SOLUTIONS MANUAL

GEOTECHNICAL EARTHQUAKE ENGINEERING

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Geotechnical Earthquake Engineering

by

Steve Kramer

Text Errata

(December 31, 1996)

Chapter 1

Figure 1.11	Part (a) of this figure is reversed. The palm trees should be on the left in (a) and (b).

Chapter 3

Equation 3.24	Coefficient in brackets should be 0.0606 rather than 0.606.
Equation 3.25	First coefficient should be negative (i.e. -3.512 rather than +3.512). First coefficient in S_{SR} term should be 0.440 instead of 0.940.
Figure E3.5	Ordinates of both graphs should be labelled 'Acceleration (g)'

Chapter 4

Example 4.4	Numerical values are incorrect due to error in Equation 3.25. Procedure is OK.

Chapter 5

Equation 5.12	The second term should read $B\cos(\bar{\omega}t+kx)$ instead of $B\cos(\bar{\omega}t-kx)$.
Equation 5.15	The second exponent on the right side should be $i(\bar{\omega}t-kx)$ instead of $i(\bar{\omega}t-tkx)$.
Equation 5.47b	Subscript 'R' missing from wave number in numerator - should be k_R.
p. 160	Subscript 'R' missing from wave number in numerator of equation for A_2 - should be k_R.
p. 161	6th line should end with "... in Figure 2.2a." instead of "... in Figure 2.2b."
Equation 5.63a	First term within parentheses should read $\frac{1}{v_{s1}^2}$ instead of $\frac{1}{v_1^2}$
Figure 5.2	Differential terms should use notation ∂ instead of δ.
Example 5.5	Should read "G = 1.6 x 10^6 psf" instead of "G=1.6 x 106 psf."

Chapter 6

Equation 6.26	Middle term should read $\frac{\omega}{2\pi}\lambda_R$ instead of $2\pi\omega\lambda_R$.
Figure 6.1	The downward-pointing arrow at the bottom of the element should be labelled $\sigma_y<0$ instead of $\sigma_x<0$.
Figure 6.41	Abcissa should be labelled $q_c/(\sigma'_v)^{0.5}$ instead of $q_c(\sigma'_v)^{0.5}$.
Figure 6.43	Curves should be labelled σ'_m instead of $\bar{\sigma}_o$.
Figure 6.46	Ordinate should be labelled τ instead of γ.
Figure 6.47(b)	Abcissa should be labelled γ instead of τ.
Figure 6.50	Abcissa should be labelled $\tau_{ave}/\tau_{strength}$.
p. 203	Third line of 2nd paragraph should read "(Figure 5.10) suggests ..." instead of "(Figure 5.11) suggests ..."

Chapter 7

p. 260	Reference between Equations 7.8 and 7.9 should be to Section 5.5.1 instead of 5.4.1.
p. 270	Incorrect table appears in final printing. Correct table is as shown below:

Depth Range (ft)	Average Shear Wave Velocity (ft/sec)
0 - 20	500
20 - 45	700
45 - 70	1500
70 - 130	1000
130 - 540	2000
>540	5000

Equation 7.23	Parenthesis at end of equation should be removed.
Equation 7.67	Should read $\omega_n = n\pi v_{ss}/H$ rather than $\omega_n = n\pi H/v_{ss}$.
Figure 7.22(b)	Ordinate should be labelled $(T_n)_{3\text{-}D}/(T_n)_{2\text{-}D}$ instead of $(T_1)_{3\text{-}D}/(T_1)_{2\text{-}D}$.

Chapter 8

Example 8.2	Errors in spectral velocity and spectral displacement calculations. Should be:

$$S_v = 1.9\,\frac{0.25g}{1.00g}\,(48\text{ in/sec}) = 22.8\text{ in/sec}$$

$$S_d = 1.4\,\frac{0.25g}{1.00g}\,(36\text{ in}) = 9\text{ in}$$

Figure E8.2 needs to be adjusted to reflect these revised values.

Chapter 9

Figure 9.14	Positions of graphs mis-labelled. Should be in the positions $\begin{matrix}(a) & (b)\\ (c) & (d)\end{matrix}$ instead of $\begin{matrix}(a) & (c)\\ (b) & (d)\end{matrix}$
Figure 9.32	Shading is missing for $D_r = 45\% - 50\%$ zone.
Figure 9.34(b)	Curve on right should be labelled $D_{50} = 0.40$ mm instead of $D_{50} = 0.20$ mm.
Figure 9.54	Abcissa values are too large by factor of 10. Should be 0.0, 1.0, 2.0, 3.0, 4.0, and 5.0%.

Chapter 10

Equation 10.16	u* should be equal to $\frac{u}{a_{max}N_{eq}T^2}$.
Equation 10.22a	Numerator of first term should be D^3S_r instead of D^3S_{su}.
Example 10.5	Eleventh line should begin $u = 0.04\ a_{max}\ T_o$ instead of $u = 0.02\ a_{max}\ T_o$.
Example 10.6	Solution should refer to Figure 9.57 (instead of 9.58) and Equation 10.22(a) (instead of 10.22).

Chapter 11

Equation 11.8	Earth pressure coefficient should be K_P instead of K_A.
p. 480	Equation after K_{AE} equation should read $p_{AE} = \ldots$ instead of $p_A = \ldots$

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Homework Problem Errata

(December 31, 1996)

Because an entire set of revisions of the draft homework problems were not made, the homework problems in the first printing of this text contain a number of errors and omissions. The following notes should allow the homework problems to be more useful to the students and instructors.

Chapter 4

Problem 4.1	The coordinate of the right end of Fault C should be labelled (62, 20) instead of (80, 20).
Problem 4.2	Add the words "in California" at the end of the first sentence.
Problem 4.6	Use a different attenuation relationship - the hypothetical one given in the problem statement shows decreasing peak acceleration with increasing magnitude at large magnitudes (due to the unforeseen effects of the last term in the equation). I suggest using the Campbell (1981) relationship given in Equation 3.24 (remember to correct it as indicated in text errata) and assuming that it can be extrapolated to distances beyond 50 km. That approach was used to develop the solution in the solutions manual.

Chapter 5

Problem 5.6	The only thing wrong with this problem is that it has no solution - at least the solution cannot be expressed explicitly in a simple analytical form. Don't assign it. It will be replaced in the next printing.

Chapter 6

Problem 6.2	The wrong figure appeared in the printed version of the text. The problem statement with the correct figure (from the page proofs) is attached.
Problem 6.4	The soil should be assumed to be saturated so that the shear strain can be computed (using Poisson's ratio) from the axial strain.
Problem 6.6	The shear wave velocities given in Part (b) should be listed as being those at 20 m depth instead of 5 m depth.

Chapter 7

Problem 7.3	Frequencies of 2.0 Hz are listed twice. Replace the second one with 3.0 Hz.
Problem 7.7	Assume height of structure is 10 ft.

Chapter 8

Problem 8.1	Reference should be to Figure 8.4 instead of Figure 8.6.
Problem 8.3	Reference should be to Figures 8.10 and 8.11 instead of Figures 8.12 and 8.13.
Problem 8.4	Reference should be to Example 7.4 instead of Example 7.5.
Problem 8.5	Reference should be to Figures 3.15 and 8.12 instead of Figures 3.16 and 8.14.
Problem 8.9	Reference should be to Problem 8.8 instead of Problem 5.

Chapter 9

Problem 9.2	Sixth word should be "simple" rather than "sample."
Problem 9.4	Need to assume some unit weight for the soils. Solution in solutions manual assumes $\gamma = 120$ pcf
Problem 9.5	Assume unit weight given in problem is *dry* unit weight. Solution in solutions manual assumes that groundwater level is at ground surface.
Problem 9.7	
Problem 9.9	Assume average density given in problem is average *dry* density.
Problem 9.12	Reference should be to Equation 9.16 and Figure 9.4 instead of Equation 9.14 and Figure 9.5.

Chapter 10

Problem 10.1	Use c = 750 psf instead of c = 500 psf.
Problem 10.12	D_{50} should be 0.10 mm instead of 0.010 mm.

Chapter 11

Problem 11.2	Use $k_h = 0.3$ instead of $k_h = 0.5$.

2.1 Convection caused by thermal gradients in the upper mantle is thought to be a primary cause of continental drift. Estimate the average thermal gradient in the upper mantle.

The temperature of the upper mantle varies considerably. At depths less than about 160 km (100 miles), the average gradient from Fig. 2.4 is about

$$13\,^\circ F/\text{mile} = 11.6\,^\circ C/\text{km}$$

At depth of 160 km - 650 km (100-400 miles), the average gradient is about

$$1\,^\circ F/\text{mile} = 0.9\,^\circ C/\text{km}$$

The overall average gradient (from bottom to top) is about

$$4.6\,^\circ F/\text{mile} = 4.1\,^\circ C/\text{km}$$

2.2 The coefficient of thermal expansion of the upper mantle is about $2.5 \times 10^{-5}/°K$. Estimate the ratio of the density at the top of the upper mantle to that at the bottom on the upper mantle.

Temperature at top of upper mantle ≈ 1500°F = 816°C = 1089°K

Temperature at bottom of upper mantle ≈ 3500°F = 1927°C = 2200°K

Temperature difference = 2200°K − 1089°K = 1111°K = ΔT

Assume volume of element at top = V_t

Then $V_b = V_t + \Delta V = V_t + \alpha \Delta T V_t = V_t (1 + \alpha \Delta T)$

$$= V_t \left(1 + (2.5 \times 10^{-5}/°K)(1111°K)\right)$$

$$= 1.028\, V_t$$

So $V_b / V_t = 1.028$

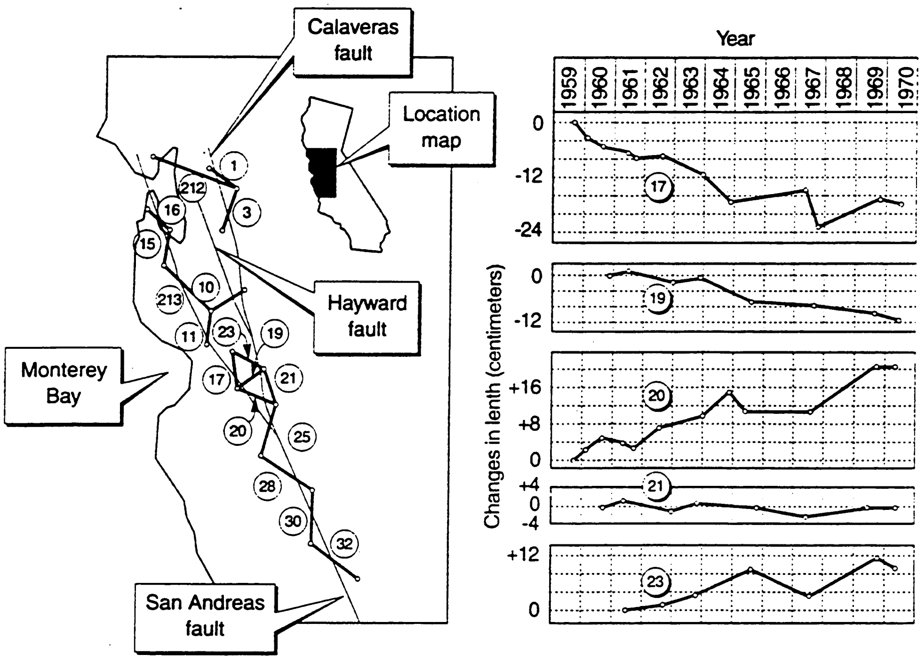
Consequently

$\rho_t / \rho_b = 1.028$ ← density difference due to thermal expansion effects

2.3 Using the data from Figure 2.21, determine whether the San Andreas and Calaveras faults are undergoing right lateral or left lateral strike slip faulting.

Chord 17 is shortening → San Andreas movement must be right lateral

Chord 23 is lengthening → Calaveras movement must be right lateral



shortening

shortening

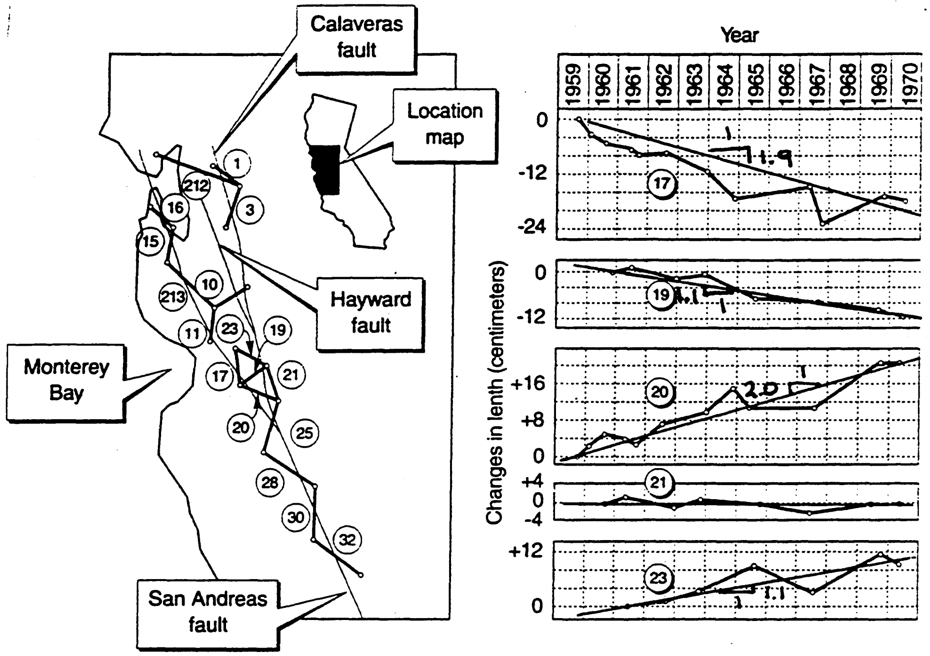
lengthening

~ constant

lengthening

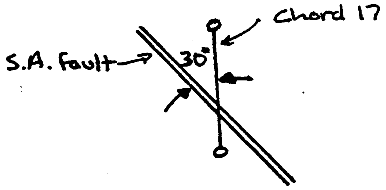
Note that Chord 20 spans both faults and shows even larger movements that are consistent with right lateral movement on both faults

2.4 Using the data from Figure 2.21, estimate the average rate of relative movement along the San Andreas and Calaveras faults during the period from 1959 to 1970.



San Andreas:

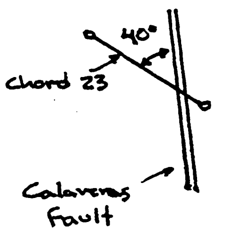
Average rate of movement on Chord 17 ≈ 1.9 cm/yr



$$\text{Fault movement} = \frac{\text{Chord movement}}{\cos 30^\circ} = \frac{1.9 \text{ cm/yr}}{0.866} = 2.2 \text{ cm/yr}$$

Calaveras:

Average rate of movement on Chord 23 ≈ 1.1 cm/yr



$$\text{Fault movement} = \frac{\text{Chord movement}}{\cos 40^\circ} = \frac{1.1 \text{ cm/yr}}{0.766} = 1.4 \text{ cm/yr}$$

2.5 Assuming p- and s-waves traveled through the crust at 6 km/sec and 3 km/sec, respectively, estimate the epicentral location (latitude and longitude) of the hypothetical earthquake whose characteristics are given below:

Seismograph			
Latitude	Longitude	p-wave arrival time	s-wave arrival time
37°22'30"	121°52'30"	06:11:18.93	06:11:26.90
37°45'00"	122°20'00"	06:11:14.84	06:11:18.71
37°52'33"	121°43'38"	06:11:17.26	06:11:23.53

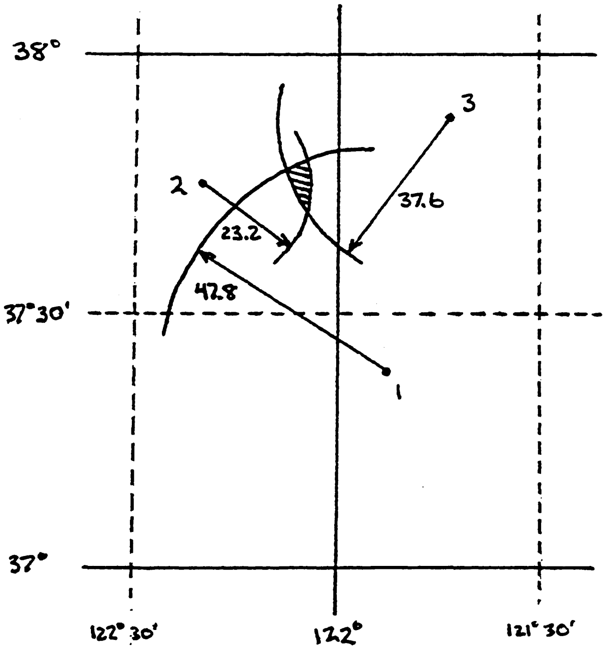
Convert latitude and longitude to distances

Latitude: $\pi d = 360°$ → for $\bar{d} = 12720$ km, 1° = 111 km

Longitude: At longitude 37.5°, 1° = (111 km) cos 37.5° = 88 km

Compute arrival times and source-site distances

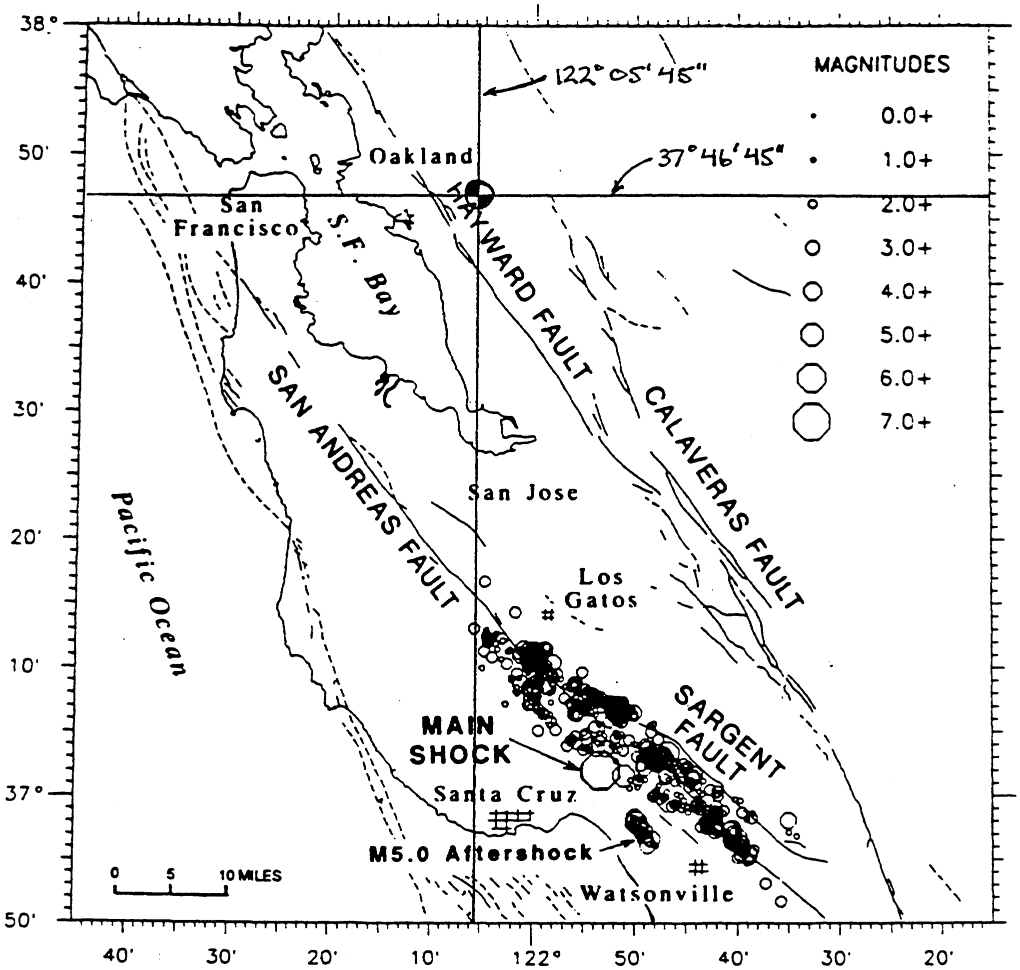
Seismograph	Δt_{p-s}	d (km)	
1	7.97	47.8	From Eq. 2.2
2	3.87	23.2	
3	6.27	37.6	



Center of shaded area is at approximately
37° 46' 45" N
122° 05' 35" W

Most likely source appears to be Hayward Fault

2.6 Using a map of California, determine which fault the hypothetical earthquake of Problem 2.5 would most likely have occurred on?



Plotting the latitude and longitude of the center of the shaded area from the solution to Problem 2.5, the Hayward Fault appears to be the most likely source.

2.7 An earthquake causes an average of 2.5 m strike-slip displacement over an 80 km long, 23 km deep portion of a transform fault. Assuming that the rock along the fault had an average rupture strength of 175 kPa, estimate the seismic moment and moment magnitude of the earthquake.

$$M_o = \mu A \bar{D}$$

$$= (175 \text{ kPa})(80 \text{ km})(23 \text{ km})(2.5 \text{ m}) = 8.05 \times 10^{14} \text{ N-m}$$

$$= 8.05 \times 10^{21} \text{ dyne-cm}$$

$$M_w = \frac{\log M_o}{1.5} - 10.7$$

$$= \frac{\log (8.05 \times 10^{21})}{1.5} - 10.7$$

$$= 3.9$$

3.1 Plot the time history of acceleration and determine:

(a) The peak acceleration.

(b) The sustained maximum acceleration (3rd cycle and 5th cycle).

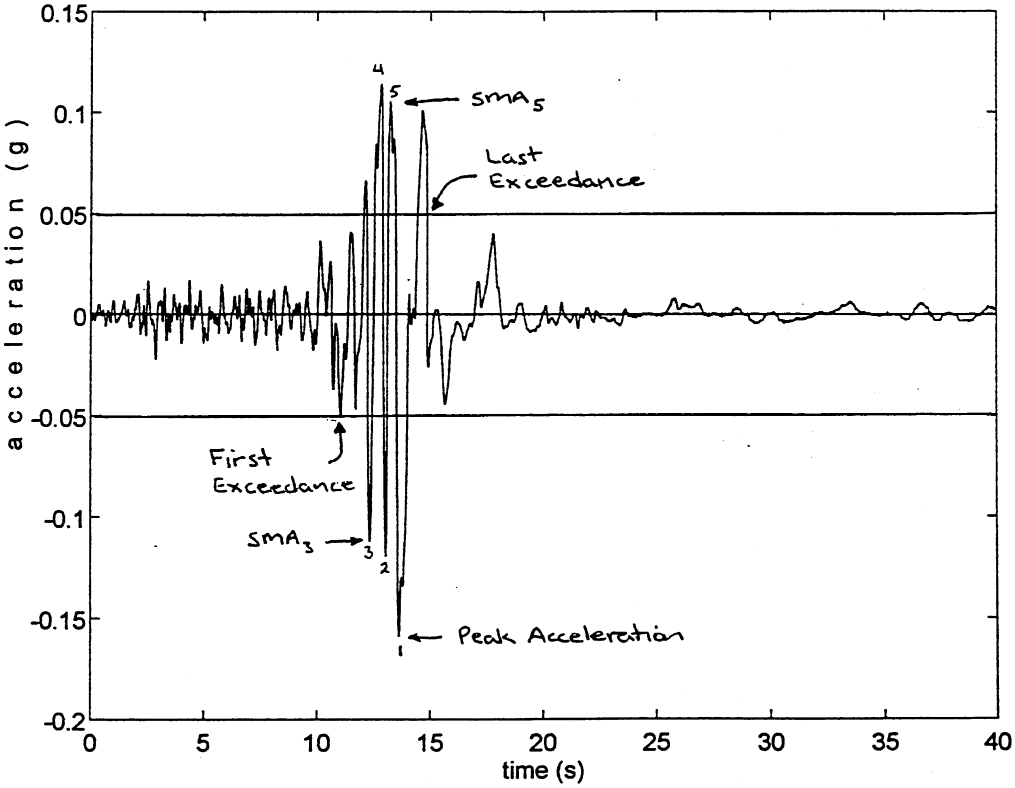
(c) The bracketed duration.

From plot of Treasure Island EW motion (Loma Prieta earthquake) shown below:

(a) PHA = 0.159 g

(b) Sustained maximum acceleration: 3rd cycle = 0.114 g
5th cycle = 0.105 g

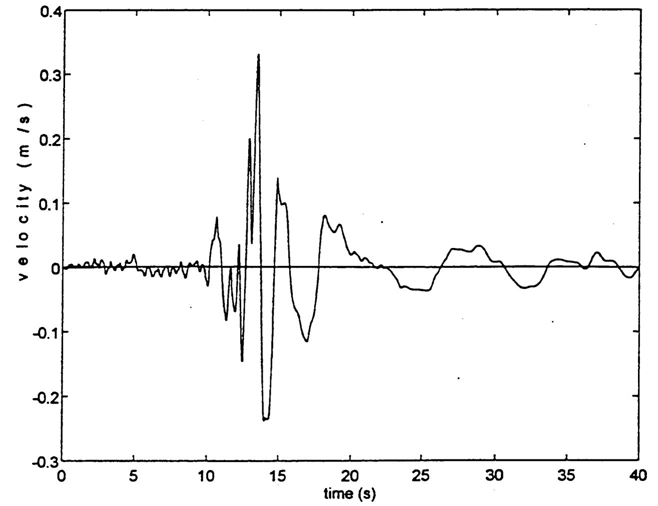
(c) Bracketed duration = 3.8 sec

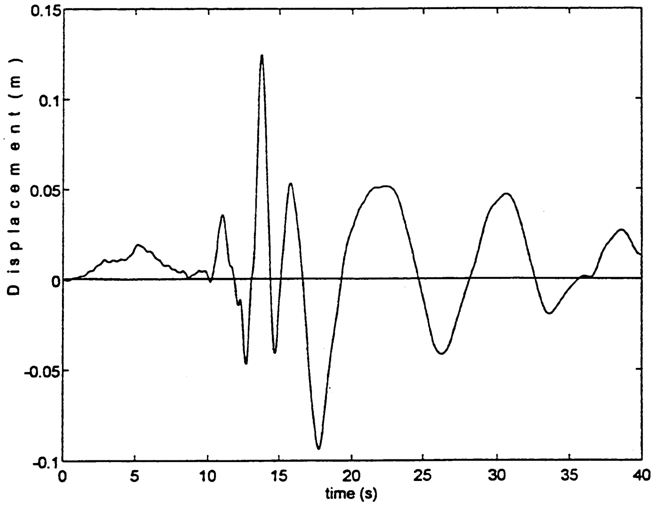


3.2 Integrate the time history of acceleration to produce time histories of velocity and displacement. Plot the time histories of velocity and displacement and determine the peak velocity and peak displacement.

Time histories are shown below. Peak values are:

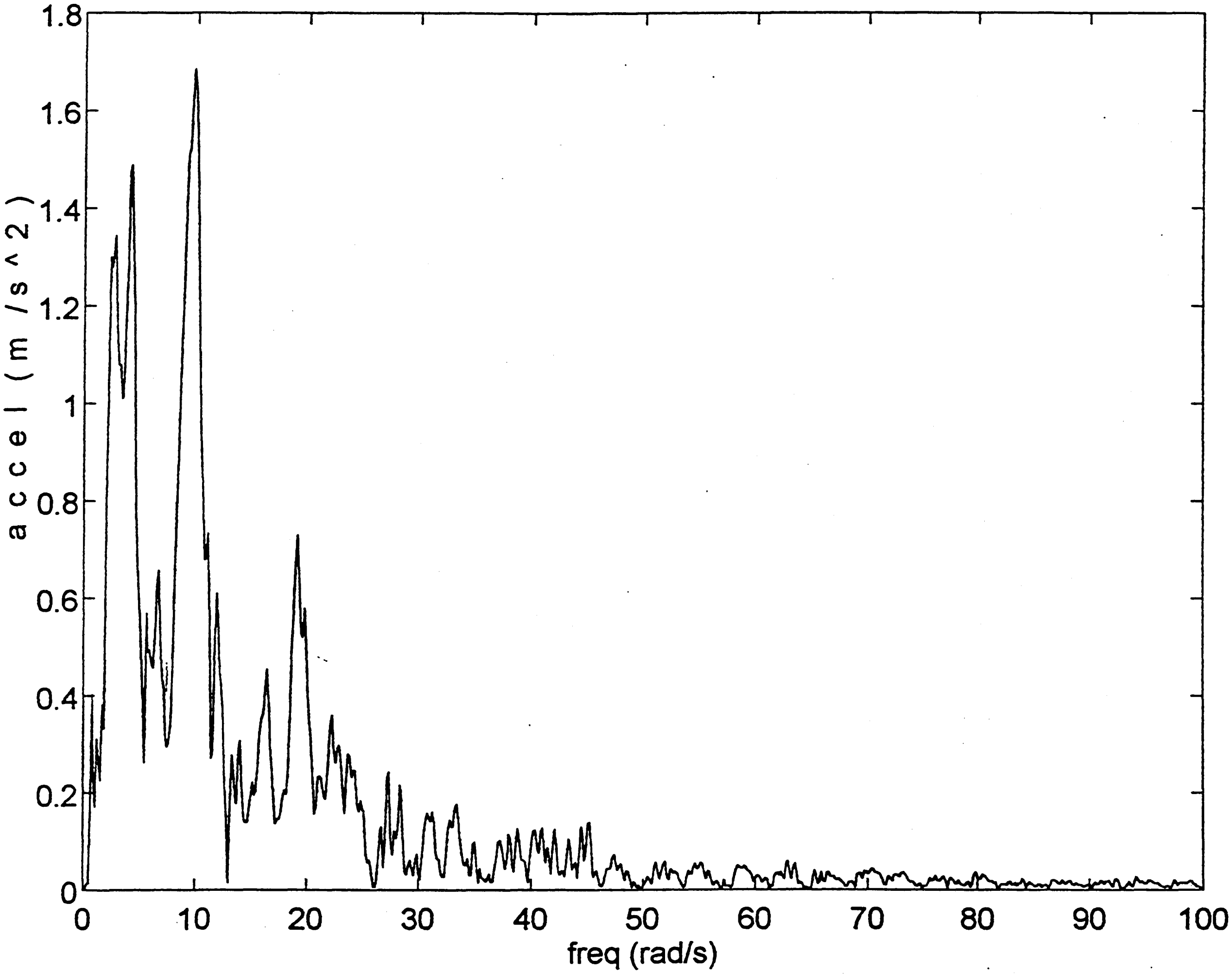
Peak velocity = 0.33 m/sec
Peak displacement = 12.7 cm





3.3 Compute and plot the Fourier amplitude spectrum of the strong motion record.

Plot of FAS (truncated below Nyquist frequency for better visibility of low frequency region) is shown below:

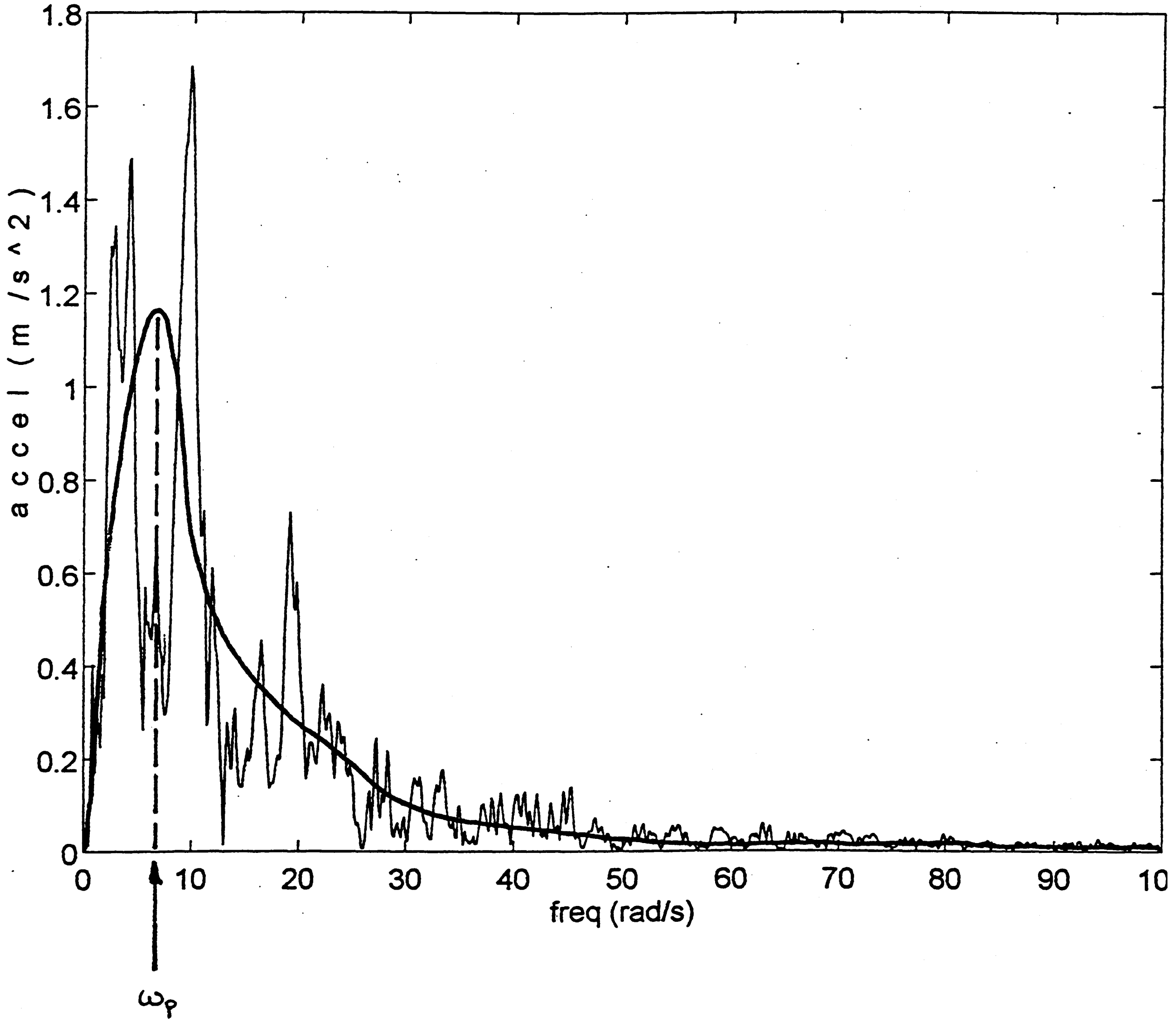


3.4 Determine the predominant period of the strong motion record.

By manual smoothing of FAS, $\omega_p \approx 6.6$ rad/sec

Then

$$T_p = \frac{2\pi}{\omega_p} \approx 0.96 \text{ sec}$$



3.5 Compute the rms acceleration for the strong motion record.

RMS acceleration

$$a_{rms} = \sqrt{\frac{1}{T_d}\int_0^{T_d} [a(t)]^2\, dt}$$

Evaluating integral numerically (trapezoidal rule) gives

$$a_{rms} = 0.73 \text{ m/sec}^2 = 0.074 \text{ g}$$