1. Limitations

The specimen and loading conditions should be bilateral symmetry.
The crack develops along the axis of symmetry.
The number of loading point should be only one.

2. Programs and data folders

(1) Programs

ini.for: Calculate the coefficients of crack equations
ym.for: Calculate Young's modulus from the experiment data
ft.for: Determine the tensile strength (initial cohesive stress)
soft.for: Calculate the entire tension softening diagram
pd.for: Calculate the load-displacement relationship using tension softening diagram obtained by soft.for

(2) Data folders

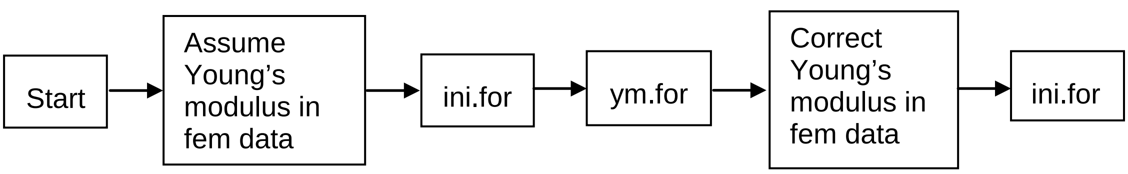
expdat: Experiment data (see “exp_format.txt”)
ftout: output of ft.for
iniout: output of ini.for (intermediate file for other programs)
input: FE-model data (input for all programs) (see “fem_format.txt”)
pdout: output of pd.for (load-displacement relations)
softout: output of soft.for (tension softening diagram)

3. Unit

Load ---> N
Length and displacement ---> mm
Stress ---> N/mm^2

4. Estimation of Young’s modulus

The Young’s modulus of flexural specimen is unknown before calculation. The program “ym.for” is used to estimate the Young’s modulus from the initial slope of load-displacement curve of experiment. In “ym.for“, the initial slope of the load-displacement curve is calculated by assuming an appropriate Young’s modulus, then the correct Young’s modulus is determined by compared with the initial slope of the load-displacement curve of experiment.



5. Program

5.1 ini.for

The coefficients of crack equation are calculated and output as a binary file (elem.tmp). The binary file is used for all other program.

	Input file	Output file
1	FE-model data （fem.dat）	
		elem.tmp

5.2 ym.for

The Young’s modulus is estimated from experiment data.

	Input file/key in data	Output file
1	FE-model data （fem.dat）	non
2	Crack eq. data （elem.tmp）	
3	Experiment data (exp.dat)	
4*	Kind of fitting data （Def.→1, CMOD→2）	
5**	Tensile strength	

4*. Kind of fitting data

[FITTING DATA (1=DEFLECTION, 2=CMOD) (I1)]

If the fitting data is deflection/displacement, key in “1”.

If the fitting data is CMOD, key in “2”.

5**. Tensile strength

[TENSILE STRENGTH (F10.0)]

This tensile strength is used as the elastic limit to calculate the initial slope of the load-deflection/CMOD curve. The accurate value is not necessary. An approximate value such one-tenth of compressive strength can be used.

5.3 ft.for

The poly-linear approximation method cannot determine the unique tensile strength (initial cohesive stress). The program “ft.for” gives the consistency of the load-deflection/CMOD curve between experiment and calculation when the perfect plasticity type tension softening diagram is assumed for the given range of tensile strength. The one of the choice may be to determine the tensile strength as the crack length (=ICR) to be the maximum for the perfect plasticity type tension softening diagram. However, there is no theoretical background to determine the tensile strength. Therefore, the tensile strength obtained by this program should be considered as a reference value for the estimation of whole tension softening curve. So, this program is not always necessary to estimate the tension softening curve.

	Input file/key in data	Output file
1	FE-model data （fem.dat）	
2	Crack eq. data （elem.tmp）	
3	Experiment data (exp.dat)	
4	Kind of fitting data （Def.→1, CMOD→2）	
5*	Tolerance of estimation	
6**	Lower limit of tensile strength	
7**	Upper limit of tensile strength	
		ftout.dat

5*. Tolerance of estimation

[TOLERANCE (F10.0)]

The tolerance of estimation is given as the difference of the load values between calculation and experiment at arbitrary identical displacement. If an error of 3% is allowed for the estimation, key in “0.03”.

6, 7**. Lower/Upper limit of tensile strength

[LOWER/UPPER LIMIT OF TENSILE STRENGTH (F10.0)]

Key in the rage of tensile strength.　The crack length (=ICR) is calculated for the tensile strength.　For example, if you key in “2.0” and “3.0” for the lower and upper limit respectively, the crack lengths are calculated for the tensile strength of 2.0, 2.1, 2.2, , , , , 2.9, 3.0 N/mm2, respectively.

5.4 soft.for

This program is main program of the poly-linear approximation method.

	Input file/key in data	Output file
1	FE-model data （fem.dat）	
2	Crack eq. data （elem.tmp）	
3	Experiment data (exp.dat)	
4	Kind of fitting data （Def.→1, CMOD→2）	
5*	Tolerance of estimation	
6**	Tensile strength	
		s-w.dat

5*. Tolerance of estimation

[TOLERANCE (F10.0)]

At the beginning of estimation, relatively large value (about 0.05) is recommended. If you give too small tolerance, the program may be suspended at early stage.

6**. Tensile strength

[TENSILE STRENGTH (F10.0)]

The tensile strength (initial cohesive stress) is the key parameter of the poly-linear approximation method. The program may be suspended at early stage depending on the tensile strength. The result of the program “ft.for” will be a reference, but in most cases the tensile strength will be determined by trial and error. When the program is suspended at early stage, in some cases the program “pd.for” is useful to find the cause of a suspension.

5.5 pd.for

This is a forward analysis program to calculate the load-displacement relations using the determined/given tension softening diagram.

	Input file	Output file
1	FE-model data （fem.dat）	
2	Crack eq. data （elem.tmp）	
3	Tension softening diagram （s-w.dat）	
		（p-d.dat）

If you make FE-model data and tension softening diagram with the same format, you can calculate the load-displacement relations for the arbitrary FE-model and tension softening diagram.