CHAPTER 5

COMPUTATION

5.1 General

It is proposed to present in this chapter a scheme of computation and details regarding the computer programme and its execution.

Computer programme is written in Fortran II. The listing of the programme is given in Appendix C.

5.2 Scheme of Computation

The basis for fixing the pattern for computational work is as follows :

The input parameters are

f, mp, Z, K_2, N, D'_Y, D'_X and R.

Output parameters are

n_u, P_u, M_u, $\propto_u$, mp critical, $\overline{mp}$ and the type of failure.

The input data parameters have the following values.

Case 1. Neutral axis bisecting the opposite sides.

f	= 0, 0.25, 0.50, 0.75	(4 values)
mp	= 0.05, 0.1, 0.15, 0.20, 0.25, 0.30, 0.40	(7 values)
Z	= 0.5, 1.0	(2 values)
K_2	= 0.15	(1 value)
N	= 0.9, 1.0, 1.1	(3 values)
D'_Y	= 0, 0.4, 0.8, 1.2, 1.6	(5 values)
D'_X	= 0, 0.4, 0.8, 1.2, 1.6	(4 values)
R	= 2.0	(1 value)

Combination of all the values shall result into total of 3360 input values.

For each input value, 7 output values are obtained.

Case 2. Neutral axis bisecting adjacent sides.

f	= 1.0, 0.9, 0.8, 0.6, 0.4	(5 values)
mp	= 0.05, 0.1, 0.2, 0.3, 0.4	(5 values)
Z	= 0.5, 1.0	(2 values)
K_2	= 0.15	(1 value)
N	= 0.9, 1.0, 1.1	(3 values)

D'_Y = 0.0, 0.4, 0.8, 1.2, 1.6 (5 values)

D'_X = 0.0, 0.4, 0.8, 1.2 (4 values)

R = 2.0 (1 value)

Combination of all the values shall result into total of 3000 input values.

For each input value, 7 output values are obtained.

5.3 Computer Programme

The computer programme is written in Fortran II. Computer programme, flow diagram is shown in Appendix A. The arrangement of main programme and the subroutines are also given in Appendix B. The programme calculates the output parameters and gives the output against each input data. The programme is so designed that all possible combinations of input values are carried out and listed properly along with the output values. To improve readability of output, a line is skipped off after each eight lines.

Computer programme for case 1 is executed on Operations Research Group Computer R 1030 at Baroda while that for case 2 is executed at IBM 1620 computer at Sardar Patel University, Vallabh Vidyanagar.

5.4 Solution of Cubic Equations

Programme for solution of cubic equation is written from reference 49. Mathematical approach to solve cubic equations is as under :

Take a cubic equation

$$a_1x^3 + a_2x^2 + a_3x + a_4 = 0 \qquad (5.1)$$

The coefficients a_1 are assumed real so that eq. 5.1 must have at least one real root. The programme first computes a real root and uses this root to reduce the cubic to a quadratic. It then calls a sub-programme named QUAD to compute the remaining two roots.

Cubic equation (5.1) can always be reduced to a cubic without the second degree term

$$Z^3 + 3PZ + 2Q = 0 \qquad (5.2)$$

by linear transformation

$$x = Z - \frac{a_2}{3a_1} \qquad (5.3)$$

where

$$2Q = \frac{a_4}{a_1} - \frac{a_2a_3}{3a_1^2} + \frac{2a_2^3}{27a_1^3} \qquad (5.4)$$

$$3P = \frac{a_3}{a_1} - \frac{a_2^2}{3a_1^2} \qquad (5.5)$$

A root of (5.2) is always given by

$$Z = (\sqrt{P^3 + Q^2} - Q)^{\frac{1}{3}} - (\sqrt{P^3 + Q^2} + Q)^{\frac{1}{3}} \qquad (5.6)$$

when $a_4 = 0$, $x = 0$ is a real root of (5.1). If $Q = 0$, $Z = 0$ is a real root of (5.2). Therefore, $Q > 0$ need be considered. Thus for $a_4 \neq 0$ and $Q > 0$ a real root of (5.2) is given by one of the five cases listed below :

(1) $P^3 + Q^2 < 0$;

$$Z = -2\sqrt{-P}\ \cos\left(\tfrac{1}{3}\tan^{-1}\left(\frac{\sqrt{-P^3 - Q^2}}{Q}\right)\right)$$

(2) $P^3 + Q^2 = 0$; $\quad Z = -2Q^{\frac{1}{3}}$

(3) $P^3 + Q^2 > 0$, $P < 0$

$$Z = -(Q + \sqrt{P^3 + Q^2})^{\frac{1}{3}} - (Q - \sqrt{P^3 + Q^2})^{\frac{1}{3}}$$

(4) $P^3 + Q^2 > 0$, $P = 0$, $Z = -(2Q)^{\frac{1}{3}}$

(5) $P^3 + Q^2 > 0$, $P > 0$;

$$Z = (\sqrt{P^3 + Q^2} - Q)^{\frac{1}{3}} - (\sqrt{P^3 + Q^2} + Q)^{\frac{1}{3}}$$

Sub programme QUAD computes the roots of the quadratic equation $a_1x^2 + a_2x + a_3 = 0$ by the formula

$$x_{1,2} = -\frac{a_2}{2a_1} \pm \sqrt{\left(\frac{a_2}{2a_1}\right)^2 - \frac{a_3}{a_1}}$$

5.5 Input and Output Cards

Job on computer was executed for input values listed in para 5.2.

Data read in by 'Read' statements, Read 2, Read 3, and Read 9, (Appendix C) contain three data cards for input values and are shown below

(a) Data cards for case 1

Card No.1 : 0407020103050401

Card No.2 : 0.0 0.25 0.50 0.75 0.05 0.1 0.15
0.20 0.25 0.30 0.40 0.5 0.1 0.15
0.90 1.0 1.1 0.0 0.4 0.8 1.2 1.6
0.0 0.4 0.8 1.2 2.0

Card No.3 : 112131

(b) Data cards for case 2

Card No.1 : 0505020104050501

Card No.2 : 0.4 0.6 0.8 0.9 1.0 0.05 0.1 0.2
0.3 0.4 0.5 1.0 0.15 0.8 0.9 1.0
1.1 0.0 0.4 0.8 1.2 1.6 0.0 0.4
0.8 1.2 1.6 2.0

Card No.3 : 122232

Data cards for experimental parameters of 24 specimens were prepared on similar lines. The programme on execution produces results in the manner indicated by 'print' statements. (Appendix C)

5.6 Use of Output Results

The output obtained from the input parameters is utilized for developing interaction charts. It is seen that each output value is utilized most effectively to bring out the interaction curves. The interaction curves are presented in Appendices E and F.