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KASETSART UNIVERSITY

Geotechnical Earthquake Engineering

ASSIGNMENT NO. 9:

Signal Processing and Ground Motion Parameters (Kobe Earthquake, 1995)

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Ground Motion Parameters

To describe the ground motion adequately for engineering purposes, three main characteristics of earthquake motion are of primary significance. They are i) Amplitude ii) Frequency content and iii) Duration of the motion.

Amplitude Parameters:

Peak Ground Acceleration (PGA): PGA is equal to the maximum ground acceleration that occurred during earthquake shaking at a location. PGA is equal to the amplitude of the largest absolute acceleration recorded on an accelerogram at a site during a particular earthquake. It is governed by high frequency ground motion.

Peak Ground Velocity (PGV): PGV is equal to the maximum ground velocity that occurred during earthquake. It is governed by Intermediate frequency ground motion. Often used instead of PGA if dealing with longer-period structures. (Eg. Bridges, Buildings, etc).

Peak Displacement (PGD): Often called Peak Ground Displacement. Not as widely used since it is governed by frequency ground motions. Appropriate for design on very high period structures such as long bridges, very tall buildings, or water tanks.

Sustained Maximum Acceleration (SMA): The absolute values of highest accelerations that sustained for 3 and 5 cycles in acceleration time history are defined as 3-cycle sustained and 5-cycle sustained accelerations respectively

Effective Design Acceleration (EDA): The acceleration which is effective in causing structural damage. Benjamin and Associates (1988) proposed that an effective design acceleration be taken as the peak acceleration that remains after filtering out accelerations above 8 to 9 Hz. Kennedy (1980) proposed that the effective design acceleration be 25% greater than the third highest (absolute) peak acceleration obtained from a filtered time history.

Frequency Content Parameters:

Response Spectra: The dynamic response of compliant objects, be they buildings, bridges, slopes, or soil deposits, is very sensitive to the frequency at which they are loaded. Response spectrum describes the maximum response of a single-degree-of-freedom (SDOF) system to a particular input motion as a function of the natural frequency (or natural period) and damping ratio of the SDOF system.

Predominant Period: The period(s) at which maximum spectral amplitudes are shown on response spectra. Normally, acceleration response spectra are used to determine the predominant period(s) of the earthquake ground motion.

Duration Parameters:

Uniform Duration: Uniform durations are also defined by a threshold level of acceleration (a0). But rather than as the interval between the first and final peaks that exceed this level, the duration is defined as the sum of the time intervals during which the acceleration is greater than the threshold.

Bracketed Duration: The total time elapsed between the first and last excursions of a specified level of acceleration. The threshold value is generally taken as +0.05g to - 0.05g. One disadvantage of this definition is that it considers only the first and last peaks that cross the specified threshold and ignores completely the characteristics of the strong shaking phase, which can result in long durations being estimated for earthquakes with small sub-events occurring after the main shock motion has passed.

Other Parameters:

Vmax / Amax: is the ratio of maximum velocity (PGV) to the maximum acceleration (PGV). The v_{max}/ a_{max} ratio of strong ground motions can be used in seismic hazard studies as a parameter that captures the influence of frequency content.

Arias Intensity: quantifies the amount of energy from a strong ground motion record by integrating the acceleration time history.

$$I_a = \frac{\pi}{2g}\int_0^{\infty} [a(t)]^2 dt$$

The significant duration is the amount of time it takes to integrate from Ia = 5% to Ia = 95%.

Kobe Earthquake (1995)

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EVENT PARAMETERS:
      DATE: year = 1995 month = 1 day = 17
      TIME: hour|minute|second (20:46:53) time code= UTC
      LOCATION: latitude = 34.59 Longitude: 135.07  depth (km): 16km
      NAME: The Kobe (Japan) Earthquake
      MAGNITUDE:6.9

SITE PARAMETERS:
      LOCATION: latitude = 34.7640 longitude = 134.8430 elevation (m) = 0.0
      STATION OWNER: Conference on the Usage of Earthquakes, Railway Technical
      Research Inst
      RECORDING STATION: KAKOGAWA(CUE90)
      EPICENTRAL DISTANCE:28.38 km

DATA FOR SEISMOSIGNAL: ACCELERATION VALUES

      0.0001      0.0001      -0.0001     -0.0001     -0.0001     -0.0001
      -0.0001     -0.0001     -0.0001     0.0001      0.0003      0.0004
      0.0004      0.0005      0.0006      0.0007      0.0006      0.0003
      0.0001      0.0002      0.0003      0.0003      -0.0006     -0.001
      -0.0009     -0.0009     -0.0008     -0.0005     0.0001      0.0004
      0.0002      -0.0004     -0.0009     -0.001      -0.0008     -0.0007
      -0.0001     0.0009      0.0019      0.0029      0.0034      0.0034
      0.0031      0.0026      0.0013      -0.0001     -0.0013     -0.0017
      -0.0016     -0.0018     -0.0018     -0.0012     -0.0002     -0.0002
      -0.0009     -0.0012     -0.0007     -0.0008     -0.0015     -0.0023
      -0.004      -0.0049     -0.0046     -0.0034     -0.0021     -0.0015
      -0.0006     0.0007      0.0006      -0.0014     -0.0033     -0.0043
      -0.0043     -0.0031     0.0003      0.0038      0.0054      0.0043
      0.0017      -0.0009     -0.0028     -0.003      -0.001      -0.0005
      -0.0022     -0.0033     -0.005      -0.0082     -0.0094     -0.0064
      -0.0023     0.0007      0.0043      0.0075      0.0091      0.009
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SIGNAL PROCESSING of Kobe Earthquake:

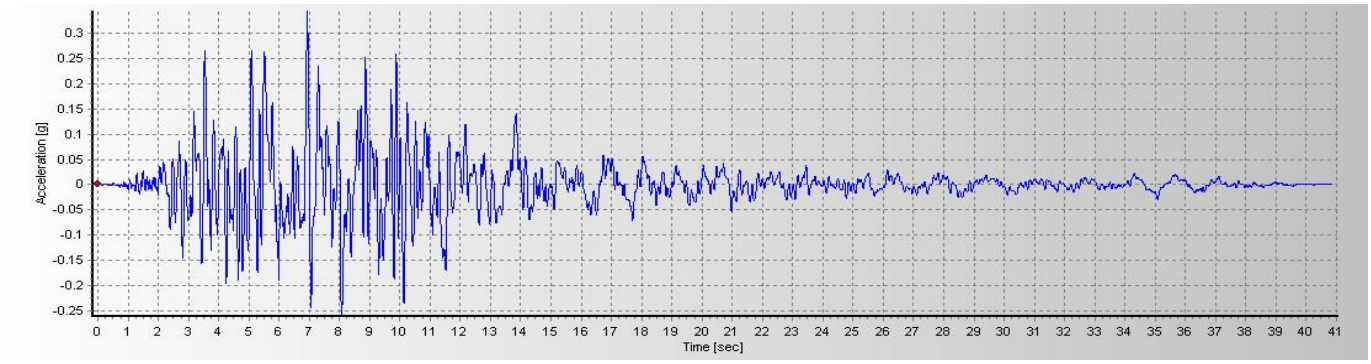


Fig: Acceleration Vs Time

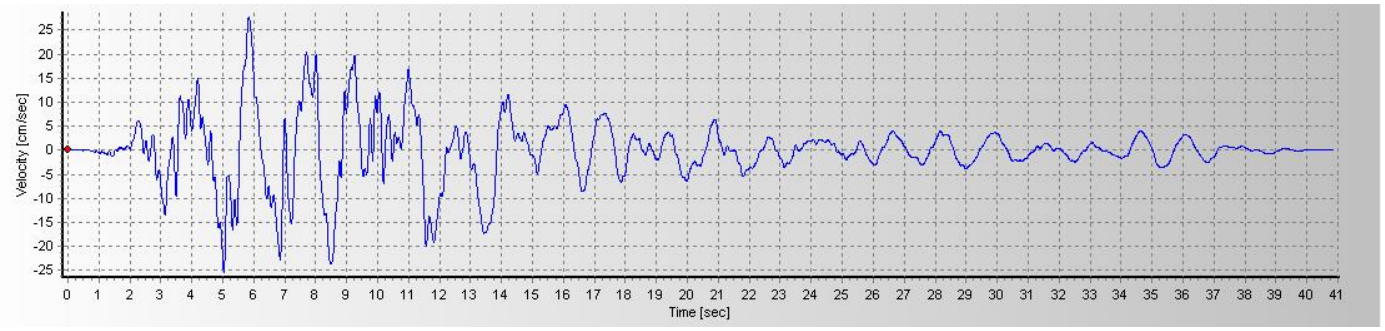


Fig: Velocity Vs Time

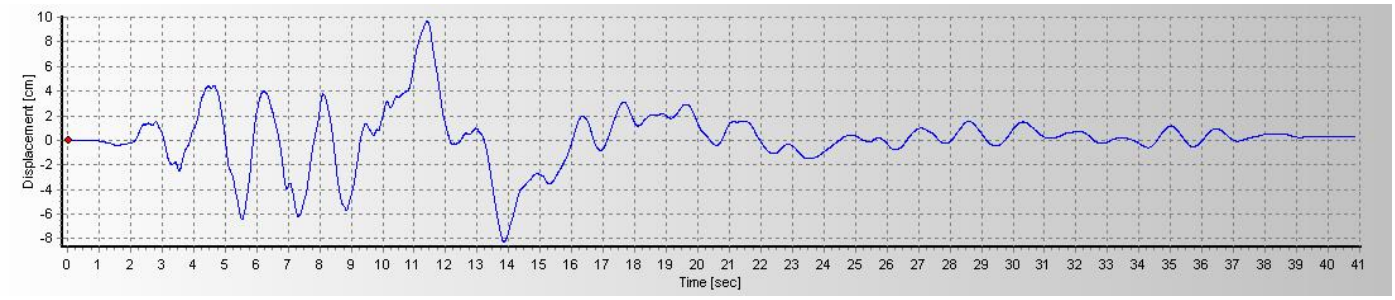


Fig: Displacement Vs Time

The above signal processing of Kobe Earthquake has been done with the help of a software called SeismoSignal Version 2016. From the processed time history of Kobe Earthquake the following ground motion parameters has been noted:

Max. Aceleration (g): 0.34470

Max. Velocity (cm/sec): 27.67793

Time of Max. Velocity (sec): 5.84000

Vmax / Amax (sec): 0.08185

Sustained Maximum Acceleration (g): 0.26640

Sustained Maximum Velocity (cm/sec): 23.63425

Maximum Displacement (cm): 9.69

Time of Maximum Displacement (sec): 11.41

Uniform Duration (sec) for Acceleration level 0.05g (sec) = 7.3

Bracketed Duration (sec) for Acceleration level 0.05g (sec) = 18.62

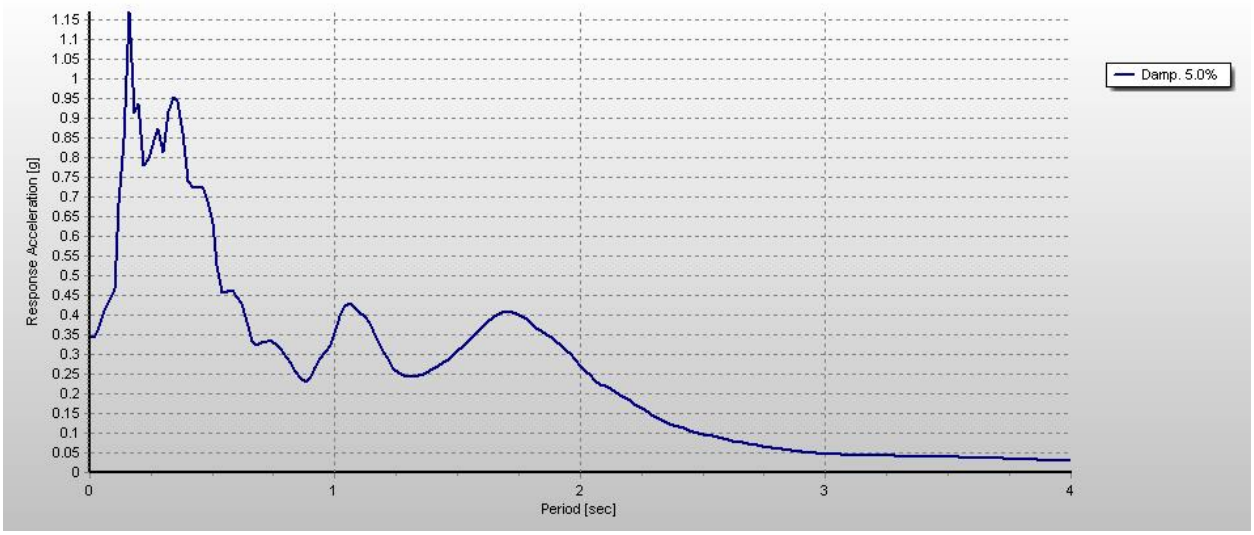
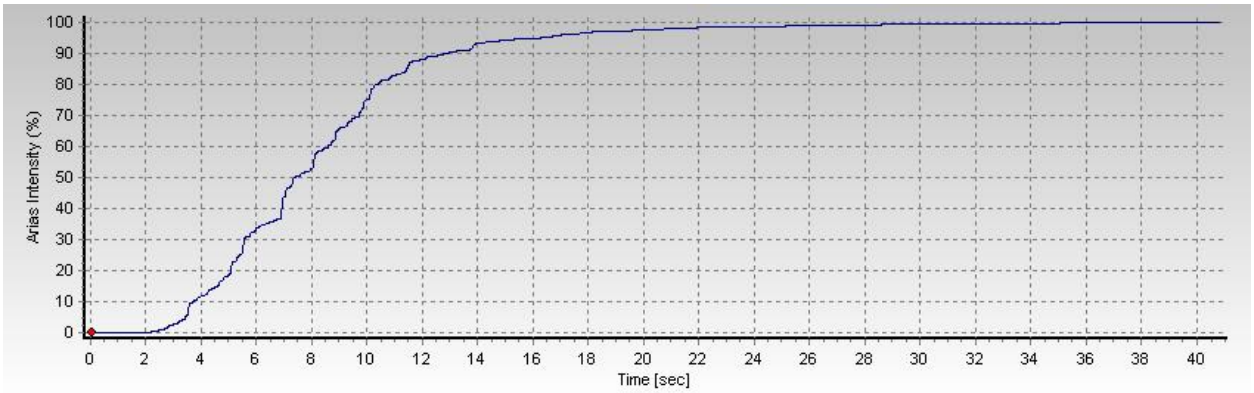


Fig: Response- Spectral Acceleration

From Response – Spectral Acceleration curve, we can see the Predominant Period (sec): 0.16000



Arias Intensity: (m/sec): 1.68744

Some other parameters that can be calculated by SeismoSignal includes, Cumulative Absolute Velocity (CAV) and Specific Energy Density (SED), Root-mean-square (RMS) of acceleration, velocity and displacement, Fourier and Power spectra, Husid and energy flux plots.

References:

Kramer, S.L. (2007). *Geotechnical Earthquake Engineering.* Pearson Education, Inc.

CESMD. Retrived from: http://www.strongmotioncenter.org/index.html

SeismoSignal. Retrived from: http://www.seismosoft.com/seismosignal