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Load-deformation behavior of reinforced fibrous concrete beams

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LOAD-DEFORMATION BEHAVIOR OF REINFORCED FIBROUS CONCRETE BEAMS

by

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ABSTRACT

Title of Thesis: Load-Deformation Behavior of Reinforced Fibrous Concrete Beams

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This study deals with the load-deformation behavior of steel fiber reinforced concrete beams.

Theoretical development of moment-curvature and load-deformation relationships is presented in this paper. It is based on the assumption that the failure at a section occurs either when the force equilibrium equation is violated or when the concrete elements start to get crushed in the member. The complete stress-strain relationship of plain fibrous concrete in reference [2] was used in this study.

A special computer program is presented herein to carry out the theoretical studies of load-deformation behavior of simply supported beam under two-point loading. The validity of the theory developed in this paper has been verified by comparing with the experimental results of eleven beams which had been tested as shown in references [3], [4] and [5]. The results of comparison indicate a good correlation between each other.

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NOTATION

f_c'	Compressive strength of concrete
ϵ_o	Concrete strain corresponding to the compressive strength
f	Concrete stress on the curve
ϵ	Concrete strain on the curve
β	Material parameter
R.I.	The reinforcing index of hooked steel fiber related to the weight fraction
r.i.	The reinforcing index of smooth steel fiber related to the weight fraction
W_f	Weight fraction of steel fibers with respect to concrete
l/ϕ	aspect ratio of steel fiber (length/diameter)
E_c	Modulus of elasticity of concrete
E_{cf}	Modulus of elasticity of fibrous concrete
ϵ_s	Steel strain
ϵ_c	Concrete strain
ϵ_y	Steel strain at yielding
ϵ_{sh}	Steel strain at the start of strain-hardening
f_y	Steel stress at yielding
E_s	Modulus of elasticity of steel
E_{ss}	Modulus of elasticity of tensile steel after strain-hardening
C_c	Compressive force in concrete
C_s	Compressive force due to compression steel
C_T	Tensile force in concrete
T_s	Tensile force in steel
n	Modular ratio

A_s	Area of tensile steel
A_s'	Area of compressive steel
M	Moment
Φ	Curvature
δ_B	Deflection at B
δ_m	Deflection at mid-span
θ_A	Rotation at A

I. INTRODUCTION

Steel fiber reinforced concrete is increasingly used as a construction material. It is a concrete made of hydraulic cements with aggregates and reinforced with discontinuous discrete low carbon steel fibers. Recently, it has been used in many applications such as hydraulic structures, airport, highway paving, refractory concrete and bridge decks. Research has been made on the subject of using steel fibers for reinforcing structural members in combination with conventional reinforcing. It has been shown that the addition of fibers to concrete substantially increased the ductility of the concrete.

This study addresses the load-deflection behavior of steel fibers reinforced concrete beams. A theoretical development of moment-curvature and load deflection relationship has been presented in this paper. The analysis is based on the assumptions that the failure at a section occurs either when the force equilibrium equation is violated or when the concrete elements start to get crushed in the member.

The stress-strain relationship of fiber reinforced concrete (eq. 1-1) proposed by Ezeldin, A. S. [2] is used in the analysis,

$$\frac{f}{f_c'} = \frac{\beta\,(\epsilon / \epsilon_o)}{\beta - 1 + (\epsilon / \epsilon_o)^{\beta}} \qquad (1\text{-}1)$$

where f_c' : compressive strength of concrete

ϵ_o : strain corresponding to the compressive strength

f, ϵ : stress and strain values on the curve.

β is a material parameter which can be calculated by using the following equations from Reference [2]:

$$\beta = 1.093 + 0.7132\ (R.I.)^{-0.926} \qquad (1\text{-}2)$$

or, $$\beta = 1.093 + 7.4818\ (r.i.)^{-1.387} \qquad (1\text{-}3)$$

where R.I. : the reinforcing index of hooked steel fiber related to the weight fraction, $R.I. = w_f * l/\phi$

w_f : weight fraction of steel fibers with respect to concrete

l/ϕ : aspect ratio of steel fiber (length/diameter)

r.i. : the reinforcing index of smooth steel fiber related to the weight fraction.

A computer program has been designed to carry out the theoretical analysis of load-deformation behavior of simply supported beam under two point loading. The experimental results of eleven beams (tested in [3], [4], [5]) are compared with the theoretical results to verify the validity of the analytical method developed herein.

Units in this study are all pounds and inches unless otherwise indicated.

II. THEORETICAL DEVELOPMENT

2.1 Assumptions and Idealizations

The theoretical development of load-deformation relationship of fibrous reinforced concrete beams is presented in this chapter. The study is based on the assumption that the failure at a section occurs either when the force equilibrium equation is violated or when the concrete elements start to get crushed in the member.

The following assumptions are made for the analysis:

(1) Plain section remains plane.

(2) Perfect bond exists between the steel and concrete.

(3) No shear and diagonal tension failure occurred in the beams.

(4) The stress-strain relationship for fibrous concrete (1-1) is used.

(5) The steel stress-strain curve is used as shown in Fig. 1.

(6) The modulus of elasticity of fibrous concrete is taken as

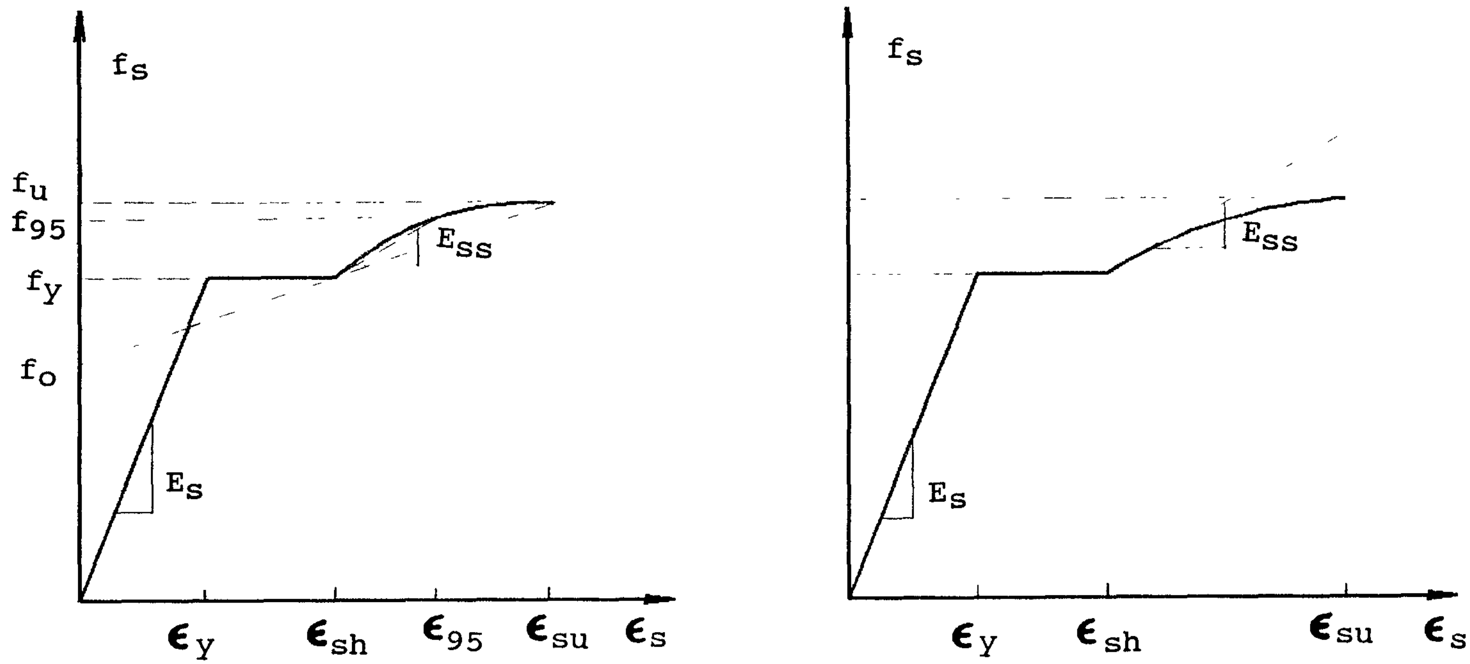
$$E_{cf} = E_c + 0.941*10^6(R.I) \qquad (2\text{-}1)$$

where $E_c = 57000\sqrt{f_c'}$

2.2 Derivation of Moment-Curvature Relationship

The following step by step procedure was used (Reference [1]):

(1) Select tensile steel strain ϵ_s .



(A) EXPERIMENTAL CURVE

(B) IDEALIZED CURVE

FIGURE 1. STEEL STRESS-STRAIN CURVES

(2) Locate the neutral axis by solving the force equilibrium equations.

(3) Obtain the concrete compressive strain ϵ_c at the extreme fiber assuming that plane section remains plane.

(4) Evaluate bending moment and curvature corresponding to the selected ϵ_s.

(5) Check force equilibrium equation across the section. If the equation is no longer satisfied or the concrete strain at extreme fiber exceed the ultimate strain of concrete, the section is assumed to have obtained the ultimate loading stage.

The analysis is involved in the three stages as follow:

2.2.1 **Before Cracking** (see Fig.2)

Force equilibrium equation can be written as

$$C_c + C_s = C_T + T_s + P \qquad (2\text{-}2)$$

where P is a constant axial load.

The compressive force in concrete is given by:

$$C_c = \frac{f_c b x'}{2} = \frac{b x' f_t x'}{2(D-x')} \qquad (2\text{-}3)$$

where $f_c/f_t = x'/(D-x')$

The compressive force due to compression steel is as follow:

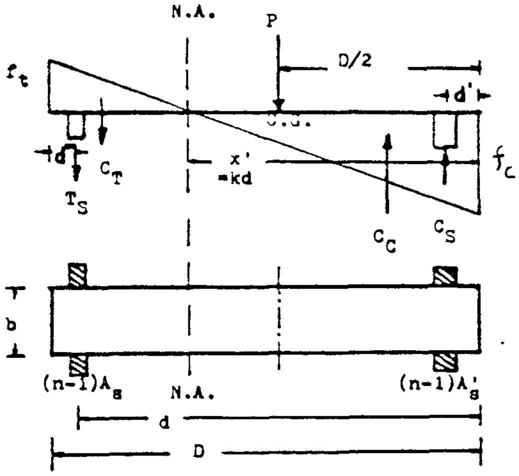


FIGURE 2. SECTION ANALYSIS : BEFORE CRACKING

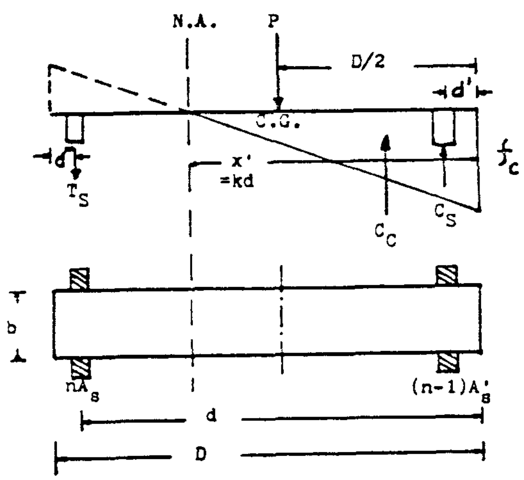


FIGURE 3. SECTION ANALYSIS : IMMEDIATELY AFTER CRACKING

$$C_s = f_c \left(\frac{x'-d'}{x'} \right)(n-1)\, A_s'$$

$$= \frac{(x'-d')(n-1)\, A_s' f_t}{(D - x')} \qquad (2-4)$$

The tensile force in steel is:

$$T_s = f_c \left(\frac{d-x'}{x'} \right)(n-1)\, A_s$$

$$= \frac{(d-x')(n-1)\, A_s\, f_t}{(D - x')} \qquad (2-5)$$

The tensile force in concrete is:

$$C_T = 0.5 * b(D-x') f_t \qquad (2-6)$$

Substitute eq.(2-3),(2-4),(2-5) and (2-6) into (2-2), x' can be solved.

$$x' = kd = \frac{(n-1) f_t (A_s' d' + A_s d) + 0.5 * f_t b D^2 + PD}{(n-1) f_t (A_s' + A_s) + b f_t D + P} \qquad (2-7)$$

The resisting moment about the neutral axis is

$$M = C_c x' * 2/3 + C_s(x'-d') + C_T(D-x') * 2/3 + T_s(d-x')$$

$$- P(x'-D/2) \qquad (2-8)$$

where $P = C_c + C_s - T_s - C_T$

Put eq. (2-3),(2-4),(2-5) and (2-6) into (2-8), one has

$$M = \frac{bf_t x'^3}{3(D-x')} + (n-1)A_s' f_t \frac{(d-x')^2}{D-x'} + \frac{bf_t(D-x')^2}{3}$$

$$+ (n-1)A_s f_t \frac{(d-x')^2}{D-x'} - P(x'-D/2) \qquad (2-9)$$

The curvature can be expressed as follow:

$$\Phi = \frac{\epsilon_s}{(1-k)d} \qquad (2-10)$$

2.2.2 Immediately After Cracking (see Fig.3)

The force equilibrium equation can be written as:

$$C_c + C_s = T_s + P \qquad (2-11)$$

where

$$C_c = 0.5*bx'f_t(\frac{x'}{D-x'}) = 0.5*f_c bx' \qquad (2-12)$$

$$C_s = (n-1)A_s'f_t(\frac{x'-d'}{D-x'})$$

$$= f_c(x'-d')(n-1)A_s'/x' \qquad (2-13)$$

$$T_s = nA_s f_t(d-x')/(D-x')$$

$$= nA_s f_c(d-x')/x' \qquad (2-14)$$

Substitute these equations into (2-11), x' can be solved. Now let

$k = x'/d$ and

$$M = 2*C_c x'/3+C_s(x'-d')+T_s(d-x')-P(x'-D/2) \qquad (2-15)$$

Since

$$\epsilon_s'/\epsilon_o = (k+j-1)/k$$

$$\epsilon_s / \epsilon_c = (d-kd)/kd = (1-k)/k$$

$$f_s'/f_c = E_s'\,\epsilon_s'/(E_c\,\epsilon_c) = n(k+j-1)/k \quad (\text{assume } E_s' = E_s)$$

$$f_s/f_c = n\,\epsilon_s/\epsilon_c = n(1-k)/k$$

Put (2-12), (2-13), (2-14) into (2-15), f_c can be solved as follow:

$$f_c = \frac{M + P(x'-D/2)}{bx'^2/3+(x'-d')^2(n-1)A_s'/x'+(d-x')^2 nA_s/x'} \qquad (2\text{-}16)$$

$$f_s = n(1-k)f_c/k \qquad (2\text{-}17)$$

$$\epsilon_s = f_s/E_s \qquad (2\text{-}18)$$

The curvature immediate after cracking can be expressed as follow:

$$\Phi_{cr(a)} = \frac{\epsilon_s}{(1-k)d} \qquad (2\text{-}19)$$

2.2.3. Between Cracking and Ultimate

Case A: ($\epsilon_c <= \epsilon_o$) (see Fig.4)

The condition of force equilibrium is

$$P + T_s = C_{c1} + C_s \qquad (2\text{-}20)$$

where the compressive force C_{c1} in the concrete can be expressed as

$$C_{c1} = b\int_0^{kd} f\,dy \qquad (2\text{-}21)$$

Now that the stress-strain equation of fibrous concrete is given by the following equation:

$$\frac{f}{f_c'} = \frac{\beta\,(\epsilon/\epsilon_o)}{\beta-1+(\epsilon/\epsilon_o)^{\beta}} \qquad (1\text{-}1)$$

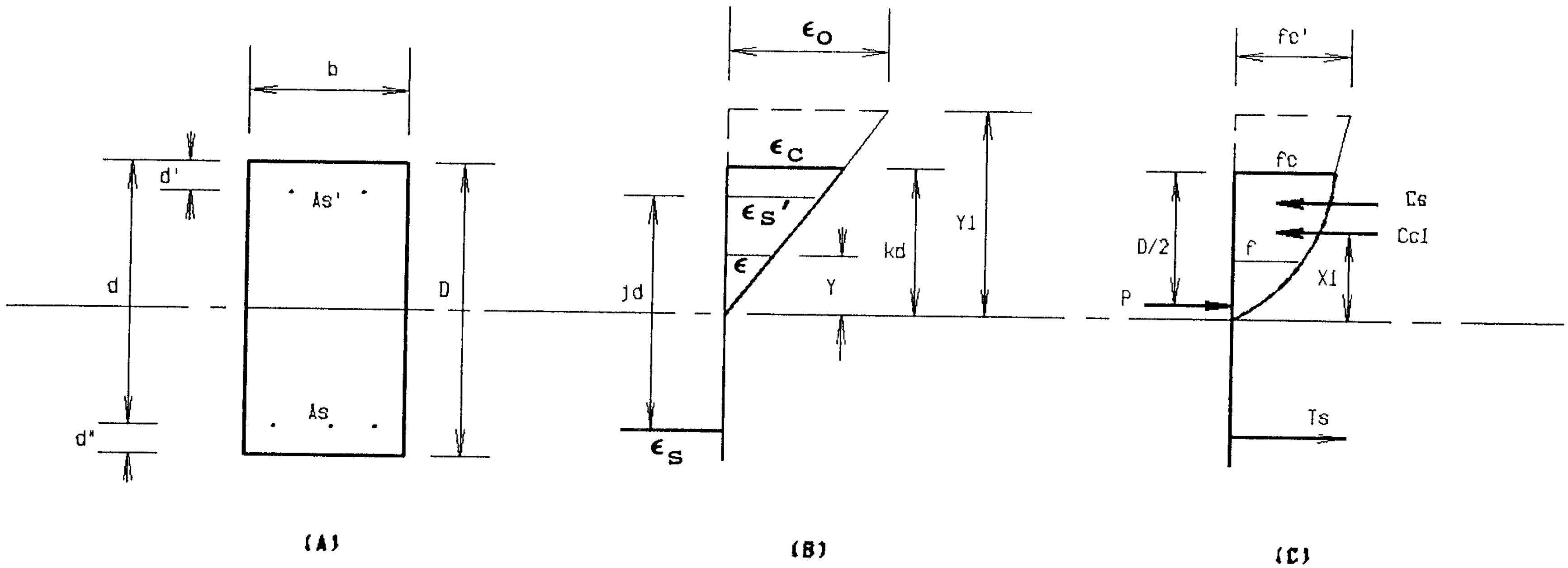


FIGURE 4. SECTION ANALYSIS : CASE A

$$\frac{\epsilon_o}{Y1} = \frac{\epsilon}{y} = \frac{\epsilon_c}{kd}, \qquad \frac{\epsilon}{\epsilon_o} = \frac{y}{Y1} \qquad (2\text{-}22)$$

Substitute (2-22) into (1-1), we get

$$f = \frac{f_c'\beta}{Y1} * \frac{y}{(\beta-1)+(y/Y1)^{\beta}} \qquad (2\text{-}23)$$

Equation (2-21) becomes

$$C_{c1} = b\int_o^{kd} \frac{f_c'\beta}{Y1} * \frac{y}{(\beta-1)+(y/Y1)^{\beta}}\, dy = F_1(k) \qquad (2\text{-}24)$$

where

$$Y1 = (1-k)d\ \epsilon_o/\epsilon_s \qquad (2\text{-}25)$$

C_{c1} is a function of k. The method of integration in (2-24) can be found in Appendix A.1

For compression steel

$$\epsilon_s' = \frac{(kd-d')\ \epsilon_s}{(1-k)d}$$

$$\epsilon_y' = \frac{f_y'}{E_s'} = \frac{f_y'}{E_s} \qquad (\text{Assume } E_s = E_s')$$

So, $f_s' = E_s'\epsilon_s' = E_s\epsilon_s'$ if $\epsilon_s' <= \epsilon_y'$

$f_s' = f_y'$ if $\epsilon_s' >= \epsilon_y'$

$C_s = A_s'f_s'$ (2-26)

For tensile steel,

$f_s = E_s\epsilon_s$ if $\epsilon_s < \epsilon_y$

$f_s = f_y$ if $\epsilon_y <= \epsilon_s < \epsilon_{sh}$

$f_s = f_y + (\epsilon_s - \epsilon_{sh})E_{ss}$ if $\epsilon_s >= \epsilon_{sh}$

where ϵ_{sh} and E_{ss} are defined in Fig. 1.

Let $T_s = A_s f_s$ (2- 27)

Substitute (2-27), (2-24), and (2-26) into equilibrium equation (2-20), one gets

$$F2\ (k, \epsilon_s) = 0 \qquad (2\text{-}28)$$

For a selected strain of tensile steel ϵ_s, k can be solved (see Appendix B). The distance between the centroid of the concrete compression block and the neutral axis is given by

$$X_1 = \frac{\int_0^{kd} yfdy}{\int_0^{kd} fdy} \qquad (2\text{-}29)$$

The method of integrations can be found in Appendix A.1 and A.2 respectively. From the compatibility equation, one has

$$\frac{F\,\epsilon_c}{k} = \frac{\epsilon_s}{1-k} \quad \text{then} \quad \epsilon_c = \frac{\epsilon_s k}{F(1-k)} \qquad (2\text{-}30)$$

Here, the compatibility factor F is assumed to be 1.0 (i.e., there is a perfect bond between steel and concrete). The curvature Φ can be obtained as follow:

$$\Phi = \frac{\epsilon_c}{kd} \qquad (2\text{-}31)$$

and the moment about the neutral axis is given by

$$M = C_{c1}[x_1+d(1-k)] + C_s jd - P(d-D/2) \qquad (2\text{-}32)$$

Case B : ($\epsilon_c >= \epsilon_o$) (see Fig.5)

If $\epsilon_c >= \epsilon_o$, the concrete compressive block consist of two parts, which were shown in Fig.5. The concrete compression forces are

$$C_{c1} = b\int_{0}^{Y1} fdy \tag{2-33}$$

$$C_{c2} = b\int_{Y1}^{kd} fdy \tag{2-34}$$

where f is defined in (2-23), and

$$Y1 = (1-k)d(\epsilon_o/\epsilon_s) \tag{2-35}$$

From Fig. 5, the distant between the centroid of C_{c2} and tensile steel are given by

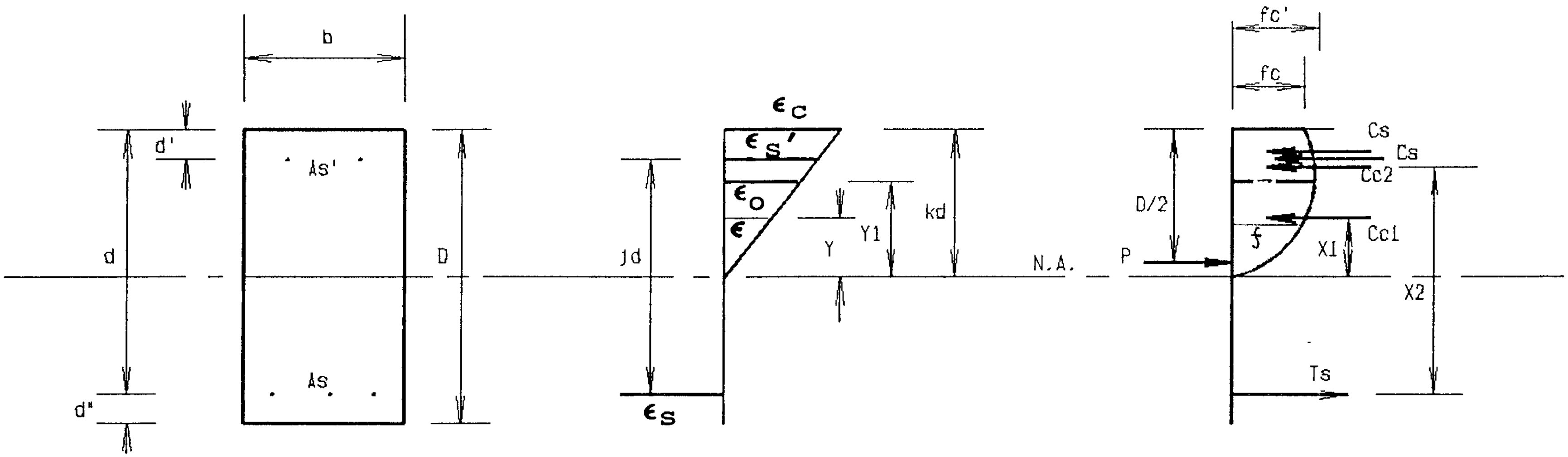
$$X_2 = (1-k)d + Y1 + \frac{\int_{Y1}^{kd} (y-Y1)fdy}{\int_{Y1}^{kd} fdy} \tag{2-36}$$

$$X_1 = \frac{\int_{0}^{Y1} yfdy}{\int_{0}^{Y1} fdy} \tag{2-37}$$

To solve X_1 and X_2, see Appendix A.1 and A.2. Now, the equilibrium equation is shown as follow:

$$P + T_s = C_{c1} + C_{c2} + C_s \tag{2-38}$$

where C_s and T_s can be found in (2-26) and (2-27). The K value can be solved when equation (2-26), (2-27), (2-33), and (2-34) were substituted into (2-38) (see Appendix B). ϵ_c and Φ are determined from equation (2-30) and (2-31). The resisting moment M about the neutral axis is:



(A) (B) (C)

FIGURE 5. SECTION ANALYSIS : CASE B

$$M = C_{c1}[X_1 + d(1-k)] + C_{c2}X_2 + C_s jd - P(d-D/2) \quad (2\text{-}39)$$

2.3 Post-Yielding Deflection in Simply Supported Beam under Two-Point Loading

The method of analysis for determining the deflections in beams shown in Reference [1] are used herein. The following formulae can be used for both linear and non-linear ranges.

$$\theta = \int_A^B \Phi \, dx \quad (2\text{-}40)$$

$$\delta = \int_A^B \Phi \, x \, dx \quad (2\text{-}41)$$

where θ = angle between the tangents to the deflected elastic curve at two points A and B.

δ = the deflection at point B on the deflected elastic curve from the tangent to the elastic curve at another point A.

2.3.1 At Cracking (see Fig.6)

Rotation at A:

$$\theta_A = \Phi_{cr} Z \quad (2\text{-}42)$$

Deflection at B:

$$\delta_B = (5/6) * \Phi_{cr} Z^2 \quad (2\text{-}43)$$

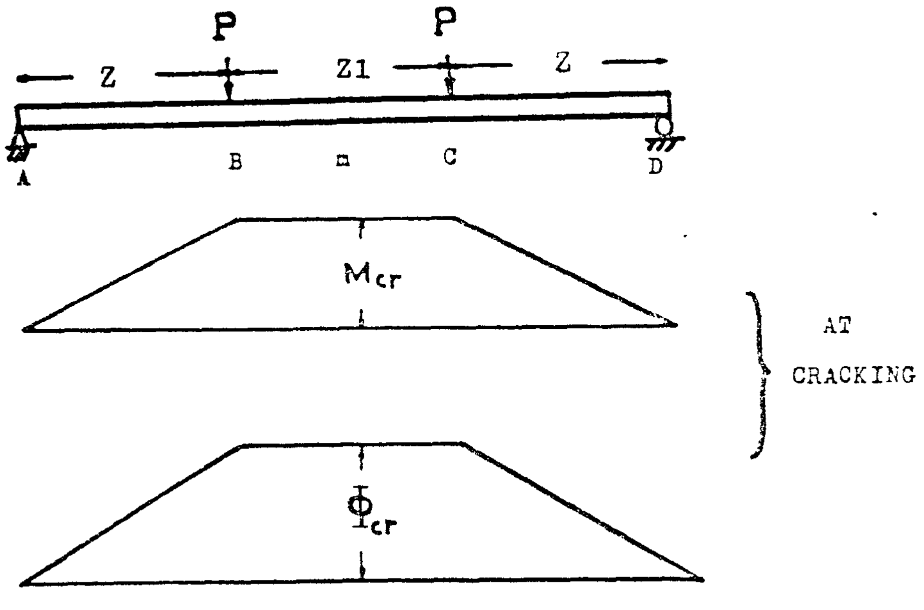


FIGURE 6. SIMPLY SUPPORTED BEAM UNDER TWO-POINT LOADING (AT CRACKING)

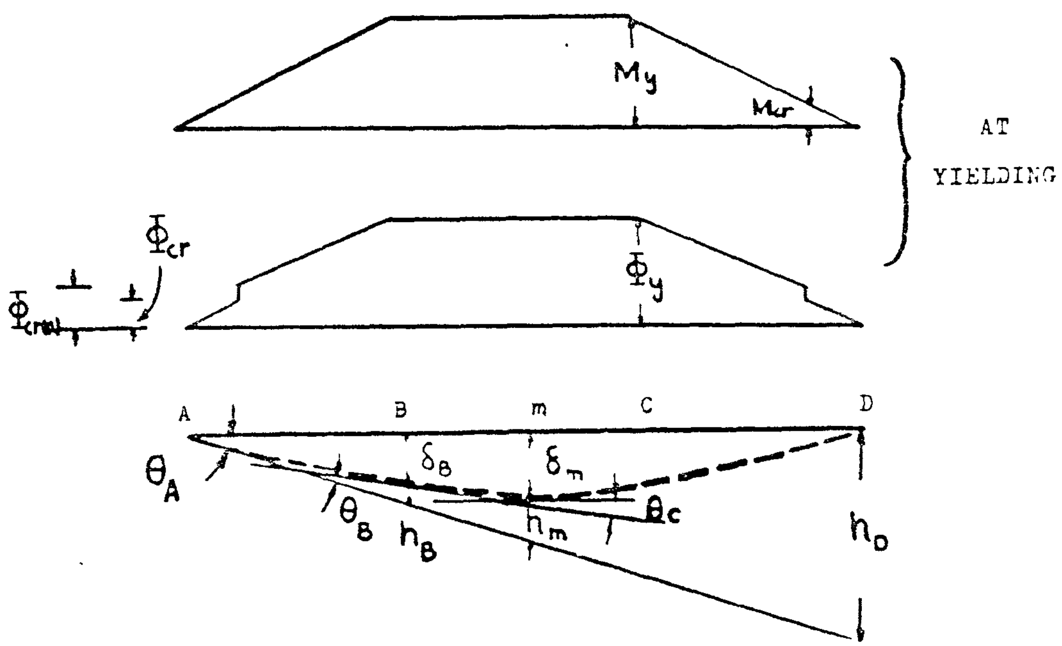


FIGURE 7. SIMPLY SUPPORTED BEAM UNDER TWO-POINT LOADING (AT YIELDING)

Deflection at mid-span:

$$\delta_m = \Phi_{cr}*[(5/6)*Z^2 + (1/8)*Z_1^2] \qquad (2-44)$$

2.3.2 At Yielding and Between Yielding and Ultimate

Using equations (2-40) and (2-41), the rotations θ_C, θ_A (see Fig. 8a, 8b) are given by,

$$\theta_C = \frac{\Phi_m Z_1}{2}$$

$$\theta_A = \frac{Z}{m} \int_B^A \Phi \, dM + \frac{\Phi_m Z_1}{2} \qquad (2-45)$$

Since, $\delta_1' = \dfrac{\Phi_m Z_1^2}{8}$ and $\theta_C = \dfrac{\delta_1'}{k'}$

Therefore, $k' = Z_1/4$

Also, $\theta_C = \dfrac{\delta_3'}{Z+k'}$

and $\delta_3' = (Z+\dfrac{Z_1}{4})\ \theta_C = (Z+\dfrac{Z_1}{4})\ \dfrac{\Phi_m Z_1}{2}$

Therefore,

$$\delta_m = \delta_2' + \delta_3' = \frac{Z^2}{M^2} \int_B^A M dM + (Z+\frac{Z_1}{4})\ \frac{\Phi_m Z_1}{2} \qquad (2-46)$$

$$\delta_B = \delta_2' + \delta_3' - \delta_1' = \delta_m - \frac{\Phi_m Z_1^2}{2} \qquad (2-47)$$

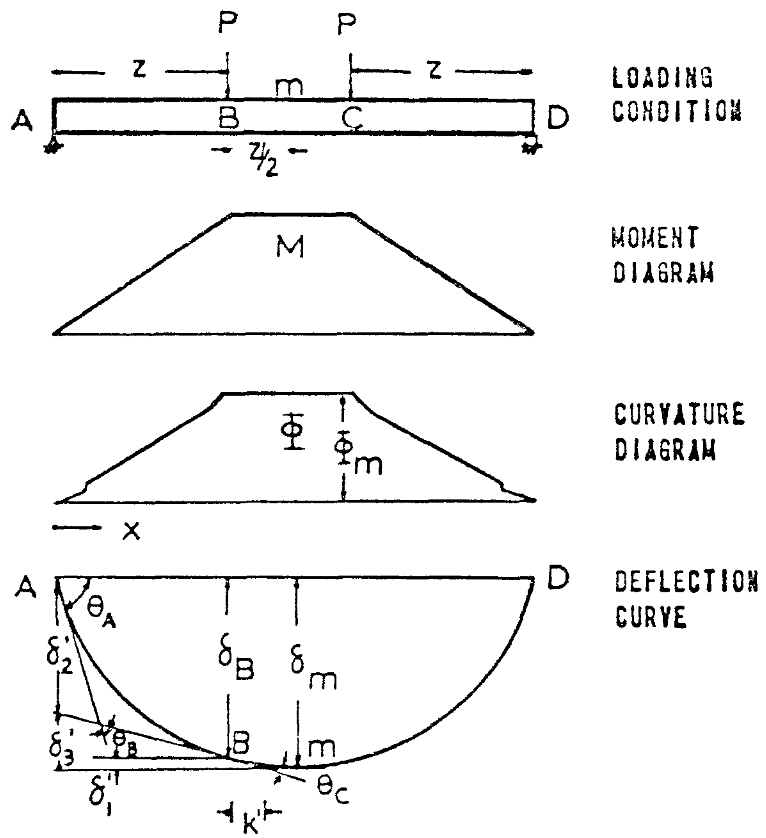


FIGURE 8a. SIMPLY SUPPORTED BEAM UNDER TWO-POINT LOADING (BETWEEN YIELDING AND MAXIMUM MOMENT)

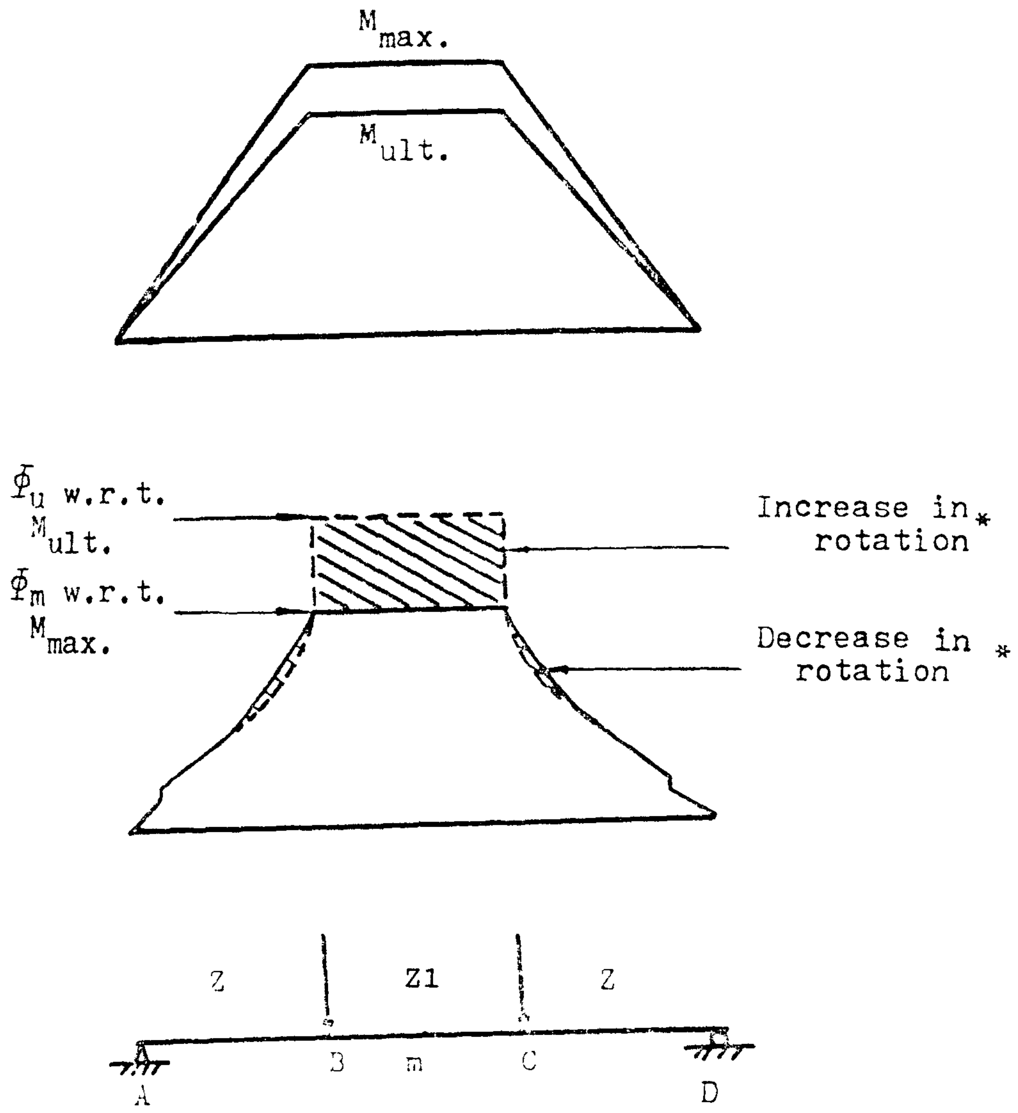


FIGURE 8b. SIMPLY SUPPORTED BEAM UNDER TWO-POINT LOADING (BETWEEN MAXIMUM AND ULTIMATE MOMENT)

III. COMPUTER METHOD

A computer program is designed to carry out the theoretical analysis of the moment-curvature and deflection behavior of simply supported beam under two-point loading (see Fig.9). The program has been included in Appendix C. It consists of several parts, and an explanation and commentary on each part of the program is listed below.

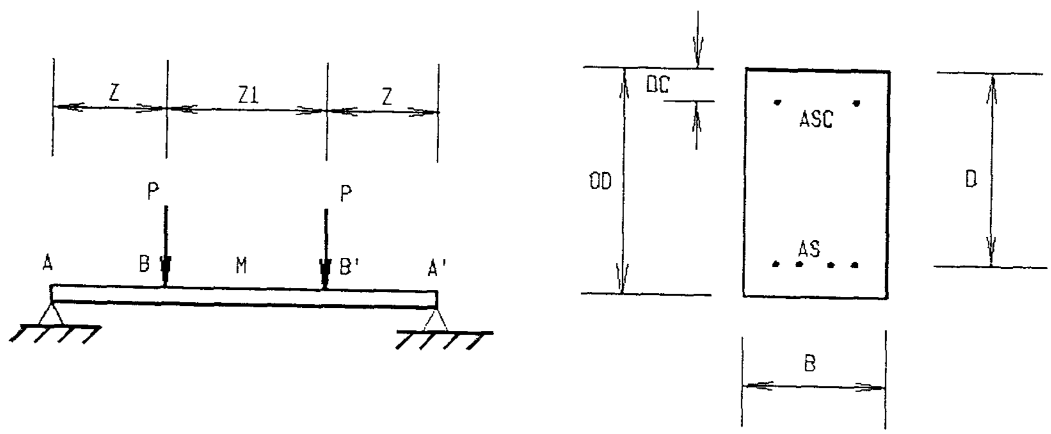


FIGURE 9. LOADING ARRANGEMENT AND CROSS SECTION OF BEAM FOR COMPUTER PROGRAM

3.1 Structural and Material Properties

The basic data for the beam and material properties are input, read and printed. The steel strain at the start of strain-hardening (ESH) and the modulus of elasticity for tensile steel after strain-hardening (ESS) is selected. The material parameter BB (i.e. β) which indicates the properties of fibrous concrete is also read.

The concrete strain parameter ϵ_o (EC1) is taken as 0.002.

3.2 Analysis at Cracking, after Cracking, between Cracking and Ultimate

General steps for the computer program is shown in the flow diagram (Fig.10)

The tensile steel strain obtained from the result of analysis after cracking has been used as an initial value of steel strain in analysis between cracking and ultimate. An increment of 0.0001 (or 0.001) is used for steel strain in a large do-loop to evaluate moment, curvature corresponding to the selected steel strain. In order to locate the neutral axis (i.e. to find K), method of halving the interval [15] is used in attempting to find a suitable k satisfying force equilibrium equation. Compression force in concrete can be obtained by integrating stress of the concrete. Here, a numerical method [15] is applied to evaluate definite integration. The load, deflection and rotation are calculated at cracking, at yielding and between yielding and ultimate. The program continues to evaluate the moment-curvature characteristics until concrete strain exceeds its

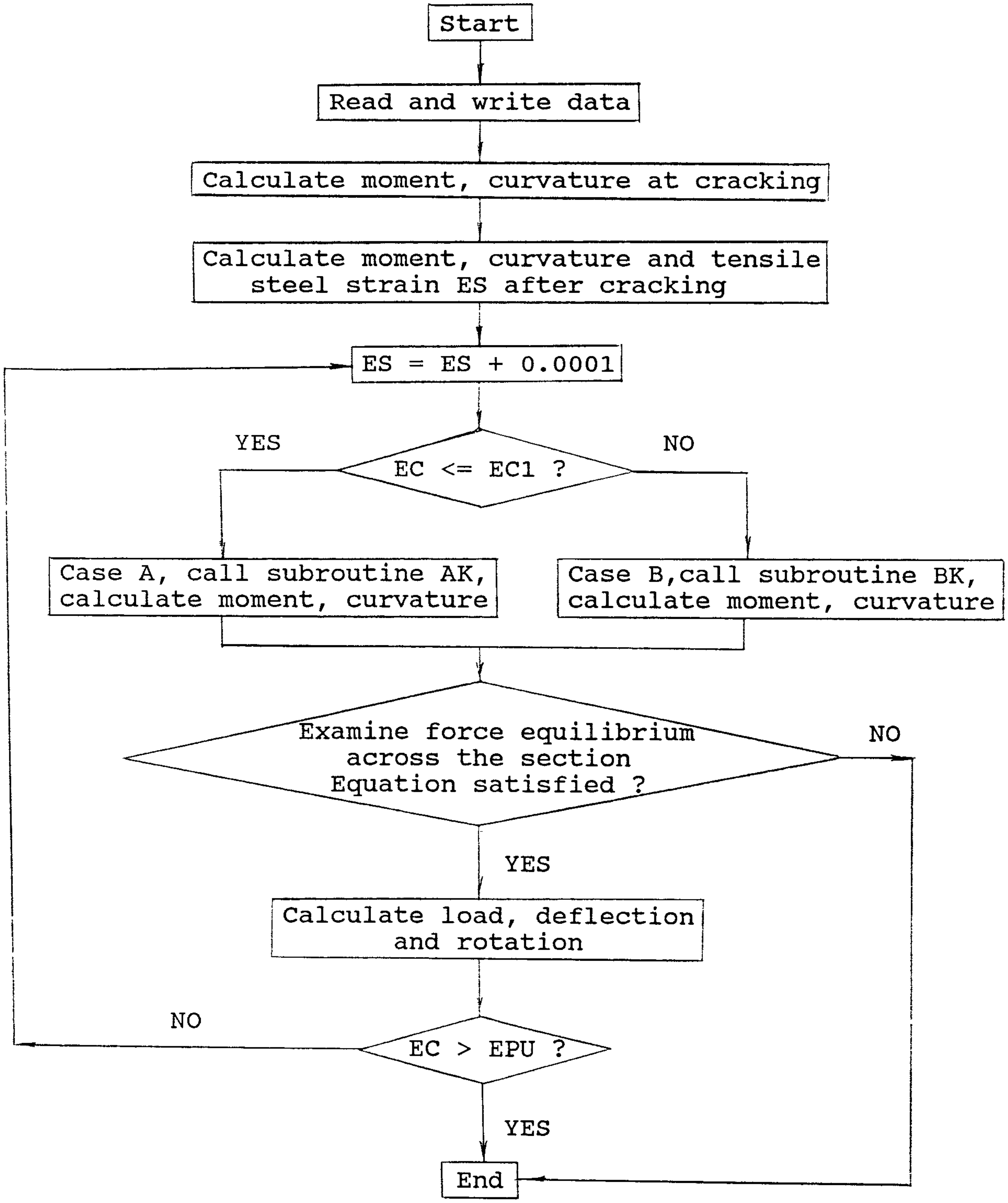


FIGURE 10. FLOW DIAGRAM OF COMPUTER PROGRAM

ultimate value (EPU) or the equilibrium equation no longer satisfied.

3.3 Output Files

Two output files are designed in this computer program. The basic input data and moment-curvature in each stage are listed in output file 6, while load, rotation and deflection after cracking and yielding are listed in output file 7.

Units in this study are all pounds and inches.

IV. COMPARISON OF THEORETICAL AND EXPERIMENTAL RESULTS

The results of experimental program from Reference [3], [4], [5] are used herein to verify the validity of the analytical method developed. The basic information of test beams is shown in table 1.

Table 1. Basic Information of Test Beams

Beam No.	Ref.No. where tested	Fiber type	Fig. of beam and cross-section	curve compared
1	[3]	Straight	Fig.11	Moment-curvature
2	[3]	Hooked	Fig.11	
3	[3]	Straight	Fig.11	
4	[3]	Hooked	Fig.11	
5	[4]	With crimped end	Fig.12,13	Moment-deflection
6	[4]		Fig.12,13	
7	[4]		Fig.12,13	
8	[4]		Fig.12,13	
9	[4]		Fig.12,13	
10	[5]	smooth	Fig.16	load-deflection
11	[5]	Crimped	Fig.16	

4.1 Material Properties of the Beams

The following assumptions are made to calculate the necessary input data for computer program.

(1) The modulus of elasticity of fibrous concrete

$$E_{cf} = E_c + 0.941*10^6(R.I.)$$

where $E_c = 57000\sqrt{f_c'}$

(2) Equation (1-2) and (1-3) is used to evaluate β (i.e, BB in the program).

(3) The modulus of elasticity of steel is taken as 29,000,000

(4) If the steel stress-strain curve is not given, the

curve is assumed to be similar to the experimental steel stress-strain curve of beam 5-9 shown in Fig.14 or Fig.15, from which the steel strain at the start of strain-hardening (ESH) and modulus of elasticity of tensile steel after strain-hardening (ESS) can be obtained.

(5) Concrete tensile strength is taken as

$$f_t = 5.7\sqrt{f_c'}$$

if it is not given.

(6) If there is no compression steel in the beam, just let

ASC = FY1 = DC = 0

in the input data of computer program.

Beam 1-4 were tested in Reference [3]. The load arrangement and beam cross-section are shown in Fig.11.

Table 2. Material Properties of Beam 1-4

Beam No.	A_s (in^2)	A_s' (in^2)	Fiber l/ϕ	volume fraction %	f_y (psi)	f_u (psi)	f_c (psi)
1	0.04	0	60.0	1.2	103844	109645	6566
2	0.04	0	77.5	0.89	103844	109645	5967
3	0.487	0	60.0	1.2	66715	94271	6566
4	0.487	0	77.5	0.89	66715	94271	5967

l/ϕ : Aspect ratio of fiber (length/diameter)

Beam 5-9 were tested in reference [4]. The load arrangement and beam cross-section are shown in Fig.12 and Fig.13, and the steel stress-strain curves are shown in Fig.14 and Fig.15.

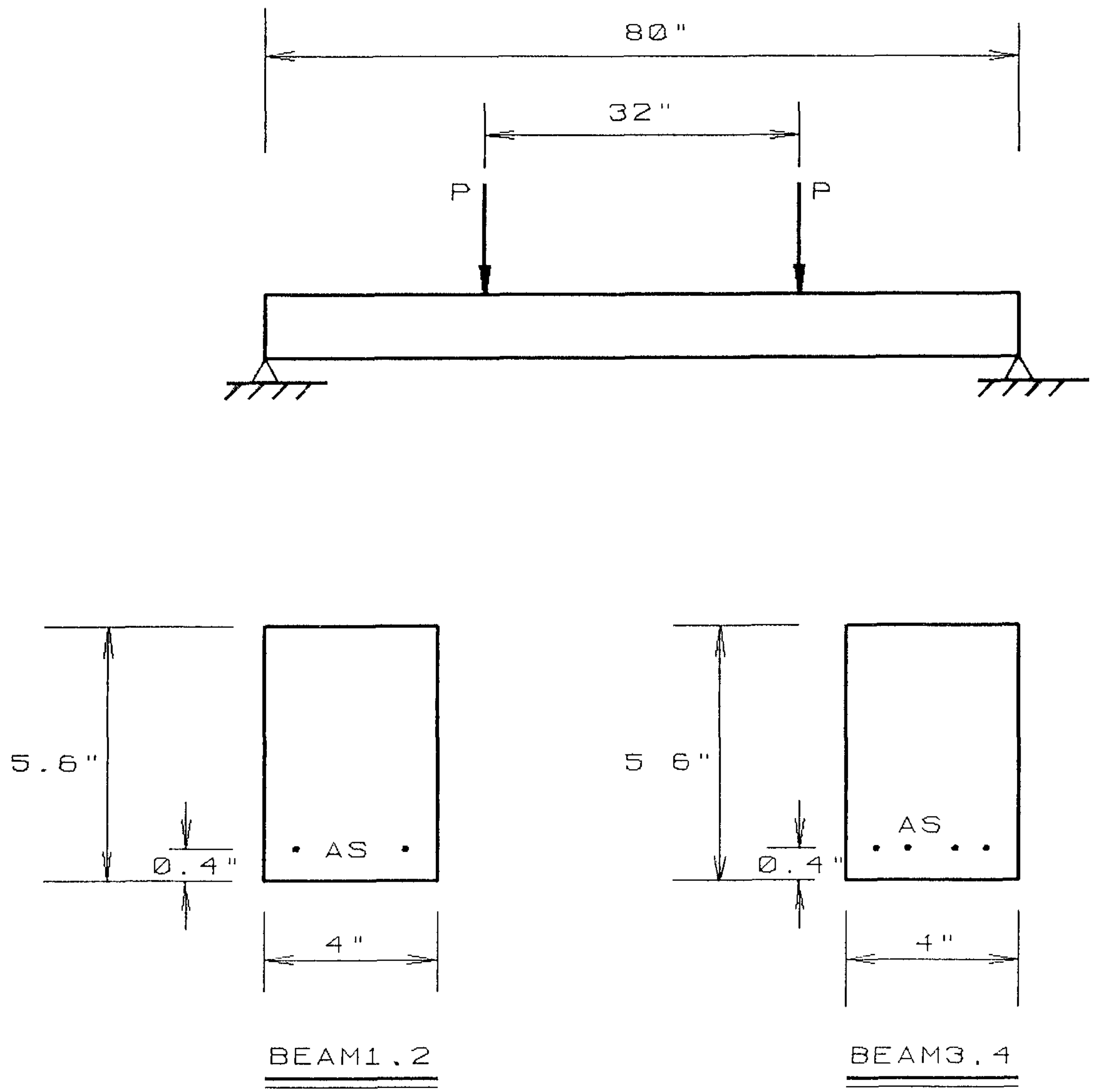


FIGURE 11. LOADING ARRANGEMENT AND CROSS SECTION OF BEAM 1-4

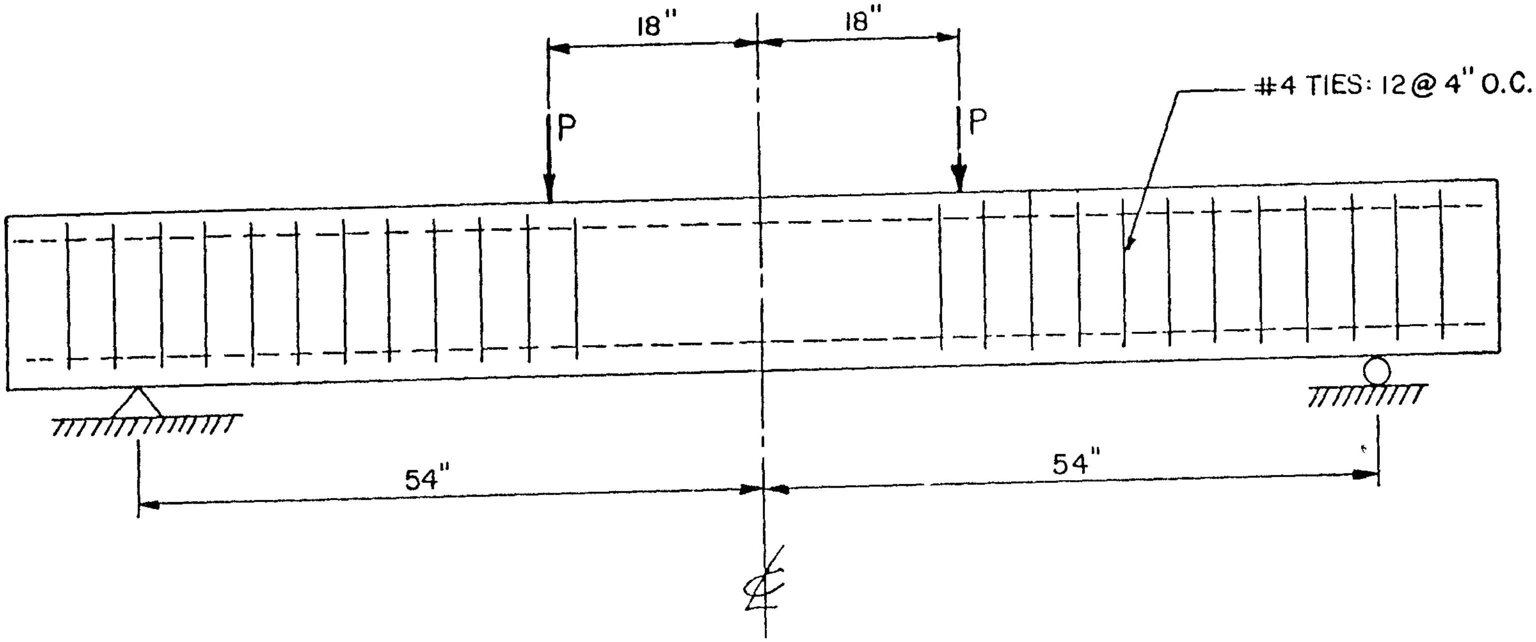


FIGURE 12. LOADING ARRANGEMENT OF BEAM 5-9

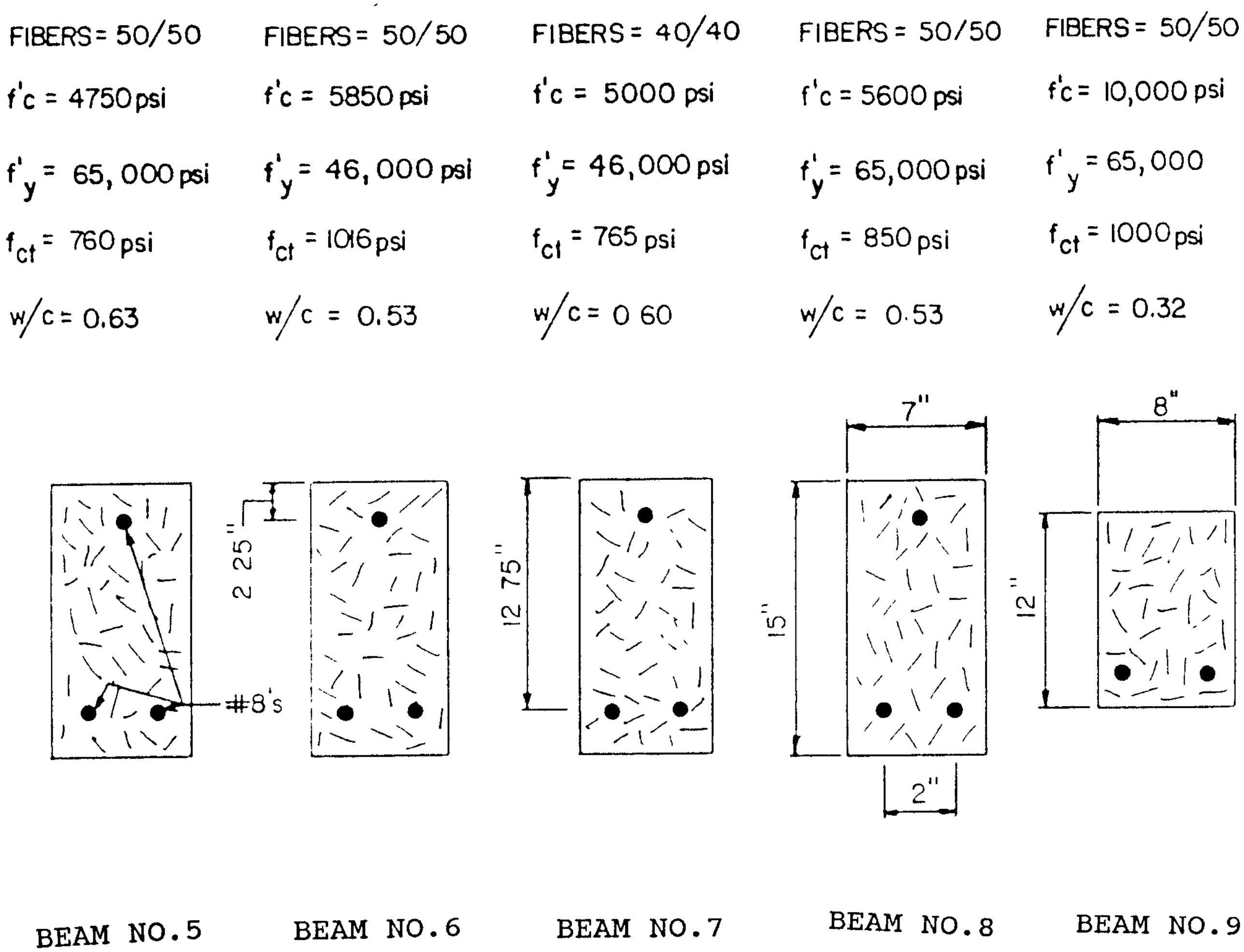


FIGURE 13. CROSS SECTION OF BEAM 5-9

Table 3. Material Properties of Beam 5-9

Beam No.	A_s (in^2)	A_s' (in^2)	Fiber by weight %	Fiber length (in)	Fiber Diameter (in)	f_c' (psi)	f_t (psi)
5	1.58	0.79	1.75	1.97	0.035	4750	760
6	1.58	0.79	1.75	1.97	0.035	5850	1016
7	1.58	0.79	1.75	1.57	0.035	5000	765
8	1.58	0.79	1.75	1.97	0.035	5600	850
9	1.58	0.00	1.75	1.97	0.035	10000	1000

According to the test curves of steel stress-strain relationship in Fig.14 and Fig.15, yield stress used in computer analysis for beam 5, 8 and 9 was determined as stress value at 0.2 percent offset. The following value was taken:

$f_y = 70500$

$\epsilon_{sh} = 0.0045$

$E_{ss} = 572080$

For the steel in beam 6 and 7,

$f_y = 50000$

$\epsilon_{sh} = 0.0125$

$E_{ss} = 640000$

Beam 10 and beam 11 were tested in reference [5]. The load arrangement and beam section are shown in Fig.16.

Table 4. Material Properties of Beam 10 and Beam 11

Beam No.	A_s (in^2)	A_s' (in^2)	Fiber $1/\phi$	Fiber fraction %	f_c (psi)	f_y (psi)	f_y' (psi)
10	0.88	0.22	90	1.22	5930	49880	68800
11	0.88	0.22	125	1.36	5970	49880	68800

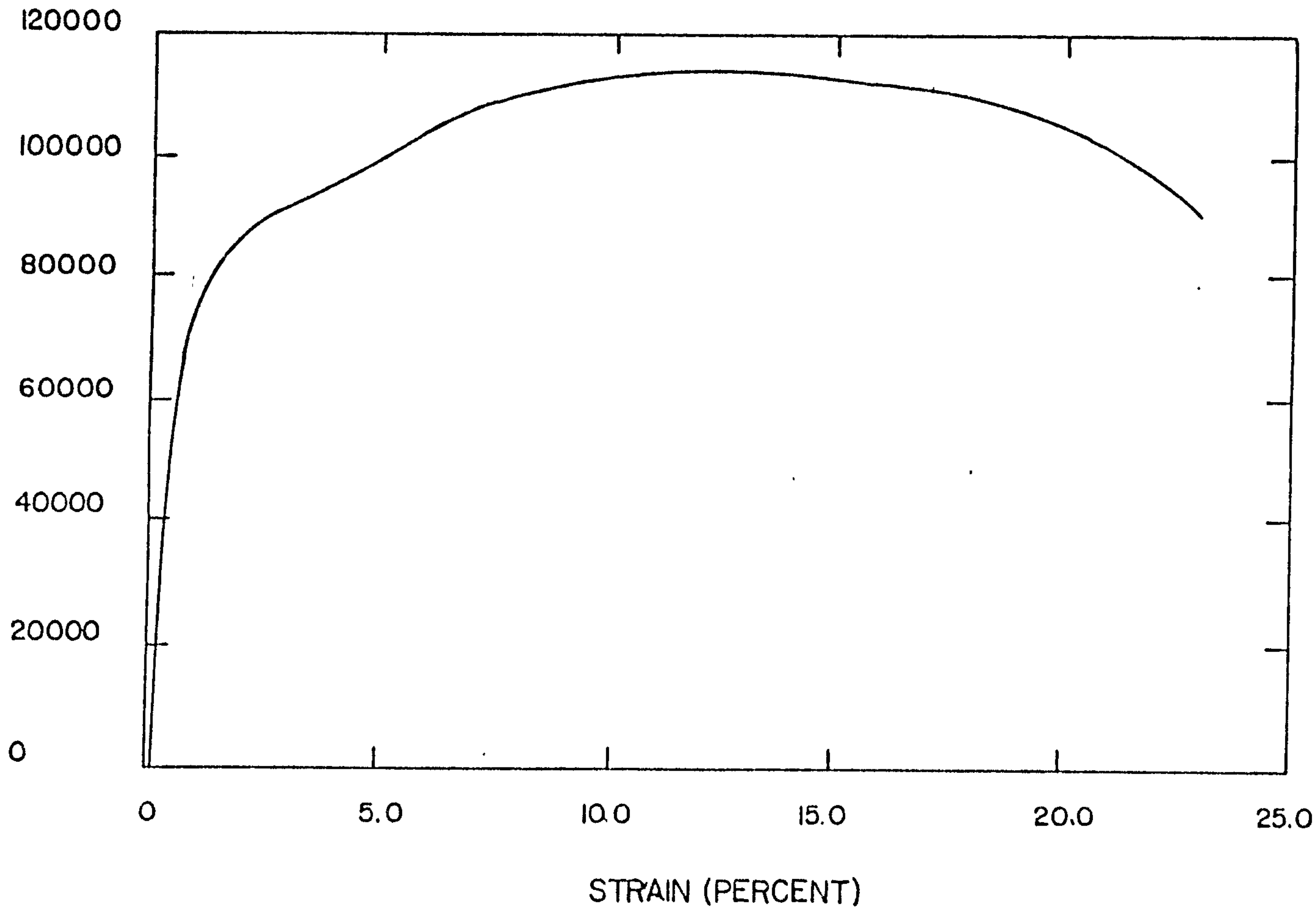


FIGURE 14. TEST STRESS-STRAIN CURVE IN TENSION FOR STEEL (BEAM 5,8,9)

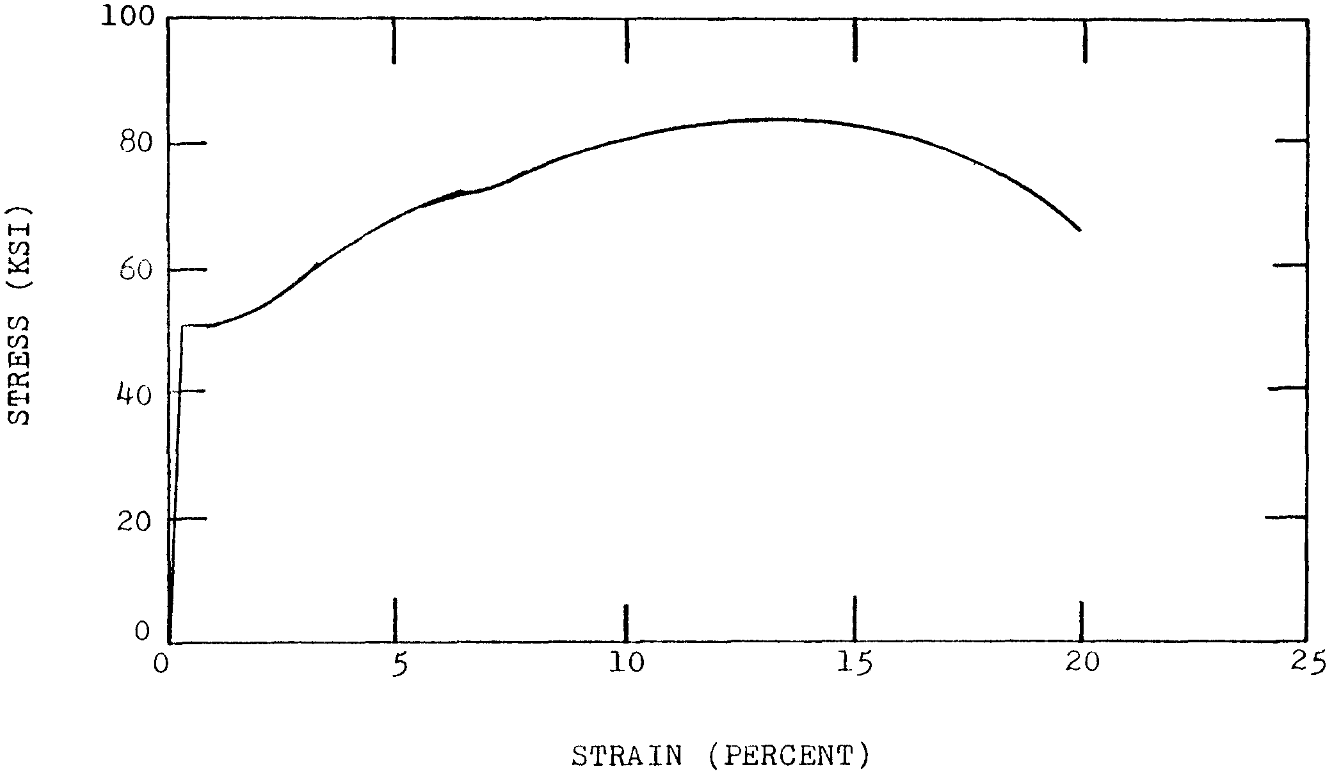


FIGURE 15. TEST STRESS-STRAIN CURVE IN TENSION FOR STEEL (BEAM 6,7)

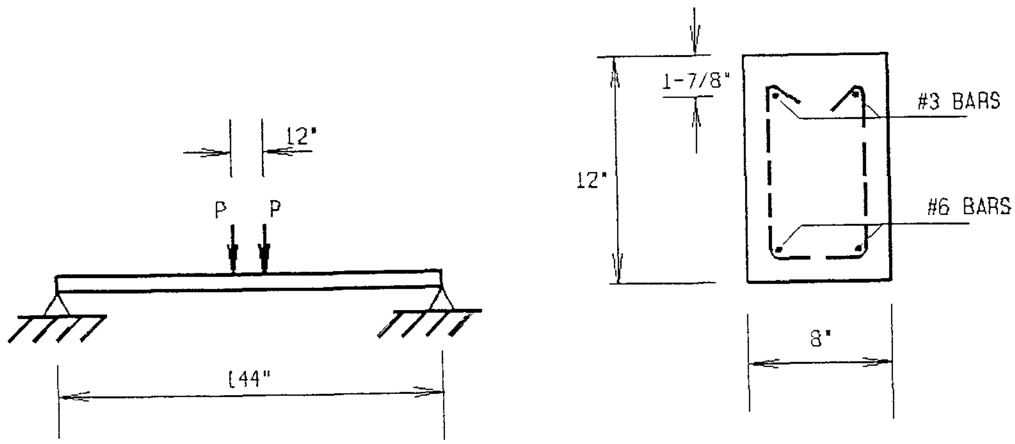


FIGURE 16. LOADING ARRANGEMENT AND CROSS SECTION OF BEAM 10, 11

4.2. Comparison of Theoretical and Test Results

All the results of computer analysis of these beams can be found in Appendix D. Graphic comparisons of theoretical results are indicated in Fig.17 through 27. Points of experimental curve are selected from the original test result which best describe the curve.

The results of comparison of ultimate moment or load are shown in table 5.

Table 5. Comparison of Theoretical and Experimental Results

Beam No.	Comparison curves	Test		Theoretical		Ratio (1)/(3) or (2)/(4)
		Moment (1)	load (2)	Moment (3)	load (4)	
1	Fig.17	27.647		22.54		1.23
2	Fig.18	25.665		22.47		1.14
3	Fig.19	153.914		161.875		0.95
4	Fig.20	152.852		165.411		0.92
5	Fig.21	1500		1432.68		1.05
6	Fig.22	1200		1240.24		0.97
7	Fig.23	1100		1129.88		0.97
8	Fig.24	1700		1497.66		1.14
9	Fig.25	1200		1178.77		1.02
10	Fig.26		14600		13818*	1.05
11	Fig.27		15500		14084*	1.10

Notes: Unit of moment in this table : Inch-kips.
The moment and load compared in this table are all in the ultimate stage.
* Based on $\epsilon_c = 0.003$ for the ultimate load calculation.

Generally speaking, these comparisons seem to indicate a good correlation between the predications based on the theory presented herein and the actual behavior of the test beams themselves. There are still some difference between each other. One of the reasons is that the theoretical development based on certain assumptions. For instance, the ultimate stage defined in the theory may not be the same in the actual case.

FIGURE 17. MOMENT-CURVATURE CURVES FOR BEAM NO.1

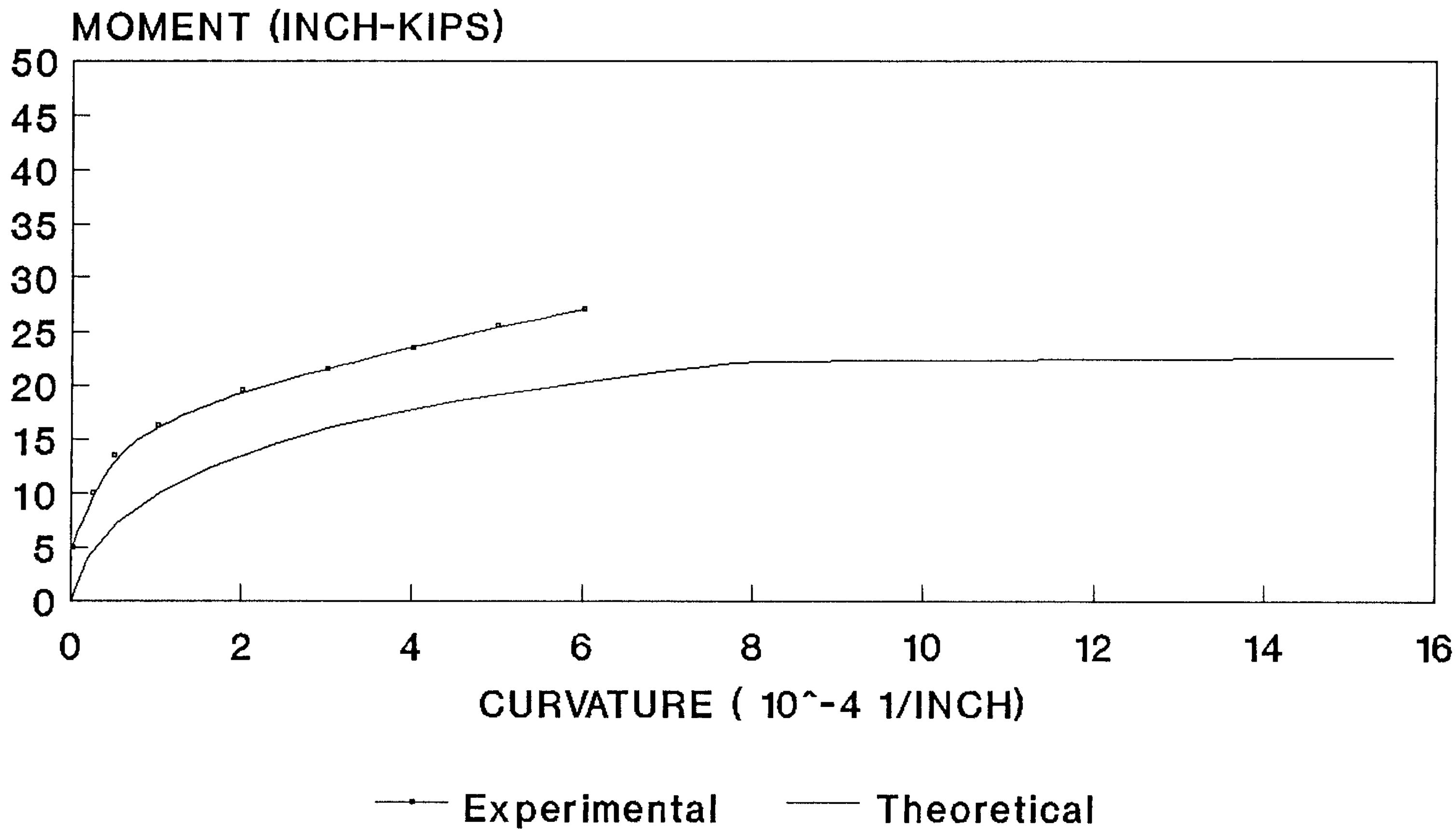


FIGURE 18. MOMENT-CURVATURE CURVES FOR BEAM NO.2

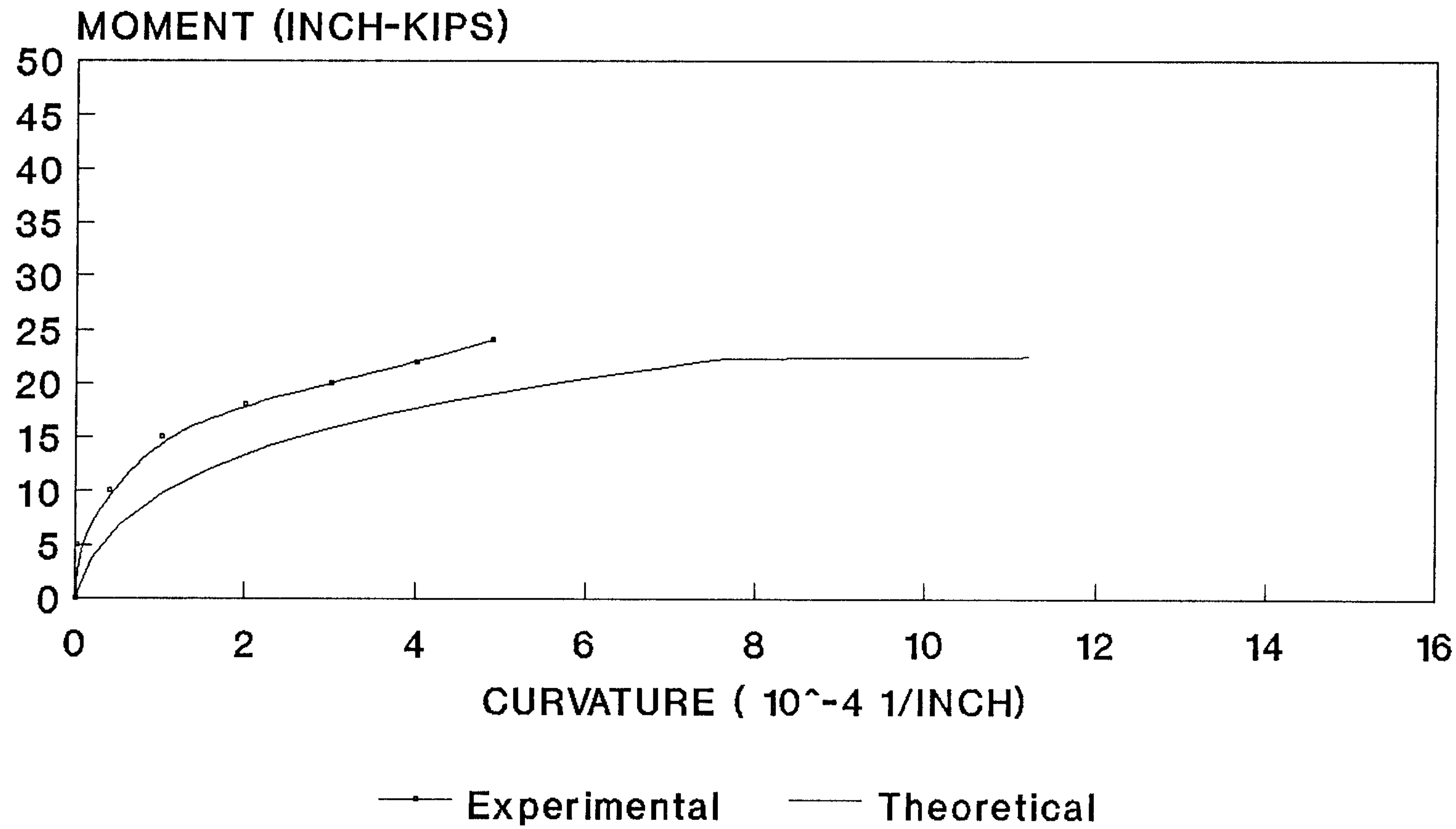


FIGURE 19. MOMENT-CURVATURE CURVES FOR BEAM NO.3

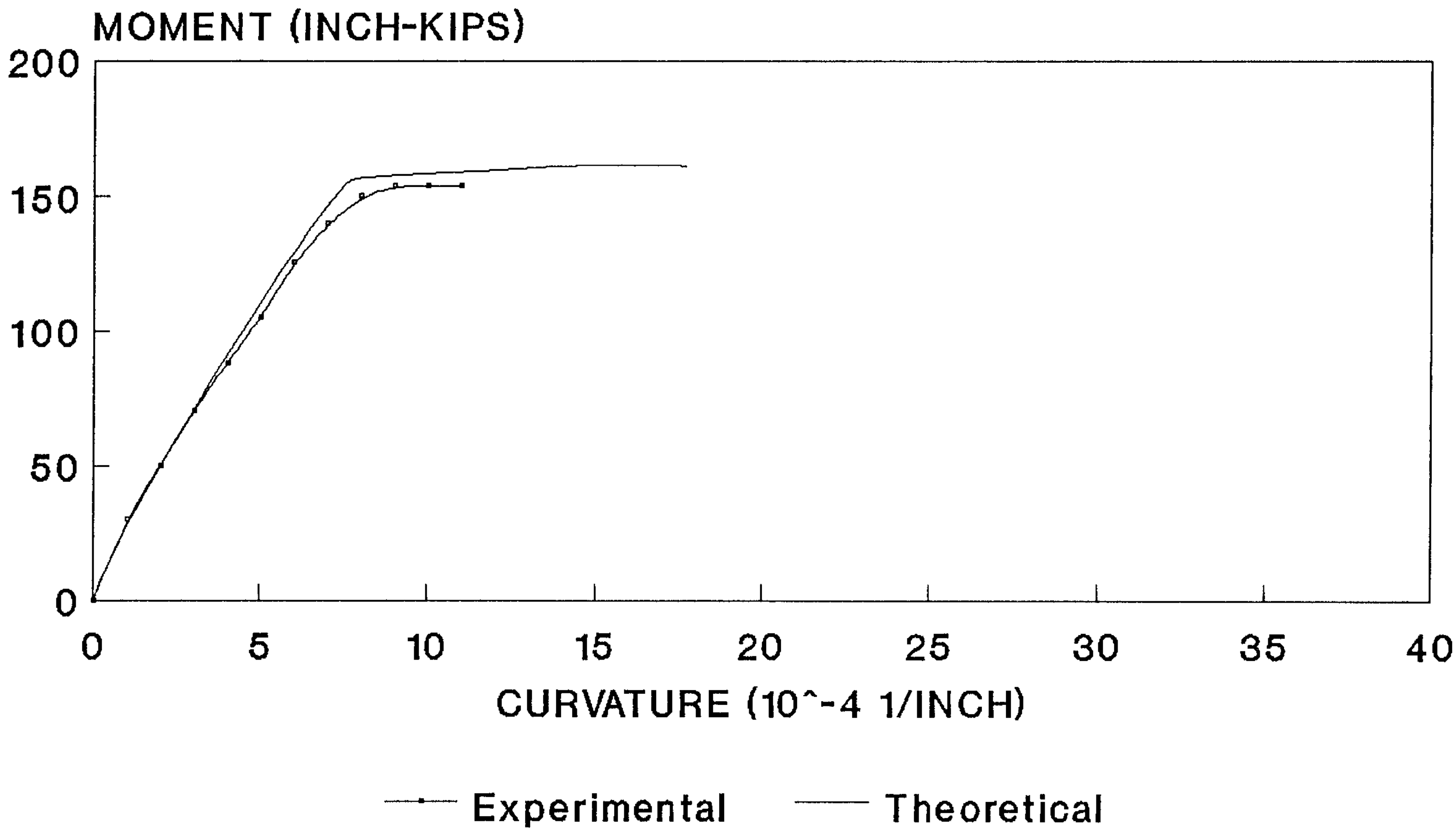


FIGURE 20. MOMENT-CURVATURE CURVES FOR BEAM NO.4

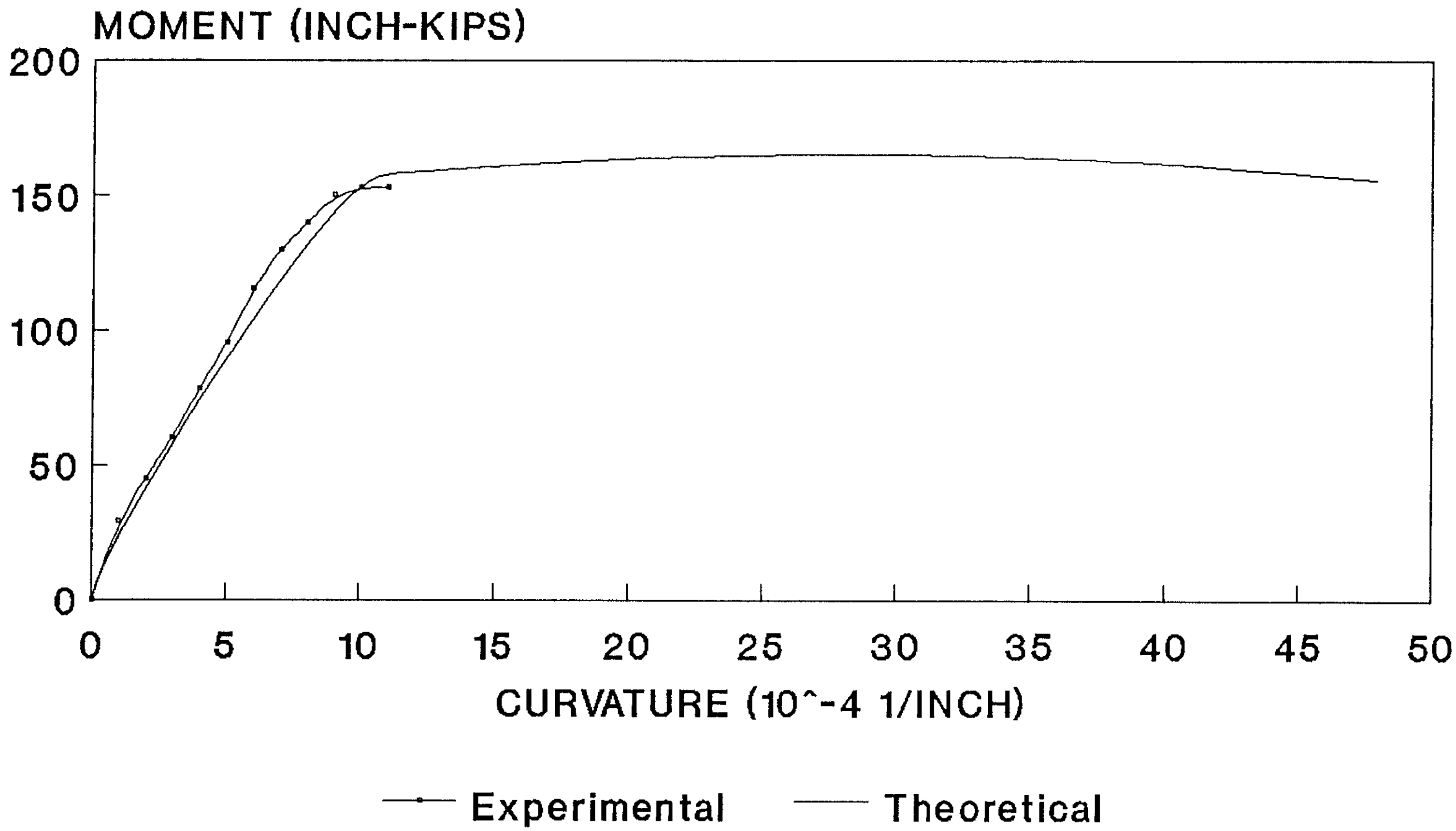


FIGURE 21. MOMENT-DEFLECTION CURVES FOR BEAM NO.5

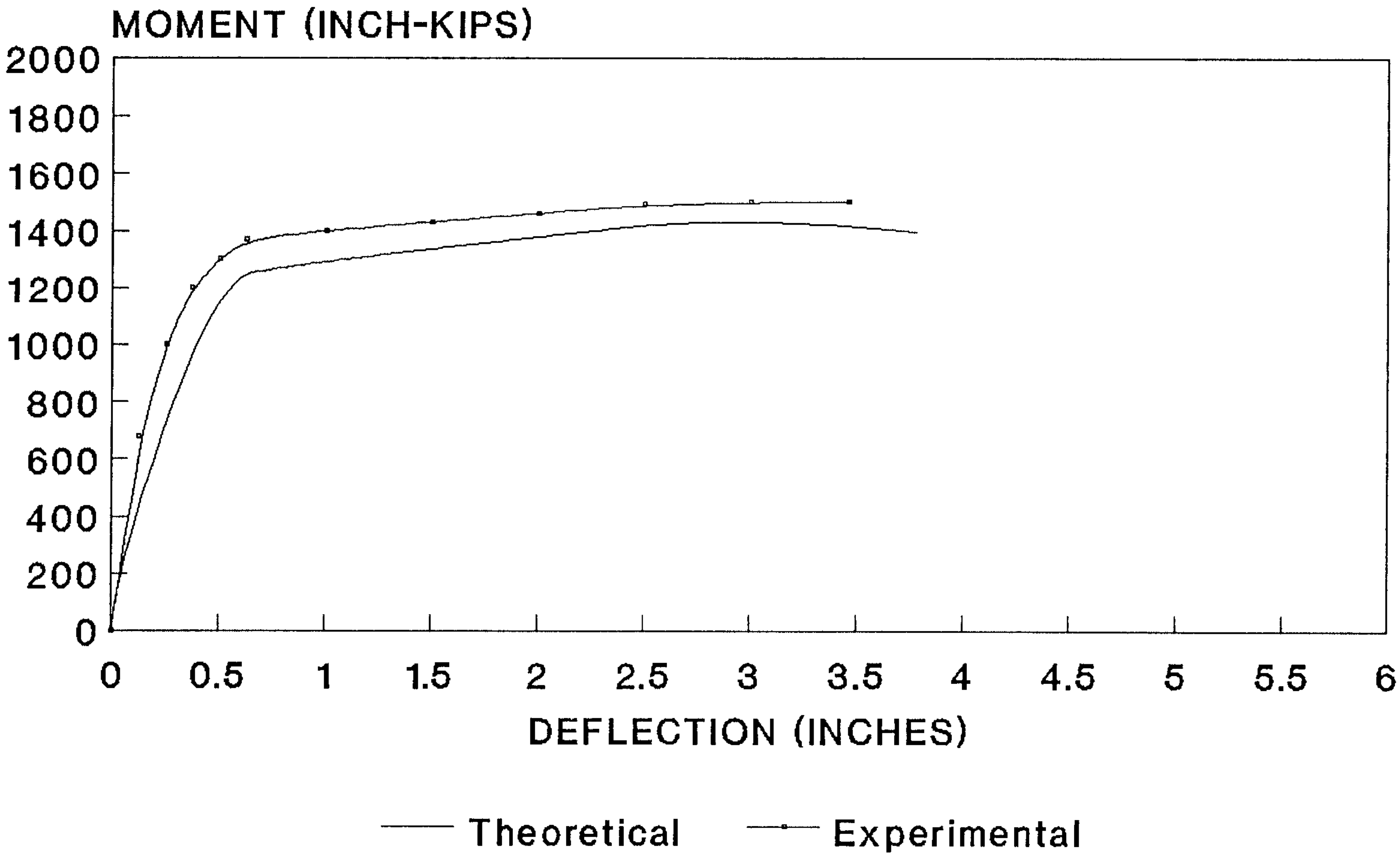


FIGURE 22. MOMENT-DEFLECTION CURVES FOR BEAM NO.6

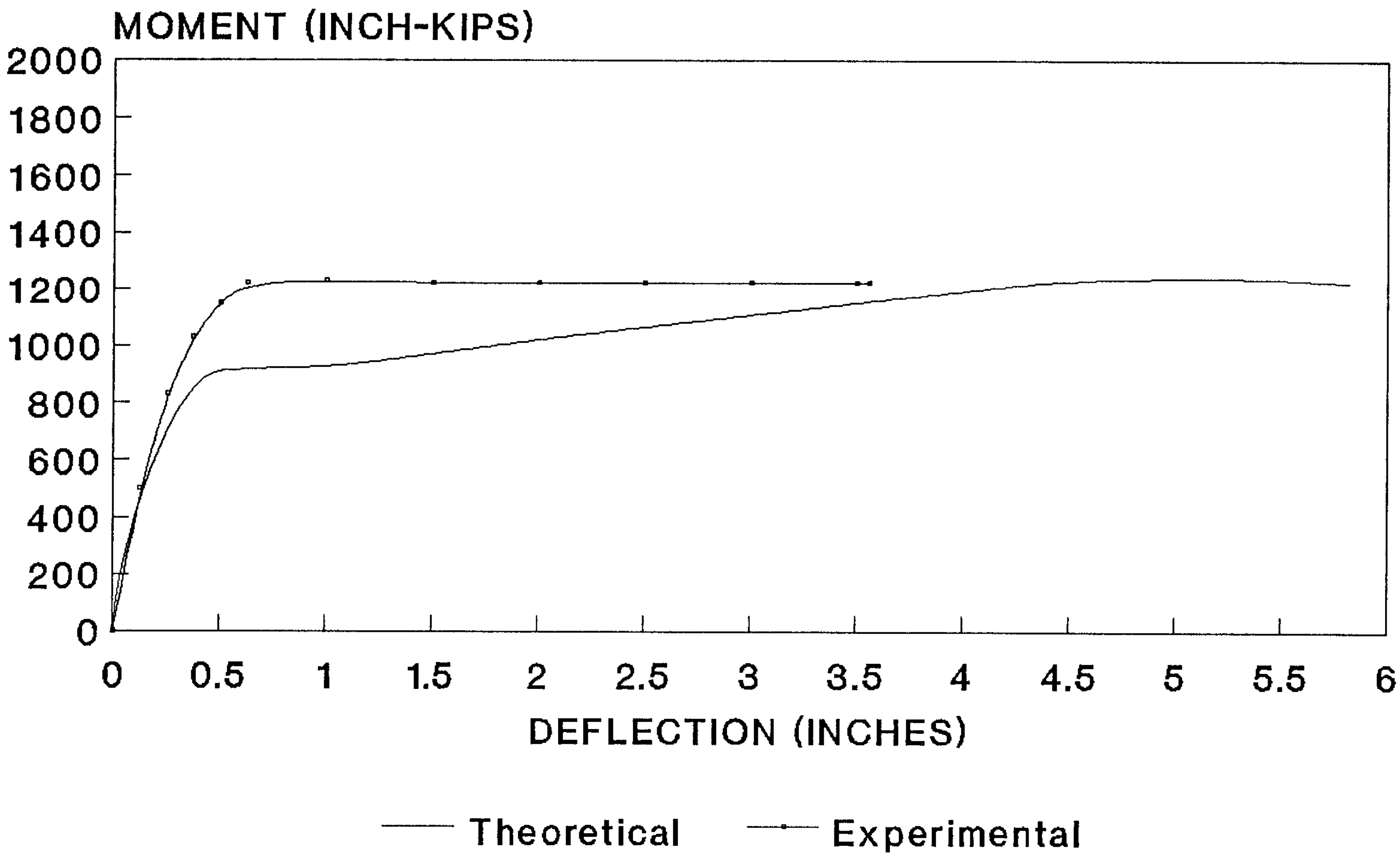


FIGURE 23. MOMENT-DEFLECTION CURVES FOR BEAM NO.7

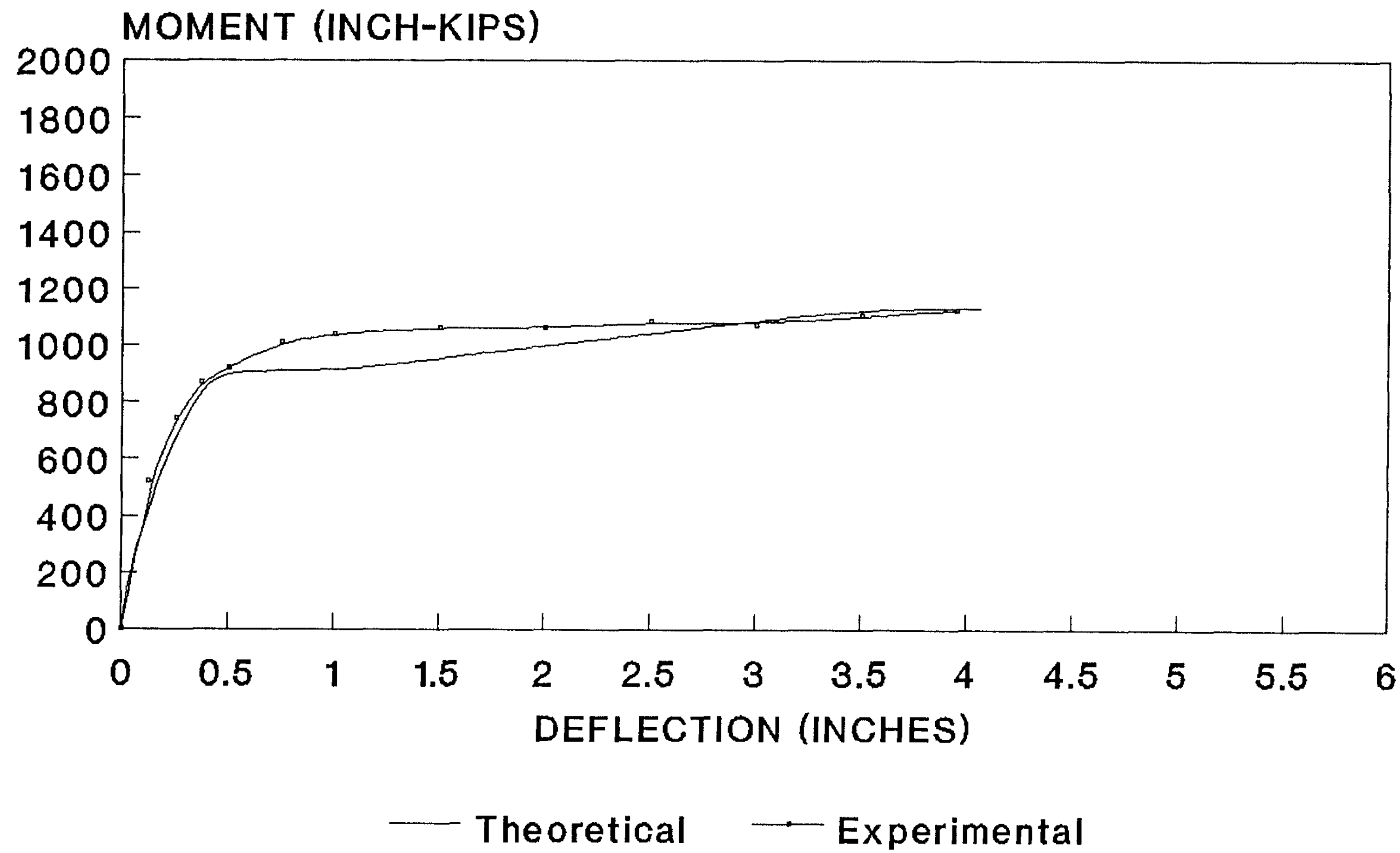


FIGURE 24. MOMENT-DEFLECTION CURVES FOR BEAM NO.8

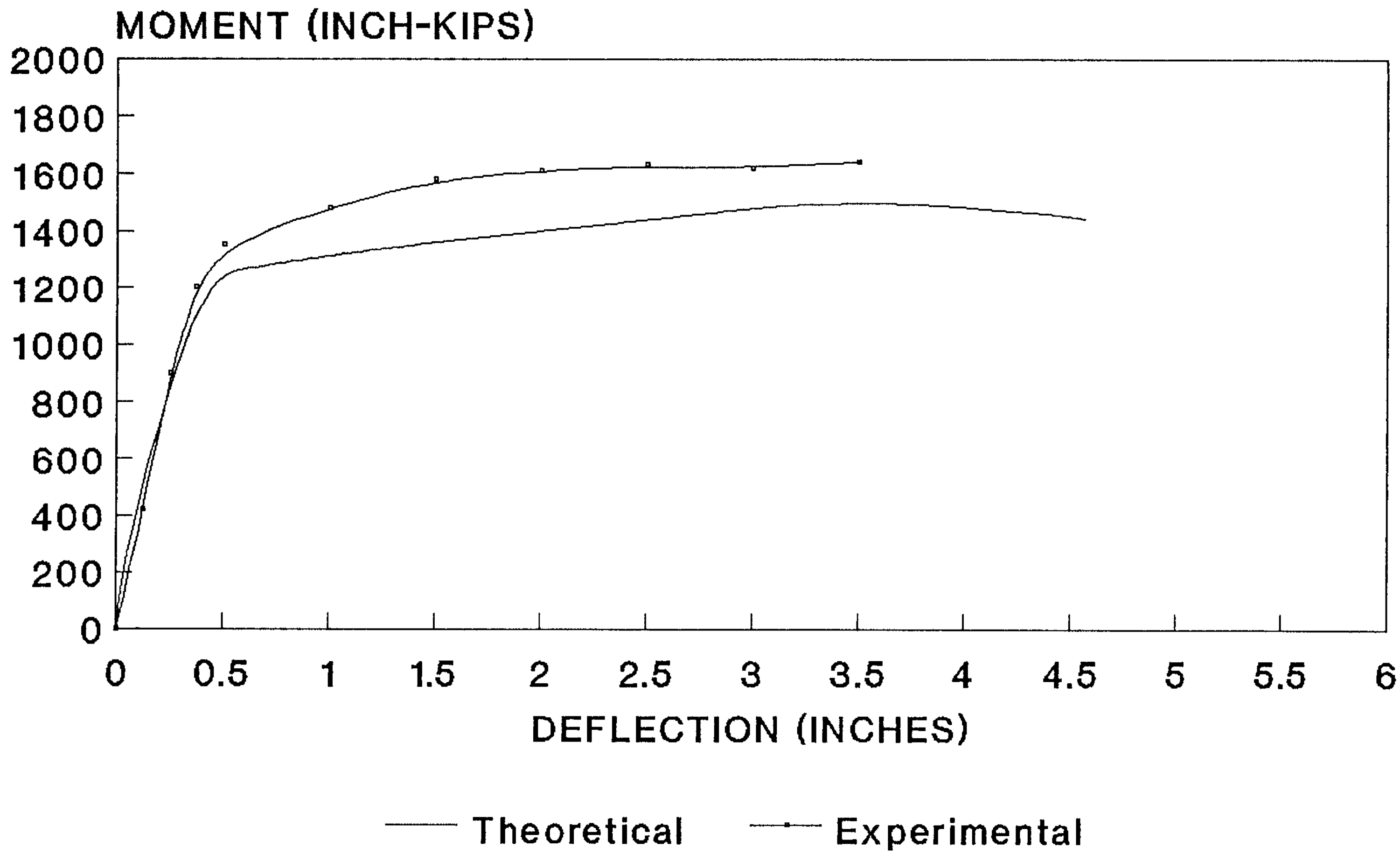


FIGURE 25. MOMENT-DEFLECTION CURVES FOR BEAM NO.9

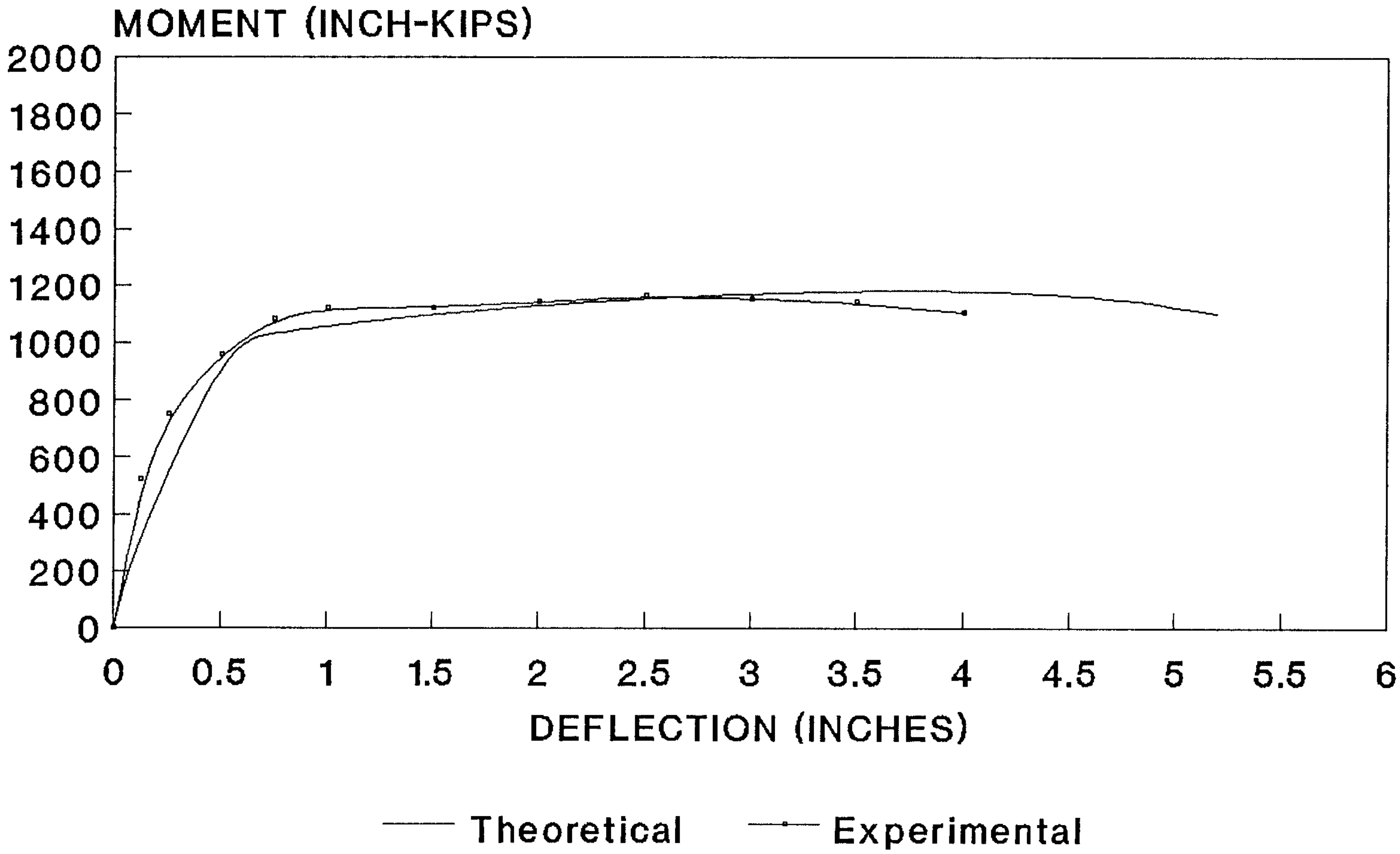


FIGURE 26. LOAD-DEFLECTION CURVES FOR BEAM NO.10

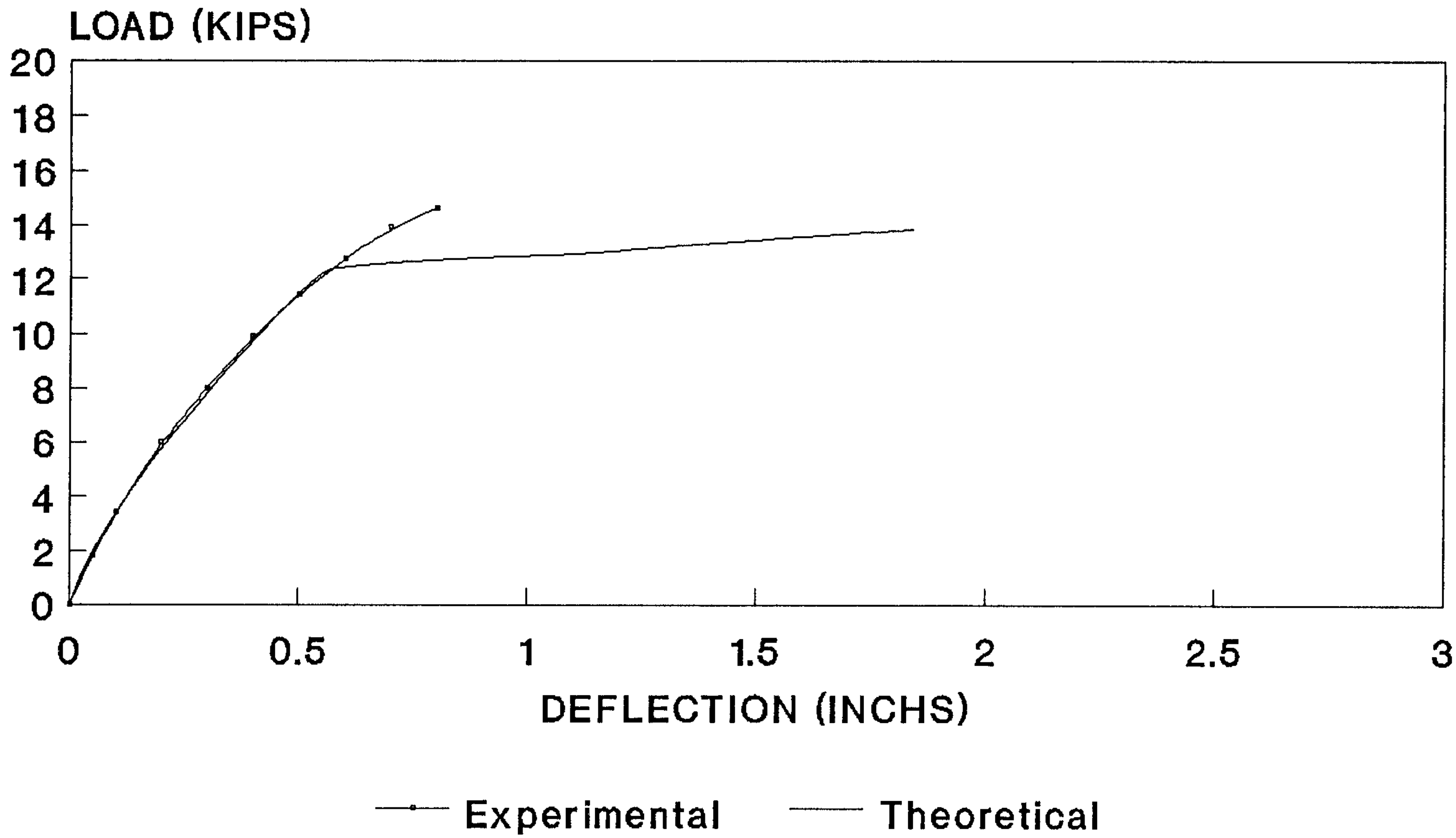
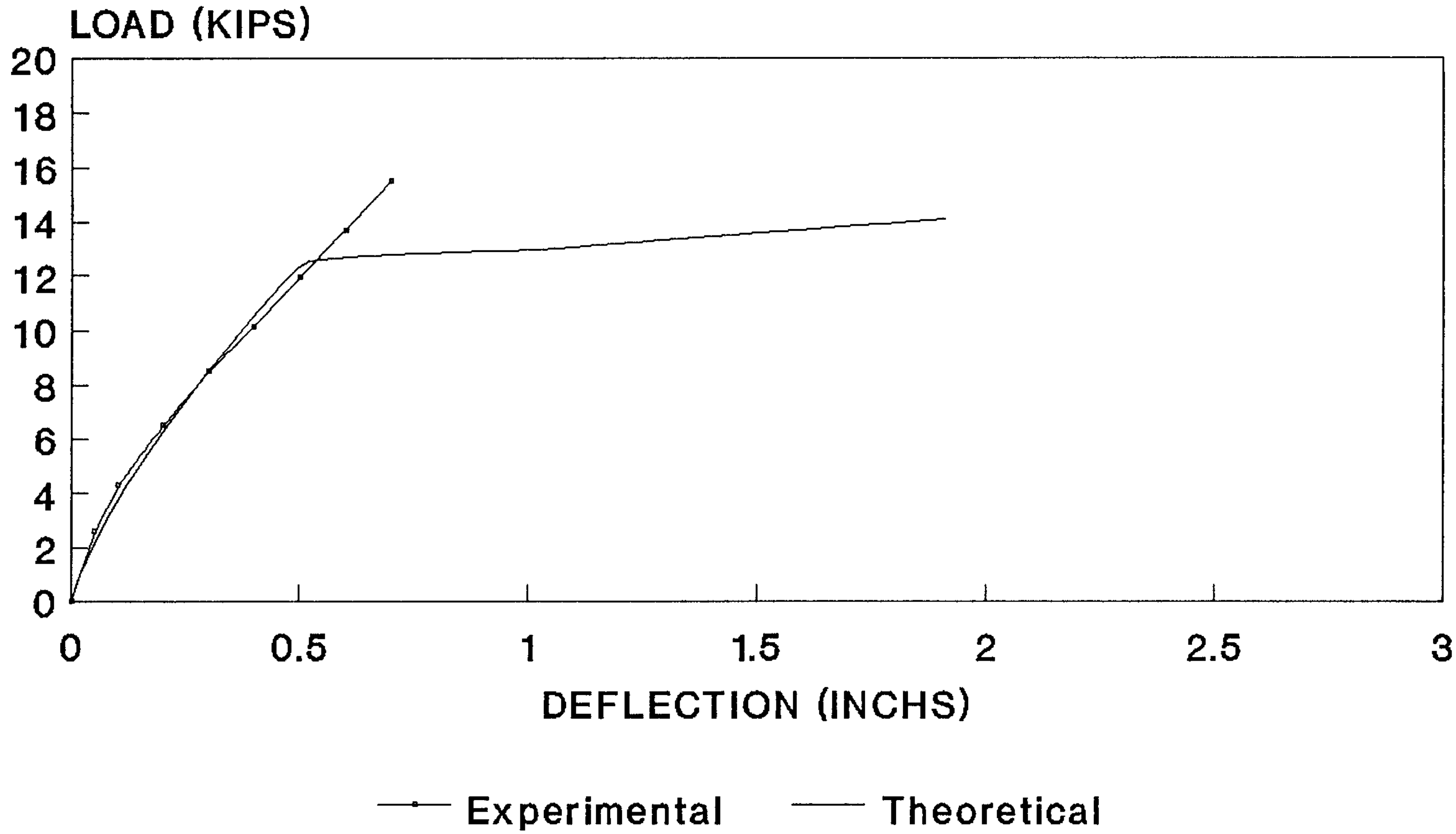


FIGURE 27. LOAD-DEFLECTION CURVES FOR BEAM NO.11



V. CONCLUSION

A theoretical moment-curvature and load-defelection relationship is developed herein to predict the behavior of steel fiber reinforced concrete beam. For simply supported beam under two point loading, the results of the theoretical analysis carried out by the computer program have been compared to the test results and it shows a good correlation between each other.

It is noted that the results of theoretical analysis show a drop in the bending strength (beyond M_{max}). The structure may has the ability to achieve a new equilibrium configuration after concrete gets spilled off in the member. However the present analysis enables one to calculate the moment-curvature-deflection curve of the beam from zero until a small portion of descending branch of the curve. After that not much physical meaning can be utilized since the concrete begins to get spilled off and crushed on compression side of the beam.

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APPENDIX A.1

APPENDIX A.1 NUMERICAL METHOD FOR EVALUATING DEFINITE INTEGRATION $FINT = \int_L^M f\, dy$

$$FINT = \int_L^M f\, dy = \int_L^M \frac{f_c'\beta}{Y1} * \frac{y}{(\beta-1)+(y/Y1)^\beta}\, dy$$

$$= \frac{f_c'\beta}{Y1} \int_L^M \frac{y}{(\beta-1)+(y/Y1)^\beta}\, dy = \frac{f_c'\beta}{Y1} A \qquad (A-1)$$

where $Y1 = (1-k)d\epsilon_o/\epsilon_s$

and $$A = \int_L^M \frac{y}{(\beta-1)+(y/Y1)^\beta}\, dy = \int_L^M g(y)\, dy$$

where $$g(y) = \frac{y}{(\beta-1)+(y/Y1)^\beta} \qquad (A-2)$$

Using the trapezoidal rule shown in References [15],

$$A = \int_L^M g(y)dy \doteq \sum_{i=1}^{n} \frac{a}{2}[g(y_i) + g(y_{i+1})]$$

$$= \sum_{i=1}^{n} \frac{M-L}{2n} [g(y_i) + g(y_{i+1})] \qquad (A-3)$$

where $y_i = L+(M-L)*i/n \qquad (i=1,2,3,...n)$

$$\text{So, } g(y_i) = g\left[L+ \frac{M-L}{n}(i-1) \right] = GG(I) \qquad (A-4)$$

$$g(y_{i+1}) = g\left[L+ \frac{M-L}{n} * i \right] = GG(I+1) \qquad (A-5)$$

where function GG is

$$GG(I) = \frac{L + (M-L)*(I-1)/n}{(\beta-1) + Y1^{-\beta}*[1+ (M-L)*(I-1)/n]^\beta} \qquad (A-6)$$

where (I=1,2,3,....n).

GG(I) and GG(I+1) can be calculated when k, ϵ_s, β, f_c', d, ϵ_o are given. By putting (A-6) into (A-4), (A-5) and (A-3), A can be evaluated, thus FINT in equation (A-1) can be obtained.

For the analysis between cracking and ultimate:

Case A:

$$CC_1 = b * \int_0^{kd} f dy = b*FINT \qquad (\ L=0,\ M=kd)$$

Case B:

$$CC_1 = b * \int_0^{Y1} f dy = b*FINT \qquad (\ L=0,\ M=Y1)$$

$$CC_2 = b * \int_{Y1}^{kd} f dy = b*FINT \qquad (\ L=Y1\ M=kd)$$

APPENDIX A.2

APPENDIX A.2 NUMERICAL METHOD FOR EVALUATING DEFINITE INTEGRATION $YINT = \int_L^M yfdy$

$$YINT = \int_L^M yfdy = \int_L^M \frac{f_c'\beta}{Y1} * \frac{y^2}{(\beta-1)+(y/Y1)^\beta} dy$$

$$= \frac{f_c'\beta}{Y1} \int_L^M \frac{y^2}{(\beta-1)+(y/Y1)^\beta} dy = \frac{f_c'\beta}{Y1} AA \quad \text{(A-7)}$$

where $Y1 = (1-k)d\,\epsilon_o/\epsilon_s$

and $AA = \int_L^M \frac{y^2}{(\beta-1)+(y/Y1)^\beta} dy = \int_L^M g(y)\, dy$

$$\text{where } g(y) = \frac{y^2}{(\beta-1)+(y/Y1)^\beta} \quad \text{(A-8)}$$

Using the trapezoidal rule shown in Reference [15],

$$AA = \int_L^M g(y)dy = \sum_{i=1}^{n} \frac{a}{2}[g(y_i) + g(y_{i+1})]$$

$$= \sum_{i=1}^{n} \frac{M-L}{2n} [g(y_i) + g(y_{i+1})] \quad \text{(A-9)}$$

where $Y1 = L+(M-L)*i/n$ (i=1,2,3,...n)

$$\text{So, } g(y_i) = g\left[L+ \frac{M-L}{n}(i-1)\right] = GY(I) \quad \text{(A-10)}$$

$$g(y_{i+1}) = g\left[L+ \frac{M-L}{n}* i \right] = GY(I+1) \quad \text{(A-11)}$$

where function GY is

$$GY(I) = \frac{[L + (M-L)*(I-1)/n]^2}{(\beta-1) + Y1^{-\beta} *[L+ (M-L)*(I-1)/n]^\beta} \quad \text{(A-12)}$$

(I=1,2,3,....n).

For the analysis between cracking and ultimate:

Case A:

$$X_1 = \frac{\int_0^{kd} yfdy}{\int_0^{kd} fdy} = \frac{YINT}{FINT} \quad \text{(where} \quad L=0, \ M=kd)$$

Case B:

$$X_2 = (1-k)d + Y1 + \frac{\int_{Y1}^{kd} yfdy - y_1 \int_{Y1}^{kd} fdy}{\int_{Y1}^{kd} fdy}$$

$$= (1-k)d + y_1 + \frac{YINT - Y1*FINT}{FINT}$$

(L = Y1, M = kd)

$$X_1 = \frac{\int_0^{Y1} yfdy}{\int_0^{Y1} fdy} = \frac{YINT}{FINT} \qquad (L=0, \ M=Y1)$$

APPENDIX B.

APPENDIX B. FINDING K USING THE HALVING INTERVAL METHOD

The method of halving the interval shown in Reference [15] is used here to find k value which must satisfy the force equilibrium equation.

For case A:

$$P + T_s + C_{c1} + C_s = 0 \tag{B-1a}$$

where $C_{c1} = b \int_0^{kd} f dy = F_1 (k)$ (B-2)

$$C_s = A_s' f_s' = F_2(k) \tag{B-3}$$

C_{c1}, C_s are function of k.

(B-1a) can be written as:

$$C_{c1} + C_s - P - T_s = 0 \tag{B-1b}$$

$$FUA = G(k) = C_{c1} + C_s - P - T_s \tag{B-4}$$

Here, the objective is to find k value which satisfies Eq.(B-1a), that is, G(k)=0. Suppose one can find k_1 and k_2 in which $G(k_1)$ and $G(k_2)$ are of opposite sign. Then, k_3 can be written as:

$$k_3 = \frac{k_1+k_2}{2} \tag{B-5}$$

The procedures to find k can be expressed as follows:

1. Choose K_1 and k_2 that $G(k_1)$ and $G(k_2)$ are of opposite sign.
2. Calculate K_3 by using equation (B-5).
3. If $G(k_1)$ and $G(k_3)$ are of opposite sign, set $k_2 = k_3$

else, set $k_1 = k_3$.

4. Back to step 2, try a new k3 until G(k3) <= 0.01 or $|k1-k2| <= 0.00001$.

For case B:

According to equation (2-28), let

$$FUB(k) = C_{c1} + C_{c2} + C_s - P - T_s \quad \text{(B-6)}$$

k can be obtained by using the similar procedures shown above.

APPENDIX C. COMPUTER PROGRAM

```
C       THIS IS A PROGRAM FOR THEORETICAL ANALYSIS OF MOMENT-
C       CURVATURE CURVE OF FIBER REINFORCED CONCRETE
C       STRUCTURE.
C       ** SIMPLY SUPPORTED BEAM UNDER TWO POINT LOADING **

C       UNITS: POUNDS,INCHES,RADIANS.

C                ****** NOTATIONS ******

C       NO          = BEAM NUMBER
C       B           = BREADTH OF BEAM SECTION
C       OD          = OVERALL DEPTH
C       D           = EFFECTIVE DEPTH OF BEAM SECTION
C       DC          = COVER TO COMPRESSIVE REINFORCEMENT
C       FCU         = CONCRETE COMPRESSIVE STRENGTH
C       AS          = AREA OF TENSILE STEEL
C       ASC         = AREA OF COMPRESSIVE STEEL
C       E           = MODULUS OF ELASTICITY OF STEEL
C       FY          = YIELD STRESS OF STEEL IN TENSION
C       FY1         = YIELD STRESS OF STEEL IN COMPRESSION
C       N           = MODULAR RATIO
C       ESH         = STEEL STRAIN AT THE START OF STRAIN-
C                     HARDENING
C       ESS         = MODULUS OF ELASTICITY OF TENSILE STEEL
C                     AFTER STRAIN-HARDENING
C       FT          = CONCRETE TENSILE STRENGTH
C       BB          = MATERIAL PARAMETER
C       K           = DEPTH OF NEUTRAL AXIS
C       M,MOM(I)    = MOMENT
C       MX          = MOMENT AFTER CRACKING
C       MC          = CRACKING MOMENT
C       MY          = YIELD MOMEMT
C       EY          = STRAIN OF TENSILE STEEL AT YIELD
C       EYC         = STRAIN OF COMPRESSION STEEL AT YIELD
C       EC1         = CONCRETE STRAIN CORRESPONDING TO FCU
C       EPU         = ULTIMATE STRAIN OF CONCRETE
C       SIC         = CURVATURE AT CRACKING
C       SICA        = CURVATURE AFTER CRACKING
C       SIY         = CURVATURE AT YIELD
C       FS          = STRESS OF TENSILE STEEL
C       FSC         = STRESS OF COMPRESSION STEEL
C       SI,CUR(I)   = CURVATURE CORRESPONDING TO M,MOM(I)
C       ES          = STRAIN OF TENSILE STEEL
C       EC          = MAX. CONCRETE STRAIN
C       P(I)        = LOAD CRRESPONDING TO MOM(I)
C       PC          = LOAD AT CRACKING
C       PY          = LOAD AT YIELD
C       R(I)        = ROTATION CRRESPONDING TO MOM(I)
C       RC          = ROTATION AT CRACKING
C       RY          = ROTATION AT YIELD
C       T(I)        = AREA UNDER M-SI DIAG.
C       H(I)        = MOMENT OF AREA UNDER M-SI DIAG.
C       DEFM(I)     = DEFLECTION AT MID-SPAN CRRESPONDING
C                     TO MOM(I)
```

```
C       DEFB(I)      = DEFLECTION AT
C       DEFC         = DEFLECTION AT CRACKING
C       DY           = DEFLECTION AT YIELD
C       K1,K2,K3     = PARAMETERS
C       K0,L,M,J     = PARAMETERS
C       K1D,K2D,KD = PARAMETERS
C       K3D,NN       = PARAMETERS
C       Z            = SHEAR SPAN
C       Z1           =
C       CC0,CC       = COMPRESSION FORCE OF CONCRETE
C       CS0,CSS,CS = FORCE IN COMPRESSION STEEL
C       TS0,TS       = FORCE IN TENSILE STEEL


C     OPEN FILES

        DIMENSION MOM(300),CUR(300),P(300),T(300),H(300)
        REAL K,K1,K2,K3,L,M,K1D,K2D,K3D,K0,KD,N,J,
      1 MC,MY,MX,MOM
        CHARACTER*20 DATA,FNAME1,FNAME2
        WRITE (*,'(A\)')' INPUT NAME OF DATA'
        READ (*,'(A)') DATA
        WRITE (*,'(/A\)')' NAME OF OUTPUT1'
        READ (*,'(A)')FNAME1
        WRITE (*,'(/A\)') ' NAME OF OUTPUT2'
        READ (*,'(A)')FNAME2
        OPEN (5,FILE=DATA,STATUS='OLD')
        OPEN (6,FILE=FNAME1,STATUS='NEW')
        OPEN (7,FILE=FNAME2,STATUS='NEW')


C     READ AND WRITE INPUT DATA

        READ (5,*) NO
        READ (5,*) B,OD,D,DC,FCU
        READ (5,*) AS,ASC,E,FY,FY1
        READ (5,*) N,ESH,ESS,FT,Z
        READ (5,*) Z1,BB,EPU,EC1

        WRITE (6,601) NO
        WRITE (6,602) B,OD,D,DC,FCU
        WRITE (6,603) AS,ASC,E,FY,FY1
        WRITE (6,604) N,ESH,ESS,FT,Z
        WRITE (6,605) Z1,BB,EPU,EC1
 601    FORMAT (//25X,'***** BASIC DATA *****'//
      1 8X,'BEAM NO.',I2,', TWO POINT LOADING.')
 602    FORMAT (/10X,'B',12X,'OD',12X,'D',10X,'DC',
      1 10X,'FCU'/1X,5F13.3)
 603    FORMAT (/10X,'AS',10X,'ASC',10X,'E',10X,'FY',
      1 10X,'FY1'/1X,F13.3,F10.3,F16.3,2F13.3)
 604    FORMAT (/10X,'N',10X,'ESH',10X,'ESS',10X,'FT'
      1 10X,'Z'/1X,F13.3,F10.4,F16.3,2F13.3)
```

```
 605   FORMAT (/10X,'Z1',10X,'BB',10X,'EPU',10X,'EC1'
     1  /1X,4F13.3)

       EY= FY/E
       EYC= FY1/E


C    ANALYSIS AT CRACKING

       X0= ((N-1.)*FT*(ASC*DC+AS*D)+0.5*FT*B*OD**2)/((N-1)
     1 *FT*(ASC+AS)+B*FT*OD)
       CC0= 0.5*B*X0*FT*X0/(OD-X0)
       CS0= (X0-DC)*(N-1.)*ASC*FT/(D-X0)
       TS0= (D-X0)*(N-1.)*AS*FT/(D-X0)
       CT= 0.5*B*(OD-X0)*FT
       MC= 2.*CC0*X0/3.+CS0*(X0-DC)+2*CT*(D-X0)/3+TS0*(D-X0)
       ES= TS0/(AS*E)
       K= X0/D
       SIC= ES/((1.-K)*D)
       RC= SIC*Z
       DECB= (5./6.)*SIC*Z**2
       DECM= SIC*(5.*Z**2/6.+Z1**2/8.)
       PC= MC/Z
       PPC=2.*PC
       WRITE (*,607)MC,SIC
       WRITE (6,607)MC,SIC
 607   FORMAT (//4X,'ANALYSIS AT INITIAL CRACKING OF',
     1 ' CONCRETE'//8X,'MC=',F13.3,'  SIC=',E12.3)
       WRITE(*,608)K,ES,CC0,CS0,TS0,MC,SIC,CT
       WRITE(6,608)K,ES,CC0,CS0,TS0,MC,SIC,CT
 608   FORMAT (/10X,'K',12X,'ES',12X,'CC0',12X,'CS0'
     1 /1X,2E14.5,2F14.3//10X,'TS0',10X,'MC',12X,'SIC',
     2 12X,'CT'/1X,2F14.3,E14.5,F14.3)


C    ANALYSIS AFTER CRACKING

       J=(D-DC)/D
       MX=MC
       PA=(N-1.)*ASC
       PB=N*AS
       X= (-PA-PB+SQRT((PA+PB)**2+2.*B*(DC*PA+D*PB)))/B
       K=X/D
       FC= MX/(B*X**2/3.+ASC*(X-DC)**2*(N-1.)/X+
     1 (D-X)**2*N*AS/X)
       FS=N*(1.-K)*FC/K
       ES=FS/E
       SICA= ES/((1.-K)*D)
       CC=FC*B*X/2.
       CS1=FC*(X-DC)*(N-1.)*ASC/X
       TS=FC*(D-X)*N*AS/X
       WRITE (*,625)
```

```
      WRITE (6,625)
 625  FORMAT(//4X,'ANALYSIS AFTER CRACKING')
      WRITE (*,609)K,ES,CC,CS1,TS,MX,SICA
      WRITE (6,609)K,ES,CC,CS1,TS,MX,SICA
 609  FORMAT (/10X,'K',12X,'ES',12X,'CC',12X,'CS1'/
     1 1X,2E14.5,2F14.3//10X,'TS',10X,'MX',12X,'SI'/
     2 1X,2F14.3,E14.5)


C    ANALYSIS BETWEEN CRACKING AND ULTIMATE

      WRITE (*,610)EY,EPU
      WRITE (6,610)EY,EPU
 610  FORMAT (///4X,'ANALYSIS BETWEEN CRACKING AND ',
     1 'ULTIMATE'//4X,'STEEL STRAIN AT YIELD =EY= ',F10.6//
     2 4X,'ULTIMATE CONCRETE STRAIN = EPU = ',F10.6//
     3 8X,'K',9X,'EC',8X,'ES',7X,'FS',8X,'FSC',6X,'MOMENT',
     4 4X,'CUR')
 620  FORMAT (4X,F8.5,2F10.5,3F10.0,F10.6)

  50  NN= -1
      DO 300 I=1,300
      ES=ES+0.0001
      IF (ES.LT.EY) THEN
        FS=E*ES
        ELSEIF (ES.LT.ESH) THEN
           FS=FY
          ELSE
           FS=FY+(ES-ESH)*ESS
      ENDIF
      TS=AS*FS
      J=(D-DC)/D

      IF (EC-EC1) 60,60,100
  60  CALL AK(K0,ES,B,FCU,BB,D,EC1,TS,
     1 ASC,DC,EYC,E,FY1)
      IF (K0.EQ.0.0) THEN
        GO TO 370
        ELSE
        K=K0
      ENDIF
      KD=K*D
      YINA= YINT(0.0,KD,K,ES,FCU,BB,D,EC1)
      FINA= FINT(0.0,KD,K,ES,FCU,BB,D,EC1)
      X1=YINA/FINA
      EC=ES*K/(1.-K)
      SI=EC/KD
      CC1=B*FINA
      CALL CSS(CSA,FSC,K,ES,D,DC,EYC,E,FY1,ASC)
      M=CC1*(X1+D*(1.-K))+CSA*J*D
      GO TO 200

 100  CALL BK(K0,ES,B,FCU,BB,D,EC1,TS,
```

```
    1 ASC,DC,EYC,E,FY1)
      IF (K0.EQ.0.0) THEN
        GO TO 370
        ELSE
        K=K0
      ENDIF
      KD=K*D
      EC=ES*K/(1.-K)
      SI=EC/KD
      CALL CSS(CSB,FSC,K,ES,D,DC,EYC,E,FY1,ASC)
      Y1=(1.-K)*D*EC1
      FINB1= FINT(0.0,Y1,K,ES,FCU,BB,D,EC1)
      FINB2= FINT(Y1,KD, K,ES,FCU,BB,D,EC1)
      YINB1= YINT(0.0,Y1,K,ES,FCU,BB,D,EC1)
      YINB2= YINT(Y1,KD, K,ES,FCU,BB,D,EC1)
      X1= YINB1/FINB1
      X2=(1.-K)*D+Y1+(YINB2-Y1*FINB2)/FINB2
      CC1B=B*FINB1
      CC2B=B*FINB2
      M=CC1B*(X1+D*(1.-K))+CC2B*X2+CSB*J*D
200   WRITE (*,620)K,EC,ES,FS,FSC,M,SI
      WRITE (6,620)K,EC,ES,FS,FSC,M,SI

      MOM(I)= M
      CUR(I)= SI
      P(I)= MOM(I)/Z
      PP=2*P(I)
      IF (I-1) 110,110,115
110   T(I)= MOM(I)*CUR(I)/2.
      H(I)= CUR(I)*MOM(I)**2/3.
      GO TO 120
115   T(I)= T(I-1)+(CUR(I)+CUR(I-1))*(MOM(I)-MOM(I-1))/2.
      H(I)= H(I-1)+(CUR(I)+CUR(I-1))*(MOM(I)-MOM(I-1))*
    1  (MOM(I)+MOM(I-1))/4.
120   IF (ES-EY)250,130,130
130   R= T(I)*Z/MOM(I)+CUR(I)*Z1/2.
      DEFM= H(I)*(Z/MOM(I))**2+CUR(I)*Z1*(Z+Z1/4.)/2.
      DEFB= DEFM-CUR(I)*Z1**2/8.
      NN=NN+1
      IF (NN) 140,140,150
140   WRITE (7,660) MC,SIC,RC,DECB,DECM,PC,PPC,
    1               MOM(I),CUR(I),R,DEFB,DEFM,P(I),PP
      WRITE (*,660) MC,SIC,RC,DECB,DECM,PC,PPC,
    1               MOM(I),CUR(I),R,DEFB,DEFM,P(I),PP
660   FORMAT (6X,'MOM',7X,'CUR',7X,'ROT',7X,'DEFB',6X,
    1  'DEFM',6X,'LOAD(P)',3X,'LOAD(2P)'/4X,'AT CRACKING'
    2  /1X,F10.0,4F10.5,2F10.0//4X,'AT YIELDING'/1X,F10.0,
    3  4F10.5,2F10.0)
      GO TO 250
150   WRITE (7,670) MOM(I),CUR(I),R,DEFB,DEFM,P(I),PP
      WRITE (*,670) MOM(I),CUR(I),R,DEFB,DEFM,P(I),PP
670   FORMAT (1X,F10.0,4F10.5,2F10.0)
```

```
C       CHECK EPU
 250    IF (EC.GT.EPU) GO TO 350
 300    CONTINUE
        GO TO 400
 350    WRITE(*,640)EC
 640    FORMAT(1X,'EC=',F10.6,'>EPU, CONCRETE FAILURE.')
        GO TO 400
 370    WRITE (*,645)
 645    FORMAT (1X,'EQUILIBRIUM EQUATION NOT SATISFIED',
     1 1X,'    STRUCTURE FAILURE')
 400    CONTINUE
        CLOSE(5)
        CLOSE(6)
        CLOSE(7)
        STOP
        END



C     FOLLOWING ARE THREE SUBROUTINES AND FOUR FUNCTIONS
        SUBROUTINE BK(K0,ES,B,FCU,BB,D,EC1,TS,
     1 ASC,DC,EYC,E,FY1)
        REAL K,K1,K2,K3,K1D,K2D,K3D,L,M,K0
        K1=0.1
        K2=0.5
    5   CALL CSS(CSB1,FSC,K1,ES,D,DC,EYC,E,FY1,ASC)
        CALL CSS(CSB2,FSC,K2,ES,D,DC,EYC,E,FY1,ASC)
        Y11=(1.-K1)*D*EC1/ES
        Y12=(1.-K2)*D*EC1/ES
        K1D=K1*D
        K2D=K2*D
        CCB11=B*FINT(0.0,Y11,K1,ES,FCU,BB,D,EC1)
        CCB12=B*FINT(0.0,Y12,K2,ES,FCU,BB,D,EC1)
        CCB21=B*FINT(Y11,K1D,K1,ES,FCU,BB,D,EC1)
        CCB22=B*FINT(Y12,K2D,K2,ES,FCU,BB,D,EC1)
        FUB1= CCB11+CCB21+CSB1-TS
        FUB2= CCB12+CCB22+CSB2-TS
        IF(FUB1*FUB2)10,60,50
   10   K3= (K1+K2)/2.
        K3D=K3*D
        CALL CSS(CSB3,FSC,K3,ES,D,DC,EYC,E,FY1,ASC)
        Y13=(1.-K3)*D*EC1/ES
        CCB13=B*FINT(0.0,Y13,K3,ES,FCU,BB,D,EC1)
        CCB23=B*FINT(Y13,K3D,K3,ES,FCU,BB,D,EC1)
        FUB3= CCB13+CCB23+CSB3-TS
          FOX=FUB1*FUB3
        IF (FOX.LT.0.0)  K2=K3
        IF (FOX.GT.0.0)  K1=K3
        IF (ABS(FUB3).LE.0.01.OR.ABS(K1-K2).LE.0.00001)
     1     THEN
            GO TO 70
           ELSE
            GO TO 5
```

```
      ENDIF
 50   K0=0.0
C     K0=0.0 MEANS THERE IS NO SOLUTION FOR THE EQUATION.
        GO TO 100
 60   IF(FUB1.EQ.0.0) THEN
         K0=K1
        ELSE
         K0=K2
      ENDIF
        GO TO 100
 70   K0=K3
C 80  WRITE(6,90)K0
C 90  FORMAT(1X,'K=',F8.5)
100   CONTINUE
      RETURN
      END



      SUBROUTINE AK(K0,ES,B,FCU,BB,D,EC1,TS,
     1 ASC,DC,EYC,E,FY1)
      REAL K,K1,K2,K3,L,M,K1D,K2D,K3D,K0
      K1=0.1
      K2=0.5
  5   K1D=K1*D
      K2D=K2*D
      CALL CSS(CS1,FSC,K1,ES,D,DC,EYC,E,FY1,ASC)
      CALL CSS(CS2,FSC,K2,ES,D,DC,EYC,E,FY1,ASC)
      CC11=B*FINT(0.0,K1D,K1,ES,FCU,BB,D,EC1)
      CC12=B*FINT(0.0,K2D,K2,ES,FCU,BB,D,EC1)
      FUA1=CC11+CS1-TS
      FUA2=CC12+CS2-TS
      IF (FUA1*FUA2)10,62,50
 10   K3= (K1+K2)/2.
      K3D=K3*D
      CALL CSS(CS3,FSC,K3,ES,D,DC,EYC,E,FY1,ASC)
      CC13=B*FINT(0.0,K3D,K3,ES,FCU,BB,D,EC1)
      FUA3=CC13+CS3-TS
      FOX=FUA1*FUA3
        IF (FOX.LT.0.0) K2=K3
        IF (FOX.GT.0.0) K1=K3
      IF (ABS(K1-K2).LE.0.00001.OR.ABS(FUA3).LE.0.01)
     1  THEN
         GO TO 60
        ELSE
          GO TO 5
      ENDIF
 50   K0=0.0
C     K0=0.0 MEANS THERE IS NO SOLUTION FOR THE EQUATION.
      GO TO 70
 60   K0=K3
      GO TO 70
 62   IF (FUA1.EQ.0.0) THEN
         K0=K1
```

```
       ELSE
         K0=K2
       ENDIF
 70    RETURN
       END


       SUBROUTINE CSS(CS,FSC,K,ES,D,DC,EYC,E,FY1,ASC)
       REAL K
       ESC= (K*D-DC)*ES/((1.-K)*D)
       IF (ESC.LT.EYC) FSC=E*ESC
       IF (ESC.GE.EYC) FSC=FY1
       CS=ASC*FSC
       RETURN
       END


       FUNCTION YINT(L,M,K,ES,FCU,BB,D,EC1)
       REAL L,M,K
       Y1=(1.-K)*D*EC1/ES
       A=0.0
       DO 100 I=1,100
       GYII=GY(I+1,L,M,BB,Y1)
       GYI =GY(I,L,M,BB,Y1)
       A=A+(M-L)*(GYII+GYI)/(2.*100.)
100    CONTINUE
       YINT=A*FCU*BB/Y1
       RETURN
       END


       FUNCTION GY(I,L,M,BB,Y1)
       REAL L,M,K
       GY=(L+(M-L)*(I-1.)/100.)**2/((BB-1.)+Y1**(-BB)*(L+
     1 (M-L)*(I-1)/100.)**BB)
       RETURN
       END


       FUNCTION FINT(L,M,K,ES,FCU,BB,D,EC1)
       REAL L,M,K
       Y1= (1.-K)*D*EC1/ES
       A=0.0
       DO 100 I=1,100
       GII=GG(I+1,L,M,BB,Y1)
       GI =GG(I,  L,M,BB,Y1)
       A=A+(M-L)*(GII+GI)/(2.*100.)
 100   CONTINUE
       FINT=A*FCU*BB/Y1
       RETURN
```

```
      END


      FUNCTION GG(I,L,M,BB,Y1)
      REAL L,M
      GG=(L+(M-L)*(I-1.)/100.)/((BB-1.)+Y1**(-BB)*(L+(M-L)
     1 *(I-1.)/100.)**BB)
      RETURN
      END
```

APPENDIX D.

COMPUTER ANALYSIS - BEAM NO.1

***** BASIC DATA *****

BEAM NO. 1, TWO POINT LOADING.

B	OD	D	DC	FCU
4.000	6.000	5.600	.000	6566.000

AS	ASC	E	FY	FY1
.040	.000	29000000.000	103844.000	.000

N	ESH	ESS	FT	Z
4.527	.0056	130653.000	607.700	24.000

Z1	BB	EPU	EC1
32.000	4.404	.080	.002

ANALYSIS AT INITIAL CRACKING OF CONCRETE

MC= 13914.380 SIC= .286E-04

K	ES	CC0	CS0
.53843E+00	.73909E-04	3701.978	.000

TS0	MC	SIC	CT
85.734	13914.380	.28594E-04	3627.733

ANALYSIS AFTER CRACKING

K	ES	CC	CS1
.11933E+00	.22307E-02	2587.636	.000

TS	MX	SI
2587.635	13914.380	.45232E-03

ANALYSIS BETWEEN CRACKING AND ULTIMATE

STEEL STRAIN AT YIELD =EY= .003581

ULTIMATE CONCRETE STRAIN = EPU = .080000

K	EC	ES	FS	FSC	MOMENT	CUR
.14444	.00039	.00233	67591.	0.	14411.	.000486
.14444	.00041	.00243	70491.	0.	15029.	.000507
.14444	.00043	.00253	73391.	0.	15647.	.000528
.14445	.00044	.00263	76291.	0.	16268.	.000549
.14445	.00046	.00273	79191.	0.	16886.	.000570
.14445	.00048	.00283	82091.	0.	17504.	.000591
.14445	.00049	.00293	84991.	0.	18122.	.000612
.14445	.00051	.00303	87891.	0.	18739.	.000633
.14445	.00053	.00313	90791.	0.	19357.	.000653
.14446	.00055	.00323	93691.	0.	19976.	.000674
.14446	.00056	.00333	96591.	0.	20595.	.000695
.14446	.00058	.00343	99491.	0.	21213.	.000716
.14446	.00060	.00353	102391.	0.	21830.	.000737

.14355	.00061	.00363	103844.	0.	22147.	.000757
.14177	.00062	.00373	103844.	0.	22162.	.000776
.14005	.00062	.00383	103844.	0.	22176.	.000795
.13839	.00063	.00393	103844.	0.	22188.	.000815
.13679	.00064	.00403	103844.	0.	22200.	.000834
.13525	.00065	.00413	103844.	0.	22213.	.000853
.13376	.00065	.00423	103844.	0.	22225.	.000872
.13232	.00066	.00433	103844.	0.	22237.	.000891
.13091	.00067	.00443	103844.	0.	22244.	.000910
.12957	.00067	.00453	103844.	0.	22257.	.000929
.12827	.00068	.00463	103844.	0.	22268.	.000949
.12700	.00069	.00473	103844.	0.	22278.	.000968
.12576	.00069	.00483	103844.	0.	22286.	.000987
.12457	.00070	.00493	103844.	0.	22295.	.001006
.12341	.00071	.00503	103844.	0.	22304.	.001025
.12228	.00071	.00513	103844.	0.	22314.	.001044
.12119	.00072	.00523	103844.	0.	22322.	.001063
.12011	.00073	.00533	103844.	0.	22327.	.001082
.11907	.00073	.00543	103844.	0.	22336.	.001101
.11806	.00074	.00553	103844.	0.	22343.	.001120
.11708	.00075	.00563	103848.	0.	22354.	.001139
.11613	.00075	.00573	103861.	0.	22365.	.001158
.11520	.00076	.00583	103874.	0.	22375.	.001177
.11429	.00077	.00593	103887.	0.	22382.	.001196
.11341	.00077	.00603	103900.	0.	22394.	.001215
.11254	.00078	.00613	103913.	0.	22402.	.001234
.11170	.00078	.00623	103926.	0.	22412.	.001253
.11087	.00079	.00633	103939.	0.	22419.	.001271
.11006	.00080	.00643	103953.	0.	22428.	.001290
.10928	.00080	.00653	103966.	0.	22440.	.001309
.10851	.00081	.00663	103979.	0.	22450.	.001328
.10776	.00081	.00673	103992.	0.	22457.	.001347
.10701	.00082	.00683	104005.	0.	22463.	.001366
.10629	.00082	.00693	104018.	0.	22472.	.001385
.10558	.00083	.00703	104031.	0.	22480.	.001404
.10490	.00084	.00713	104044.	0.	22492.	.001423
.10422	.00084	.00723	104057.	0.	22498.	.001441
.10356	.00085	.00733	104070.	0.	22509.	.001460
.10290	.00085	.00743	104083.	0.	22514.	.001479
.10226	.00086	.00753	104096.	0.	22523.	.001498
.10163	.00086	.00763	104109.	0.	22528.	.001517
.10102	.00087	.00773	104122.	0.	22538.	.001536
.10041	.00087	.00783	104135.	0.	22542.	.001554

MOM	CUR	ROT	DEFB	DEFM	LOAD(P)	LOAD(2P)
AT CRACKING						
13914.	.00003	.00069	.01372	.01738	580.	1160.
AT YIELDING						
22147.	.00076	.02109	.43426	.53116	923.	1846.
22162.	.00078	.02140	.44176	.54111	923.	1847.
22176.	.00080	.02171	.44923	.55105	924.	1848.
22188.	.00081	.02203	.45670	.56097	924.	1849.
22200.	.00083	.02234	.46416	.57089	925.	1850.
22213.	.00085	.02265	.47164	.58083	926.	1851.
22225.	.00087	.02296	.47911	.59074	926.	1852.
22237.	.00089	.02328	.48657	.60065	927.	1853.
22244.	.00091	.02359	.49398	.61051	927.	1854.
22257.	.00093	.02390	.50146	.62044	927.	1855.
22268.	.00095	.02421	.50892	.63034	928.	1856.
22278.	.00097	.02452	.51635	.64021	928.	1856.
22286.	.00099	.02483	.52378	.65008	929.	1857.
22295.	.00101	.02514	.53120	.65994	929.	1858.
22304.	.00102	.02546	.53864	.66981	929.	1859.
22314.	.00104	.02577	.54609	.67970	930.	1860.
22322.	.00106	.02608	.55350	.68954	930.	1860.
22327.	.00108	.02638	.56087	.69935	930.	1861.
22336.	.00110	.02670	.56829	.70920	931.	1861.
22343.	.00112	.02700	.57569	.71903	931.	1862.
22354.	.00114	.02732	.58316	.72893	931.	1863.
22365.	.00116	.02763	.59062	.73882	932.	1864.
22375.	.00118	.02794	.59809	.74872	932.	1865.
22382.	.00120	.02825	.60548	.75853	933.	1865.
22394.	.00121	.02857	.61297	.76845	933.	1866.
22402.	.00123	.02888	.62040	.77830	933.	1867.
22412.	.00125	.02919	.62786	.78819	934.	1868.
22419.	.00127	.02950	.63526	.79800	934.	1868.
22428.	.00129	.02981	.64270	.80787	935.	1869.
22440.	.00131	.03012	.65020	.81779	935.	1870.
22450.	.00133	.03043	.65766	.82766	935.	1871.
22457.	.00135	.03074	.66507	.83749	936.	1871.
22463.	.00137	.03105	.67243	.84727	936.	1872.
22472.	.00138	.03136	.67989	.85715	936.	1873.
22480.	.00140	.03167	.68731	.86699	937.	1873.
22492.	.00142	.03199	.69484	.87693	937.	1874.
22498.	.00144	.03230	.70222	.88672	937.	1875.
22509.	.00146	.03261	.70972	.89664	938.	1876.
22514.	.00148	.03292	.71707	.90639	938.	1876.
22523.	.00150	.03323	.72455	.91629	938.	1877.
22528.	.00152	.03354	.73188	.92603	939.	1877.
22538.	.00154	.03385	.73937	.93593	939.	1878.
22542.	.00155	.03416	.74671	.94568	939.	1879.

COMPUTER ANALYSIS - BEAM NO.2

***** BASIC DATA *****

BEAM NO. 2, TWO POINT LOADING.

B	OD	D	DC	FCU
4.000	6.000	5.600	.000	5967.000

AS	ASC	E	FY	FY1
.040	.000	29000000.000	103844.000	.000

N	ESH	ESS	FT	Z
4.812	.0056	130653.000	579.300	24.000

Z1	BB	EPU	EC1
32.000	1.911	.080	.002

ANALYSIS AT INITIAL CRACKING OF CONCRETE

MC= 13287.350 SIC= .295E-04

K	ES	CC0	CS0
.53865E+00	.76148E-04	3533.271	.000

TS0	MC	SIC	CT
88.332	13287.350	.29474E-04	3456.782

ANALYSIS AFTER CRACKING

K	ES	CC	CS1
.12278E+00	.21328E-02	2473.995	.000

TS	MX	SI
2473.995	13287.350	.43416E-03

ANALYSIS BETWEEN CRACKING AND ULTIMATE

STEEL STRAIN AT YIELD =EY= .003581

ULTIMATE CONCRETE STRAIN = EPU = .080000

K	EC	ES	FS	FSC	MOMENT	CUR
.12151	.00031	.00223	64750.	0.	13912.	.000454
.12160	.00032	.00233	67650.	0.	14536.	.000474
.12167	.00034	.00243	70550.	0.	15157.	.000495
.12176	.00035	.00253	73450.	0.	15779.	.000515
.12184	.00037	.00263	76350.	0.	16401.	.000535
.12194	.00038	.00273	79250.	0.	17025.	.000556
.12203	.00039	.00283	82150.	0.	17644.	.000576
.12213	.00041	.00293	85050.	0.	18266.	.000597
.12224	.00042	.00303	87950.	0.	18891.	.000617
.12233	.00044	.00313	90850.	0.	19511.	.000637
.12244	.00045	.00323	93750.	0.	20133.	.000658
.12255	.00047	.00333	96650.	0.	20755.	.000678
.12266	.00048	.00343	99550.	0.	21375.	.000699

.12278	.00049	.00353	102450.	0.	21998.	.000719
.12204	.00050	.00363	103844.	0.	22300.	.000739
.12055	.00051	.00373	103844.	0.	22310.	.000758
.11912	.00052	.00383	103844.	0.	22321.	.000777
.11776	.00052	.00393	103844.	0.	22335.	.000796
.11642	.00053	.00403	103844.	0.	22343.	.000815
.11514	.00054	.00413	103844.	0.	22352.	.000834
.11391	.00054	.00423	103844.	0.	22361.	.000853
.11273	.00055	.00433	103844.	0.	22374.	.000872
.11157	.00056	.00443	103844.	0.	22380.	.000891
.11046	.00056	.00453	103844.	0.	22390.	.000910
.10937	.00057	.00463	103844.	0.	22396.	.000929
.10833	.00057	.00473	103844.	0.	22407.	.000948
.10731	.00058	.00483	103844.	0.	22410.	.000967
.10633	.00059	.00493	103844.	0.	22421.	.000986
.10538	.00059	.00503	103844.	0.	22429.	.001005
.10445	.00060	.00513	103844.	0.	22436.	.001023
.10355	.00060	.00523	103844.	0.	22443.	.001042
.10267	.00061	.00533	103844.	0.	22448.	.001061
.10181	.00062	.00543	103844.	0.	22454.	.001080
.10098	.00062	.00553	103844.	0.	22460.	.001099
.10018	.00063	.00563	103848.	0.	22467.	.001118

MOM	CUR	ROT	DEFB	DEFM	LOAD(P)	LOAD(2P)
AT CRACKING						
13287.	.00003	.00071	.01415	.01792	554.	1107.
AT YIELDING						
22300.	.00074	.02056	.42356	.51814	929.	1858.
22310.	.00076	.02087	.43095	.52796	930.	1859.
22321.	.00078	.02118	.43834	.53779	930.	1860.
22335.	.00080	.02149	.44576	.54765	931.	1861.
22343.	.00082	.02180	.45313	.55745	931.	1862.
22352.	.00083	.02211	.46050	.56725	931.	1863.
22361.	.00085	.02241	.46788	.57706	932.	1863.
22374.	.00087	.02272	.47529	.58691	932.	1864.
22380.	.00089	.02303	.48263	.59667	932.	1865.
22390.	.00091	.02334	.49002	.60649	933.	1866.
22396.	.00093	.02365	.49736	.61625	933.	1866.
22407.	.00095	.02396	.50476	.62608	934.	1867.
22410.	.00097	.02426	.51207	.63581	934.	1868.
22421.	.00099	.02457	.51947	.64563	934.	1868.
22429.	.00100	.02488	.52684	.65542	935.	1869.
22436.	.00102	.02519	.53419	.66519	935.	1870.
22443.	.00104	.02549	.54153	.67495	935.	1870.
22448.	.00106	.02580	.54886	.68470	935.	1871.
22454.	.00108	.02611	.55619	.69444	936.	1871.
22460.	.00110	.02641	.56353	.70420	936.	1872.
22467.	.00112	.02672	.57088	.71397	936.	1872.

COMPUTER ANALYSIS - BEAM NO.3

***** BASIC DATA *****

BEAM NO. 3, TWO POINT LOADING.

B	OD	D	DC	FCU
4.000	6.000	5.600	.000	6566.000

AS	ASC	E	FY	FY1
.487	.000	29000000.000	66715.000	.000

N	ESH	ESS	FT	Z
4.527	.0043	798725.000	607.700	24.000

Z1	BB	EPU	EC1
32.000	4.404	.080	.002

ANALYSIS AT INITIAL CRACKING OF CONCRETE

MC= 17253.120 SIC= .305E-04

K	ES	CC0	CS0
.56672E+00	.73909E-04	4331.234	.000

TS0	MC	SIC	CT
1043.815	17253.120	.30461E-04	3435.145

ANALYSIS AFTER CRACKING

K	ES	CC	CS1
.35603E+00	.24752E-03	3495.787	.000

TS	MX	SI
3495.787	17253.120	.68638E-04

ANALYSIS BETWEEN CRACKING AND ULTIMATE

STEEL STRAIN AT YIELD =EY= .002301

ULTIMATE CONCRETE STRAIN = EPU = .080000

K	EC	ES	FS	FSC	MOMENT	CUR
.41629	.00025	.00035	10078.	0.	23672.	.000106
.41629	.00032	.00045	12978.	0.	30483.	.000137
.41629	.00039	.00055	15878.	0.	37293.	.000168
.41630	.00046	.00065	18778.	0.	44104.	.000198
.41633	.00053	.00075	21678.	0.	50916.	.000229
.41636	.00060	.00085	24578.	0.	57725.	.000259
.41640	.00068	.00095	27478.	0.	64532.	.000290
.41647	.00075	.00105	30378.	0.	71341.	.000321
.41656	.00082	.00115	33278.	0.	78141.	.000351
.41668	.00089	.00125	36178.	0.	84940.	.000382
.41685	.00096	.00135	39078.	0.	91738.	.000413
.41706	.00104	.00145	41978.	0.	98524.	.000443
.41733	.00111	.00155	44878.	0.	105303.	.000474

.41766	.00118	.00165	47778.	0.	112067.	.000505
.41807	.00126	.00175	50678.	0.	118820.	.000536
.41857	.00133	.00185	53578.	0.	125550.	.000567
.41920	.00141	.00195	56478.	0.	132268.	.000599
.41994	.00148	.00205	59378.	0.	138955.	.000630
.42083	.00156	.00215	62278.	0.	145608.	.000662
.42189	.00164	.00225	65178.	0.	152219.	.000694
.41964	.00170	.00235	66715.	0.	155863.	.000722
.41371	.00173	.00245	66715.	0.	156186.	.000745
.40811	.00176	.00255	66715.	0.	156486.	.000769
.40280	.00179	.00265	66715.	0.	156766.	.000792
.39777	.00181	.00275	66715.	0.	157033.	.000815
.39299	.00184	.00285	66715.	0.	157276.	.000838
.38845	.00187	.00295	66715.	0.	157509.	.000861
.38412	.00190	.00305	66715.	0.	157725.	.000884
.38001	.00193	.00315	66715.	0.	157927.	.000907
.37609	.00196	.00325	66715.	0.	158116.	.000929
.37236	.00199	.00335	66715.	0.	158291.	.000952
.36880	.00201	.00345	66715.	0.	158461.	.000975
.36541	.00204	.00355	66715.	0.	158615.	.000998
.36218	.00207	.00365	66715.	0.	158760.	.001021
.35909	.00210	.00375	66715.	0.	158891.	.001044
.35613	.00213	.00385	66715.	0.	159007.	.001067
.35333	.00216	.00395	66715.	0.	159120.	.001090
.35064	.00219	.00405	66715.	0.	159217.	.001113
.34809	.00221	.00415	66715.	0.	159312.	.001136
.34566	.00224	.00425	66715.	0.	159398.	.001159
.34345	.00227	.00435	66753.	0.	159549.	.001182
.34149	.00231	.00445	66833.	0.	159784.	.001206
.33963	.00234	.00455	66913.	0.	160004.	.001230
.33790	.00237	.00465	66993.	0.	160218.	.001253
.33626	.00241	.00475	67072.	0.	160413.	.001277
.33475	.00244	.00485	67152.	0.	160603.	.001301
.33336	.00247	.00495	67232.	0.	160790.	.001325
.33206	.00251	.00505	67312.	0.	160958.	.001349
.33088	.00255	.00515	67392.	0.	161113.	.001374
.32980	.00258	.00525	67472.	0.	161254.	.001398
.32885	.00262	.00535	67552.	0.	161389.	.001423
.32801	.00266	.00545	67632.	0.	161506.	.001448
.32728	.00270	.00555	67711.	0.	161606.	.001473
.32668	.00274	.00565	67791.	0.	161697.	.001498
.32620	.00278	.00575	67871.	0.	161769.	.001523
.32586	.00283	.00585	67951.	0.	161825.	.001549
.32565	.00287	.00595	68031.	0.	161861.	.001575
.32559	.00292	.00605	68111.	0.	161875.	.001601
.32569	.00297	.00615	68191.	0.	161867.	.001628
.32596	.00302	.00625	68271.	0.	161833.	.001655
.32641	.00308	.00635	68350.	0.	161769.	.001683
.32707	.00313	.00645	68430.	0.	161674.	.001711
.32797	.00320	.00655	68510.	0.	161544.	.001740
.32913	.00326	.00665	68590.	0.	161368.	.001769

MOM	CUR	ROT	DEFB	DEFM	LOAD(P)	LOAD(2P)
AT CRACKING						
17253.	.00003	.00073	.01462	.01852	719.	1438.
AT YIELDING						
155863.	.00072	.02000	.41269	.50515	6494.	12989.
156186.	.00075	.02039	.42190	.51732	6508.	13015.
156486.	.00077	.02078	.43110	.52947	6520.	13041.
156766.	.00079	.02117	.44027	.54160	6532.	13064.
157033.	.00081	.02156	.44944	.55372	6543.	13086.
157276.	.00084	.02194	.45858	.56581	6553.	13106.
157509.	.00086	.02233	.46773	.57789	6563.	13126.
157725.	.00088	.02271	.47685	.58996	6572.	13144.
157927.	.00091	.02309	.48597	.60201	6580.	13161.
158116.	.00093	.02348	.49508	.61405	6588.	13176.
158291.	.00095	.02386	.50417	.62608	6595.	13191.
158461.	.00098	.02424	.51328	.63812	6603.	13205.
158615.	.00100	.02462	.52236	.65014	6609.	13218.
158760.	.00102	.02500	.53144	.66216	6615.	13230.
158891.	.00104	.02538	.54051	.67416	6620.	13241.
159007.	.00107	.02576	.54956	.68615	6625.	13251.
159120.	.00109	.02614	.55863	.69816	6630.	13260.
159217.	.00111	.02652	.56768	.71015	6634.	13268.
159312.	.00114	.02690	.57674	.72216	6638.	13276.
159398.	.00116	.02728	.58580	.73418	6642.	13283.
159549.	.00118	.02767	.59512	.74648	6648.	13296.
159784.	.00121	.02808	.60478	.75915	6658.	13315.
160004.	.00123	.02849	.61443	.77184	6667.	13334.
160218.	.00125	.02889	.62413	.78457	6676.	13352.
160413.	.00128	.02930	.63381	.79730	6684.	13368.
160603.	.00130	.02971	.64354	.81010	6692.	13384.
160790.	.00133	.03012	.65333	.82297	6700.	13399.
160958.	.00135	.03053	.66311	.83584	6707.	13413.
161113.	.00137	.03094	.67292	.84876	6713.	13426.
161254.	.00140	.03136	.68275	.86172	6719.	13438.
161389.	.00142	.03177	.69264	.87476	6725.	13449.
161506.	.00145	.03219	.70255	.88784	6729.	13459.
161606.	.00147	.03260	.71247	.90096	6734.	13467.
161697.	.00150	.03302	.72247	.91419	6737.	13475.
161769.	.00152	.03344	.73250	.92747	6740.	13481.
161825.	.00155	.03386	.74258	.94084	6743.	13485.
161861.	.00157	.03428	.75270	.95429	6744.	13488.
161875.	.00160	.03471	.76286	.96783	6745.	13490.
161867.	.00163	.03513	.77309	.98147	6744.	13489.
161833.	.00166	.03556	.78338	.99523	6743.	13486.
161769.	.00168	.03599	.79372	1.00911	6740.	13481.
161674.	.00171	.03642	.80414	1.02314	6736.	13473.
161544.	.00174	.03686	.81466	1.03736	6731.	13462.
161368.	.00177	.03730	.82525	1.05174	6724.	13447.

COMPUTER ANALYSIS - BEAM NO.4

***** BASIC DATA *****

BEAM NO. 4, TWO POINT LOADING.

B	OD	D	DC	FCU
4.000	6.000	5.600	.000	5967.000

AS	ASC	E	FY	FY1
.487	.000	29000000.000	66715.000	.000

N	ESH	ESS	FT	Z
4.812	.0043	798725.000	579.300	24.000

Z1	BB	EPU	EC1
32.000	1.911	.080	.002

ANALYSIS AT INITIAL CRACKING OF CONCRETE

MC= 16724.120 SIC= .316E-04

K	ES	CC0	CS0
.56905E+00	.76148E-04	4182.050	.000

TS0	MC	SIC	CT
1075.438	16724.120	.31553E-04	3259.518

ANALYSIS AFTER CRACKING

K	ES	CC	CS1
.36462E+00	.24072E-03	3399.638	.000

TS	MX	SI
3399.638	16724.120	.67652E-04

ANALYSIS BETWEEN CRACKING AND ULTIMATE

STEEL STRAIN AT YIELD =EY= .002301

ULTIMATE CONCRETE STRAIN = EPU = .080000

K	EC	ES	FS	FSC	MOMENT	CUR
.37016	.00073	.00124	35981.	0.	85663.	.000352
.39586	.00147	.00224	64981.	0.	151580.	.000662
.36081	.00183	.00324	66715.	0.	157141.	.000905
.33652	.00215	.00424	66715.	0.	158133.	.001141
.32343	.00251	.00524	67466.	0.	160136.	.001383
.31624	.00289	.00624	68265.	0.	161839.	.001630
.31324	.00330	.00724	69064.	0.	163205.	.001883
.31364	.00377	.00824	69863.	0.	164270.	.002144
.31705	.00429	.00924	70661.	0.	165015.	.002416
.32341	.00489	.01024	71460.	0.	165411.	.002703
.33289	.00561	.01124	72259.	0.	165386.	.003009
.34606	.00648	.01224	73057.	0.	164823.	.003343
.36409	.00758	.01324	73856.	0.	163506.	.003718

.38965	.00909	.01424	74655.	0.	160971.	.004166
.43151	.01157	.01524	75454.	0.	155745.	.004787

MOM	CUR	ROT	DEFB	DEFM	LOAD(P)	LOAD(2P)
AT CRACKING						
16724.	.00003	.00076	.01515	.01918	697.	1394.
AT YIELDING						
157141.	.00091	.02256	.47590	.59179	6548.	13095.
158133.	.00114	.02644	.56861	.71471	6589.	13178.
160136.	.00138	.03058	.66728	.84433	6672.	13345.
161839.	.00163	.03482	.76821	.97683	6743.	13487.
163205.	.00188	.03915	.87139	1.11238	6800.	13600.
164270.	.00214	.04358	.97729	1.25173	6845.	13689.
165015.	.00242	.04814	1.08634	1.39561	6876.	13751.
165411.	.00270	.05285	1.19916	1.54512	6892.	13784.
165386.	.00301	.05774	1.31651	1.70165	6891.	13782.
164823.	.00334	.06285	1.43949	1.86734	6868.	13735.
163506.	.00372	.06825	1.56979	2.04572	6813.	13626.
160971.	.00417	.07407	1.71040	2.24371	6707.	13414.
155745.	.00479	.08065	1.86839	2.48117	6489.	12979.

COMPUTER ANALYSIS - BEAM NO.5

***** BASIC DATA *****

BEAM NO. 5, TWO POINT LOADING.

B	OD	D	DC	FCU
7.000	15.000	12.750	2.250	4750.000

AS	ASC	E	FY	FY1
1.580	.790	29000000.000	70500.000	70500.000

N	ESH	ESS	FT	Z
5.973	.0045	572080.000	760.000	36.000

Z1	BB	EPU	EC1
36.000	1.816	.080	.002

ANALYSIS AT INITIAL CRACKING OF CONCRETE

MC= 223057.600 SIC= .257E-04

K	ES	CC0	CS0
.60209E+00	.13033E-03	21404.660	3193.666

TS0	MC	SIC	CT
5971.579	223057.600	.25688E-04	19480.220

ANALYSIS AFTER CRACKING

K	ES	CC	CS1
.34969E+00	.43547E-03	17740.600	2212.411

TS	MX	SI
19953.010	223057.600	.52519E-04

ANALYSIS BETWEEN CRACKING AND ULTIMATE

STEEL STRAIN AT YIELD =EY= .002431

ULTIMATE CONCRETE STRAIN = EPU = .080000

K	EC	ES	FS	FSC	MOMENT	CUR
.34897	.00077	.00144	41628.	11030.	731090.	.000173
.36973	.00143	.00244	70500.	21657.	1218386.	.000303
.33173	.00171	.00344	70500.	23147.	1230571.	.000403
.30753	.00197	.00444	70500.	24344.	1237384.	.000502
.29205	.00224	.00544	71035.	25734.	1249917.	.000602
.28116	.00252	.00644	71607.	27179.	1261341.	.000702
.27320	.00279	.00744	72179.	28698.	1271509.	.000802
.26728	.00308	.00844	72751.	30318.	1280973.	.000903
.26279	.00336	.00944	73323.	32038.	1289789.	.001004
.25934	.00365	.01044	73896.	33862.	1298217.	.001105
.25667	.00395	.01144	74468.	35781.	1306323.	.001207
.25457	.00425	.01244	75040.	37784.	1314195.	.001308
.25291	.00455	.01344	75612.	39866.	1321969.	.001410

.25159	.00485	.01444	76184.	42020.	1329766.	.001513
.25051	.00516	.01544	76756.	44217.	1337385.	.001615
.24962	.00547	.01644	77328.	46460.	1345042.	.001718
.24887	.00578	.01744	77900.	48737.	1352734.	.001821
.24824	.00609	.01844	78472.	51037.	1360460.	.001923
.24769	.00640	.01944	79044.	53355.	1368250.	.002026
.24720	.00671	.02044	79616.	55679.	1376074.	.002129
.24676	.00702	.02144	80188.	58007.	1383965.	.002232
.24636	.00733	.02244	80761.	60333.	1391920.	.002335
.24598	.00765	.02344	81333.	62649.	1399908.	.002438
.24562	.00796	.02444	81905.	64960.	1407995.	.002541
.24528	.00827	.02544	82477.	67253.	1416109.	.002643
.24495	.00858	.02644	83049.	69532.	1424285.	.002746
.25025	.00916	.02744	83621.	70500.	1429582.	.002870
.26065	.01002	.02844	84193.	70500.	1431789.	.003016
.27252	.01103	.02944	84765.	70500.	1432740.	.003173
.28622	.01220	.03044	85337.	70500.	1432112.	.003344
.30234	.01362	.03144	85909.	70500.	1429387.	.003534
.32187	.01540	.03244	86481.	70500.	1423723.	.003751
.34683	.01775	.03344	87053.	70500.	1413410.	.004015
.38293	.02137	.03444	87625.	70500.	1393681.	.004377

MOM	CUR	ROT	DEFB	DEFM	LOAD(P)	LOAD(2P)
AT CRACKING						
223058.	.00003	.00092	.02774	.03190	6196.	12392.
AT YIELDING						
1218386.	.00030	.01075	.32199	.37108	33844.	67688.
1230571.	.00040	.01263	.38891	.45422	34183.	68365.
1237384.	.00050	.01447	.45499	.53637	34372.	68744.
1249917.	.00060	.01641	.52422	.62177	34720.	69440.
1261341.	.00070	.01837	.59421	.70796	35037.	70074.
1271509.	.00080	.02035	.66470	.79469	35320.	70639.
1280973.	.00090	.02234	.73587	.88215	35583.	71165.
1289789.	.00100	.02435	.80761	.97023	35827.	71655.
1298217.	.00111	.02638	.88001	1.05903	36062.	72123.
1306323.	.00121	.02842	.95305	1.14852	36287.	72573.
1314195.	.00131	.03049	1.02671	1.23868	36505.	73011.
1321969.	.00141	.03257	1.10109	1.32959	36721.	73443.
1329766.	.00151	.03468	1.17628	1.42135	36938.	73876.
1337385.	.00162	.03680	1.25196	1.51363	37150.	74299.
1345042.	.00172	.03895	1.32837	1.60667	37362.	74725.
1352734.	.00182	.04111	1.40549	1.70043	37576.	75152.
1360460.	.00192	.04330	1.48328	1.79487	37791.	75581.
1368250.	.00203	.04551	1.56177	1.89002	38007.	76014.
1376074.	.00213	.04773	1.64088	1.98579	38224.	76449.
1383965.	.00223	.04998	1.72064	2.08222	38443.	76887.
1391920.	.00233	.05224	1.80104	2.17929	38664.	77329.
1399908.	.00244	.05453	1.88201	2.27691	38886.	77773.
1407995.	.00254	.05683	1.96365	2.37521	39111.	78222.
1416109.	.00264	.05915	2.04581	2.47402	39336.	78673.
1424285.	.00275	.06149	2.12855	2.57340	39563.	79127.
1429582.	.00287	.06405	2.21979	2.68473	39711.	79421.
1431789.	.00302	.06683	2.31946	2.80813	39772.	79544.
1432740.	.00317	.06972	2.42338	2.93748	39798.	79597.
1432112.	.00334	.07275	2.53254	3.07432	39781.	79562.
1429387.	.00353	.07596	2.64833	3.22084	39705.	79410.
1423723.	.00375	.07940	2.77327	3.38100	39548.	79096.
1413410.	.00401	.08321	2.91215	3.56256	39261.	78523.
1393681.	.00438	.08774	3.07803	3.78708	38713.	77427.

COMPUTER ANALYSIS - BEAM NO.6

***** BASIC DATA *****

BEAM NO. 6, TWO POINT LOADING.

B	OD	D	DC	FCU
7.000	15.000	12.750	2.250	5850.000

AS	ASC	E	FY	FY1
1.580	.790	29000000.000	50000.000	50000.000

N	ESH	ESS	FT	Z
5.485	.0125	640000.000	1016.000	36.000

Z1	BB	EPU	EC1
36.000	1.816	.080	.002

ANALYSIS AT INITIAL CRACKING OF CONCRETE

MC= 291125.100 SIC= .309E-04

K	ES	CC0	CS0
.60085E+00	.15713E-03	28436.340	3827.429

TS0	MC	SIC	CT
7199.681	291125.100	.30876E-04	26097.940

ANALYSIS AFTER CRACKING

K	ES	CC	CS1
.33957E+00	.56601E-03	23316.040	2618.543

TS	MX	SI
25934.570	291125.100	.67218E-04

ANALYSIS BETWEEN CRACKING AND ULTIMATE

STEEL STRAIN AT YIELD =EY= .001724

ULTIMATE CONCRETE STRAIN = EPU = .080000

K	EC	ES	FS	FSC	MOMENT	CUR
.32402	.00075	.00157	45414.	9913.	805953.	.000182
.28231	.00101	.00257	50000.	10974.	898250.	.000280
.25167	.00120	.00357	50000.	10392.	907125.	.000374
.23213	.00138	.00457	50000.	9599.	912913.	.000466
.21867	.00156	.00557	50000.	8718.	916970.	.000559
.20895	.00173	.00657	50000.	7819.	920014.	.000651
.20173	.00191	.00757	50000.	6942.	922306.	.000743
.19625	.00209	.00857	50000.	6112.	923985.	.000836
.19203	.00227	.00957	50000.	5344.	925112.	.000929
.18880	.00246	.01057	50000.	4657.	925968.	.001022
.18631	.00265	.01157	50000.	4056.	926525.	.001115
.18447	.00284	.01257	50042.	3573.	927421.	.001208
.18415	.00306	.01357	50682.	3703.	938137.	.001304

.18416	.00329	.01457	51322.	3982.	948514.	.001400
.18444	.00352	.01557	51962.	4412.	958676.	.001497
.18493	.00376	.01657	52602.	4986.	968611.	.001594
.18558	.00400	.01757	53242.	5696.	978324.	.001692
.18635	.00425	.01857	53882.	6535.	987854.	.001790
.18720	.00451	.01957	54522.	7491.	997173.	.001888
.18813	.00477	.02057	55162.	8564.	1006439.	.001987
.18911	.00503	.02157	55802.	9745.	1015644.	.002086
.19011	.00530	.02257	56442.	11018.	1024736.	.002185
.19112	.00557	.02357	57082.	12377.	1033753.	.002285
.19214	.00584	.02457	57722.	13822.	1042833.	.002385
.19316	.00612	.02557	58362.	15334.	1051830.	.002485
.19415	.00640	.02657	59002.	16899.	1060698.	.002586
.19512	.00668	.02757	59642.	18526.	1069643.	.002686
.19608	.00697	.02857	60282.	20202.	1078588.	.002787
.19700	.00725	.02957	60922.	21924.	1087578.	.002888
.19791	.00754	.03057	61562.	23689.	1096649.	.002989
.19877	.00783	.03157	62202.	25481.	1105679.	.003090
.19960	.00812	.03257	62842.	27295.	1114679.	.003191
.20041	.00841	.03357	63482.	29142.	1123810.	.003292
.20118	.00871	.03457	64122.	31004.	1132924.	.003394
.20191	.00900	.03557	64762.	32877.	1142014.	.003495
.20262	.00929	.03657	65402.	34773.	1151236.	.003597
.20329	.00959	.03757	66042.	36672.	1160420.	.003698
.20394	.00988	.03857	66682.	38588.	1169721.	.003800
.20455	.01017	.03957	67322.	40499.	1178957.	.003901
.20513	.01047	.04057	67962.	42421.	1188282.	.004003
.20569	.01076	.04157	68602.	44349.	1197685.	.004104
.20623	.01106	.04257	69242.	46282.	1207151.	.004206
.20674	.01135	.04357	69882.	48217.	1216665.	.004307
.20783	.01169	.04457	70522.	50000.	1225833.	.004412
.21707	.01263	.04557	71162.	50000.	1230975.	.004565
.22731	.01370	.04657	71802.	50000.	1235211.	.004727
.23879	.01492	.04757	72442.	50000.	1238379.	.004901
.25180	.01634	.04857	73082.	50000.	1240214.	.005091
.26679	.01804	.04957	73722.	50000.	1240320.	.005302
.28450	.02011	.05057	74362.	50000.	1238078.	.005543
.30632	.02277	.05157	75002.	50000.	1232345.	.005830
.33544	.02653	.05257	75642.	50000.	1220474.	.006204

MOM	CUR	ROT	DEFB	DEFM	LOAD(P)	LOAD(2P)
AT CRACKING						
291125.	.00003	.00111	.03335	.03835	8087.	16174.
AT YIELDING						
898250.	.00028	.00884	.27409	.31952	24951.	49903.
907125.	.00037	.01059	.33690	.39744	25198.	50396.
912913.	.00047	.01233	.39917	.47472	25359.	50717.
916970.	.00056	.01406	.46108	.55160	25471.	50943.
920014.	.00065	.01578	.52282	.62828	25556.	51112.
922306.	.00074	.01749	.58441	.70483	25620.	51239.
923985.	.00084	.01920	.64584	.78125	25666.	51332.
925112.	.00093	.02091	.70706	.85749	25698.	51395.
925968.	.00102	.02261	.76829	.93378	25721.	51443.
926525.	.00111	.02431	.82943	1.01003	25737.	51474.
927421.	.00121	.02603	.89136	1.08714	25762.	51523.
938137.	.00130	.02822	.96938	1.18066	26059.	52119.
948514.	.00140	.03043	1.04805	1.27491	26348.	52695.
958676.	.00150	.03267	1.12751	1.37002	26630.	53260.
968611.	.00159	.03493	1.20768	1.46592	26906.	53812.
978324.	.00169	.03721	1.28848	1.56253	27176.	54351.
987854.	.00179	.03951	1.36995	1.65987	27440.	54881.
997173.	.00189	.04183	1.45195	1.75781	27699.	55398.
1006439.	.00199	.04418	1.53477	1.85663	27957.	55913.
1015644.	.00209	.04655	1.61835	1.95626	28212.	56425.
1024736.	.00219	.04895	1.70251	2.05653	28465.	56930.
1033753.	.00229	.05136	1.78730	2.15747	28715.	57431.
1042833.	.00239	.05380	1.87301	2.25938	28968.	57935.
1051830.	.00249	.05626	1.95924	2.36184	29217.	58435.
1060698.	.00259	.05874	2.04583	2.46469	29464.	58928.
1069643.	.00269	.06124	2.13329	2.56845	29712.	59425.
1078588.	.00279	.06376	2.22137	2.67285	29961.	59922.
1087578.	.00289	.06631	2.31018	2.77801	30211.	60421.
1096649.	.00299	.06888	2.39979	2.88398	30462.	60925.
1105679.	.00309	.07147	2.48982	2.99040	30713.	61427.
1114679.	.00319	.07408	2.58029	3.09726	30963.	61927.
1123810.	.00329	.07672	2.67164	3.20502	31217.	62434.
1132924.	.00339	.07937	2.76341	3.31321	31470.	62940.
1142014.	.00350	.08204	2.85555	3.42178	31723.	63445.
1151236.	.00360	.08473	2.94854	3.53120	31979.	63958.
1160420.	.00370	.08744	3.04182	3.64092	32234.	64468.
1169721.	.00380	.09017	3.13587	3.75141	32492.	64985.
1178957.	.00390	.09292	3.23007	3.86207	32749.	65498.
1188282.	.00400	.09568	3.32493	3.97338	33008.	66016.
1197685.	.00410	.09847	3.42040	4.08530	33269.	66538.
1207151.	.00421	.10128	3.51641	4.19776	33532.	67064.
1216665.	.00431	.10411	3.61288	4.31070	33796.	67592.
1225833.	.00441	.10697	3.71073	4.42554	34051.	68102.
1230975.	.00456	.11027	3.82654	4.56601	34194.	68388.
1235211.	.00473	.11366	3.94618	4.71191	34311.	68623.
1238379.	.00490	.11717	4.07055	4.86450	34399.	68799.
1240214.	.00509	.12082	4.20064	5.02538	34450.	68901.
1240320.	.00530	.12463	4.33782	5.19675	34453.	68907.
1238078.	.00554	.12866	4.48444	5.38239	34391.	68782.
1232345.	.00583	.13302	4.64461	5.58912	34232.	68464.
1220474.	.00620	.13791	4.82739	5.83242	33902.	67804.

COMPUTER ANALYSIS - BEAM NO.7

***** BASIC DATA *****

BEAM NO. 7, TWO POINT LOADING.

B	OD	D	DC	FCU
7.000	15.000	12.750	2.250	5000.000

AS	ASC	E	FY	FY1
1.580	.790	29000000.000	50000.000	50000.000

N	ESH	ESS	FT	Z
6.080	.0125	640000.000	765.000	36.000

Z1	BB	EPU	EC1
36.000	1.985	.080	.002

ANALYSIS AT INITIAL CRACKING OF CONCRETE

MC= 225693.000 SIC= .264E-04

K	ES	CC0	CS0
.60235E+00	.13401E-03	21574.660	3288.116

TS0	MC	SIC	CT
6140.196	225693.000	.26431E-04	19599.250

ANALYSIS AFTER CRACKING

K	ES	CC	CS1
.35181E+00	.44099E-03	17922.750	2283.392

TS	MX	SI
20206.140	225693.000	.53360E-04

ANALYSIS BETWEEN CRACKING AND ULTIMATE

STEEL STRAIN AT YIELD =EY= .001724

ULTIMATE CONCRETE STRAIN = EPU = .080000

K	EC	ES	FS	FSC	MOMENT	CUR
.35106	.00078	.00144	41789.	11242.	734120.	.000174
.31288	.00111	.00244	50000.	14054.	886978.	.000279
.27724	.00132	.00344	50000.	13913.	896380.	.000373
.25472	.00152	.00444	50000.	13522.	902343.	.000467
.23925	.00171	.00544	50000.	13022.	906256.	.000561
.22812	.00190	.00644	50000.	12498.	909014.	.000654
.21985	.00210	.00744	50000.	12000.	910957.	.000748
.21359	.00229	.00844	50000.	11555.	912239.	.000842
.20878	.00249	.00944	50000.	11181.	912958.	.000936
.20507	.00269	.01044	50000.	10894.	913297.	.001030
.20220	.00290	.01144	50000.	10702.	913331.	.001125
.19997	.00311	.01244	50000.	10597.	912945.	.001220
.19946	.00335	.01344	50602.	11192.	922434.	.001317

.19937	.00360	.01444	51242.	11979.	932140.	.001415
.19957	.00385	.01544	51882.	12921.	941582.	.001513
.19999	.00411	.01644	52522.	14019.	950956.	.001612
.20057	.00438	.01744	53162.	15246.	960030.	.001711
.20126	.00465	.01844	53802.	16600.	969006.	.001811
.20204	.00492	.01944	54442.	18069.	977906.	.001911
.20287	.00520	.02044	55082.	19636.	986685.	.002011
.20374	.00549	.02144	55722.	21295.	995463.	.002112
.20462	.00577	.02244	56362.	23032.	1004204.	.002213
.20550	.00606	.02344	57002.	24837.	1012943.	.002314
.20637	.00636	.02444	57642.	26699.	1021681.	.002415
.20722	.00665	.02544	58282.	28617.	1030513.	.002517
.20804	.00695	.02644	58922.	30564.	1039264.	.002619
.20883	.00724	.02744	59562.	32550.	1048105.	.002720
.20960	.00754	.02844	60202.	34572.	1057078.	.002822
.21032	.00784	.02944	60842.	36599.	1065944.	.002924
.21102	.00814	.03044	61482.	38654.	1074979.	.003026
.21168	.00844	.03144	62122.	40719.	1084055.	.003128
.21229	.00874	.03244	62762.	42776.	1093026.	.003230
.21288	.00904	.03344	63402.	44865.	1102311.	.003332
.21343	.00935	.03444	64042.	46936.	1111469.	.003434
.21396	.00965	.03544	64682.	49018.	1120777.	.003536
.22057	.01031	.03644	65322.	50000.	1127136.	.003667
.23452	.01147	.03744	65962.	50000.	1129669.	.003836
.25148	.01292	.03844	66602.	50000.	1129933.	.004028
.27315	.01482	.03944	67242.	50000.	1126690.	.004256

MOM	CUR	ROT	DEFB	DEFM	LOAD(P)	LOAD(2P)
AT CRACKING						
225693.	.00003	.00095	.02855	.03283	6269.	12538.
AT YIELDING						
886978.	.00028	.00901	.27830	.32344	24638.	49277.
896380.	.00037	.01080	.34208	.40257	24899.	49799.
902343.	.00047	.01257	.40523	.48094	25065.	50130.
906256.	.00056	.01431	.46787	.55875	25174.	50348.
909014.	.00065	.01605	.53023	.63625	25250.	50501.
910957.	.00075	.01778	.59236	.71355	25304.	50609.
912239.	.00084	.01950	.65428	.79066	25340.	50680.
912958.	.00094	.02122	.71593	.86754	25360.	50720.
913297.	.00103	.02292	.77742	.94431	25369.	50739.
913331.	.00112	.02463	.83877	1.02099	25370.	50741.
912945.	.00122	.02632	.89972	1.09730	25360.	50719.
922434.	.00132	.02849	.97728	1.19061	25623.	51246.
932140.	.00141	.03072	1.05643	1.28561	25893.	51786.
941582.	.00151	.03296	1.13629	1.38140	26155.	52310.
950956.	.00161	.03524	1.21715	1.47827	26415.	52831.
960030.	.00171	.03753	1.29848	1.57568	26668.	53335.
969006.	.00181	.03985	1.38062	1.67397	26917.	53834.
977906.	.00191	.04220	1.46356	1.77312	27164.	54328.
986685.	.00201	.04456	1.54712	1.87295	27408.	54816.
995463.	.00211	.04696	1.63155	1.97368	27652.	55303.
1004204.	.00221	.04937	1.71669	2.07517	27895.	55789.
1012943.	.00231	.05181	1.80258	2.17746	28137.	56275.
1021681.	.00242	.05428	1.88920	2.28049	28380.	56760.
1030513.	.00252	.05678	1.97674	2.38448	28625.	57251.
1039264.	.00262	.05929	2.06470	2.48891	28868.	57737.
1048105.	.00272	.06183	2.15352	2.59421	29114.	58228.
1057078.	.00282	.06440	2.24329	2.70048	29363.	58727.
1065944.	.00292	.06698	2.33329	2.80700	29610.	59219.
1074979.	.00303	.06960	2.42431	2.91454	29861.	59721.
1084055.	.00313	.07223	2.51594	3.02269	30113.	60225.
1093026.	.00323	.07488	2.60772	3.13099	30362.	60724.
1102311.	.00333	.07757	2.70091	3.24073	30620.	61240.
1111469.	.00343	.08026	2.79412	3.35047	30874.	61748.
1120777.	.00354	.08299	2.88822	3.46110	31133.	62265.
1127136.	.00367	.08596	2.99242	3.58647	31309.	62619.
1129669.	.00384	.08927	3.11022	3.73168	31380.	62759.
1129933.	.00403	.09275	3.23536	3.88789	31387.	62774.
1126690.	.00426	.09648	3.37122	4.06068	31297.	62594.

COMPUTER ANALYSIS - BEAM NO.8

***** BASIC DATA *****

BEAM NO. 8, TWO POINT LOADING.

B	OD	D	DC	FCU
7.000	15.000	12.750	2.250	5600.000

AS	ASC	E	FY	FY1
1.580	.790	29000000.000	70500.000	70500.000

N	ESH	ESS	FT	Z
5.586	.0045	572080.000	850.000	36.000

Z1	BB	EPU	EC1
36.000	1.816	.080	.002

ANALYSIS AT INITIAL CRACKING OF CONCRETE

MC= 244782.400 SIC= .264E-04

K	ES	CC0	CS0
.60111E+00	.13442E-03	23821.290	3278.292

TS0	MC	SIC	CT
6158.998	244782.400	.26430E-04	21824.140

ANALYSIS AFTER CRACKING

K	ES	CC	CS1
.34173E+00	.47633E-03	19576.310	2249.124

TS	MX	SI
21825.430	244782.400	.56753E-04

ANALYSIS BETWEEN CRACKING AND ULTIMATE

STEEL STRAIN AT YIELD =EY= .002431

ULTIMATE CONCRETE STRAIN = EPU = .080000

K	EC	ES	FS	FSC	MOMENT	CUR
.32833	.00072	.00148	42814.	9680.	758615.	.000172
.34301	.00129	.00248	70500.	18204.	1233922.	.000296
.30711	.00154	.00348	70500.	19008.	1246288.	.000394
.28423	.00178	.00448	70500.	19544.	1253503.	.000491
.26962	.00202	.00548	71059.	20255.	1267060.	.000588
.25933	.00227	.00648	71631.	21012.	1279111.	.000686
.25187	.00252	.00748	72203.	21853.	1289938.	.000784
.24638	.00277	.00848	72775.	22803.	1299844.	.000882
.24232	.00303	.00948	73347.	23882.	1309163.	.000981
.23929	.00330	.01048	73919.	25088.	1317900.	.001080
.23704	.00357	.01148	74491.	26422.	1326217.	.001180
.23539	.00384	.01248	75063.	27883.	1334266.	.001280
.23421	.00412	.01348	75635.	29467.	1342186.	.001380

.23336	.00441	.01448	76207.	31150.	1349808.	.001481
.23277	.00470	.01548	76779.	32934.	1357364.	.001582
.23238	.00499	.01648	77351.	34801.	1364811.	.001683
.23213	.00528	.01748	77924.	36740.	1372187.	.001785
.23201	.00558	.01848	78496.	38751.	1379646.	.001887
.23196	.00588	.01948	79068.	40810.	1387039.	.001989
.23198	.00618	.02048	79640.	42915.	1394483.	.002091
.23204	.00649	.02148	80212.	45064.	1402051.	.002193
.23211	.00679	.02248	80784.	47229.	1409529.	.002296
.23221	.00710	.02348	81356.	49424.	1417150.	.002398
.23231	.00741	.02448	81928.	51626.	1424753.	.002501
.23242	.00771	.02548	82500.	53848.	1432531.	.002603
.23251	.00802	.02648	83072.	56067.	1440276.	.002706
.23261	.00833	.02748	83644.	58293.	1448153.	.002808
.23270	.00864	.02848	84216.	60513.	1456054.	.002911
.23277	.00894	.02948	84788.	62726.	1463991.	.003013
.23283	.00925	.03048	85361.	64930.	1471975.	.003116
.23289	.00956	.03148	85933.	67138.	1480156.	.003218
.23293	.00986	.03248	86505.	69319.	1488241.	.003321
.23705	.01040	.03348	87077.	70500.	1494117.	.003441
.24672	.01129	.03448	87649.	70500.	1496481.	.003590
.25760	.01231	.03548	88221.	70500.	1497744.	.003748
.26995	.01349	.03648	88793.	70500.	1497631.	.003919
.28420	.01488	.03748	89365.	70500.	1495757.	.004106
.30098	.01657	.03848	89937.	70500.	1491507.	.004317
.32150	.01871	.03948	90509.	70500.	1483803.	.004563
.34839	.02164	.04048	91081.	70500.	1470275.	.004872
.39113	.02664	.04148	91653.	70500.	1442484.	.005343

MOM	CUR	ROT	DEFB	DEFM	LOAD(P)	LOAD(2P)
AT CRACKING						
244782.	.00003	.00095	.02854	.03283	6800.	13599.
AT YIELDING						
1233922.	.00030	.01047	.31404	.36193	34276.	68551.
1246288.	.00039	.01231	.37945	.44320	34619.	69238.
1253503.	.00049	.01412	.44417	.52363	34820.	69639.
1267060.	.00059	.01602	.51214	.60741	35196.	70392.
1279111.	.00069	.01795	.58075	.69185	35531.	71062.
1289938.	.00078	.01989	.64993	.77691	35832.	71663.
1299844.	.00088	.02184	.71971	.86262	36107.	72214.
1309163.	.00098	.02381	.79018	.94909	36366.	72731.
1317900.	.00108	.02581	.86125	1.03623	36608.	73217.
1326217.	.00118	.02781	.93294	1.12406	36839.	73679.
1334266.	.00128	.02984	1.00532	1.21264	37063.	74126.
1342186.	.00138	.03189	1.07847	1.30207	37283.	74566.
1349808.	.00148	.03396	1.15214	1.39206	37495.	74989.
1357364.	.00158	.03604	1.22653	1.48283	37705.	75409.
1364811.	.00168	.03815	1.30154	1.57426	37911.	75823.
1372187.	.00179	.04027	1.37717	1.66635	38116.	76233.
1379646.	.00189	.04242	1.45362	1.75930	38323.	76647.
1387039.	.00199	.04458	1.53061	1.85281	38529.	77058.
1394483.	.00209	.04676	1.60831	1.94706	38736.	77471.
1402051.	.00219	.04897	1.68681	2.04214	38946.	77892.
1409529.	.00230	.05119	1.76571	2.13762	39154.	78307.
1417150.	.00240	.05344	1.84543	2.23393	39365.	78731.
1424753.	.00250	.05570	1.92562	2.33072	39576.	79153.
1432531.	.00260	.05798	2.00667	2.42838	39793.	79585.
1440276.	.00271	.06028	2.08812	2.52644	40008.	80015.
1448153.	.00281	.06261	2.17033	2.62526	40226.	80453.
1456054.	.00291	.06494	2.25302	2.72457	40446.	80892.
1463991.	.00301	.06730	2.33624	2.82439	40666.	81333.
1471975.	.00312	.06967	2.41997	2.92472	40888.	81776.
1480156.	.00322	.07207	2.50459	3.02594	41115.	82231.
1488241.	.00332	.07448	2.58936	3.12730	41340.	82680.
1494117.	.00344	.07707	2.68138	3.23888	41503.	83007.
1496481.	.00359	.07992	2.78323	3.36476	41569.	83138.
1497744.	.00375	.08286	2.88901	3.49617	41604.	83208.
1497631.	.00392	.08593	2.99941	3.63425	41601.	83202.
1495757.	.00411	.08914	3.11559	3.78081	41549.	83098.
1491507.	.00432	.09255	3.23921	3.93858	41431.	82861.
1483803.	.00456	.09623	3.37336	4.11261	41217.	82433.
1470275.	.00487	.10035	3.52458	4.31384	40841.	81682.
1442484.	.00534	.10553	3.71519	4.58072	40069.	80138.

COMPUTER ANALYSIS - BEAM NO.9

***** BASIC DATA *****

BEAM NO. 9, TWO POINT LOADING.

B	OD	D	DC	FCU
8.000	12.000	10.000	.000	10000.000

AS	ASC	E	FY	FY1
1.580	.000	29000000.000	70500.000	.000

N	ESH	ESS	FT	Z
4.380	.0045	572080.000	1000.000	36.000

Z1	BB	EPU	EC1
36.000	1.816	.080	.002

ANALYSIS AT INITIAL CRACKING OF CONCRETE

MC= 189087.800 SIC= .308E-04

K	ES	CC0	CS0
.62108E+00	.11655E-03	26652.290	.000

TS0	MC	SIC	CT
5340.400	189087.800	.30759E-04	23156.840

ANALYSIS AFTER CRACKING

K	ES	CC	CS1
.33834E+00	.46513E-03	21312.390	.000

TS	MX	SI
21312.390	189087.800	.70298E-04

ANALYSIS BETWEEN CRACKING AND ULTIMATE

STEEL STRAIN AT YIELD =EY= .002431

ULTIMATE CONCRETE STRAIN = EPU = .080000

K	EC	ES	FS	FSC	MOMENT	CUR
.28079	.00057	.00147	42489.	0.	606997.	.000204
.29114	.00101	.00247	70500.	0.	999241.	.000348
.25781	.00120	.00347	70500.	0.	1010587.	.000467
.23622	.00138	.00447	70500.	0.	1017662.	.000585
.22203	.00156	.00547	71052.	0.	1029930.	.000702
.21177	.00174	.00647	71624.	0.	1041081.	.000820
.20414	.00191	.00747	72196.	0.	1051240.	.000938
.19839	.00210	.00847	72768.	0.	1060664.	.001056
.19406	.00228	.00947	73340.	0.	1069536.	.001174
.19085	.00247	.01047	73913.	0.	1078065.	.001293
.18852	.00266	.01147	74485.	0.	1086093.	.001413
.18693	.00287	.01247	75057.	0.	1093780.	.001533
.18599	.00308	.01347	75629.	0.	1101230.	.001654

.18560	.00330	.01447	76201.	0.	1108346.	.001776
.18571	.00353	.01547	76773.	0.	1115208.	.001899
.18626	.00377	.01647	77345.	0.	1121719.	.002023
.18724	.00402	.01747	77917.	0.	1128004.	.002149
.18862	.00429	.01847	78489.	0.	1134043.	.002276
.19037	.00458	.01947	79061.	0.	1139783.	.002404
.19250	.00488	.02047	79633.	0.	1145201.	.002534
.19499	.00520	.02147	80205.	0.	1150307.	.002666
.19786	.00554	.02247	80777.	0.	1155127.	.002801
.20110	.00591	.02347	81350.	0.	1159611.	.002937
.20473	.00630	.02447	81922.	0.	1163694.	.003076
.20876	.00672	.02547	82494.	0.	1167379.	.003218
.21323	.00717	.02647	83066.	0.	1170678.	.003364
.21813	.00766	.02747	83638.	0.	1173460.	.003513
.22354	.00820	.02847	84210.	0.	1175754.	.003666
.22947	.00878	.02947	84782.	0.	1177444.	.003824
.23600	.00941	.03047	85354.	0.	1178501.	.003988
.24319	.01011	.03147	85926.	0.	1178812.	.004158
.25114	.01089	.03247	86498.	0.	1178278.	.004335
.25997	.01176	.03347	87070.	0.	1176757.	.004522
.26982	.01274	.03447	87642.	0.	1174040.	.004720
.28093	.01386	.03547	88215.	0.	1169878.	.004932
.29363	.01516	.03647	88787.	0.	1163903.	.005162
.30842	.01671	.03747	89359.	0.	1155509.	.005417
.32619	.01862	.03847	89931.	0.	1143706.	.005709
.34874	.02113	.03947	90503.	0.	1126450.	.006060
.38123	.02493	.04047	91075.	0.	1097921.	.006540

MOM	CUR	ROT	DEFB	DEFM	LOAD(P)	LOAD(2P)
AT CRACKING						
189088.	.00003	.00111	.03322	.03820	5252.	10505.
AT YIELDING						
999241.	.00035	.01238	.37057	.42691	27757.	55513.
1010587.	.00047	.01462	.45041	.52604	28072.	56144.
1017662.	.00058	.01683	.52937	.62408	28268.	56537.
1029930.	.00070	.01915	.61206	.72586	28609.	57218.
1041081.	.00082	.02150	.69552	.82839	28919.	57838.
1051240.	.00094	.02386	.77965	.93161	29201.	58402.
1060664.	.00106	.02624	.86452	1.03559	29463.	58926.
1069536.	.00117	.02864	.95020	1.14046	29709.	59419.
1078065.	.00129	.03108	1.03689	1.24641	29946.	59893.
1086093.	.00141	.03353	1.12432	1.35320	30169.	60338.
1093780.	.00153	.03601	1.21268	1.46104	30383.	60766.
1101230.	.00165	.03852	1.30210	1.57008	30590.	61179.
1108346.	.00178	.04106	1.39244	1.68018	30787.	61575.
1115208.	.00190	.04362	1.48382	1.79149	30978.	61956.
1121719.	.00202	.04621	1.57606	1.90385	31159.	62318.
1128004.	.00215	.04884	1.66944	2.01756	31333.	62667.
1134043.	.00228	.05149	1.76396	2.13263	31501.	63002.
1139783.	.00240	.05417	1.85953	2.24901	31661.	63321.
1145201.	.00253	.05688	1.95613	2.36670	31811.	63622.
1150307.	.00267	.05963	2.05385	2.48581	31953.	63906.
1155127.	.00280	.06241	2.15285	2.60656	32087.	64174.
1159611.	.00294	.06522	2.25308	2.72891	32211.	64423.
1163694.	.00308	.06806	2.35444	2.85280	32325.	64650.
1167379.	.00322	.07093	2.45706	2.97844	32427.	64854.
1170678.	.00336	.07385	2.56118	3.10611	32519.	65038.
1173460.	.00351	.07679	2.66648	3.23555	32596.	65192.
1175754.	.00367	.07977	2.77334	3.36723	32660.	65320.
1177444.	.00382	.08279	2.88155	3.50104	32707.	65414.
1178501.	.00399	.08585	2.99136	3.63735	32736.	65472.
1178812.	.00416	.08894	3.10271	3.77624	32745.	65490.
1178278.	.00434	.09208	3.21571	3.91802	32730.	65460.
1176757.	.00452	.09525	3.33040	4.06299	32688.	65375.
1174040.	.00472	.09847	3.44666	4.21131	32612.	65224.
1169878.	.00493	.10171	3.56450	4.36349	32497.	64993.
1163903.	.00516	.10499	3.68386	4.52016	32331.	64661.
1155509.	.00542	.10828	3.80402	4.68162	32097.	64195.
1143706.	.00571	.11157	3.92409	4.84888	31770.	63539.
1126450.	.00606	.11478	4.04088	5.02257	31290.	62581.
1097921.	.00654	.11767	4.14292	5.20234	30498.	60996.

COMPUTER ANALYSIS - BEAM NO.10

***** BASIC DATA *****

BEAM NO.10, TWO POINT LOADING.

B	OD	D	DC	FCU
8.000	12.000	10.125	1.875	5930.000
AS	ASC	E	FY	FY1
.880	.220	29000000.000	49880.000	68800.000
N	ESH	ESS	FT	Z
4.159	.0125	640000.000	578.000	66.000
Z1	BB	EPU	EC1	
12.000	2.937	.003	.002	

ANALYSIS AT INITIAL CRACKING OF CONCRETE

MC= 103831.800 SIC= .156E-04

K	ES	CC0	CS0
.60113E+00	.62962E-04	14483.360	418.898
TS0	MC	SIC	CT
1606.794	103831.800	.15590E-04	13672.110

ANALYSIS AFTER CRACKING

K	ES	CC	CS1
.25678E+00	.44033E-03	11031.740	205.550
TS	MX	SI	
11237.290	103831.800	.58515E-04	

ANALYSIS BETWEEN CRACKING AND ULTIMATE

STEEL STRAIN AT YIELD =EY= .001720

ULTIMATE CONCRETE STRAIN = EPU = .003000

K	EC	ES	FS	FSC	MOMENT	CUR
.30609	.00064	.00144	41770.	7277.	332713.	.000205
.26636	.00089	.00244	49880.	7831.	402941.	.000329
.23185	.00104	.00344	49880.	6062.	408129.	.000442
.20947	.00118	.00444	49880.	3956.	411752.	.000555
.19363	.00131	.00544	49880.	1653.	414518.	.000666
.18182	.00143	.00644	49880.	-769.	416752.	.000777
.17270	.00155	.00744	49880.	-3257.	418641.	.000888
.16548	.00167	.00844	49880.	-5778.	420187.	.000999
.15972	.00179	.00944	49880.	-8296.	421617.	.001110
.15506	.00192	.01044	49880.	-10795.	422795.	.001220
.15130	.00204	.01144	49880.	-13246.	423874.	.001331
.14826	.00217	.01244	49880.	-15640.	424726.	.001443
.14675	.00231	.01344	50482.	-17559.	430227.	.001556

.14584	.00247	.01444	51122.	-19288.	435818.	.001670
.14545	.00263	.01544	51762.	-20819.	441211.	.001785
.14554	.00280	.01644	52402.	-22122.	446363.	.001900
.14609	.00298	.01744	53042.	-23157.	451296.	.002017
.14709	.00318	.01844	53682.	-23886.	455989.	.002135

MOM	CUR	ROT	DEFB	DEFM	LOAD(P)	LOAD(2P)
AT CRACKING						
103832.	.00002	.00103	.05659	.05687	1573.	3146.
AT YIELDING						
402941.	.00033	.01063	.51793	.52384	6105.	12210.
408129.	.00044	.01152	.57441	.58237	6184.	12368.
411752.	.00055	.01241	.63095	.64094	6239.	12477.
414518.	.00067	.01329	.68736	.69935	6281.	12561.
416752.	.00078	.01416	.74363	.75763	6314.	12629.
418641.	.00089	.01503	.79992	.81591	6343.	12686.
420187.	.00100	.01589	.85555	.87353	6366.	12733.
421617.	.00111	.01675	.91182	.93179	6388.	12776.
422795.	.00122	.01760	.96717	.98914	6406.	12812.
423874.	.00133	.01846	1.02279	1.04675	6422.	12845.
424726.	.00144	.01929	1.07694	1.10291	6435.	12870.
430227.	.00156	.02110	1.19188	1.21989	6519.	13037.
435818.	.00167	.02299	1.31189	1.34194	6603.	13207.
441211.	.00178	.02492	1.43294	1.46506	6685.	13370.
446363.	.00190	.02685	1.55421	1.58842	6763.	13526.
451296.	.00202	.02880	1.67583	1.71214	6838.	13676.
455989.	.00214	.03074	1.79726	1.83570	6909.	13818.

COMPUTER ANALYSIS - BEAM NO.11

***** BASIC DATA *****

BEAM NO.11, TWO POINT LOADING.

B	OD	D	DC	FCU
8.000	12.000	10.125	1.875	5970.000

AS	ASC	E	FY	FY1
.880	.220	29000000.000	49880.000	68800.000

N	ESH	ESS	FT	Z
3.450	.0125	640000.000	579.000	66.000

Z1	BB	EPU	EC1
12.000	1.448	.003	.002

ANALYSIS AT INITIAL CRACKING OF CONCRETE

MC= 101719.900 SIC= .121E-04

K	ES	CC0	CS0
.59927E+00	.48916E-04	14372.700	322.477

TS0	MC	SIC	CT
1248.324	101719.900	.12056E-04	13739.480

ANALYSIS AFTER CRACKING

K	ES	CC	CS1
.23760E+00	.42813E-03	10792.520	133.359

TS	MX	SI
10925.870	101719.900	.55462E-04

ANALYSIS BETWEEN CRACKING AND ULTIMATE

STEEL STRAIN AT YIELD =EY= .001720

ULTIMATE CONCRETE STRAIN = EPU = .003000

K	EC	ES	FS	FSC	MOMENT	CUR
.23658	.00044	.00143	41416.	2788.	338043.	.000185
.21174	.00065	.00243	49880.	2372.	410337.	.000304
.18725	.00079	.00343	49880.	253.	414217.	.000417
.17188	.00092	.00443	49880.	-2063.	416902.	.000528
.16131	.00104	.00543	49880.	-4481.	418930.	.000639
.15364	.00117	.00643	49880.	-6947.	420619.	.000750
.14787	.00129	.00743	49880.	-9433.	421997.	.000861
.14343	.00141	.00843	49880.	-11915.	423192.	.000972
.13996	.00153	.00943	49880.	-14378.	424268.	.001083
.13723	.00166	.01043	49880.	-16811.	425217.	.001194
.13505	.00178	.01143	49880.	-19209.	426018.	.001305
.13334	.00191	.01243	49880.	-21559.	426787.	.001416
.13288	.00206	.01343	50474.	-23490.	432149.	.001529

.13277	.00221	.01443	51114.	-25289.	437773.	.001643
.13290	.00236	.01543	51754.	-26977.	443330.	.001757
.13325	.00253	.01643	52394.	-28549.	448826.	.001872
.13375	.00269	.01743	53034.	-30012.	454165.	.001987
.13441	.00286	.01843	53674.	-31351.	459481.	.002103
.13519	.00304	.01943	54314.	-32573.	464691.	.002219

MOM	CUR	ROT	DEFB	DEFM	LOAD(P)	LOAD(2P)
AT CRACKING						
101720.	.00001	.00080	.04376	.04398	1541.	3082.
AT YIELDING						
410337.	.00030	.00969	.47365	.47913	6217.	12434.
414217.	.00042	.01051	.52620	.53370	6276.	12552.
416902.	.00053	.01133	.57894	.58844	6317.	12633.
418930.	.00064	.01215	.63164	.64315	6347.	12695.
420619.	.00075	.01296	.68465	.69815	6373.	12746.
421997.	.00086	.01377	.73745	.75295	6394.	12788.
423192.	.00097	.01459	.79036	.80785	6412.	12824.
424268.	.00108	.01540	.84357	.86306	6428.	12857.
425217.	.00119	.01621	.89674	.91823	6443.	12885.
426018.	.00130	.01702	.94941	.97289	6455.	12910.
426787.	.00142	.01783	1.00262	1.02812	6466.	12933.
432149.	.00153	.01960	1.11565	1.14318	6548.	13095.
437773.	.00164	.02150	1.23585	1.26543	6633.	13266.
443330.	.00176	.02344	1.35873	1.39036	6717.	13434.
448826.	.00187	.02544	1.48420	1.51790	6800.	13601.
454165.	.00199	.02746	1.61064	1.64640	6881.	13763.
459481.	.00210	.02953	1.73993	1.77778	6962.	13924.
464691.	.00222	.03164	1.87061	1.91055	7041.	14082.