

Envelope Function—ENVL

The program ENVL (**Envelope Function**) is a subroutine subprogram that calculates the shape of the envelope curve of the acceleration time history when given the magnitude of the earthquake.

ENVL (**Envelope Function**)

【Purpose】

To create an envelope curve of the seismic motion (acceleration time history) according to the magnitude of the earthquake.

【Usage】

(1) How to connect

CALL ENVL (EM, TB, TC, TD, N, E, ND)

Argument	Type	Parameter in calling program	Return Parameter
EM	R	Magnitude of earthquake	Unchanged
TB	R	No need to input here	Start time of principal shock (unit : sec)
TC	R	No need to input here	End time of principal shock (unit : sec)
TD	R	No need to input here	Duration time (unit : sec)
N	I	Number of points that represent an envelope function	Unchanged
E	R 1-D array (ND)	No need to input here	Envelope function
ND	I	Dimension size of E in calling program (ND .GE. N)	Unchanged

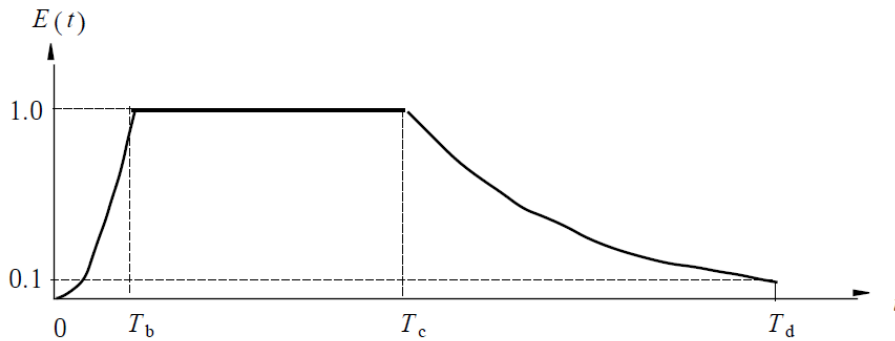
(2) Necessary subroutines and function subprograms

None

【Calculation Method】

The envelopment curve function $E(t)$ is defined by a quadratic curve between 0 and T_b , a horizontal straight line with $E(t) = 1$ between T_b and T_c representing the principal motion, and an exponential curve between T_c and T_d (T_d : duration of the earthquake motion), as shown in the following figure.

$$\left. \begin{array}{l} 0 \leq t \leq T_b : E(t) = (t/T_b)^2 \\ T_b \leq t \leq T_c : E(t) = 1 \\ T_c \leq t \leq T_d : E(t) = e^{-a(t-T_c)} \end{array} \right\} \quad (a)$$



Determine the values of T_b , T_c , and T_d , and calculate the value of $E(t)$ at any number of time points equally divided between 0 and T_d . If $E(t) = 0.1$ at $t = T_d$, then the third equation in equation (a) must be the following equation.

$$a = -\ln(0.1) / (T_d - T_c)$$

The duration of seismic motion, T_d (in sec), is given by the following equation if the magnitude of the earthquake is M .

$$T_d = 10^{0.31M - 0.774}$$

The relationship between the time ratios of T_b and T_c to T_d and the magnitude is shown in the following table. For values other than the magnitudes indicated, the time ratios in the table are linearly interpolated or extrapolated according to the magnitude.

$$\left. \begin{array}{l} T_b = [0.12 - 0.04(M - 7)]T_d \\ T_c = [0.50 - 0.04(M - 7)]T_d \end{array} \right\}$$

Magnitude M	T_b/T_d	T_c/T_d
8	0.08	0.46
7	0.12	0.50
6	0.16	0.54

【Program List】

C * * * * *	ENVL 1
C SUBROUTINE FOR ENVELOPE FUNCTION	ENVL 2
C * * * * *	ENVL 3
C	ENVL 4
C CODED BY Y. OHSAKI	ENVL 5
C	ENVL 6
C PURPOSE	ENVL 7
C TO GENERATE THE ENVELOPE FUNCTION IN COMPLIANCE WITH THE	ENVL 8
C MAGNITUDE OF EARTHQUAKE	ENVL 9
C	ENVL 10
C USAGE	ENVL 11
C CALL ENVL (EM, TB, TC, TD, N, Z, ND)	ENVL 12
C	ENVL 13
C DESCRIPTION OF ARGUMENTS	ENVL 14
C EM - MAGNITUDE OF EARTHQUAKE	ENVL 15
C TB - TIME AT THE BEGINNING OF PRINCIPAL SHOCK IN SEC	ENVL 16
C TC - TIME AT THE END OF PRINCIPAL SHOCK IN SEC	ENVL 17
C TD - DURATION OF EARTHQUAKE MOTION IN SEC	ENVL 18
C N - TOTAL NUMBER OF POINTS DESCRIBING THE ENVELOPE FUNCTION	ENVL 19
C Z(ND) - ENVELOPE FUNCTION	ENVL 20
C ND - DIMENSION OF Z IN CALLING PROGRAM ND.GE.N	ENVL 21
C	ENVL 22
C SUBROUTINES AND FUNCTION SUBPROGRAMS REQUIRED	ENVL 23
C NONE	ENVL 24
C	ENVL 25
C SUBROUTINE ENVL (EM, TB, TC, TD, N, Z, ND)	ENVL 26
C	ENVL 27
C DIMENSION Z(ND)	ENVL 28
C	ENVL 29
C TD=10.**(0.31*EM-0.774)	ENVL 30
C DT=TD/REAL(N-1)	ENVL 31
C TB=(0.12-(EM-7.)*0.04)*TD	ENVL 32
C TC=(0.50-(EM-7.)*0.04)*TD	ENVL 33
C A=-ALOG(0.1)/(TD-TC)	ENVL 34
C DO 130 M=1,N	ENVL 35
C T=REAL(M-1)*DT	ENVL 36
C IF(T.GE.TB) GO TO 110	ENVL 37
C Z(M)=(T/TB)**2	ENVL 38
C GO TO 130	ENVL 39
C 110 IF(T.GT.TC) GO TO 120	ENVL 40
C Z(M)=1.	ENVL 41
C GO TO 130	ENVL 42
C 120 Z(M)=EXP(-A*(T-TC))	ENVL 43
C 130 CONTINUE	ENVL 44
C RETURN	ENVL 45
C END	ENVL 46

【Example】

Calculate the values of time T_b , T_c , and T_d (duration) assuming that the magnitude is $M = 7.3$.

```
DIMENSION E(51)
DATA NN/51/, EM/7.3/
C
CALL ENVL(EM, TB, TC, TD, N, E, 51)
WRITE(6, 601) EM, TB, TC, TD
STOP
C
601 FORMAT(' EM=', F4.1//T4, ' TB', F7.2/T4, ' TC', F7.2/T4, ' TD', F7.2)
END
```

Output:

```
EM= 7.3

TB   3.33
TC  15.05
TD  30.83
```