5720	0.8193	48.6697	0.0000	0.6083	0.0000
0.0244	40.9600	1.5723	0.6145	49.5329	0.0000	1.0842	0.0000
0.0305	32.7680	1.5727	0.4916	51.0377	0.0000	1.6283	0.0000
0.0366	27.3067	1.5731	0.4096	52.4892	0.0000	2.1321	0.0000
0.0427	23.4057	1.5735	0.3511	53.3215	0.0000	2.9282	0.0000

(continue)

F(Hz)	Frequency
T(s)	Period
Phase	Phase spectrum of generated wave
Spec(cm/s)	Fourier spectrum of generated wave
Sv(cm/s)	Velocity response spectrum of generated wave
Sv(target)	Velocity response spectrum (target)
Sa(cm/s/s)	Acceleration response spectrum of generated wave
Sa(target)	Acceleration response spectrum (target)

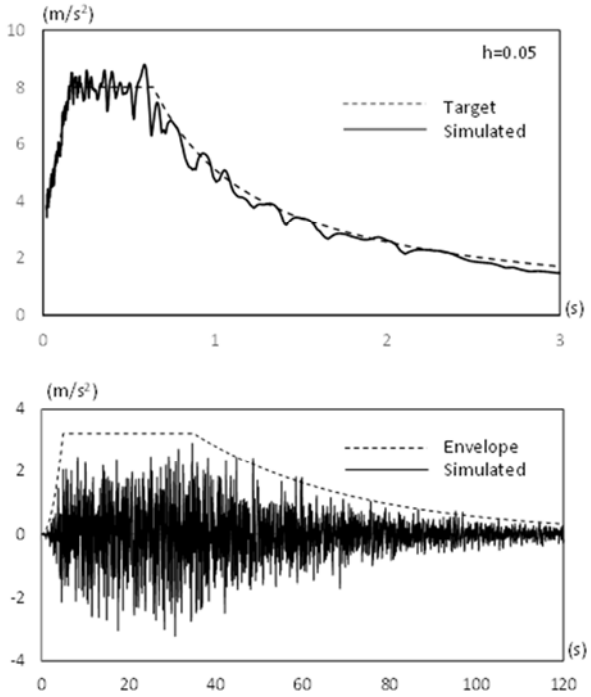
3) out_wave.txt

output of generated wave

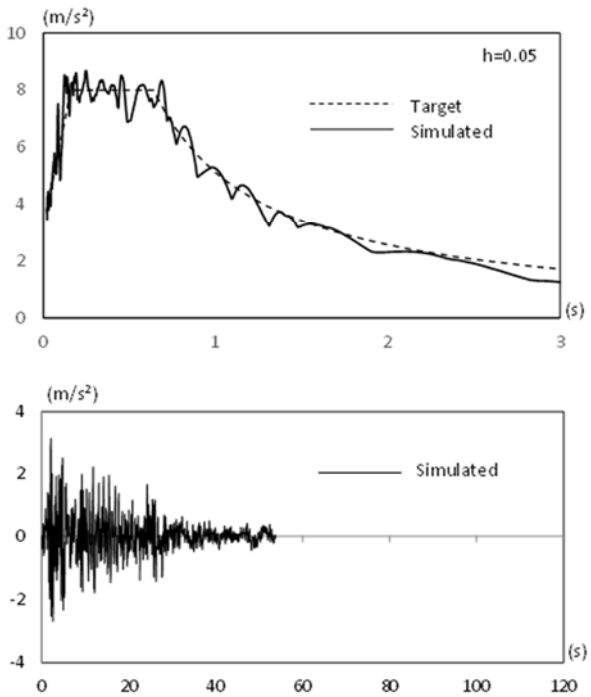
time(s)	acc(gal)
0.02000	-0.231
0.04000	-11.191
0.06000	-41.506
0.08000	-31.048
(continue)	

6. Example

The following figures show examples of simulated ground motions those match the design acceleration response spectrum and have different phase spectrum; one is the random phase and another one is the phase of 1995 Kobe earthquake NS component record. In both cases, the acceleration response spectral match the target ones, but the waveform shapes are significantly different.



(a) random phase



(b) phase of 1995 Kobe earthquake