

iii .ii .i

$$M_w = / \quad / /$$

Simulation of the Avaj earthquake 2002 by semi-empirical Green's function

A. Moghaddasi M.; H. Hamzehloo; H. Shakib

ABSTRACT

The Avaj earthquake in June 22, 2002 with a magnitude of $M_w=6.5$ occurred in western north of Iran. The requirement characteristics for modelling of strong ground motion such as length and wide of fault plate, strike, dip, focal position, stations position and etc. is defined by field study. These parameters are used in order to generate artificial earthquake based on the semi-empirical Green's function methods for Avaj, Bahar, Kabudar Ahang, Shirin Su and Bakandi stations. Then, some parameters such as peak ground acceleration, effective duration, acceleration response spectrum and root mean square error of the generated earthquake compared with the real records.

In this paper, semi-empirical Green's function method is further developed for Iran condition. The results of the study are shown that the method can be applied for the other region with the fault of same mechanism such as Tehran faults.

KEYWORDS

Synthetic earthquake, semi-empirical Green's function, Avaj earthquake

Email: moghad_a@modares.ac.ir

Email: hhamzehloo@iiees.ac.ir

Email: shakib@modares.ac.ir

i

ii

iii



[] NEIC () / /

$$m_b = M_s = / M_w = /$$

[]

[]

[] Kanai-Tajimi

[]

[]

/ /

[]

[]

()

IX VIII

Boore

()

Hartzell

Atkinson

Irikura

Kamae Irikura

Somerville

(Beresnev .

Bolt

Atkinson

Gibson .



$$A'(f)$$

()

$$a'(t)$$

(

(

()

()

$$M$$

[]

$$n = 10^{0.5(M - M')}$$

$$M'$$

()

[]

[]

()

()

$$e(t) = [(a.t)/d]. \exp(1-t/d)$$

()

()

$$d$$

$$a$$

)

$$e(t)$$

(

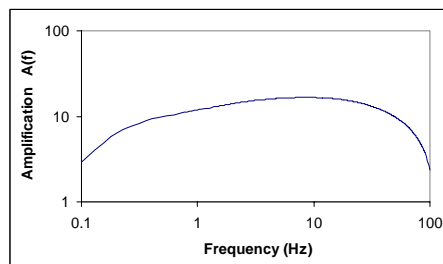
[]

$$E(t) = \left[\sum_{i=1}^n \sum_{j=1}^n e_{ij}^2(t-t_{ij}) \right]^{1/2}$$

()

()

E(t)



A(f) : ()

$$A(f)$$

[]

$$A(f) = \frac{S(f).P(f).e^{-\pi f R/Q\beta}}{R}$$

()

$$\beta$$

$$Q$$

$$R$$

$$e^{-\pi R/Q\beta}$$

S(f)

:

$$S(f) = \frac{(2\pi f)^2}{1 + \left(\frac{f}{f_0}\right)^2}$$

()

P(f)

[]

$$\log(A) = a.M + b.X - \log(X) + C_i S_i + \sigma.P$$

()

$$M$$

$$A$$

$$X$$

$$P(f) = \frac{I}{I + f/f_m}$$

()

[]

$$f_m$$

f_m

$$f_m = 7.31 \times 10^3 M_0^{-0.12}$$

()

$$\sigma S_i$$

$$S_i$$

$$C_i$$

$$a$$

$$P$$

$$P$$

$$M_0$$

$$b$$

$$M_0 = 10^{(1.5M_w + 16.05)}$$

()

A(f)



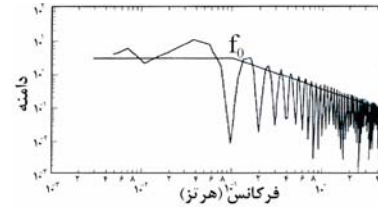
:[]

$$d = \begin{cases} 1/f_0 & R < 100km \\ 1/f_0 + 0.1(R-100) & 100 < R < 200 \\ 1/f_0 + 0.05R & R > 200km \end{cases} \quad ()$$

[]

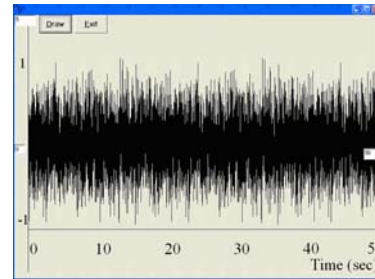
$$f_0 = 10^{(2.623-0.5M)} \quad ()$$

$a'(t)$ ()
 ()
 ()



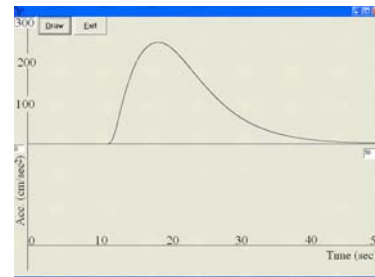
[] : ()

()



: ()

: ()

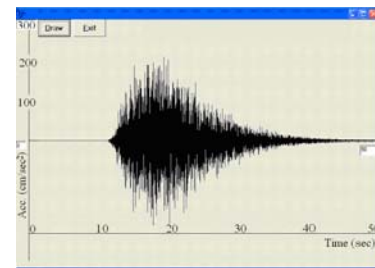


: ()

/	
	(km)
	(km)
/	(km/s)
$Q = f'$	[]
\times	
/	
/	
	[] (bar)

()

()



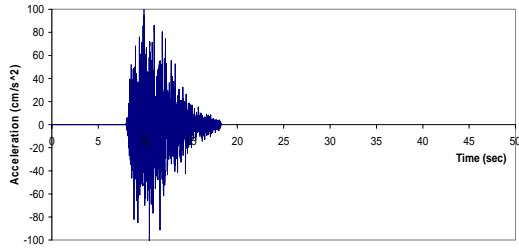
: ()



[]

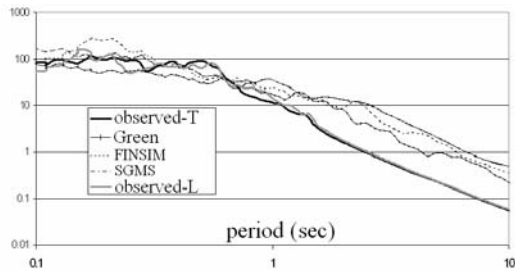
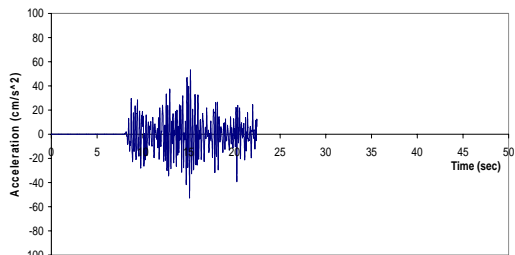
:()

	f_{max}			(cm/s^2)	(cm/s^2)	(cm/s^2)	(km)	
I		/	/				/	
I		/	/					
III		/	/				/	
I		/	/					
II		/	/				/	



:()

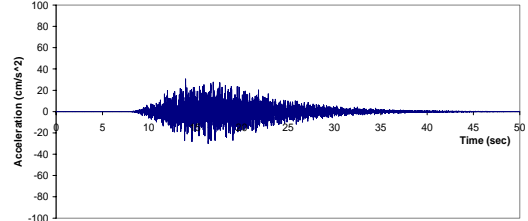
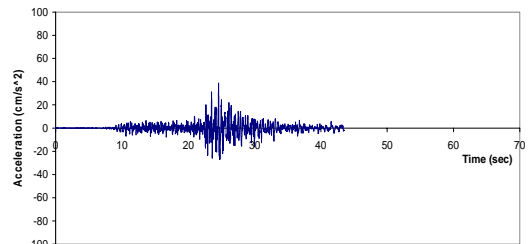
SGMS



:()

FINSIM

()



([] SGMS FINSIM

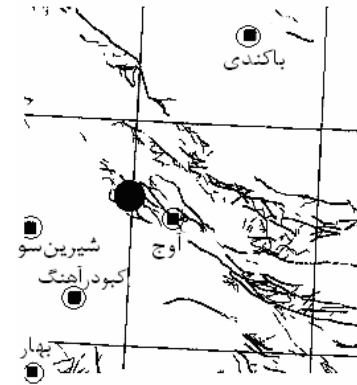
()

]

[

)

([]



: ()

(km)	(sec)	(cm/sec ²)		
/			L	
	/		T	
	/			
	/			FINSIM
	/			SGMS
/	,		L	
	,		T	
	/			
	/			FINSIM
	/			SGMS
/	,		L	
	,		T	
	/			
	/			FINSIM
	/			SGMS
/	/		L	
	/	/	T	
	/			
	/			FINSIM
	/			SGMS

SGMS FINSIM

SGMS FINSIM

()

()

/ × M₀ CMT

FINSIM

()



Faccioli, E., "A Study of Strong Motions from Italy and Yugoslavia in terms of Gross Source Properties", In Earthquake Source Mechanics (S. Das, J. Boatwright, and C. Scholz, eds.), Amer. Geophys. Union Geophysical Monograph 37, P.P.297-309, 1986. []

Gibson, G., "Artificial ground motions," Proceedings of a Seminar Held by the Australian Earthquake Engineering Society of The Institute for Engineers Australia, Melbourne, Australia, P.P.83-86, 1993. []

Hartzell, S.H. Earthquake "Aftershocks as Green's Functions", Geophys. Res. Lett. Vol.5, No.1, P.P.1-4. 1978. []

Irikura, K. "Prediction of strong acceleration motions using empirical Green's function," Proceedings of the 7th Japan Earthquake Engineering Symposium, P.P.151-156, 1986. [] []

Irikura, K., Kamae, K. "Simulation of strong ground motion based on fractal composite faulting model and empirical Green's function," proceedings of the 9th Japan Earthquake Engineering Symposium, Tokyo, 1994. [] []

Joshi, A.; Kumar, B.; Sinvhal, A.; Sinvhal, H.; "Generation of synthetic accelerograms by modeling of rupture plane", ISET Journal of Earthquake Technology, Vol. 36, No. 1, P.P. 43-60, 1999. [] - Q " S []

Kamae, K.; Irikura, K., "Prediction of site-specific strong ground motion using semi empirical methods", in Proc. of the Tenth World Conference on Earthquake Engineering, Madrid, Spain, P.P.801-806, 1992. [] - "() []

Kameda, H.; Sugito, M., "Prediction of strong earthquake motion by evolutionary process model", Proc. 6th Japan earthquake engineering symp., P.P.41-48, 1978. [] []

Lam, N.; Wilson, J.; Hutchinson, G.; "Generation of synthetic earthquake accelerograms using seismological modeling: a review", Journal of Earthquake Engineering, Vol. 4, No. 3, P.P. 321-354, 2000. [] $M_w = / ()$ []

Lay, T.; Wallace. T.; "Modern global seismology. Academic press", 1995. [] []

Midorikawa, S.; "Semi-empirical estimation of peak ground acceleration from large earthquakes", Tectonophysics, vol. 218, P.P. 287-295, 1993. [] Atkinson, G. M.; Boore, D. M., "On the M_N , M Relation for Eastern North American Earthquakes", Seism. Res. Lett. 58, P.P.119-124, 1987. []

Papageorgiou, A.; Halldorsson, B.; Dong, G.; "Strong Ground Motion Simulation Code for Eastern North America: User's Manual, Version 1.0", University at Buffalo. [] Atkinson, G.M.; Somerville, P.G., "Calibration of time history simulation methods", Bull. Seism. Soc. Am. 84, P.P.400-414, 1994. []

Rofooei, F.; Aghababaii Mobarake, R.; Ahmadi, G.; "Generation of artificial earthquake records with a nonstationary Kanai-Tajimi model", Engineering Structures, Vol. 23, P.P. 827-837, 2001. [] Beresnev, I. A.; Atkinson, G. M. "Modelling finite-fault radiation from the ω_n spectrum," Bull. Seism. Soc. Am. 87(1), P.P.67-84, 1997. []

Shakib, H.; Datta, T.K.; Kazimi, S.M.A.; "Response of torsionally coupled system to random ground motion", European Earthquake Engineering, Vol. 3, P.P. 16-27, 1991. [] Bolt, B.A., "Interplate seismicity and zonation", Proceedings of the fifth pacific conference on earthquake engineering, Melbourne, Australia, Vol. 1, P.P.1-11, 1995. []

Toro, G. R.; McGuire, R. K., "An Investigation into Earthquake Ground Motion Characteristics in Eastern North America", Bull. Seismol. Soc. Am. 77, P.P.468-489, 1987. [] Boore, D. M. "Stochastic simulation of high-frequency ground motions based on seismological model of the radiated spectra", Bull. Seism. Soc. Am. 73(6), P.P.1865-1894, 1983. []

Boore, D.M.; "Simulation of Ground Motion Using the Stochastic Method", Pure appl. Geophys. Vol. 160, P.P. 635-676, 2003. []

Walker, R.T.; Bergman, E.; Jackson, J.; Ghorashi, M.; Talebian, M., "The 2002 June 22 Changureh (Avaj) earthquake in Qazvin province, northwest Iran: epicentral relocation, source parameters, surface deformation and geomorphology", *Geophys. J. Int.*, P.P. 707-720, 2005. []

Zare, M.; Ghafory, M.; Bard, P.; "Attenuation law for the strong motions in Iran", Third international conference on seismology and earthquake engineering, Vol. 1, P.P. 345-354, 1999. []

"the study on seismic Micro zoning of the Greater Tehran Area in the Islamic Republic of Iran", JICA, 2000 []

-
1. Peak Ground Acceleration
 2. Semi Empirical Green's Function
 3. Hybrid
 4. Deterministic
 5. White Noise
 6. Envelope Function
 7. Kamae
 8. Irikura
 9. Brune
 10. Faccioli
 11. Kameda
 12. Sugito
 13. Midorikawa
 14. Duration
 15. Toro
 16. McGuire
 17. Frankel
 18. Root Mean Square Error
 19. Effective Duration

