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Combined shear-torsion behavior of one-way slabs

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COMBINED SHEAR/TORSION BEHAVIOR

OF

ONE-WAY SLABS

BY

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1.0 INTRODUCTION

Single span, one-way reinforced concrete slabs have a broad application in bridges, elevated highways and industrial buildings. Large combined shear and torsional stresses can develop in such structures when they are subjected to concentrated loadings, especially if the loads are not symmetrically applied.

A broad effort has been devoted to the analysis and experimental observation of rectangular (Refs. 1 & 2), T (Ref. 3) and L (Refs. 4 & 5) cross-sectional reinforced concrete beams under combined flexure, shear, and torsion. However, no such study has been made for the analysis and experimental observation of one-way reinforced concrete slabs under combined flexure, shear and torsional loadings.

At the present time, ACI Code 318-83 (Ref. 6) has recommended formulas for the design of reinforced concrete beams under combined flexure, shear and torsion. These recommendations are based on the above mentioned research studies. Applicability of these formulas for non-symmetrically loaded one-way reinforced concrete slabs are, however, questionable.

During a study of channel beams (Ref. 7), it was found that post cracking torsional rigidities obtained from torque twist tests of thin rectangular concrete plate specimens, were larger than calculated values. The ratio of experimental to calculated values were of the order of 1.71 to 1.92. Post cracking torsional rigidity is a function of the cross-sectional dimensions, moduli of elasticity of steel and concrete and the reinforcement ratio of longitudinal steel and hoop steel.

An experimental study of the orthogonally reinforced concrete slab elements subjected to pure torsional moments was conducted by Marti, P. and et al. (Ref. 8). They achieved this purpose by applying two concentrated loads at the ends of one diagonal axis and supporting at the ends of the other diagonal axis of the plates. In this study, it was observed that peak torsional moments were 8 to 117% greater than the ACI Code 318-83 allowable torsional moment. The observed increased torsional moment capacity of plate elements were as follows:

Plates without stirrups:

8% for $\rho_x = \rho_y = 0.0025$

24% for $\rho_x = 2\rho_y = 0.005$

65% for $\rho_x = \rho_y = 0.005$

61% for $\rho_x = 4\rho_y = 0.01$

87% for $\rho_x = 2\rho_y = 0.01$

117% for $\rho_x = \rho_y = 0.01$

Plates with stirrups:

16% for $\rho_x = \rho_y = 0.0025$

83% for $\rho_x = 4\rho_y = 0.01$

116% for $\rho_x = \rho_y = 0.01$

This study shows that increasing reinforcement ratio in both directions of orthogonally reinforced concrete slabs, top and bottom, increases torsional moment capacity of concrete plates under pure torsion. Use of stirrups increases torsional capacity of reinforced concrete for light and medium reinforcement ratios, but not for heavily reinforced concrete slabs. No experimental study of combined shear and torsion in reinforced concrete slabs with or without stirrups has been found in the open literatures.

The objective of this thesis is to develop methods suitable for predicting the strength of one-way reinforced concrete slabs subject to non-symmetrical loadings. The problem was first encountered when attempting to estimate the load carrying capacity of actual slabs subjected to heavy wheel loads. Predictions of capacity using the ACI combined shear and torsion interaction indicated the possibility of overload of these plates while no apparent distress was observed in the field. A preliminary study, phase "I" experimental study, was performed to further investigate this discrepancy. The test program is described in Appendix B.

During the Phase "I" experimental study, it was found that non-symmetrical loaded reinforced concrete slabs without stirrups have significantly higher combined shear and torsional capacity than that computed from the current ACI Code 318-83. The following conditions were found to be necessary to make the results of the Phase "I" study correlate with the ACI shear and torsion interaction formula:

(a) Shear and torsional stresses must be properly determined, employing an analytical plate solution rather than using an equivalent beam analysis.

(b) Due to non-homogeneity of reinforced concrete, it is also required to employ appropriate flexural rigidities in both the longitudinal and transverse plate directions. Therefore, effective moment of inertia based on the cracked section will be used instead of moment of inertia of gross concrete section (see 2.5).

(c) In order to evaluate torsional strength of concrete plates in combined shear and torsional strength, the actual shear strength value should be included in the computation. Therefore, experimental values of shear strengths, based on the beam tests with identical concrete strength, longitudinal reinforcement, load span and load condition should be included in the study, rather than calculated values based on the ACI Code 318-83 allowable shear strength for beams.

2.0 RESEARCH PLAN

2.1 OBJECTIVE

It is the main purpose of this thesis to develop an interaction formula that can be considered in the design of one-way reinforced concrete slabs that are subjected to combined shear and torsion. As mentioned earlier, the current ACI Code contains provisions for the design of reinforced concrete beams subjected to combined shear and torsion. There are no provisions or recommendations for the design of one-way reinforced concrete slabs in current codes.

An extensive set of experimental data are developed and these data are used to develop parameters of an interaction formula that is modeled after the ACI 318-83 combined shear and torsion provisions for concrete beams. The general form of this interaction formula is taken as:

$$\left(\frac{V_{cp}}{V_{cpo}}\right)^{\alpha} + \left(\frac{T_{cp}}{T_{cpo}}\right)^{\beta} = 1 \qquad (2.1\text{-}1)$$

where:

Vcp = shear strength provided by concrete of concrete plates under torsion and shear

Vcpo = shear strength provided by concrete of concrete plates with zero torsion

Tcp = torsional moment strength provided by concrete of concrete plates under torsion and shear

Tcpo = torsional moment strength provided by concrete plates in pure torsion

α & β = parameters to be determined by experimental data

Esq. (2.1-1) is the general form of the shear and torsion interaction formula of Eq. (2.2-3) that was suggested by Kemp (Ref. 1) and accepted by current ACI Code for beams under combined shear and torsion. The values of "α" and "β" are equal "2" for beam design according to the ACI 318-83.

In search for appropriate values for Vcp, Vcpo, Tcp and Tcpo in Eq. (2.1-1) that will be applicable for reinforced concrete slabs without stirrups under combined shear and torsion the following approaches were taken into account:

For Vcp and Tcp, the following values were taken into consideration:

(a) The flexural shear and torsional moment developed under non-symmetrical load condition were calculated based on the simple beam analysis at failure.

$$V_{cp} = V_{cbf}, \quad T_{cp} = T_{cbf}$$

(b) The flexural shear and torsional moment developed under non-symmetrical load conditions were the maximum values based on the plate solution at failure.

$$V_{cp} = V_{cpfm}, \quad T_{cp} = T_{cpfm}$$

For Vcpo and Tcpo, the following values were taken into consideration:

(a) The current ACI Code values based on the Kemp suggestions see section 2.2-1:

$$V_{cpo} = V_o, \quad T_{cpo} = T_o$$

(b) The values suggested by HSU see section 2.2-2:

$$V_{cpo} = V_{cro}, \quad T_{cop} = T_{cro}$$

(c) The value suggested herein based on the test results of the experimental study (see Appendix C):

$$V_{cpo} = V_{fo}, \quad T_{cpo} = T_{fo}$$

yielding:

$$(V_{op}/V_{fo})^2 + (T_{op}/T_{fo})^2 = 1 \qquad (2.1\text{-}A)$$

$$(V_{op}/V_{fo})^2 + (T_{op}/T_{oro})^2 = 1 \qquad (2.1\text{-}B)$$

For definition of Vo, To, Vcro and Tcro see section 2.2, for Vfo and Tfo see Tables C-5 and C-6.

Shear and torsional strength values suggested by Kemp and recommended by the ACI Code for beam design are based on the cracked concrete capacity while HSU suggest the same values for cracked sections with stirrups, but higher value only for torsional strength before and at cracking stage for concrete sections without stirrups.

Shear and torsional values suggested by Kemp (Ref. 1) and ACI Code (Ref. 6) are based on the assumption that the effective concrete area of the cracked section to resist shear and torsion is less than the uncracked section. For concrete section with stirrups that will resist extra shear and torsion after cracking stage, this assumption is reasonable. For concrete section without stirrups the total area is effective before cracking and at the cracking stage. The concrete specimen will fail at cracking stage. Therefore, values suggested by HSU (Ref. 9) are valid for reinforced concrete without stirrups.

2.2 BACKGROUND MATERIAL FOR INTERACTION FORMULA

2.2-1 ACI CODE 318-83

Shear and torsional strength of reinforced concrete without stirrups in combined shear and torsion according to the current ACI Code 318-83 can be determined from:

$$V_c = \frac{V_o}{\sqrt{1 + \left(\frac{C_t T_u}{0.4 V_u}\right)^2}} \qquad (2.2\text{-}1)$$

$$T_c = \frac{T_o}{\sqrt{1 + \left(\frac{0.4 V_u}{C_t T_u}\right)^2}} \qquad (2.2\text{-}2)$$

Combining Eqs. (2.2-1) and (2.2-2), one can obtain interaction formula for combined shear and torsion as follows:

$$\left(\frac{V_c}{V_o}\right)^2 + \left(\frac{T_c}{T_o}\right)^2 = 1 \qquad (2.2\text{-}3)$$

Where:

Vc = nominal shear strength provided by concrete under torsion and shear

Vo = shear strength of the concrete with zero torsion

$$= (1.9\sqrt{f'c} + 2500\rho\frac{Vud}{Mu})bd$$

Vu = factored shear force at section

Mu = " moment at section

Tu = " torsional moment at section

Tc = nominal torsional moment strength provider by concrete under torsion and shear

To = torsional strength of concrete in pure torsion

$$= 0.8\sqrt{f'c}\ x^2y$$

b = width of cross-section

d = distance from extreme compression fiber to centroid of longitudinal tension reinforcement

x = shorter dimension of cross-section

y = longer dimension of cross-section

f'c = compressive strength of concrete in psi

C_t = factor relating shear and torsional stress properties = bd/x^2y

Originally, the interaction formula of Eq. (2.2-3) was presented by Kemp (Ref. 1). Eqs. (2.2-1) and (2.2-2) are presented in the current ACI Code are derived from the interaction formula (2.2-3).

2.2-2 SUGGESTED BY HSU (Ref. 9)

The interaction of torsional and shear cracking for reinforced concrete beams without stirrups is introduced by HSU (Ref. 9) as follows:

$$\left(\frac{V_{cr}}{V_{cro}}\right)^2 + \left(\frac{T_{cr}}{T_{cro}}\right)^2 = 1 \qquad (2.2\text{-}4)$$

The cracking shear and torsional strength are as follows:

$$V_{cr} = \frac{V_{cro}}{\sqrt{1 + \left(\frac{C_t T_u}{V_u}\right)^2}} \qquad (2.2\text{-}5)$$

$$T_{cr} = \frac{T_{cro}}{\sqrt{1 + \left(\frac{V_u}{C_t T_u}\right)^2}} \qquad (2.2\text{-}6)$$

Where:

Vcr = diagonal cracking shear under torsion and shear

Vcro = diagonal cracking with zero torsion

$$= V_o = (1.9\sqrt{f'c} + 2500\rho\, V_u d/M_u)\, bd$$

Tcr = diagonal cracking torque under torsion and shear

Tcro = diagonal cracking torque under pure torsion

$$= 2.5T_o = 2\sqrt{f'c}\, x^2 y$$

And Vo, To, Vu, Tu, and Ct are as previously defined.

2.3 SIMPLIFIED ANALYSIS FOR NON-SYMMETRICALLY LOADED PLATES

Shear bending and torsion developed in a non-symmetrically loaded plate as shown in Fig. 1, can be expressed in terms of the applied load as follows:

$$V = P/2 \qquad (2.3\text{-}1)$$

$$M = Px1/2 \qquad (2.3\text{-}2)$$

$$T = (P/2) \times (b) \qquad (2.3\text{-}3)$$

Where:

P = applied load, V = shear, x1 = shear span

M = bending moment, T = torsional moment,

b = eccentricity of the applied load

v = width of the partially distributed load parallel to the supports

Therefore, it is anticipated that a concrete plate under non-symmetrical loading conditions, which has adequate flexural reinforcement to prevent bending failure, will fail under diagonal spiral shear and torsional cracks.

Therefore, shear and torsion at failure can be expressed in terms of failure load as follows:

$$V_{cbf} = P_f/2 \qquad (2.3\text{-}4)$$

$$T_{cbf} = (P_f/2) \times (b) \qquad (2.3\text{-}5)$$

2.4 PLATE SOLUTION FOR NON-SYMMETRICAL LOADED PLATES

Bendings, torsion and shears developed in a non-symmetrical loaded plate can be expressed in terms of deflection, w, flexural rigidity, D, and poisson's ratio, ν, as follows:

$$M_x = -D\left(\frac{\partial^2 w}{\partial x^2} + \nu\frac{\partial^2 w}{\partial y^2}\right) \tag{2.4-1}$$

$$M_y = -D\left(\frac{\partial^2 w}{\partial y^2} + \nu\frac{\partial^2 w}{\partial x^2}\right) \tag{2.4-2}$$

$$M_{xy} = M_{yx} = -D(1-\nu)\left(\frac{\partial^2 w}{\partial x \partial y}\right) \tag{2.4-3}$$

$$Q_x = -D\frac{\partial}{\partial x}\left(\frac{\partial^2 w}{\partial x^2} + \frac{\partial^2 w}{\partial y^2}\right) \tag{2.4-4}$$

$$Q_y = -D\frac{\partial}{\partial y}\left(\frac{\partial^2 w}{\partial x^2} + \frac{\partial^2 w}{\partial y^2}\right) \tag{2.4-5}$$

Where deflection is in terms of applied load, $p_z(x)$, and flexural rigidity, D. For complete plate solution see Appendix "A".

2.5 FLEXURAL RIGIDITY OF CONCRETE SLABS

The flexural rigidity of elastic plates is classically defined as $D = EI/(1 - \nu^2)$. However, for reinforced concrete slabs subjected to non-symmetrical loads, many hairline bending cracks will develop before shear or torsional cracking occurs.

The flexural rigidity is, therefore, influenced by these cracks. For one-way construction, concrete beams and slabs, the current ACI Code recommends the use of modulus of elasticity of concrete, Ec, and effective moment of inertia, Ie, for computation of deflection, as follows:

$$I_e = \left(\frac{M_{cr}}{M_a}\right)^3 I_g + \left[1 - \left(\frac{M_{cr}}{M_a}\right)^3\right] I_{cr} \qquad (2.5\text{-}1)$$

$$D = \frac{E_c I}{(1 - \nu^2)} \qquad (2.5\text{-}2)$$

Where:

$I = I_g$ for $M_a < M_{cr}$

$I = I_e$ for $M_a > M_{cr}$

Ec = moment of inertia of gross concrete section about centroidal axis, neglecting reinforcement.

I_e = effective moment of inertia for computation of deflection.

I_{cr} = moment of inertia of cracked section transformed to concrete.

M_a = maximum bending moment in member at stage deflection is computed.

M_{cr} = cracking moment.

= $f_r I_g / Y_t$

f_r = modulus of rupture of concrete, psi

= $7.5 \sqrt{f'c}$

Y_t = distance from centroidal axis of gross-section, neglecting reinforcement to extreme fiber in tension.

$f'c$ = compressive strength of concrete, psi.

ν = poisson's ratio of the concrete.

3.0 SUMMARY OF PRELIMINARY STUDIES (APPENDIX "B")

A limited set of experiments were performed using 10" wide, 22" long and 2" thick one-way plates and subjected to non-symmetrical loading. Detail of the test program are given in Appendix B.

The results of the test program based on the simple beam analysis are given in Table B-5, and based on the plate solution are given in Table B-6.

As may be seen, all of the interaction equations give values greater than unit indicating that the ACI Code predicts failure loads smaller than measured by experiments by at least a factor of $1/\sqrt{6}$. Note that load condition and plate dimensions for all preliminary studies were identical and loads were applied with eccentricity of 4 inches. This eccentricity created a T/V ration of 4 for beam analysis and about 1.2 to 1.4 for the plate analysis.

Experimental studies of plates having different widths and various eccentricity were conducted to further investigation ACI formula with various T/V ratios. For detail of experimental studies see Appendix C.

4.0 EXPERIMENTAL STUDY

4.1 INTRODUCTION

As discussed previously, the motivation for the research was developed when the ACI Code provision for evaluating the combined shear-torsion capacity of flexural members was found to be overly conservative when applied to non-symmetrically loaded one-way slabs. In this study, an experimental evaluation was undertaken to determine the applicability of the code recommendation to plate configuration.

A preliminary study of the one-way reinforced concrete slabs during the phase "I" program (see Appendix B) revealed that a more comprehensive test series of beam and plate specimens was required in order to study the shear/torsion behavior of one-way R.C. plates.

It was found that the true shear strength of the reinforced concrete beam specimens is an essential part of the plate shear/torsion study. A comprehensive series of beam specimens were, therefore, cast and tested to evaluate the shear strength of the concrete test specimens.

The shear strength results collected from the beam specimens tests were then used to eliminate the uncertainty associated with the shear strength value used in the combined shear/torsion study. The results of this study are presented in Section 4.2.

During the preliminary plate study, the eccentricities of the applied loads and plate width were kept constant. In order to generalize the behavior of one-way R.C. slabs under non-symmetrical loading, it was necessary to vary both the width of the plate specimens and the load eccentricities about the transverse "y" axis. A comprehensive series of plate specimens with various widths were cast and subjected to loads with various eccentricities about the transverse "y" axis.

In addition to the load patterns and plate specimens widths, the transverse reinforcement ratios and transverse reinforcement location (i.e., a top or bottom reinforcement), were varied in the plate specimens. The results of this study are presented in Section 4.3.

4.2 SHEAR STRENGTH STUDY

4.2.1 DISCUSSION

In order to study the combined effects of shear/torsion on the capacity of the R.C. plates, the shear strength of the concrete specimens must be defined. Forty beam specimens, with longitudinal reinforcement similar to the plate specimens, were cast and tested to determine the actual shear strength of the concrete specimens.

All the beam specimens were 3" thick 28" long with No. 3 rebar at 2.5" c/c and placed at a depth of 2.0625 inches. The widths of the beam specimens were 2.5, 5.0, 7.5, 10.0, 12.5 and 25 inches for beam series A through F respectively.

Beam specimens were tested under the action of two symmetrically placed concentrated loads, with the shear-span/depth (a/d) ratio varying from 1.94 to 5.94. The specific test beam data and load conditions are given in Table C-4.

4.2.2 ANALYSIS OF THE BEAM TEST RESULTS

The observed failure loads, calculated ultimate shear strength values and comparison with theoretical values are summarized in Table C-5. Non-dimensional values of the $(1000\ Vd/M\sqrt{f'c})$ and $(V/bd\sqrt{f'c})$ are given in Table C-5a and were used on Fig. 2.

Comparison of the experimentally determined shear strength with the ACI-ASCE Committee 316 report are shown graphically on Fig. 2. As may be seen, all of the test beams had higher shear strengths than that predicted by the ACI Code 318-83.

Although the shear strength values of the test beams are more than twice the values suggested by the ACI Code, the comparison of the test beams shear strength values with results reported by the ACI-ASCE Committee 326 indicate that this test data is about 30 to 70 precent higher than the ACI-ASCE data.

The higher shear strength values of the test beams are the result of the higher reinforcement ratio (ρmax) at the shear span section.

As explained earlier, a series of short span beams, similar to those of the short span test plates, were cast and tested. A large reinforcement ratio (ρmax) was used to avoid bending failures and to force combined shear/torsion failures.

In actual practice, some of the reinforcement would normally be cut off and the shear span section would thus, have a smaller reinforcement ratio than the ρ_{max}. Therefore, the 30 to 70 percent increase of the shear strength values of the test beams could be due to the heavily reinforcement (ρ_{max}) at the shear span section.

4.2.3 SUMMARY

A comparison of the theoretical and experimental values indicate that the experimental values of shear strength of the heavily reinforced test beams were much higher than the theoretical values based on the ACI code.

Also, it was observed that the shear stress capacity of the beams were independent of the beam widths. Thus, the shear capacity of the beams are directly proportional to the beam width. A comparison of the theoretical and experimental values of shear strength for load conditions 4 and 5 (corresponding to the loading of the test plates), indicate that shear strengths of the beams are higher than the predicted values by ACI by a factor of 2.71 and 2.15 respectively.

These experimental values were used to represent the shear strength of concrete in the plate analysis under the combined effects of shear and torsion.

Theoretical and experimental shear and torsion values used in the anlaysis of the plate specimens for load conditions 4 and 5 and Batch Nos. I, II and III are given in Table C-6.

4.3 COMBINED SHEAR/TORSION STUDY

4.3.1 DISCUSSION

In order to determine the ultimate shear and torsional capacity of reinforced concrete plates symmetrical (with respect to the center line between the two free edge of the one-way plate) and non-symmetrical load conditions were imposed on fifty-four plate specimens.

Three different categories of reinforced concrete plates were used: narrow plates with width/length (B/L) ratios of 0.29, 0.38 and 0.48; wide plates with B/L = 1; and extra wide plates with B/L = 2. All the plate specimens were 3" thick , 28" long and were cast with #3 longitudinal reinforcement at 2.5 inches spacing c/c and 0.75 inches cover. Plate series C, D, and E were 7.5, 10 and 12.5 inches wide respectively. Plate series F to M and P121, P122, and P123 were 25 inches wide. Plate series M, O and P131, P231, P132, P133 and P233 were 50 inches wide. In addition to the longitudinal rebar, plate series H, I, J, K, L, M, N and O were cast with 5 bottom, 5 top, 3 bottom, 7 bottom, 3 top, 7 top, 5 top and 5 bottom #3 transverse reinforcement respectively. Top transverse bars had 0.75 inches and bottom transverse bars had 1.125 inches cover.

These plates were subjected to partially distributed loads, the applied loads were symmetrically placed relative to the longitudinal "x" axis and symmetrically and non-symmetrically placed relative to the transverse "y" axis. Details of the test program are given in Appendix C.4.0.

It was found that the test beam specimens under load condition 4 and 5 failed due to diagonal tension with the obvious presence of the bending cracks. Since test beams under load condition 6 with slightly higher a/d ratio failed in bending, the shear-span/depth (a/d) ratio of load conditions 4 and 5 were chosen for the plate test study.

Plate specimens in each series were loaded in three different load patterns (see Fig. C-2). Load pattern "I" was center strip loading with small and negligible torsional moment. Load pattern "II" was center strip loading with moderate torsional moment. Load pattern "III" was edge strip loading with considerable torsional moment. For plate specimens data, eccentricity of the applied load b and loading patterns, see Table C-7.

4.3.2. ANALYSIS OF THE PLATE TEST RESULTS

The observed failure loads and comparison of the experimental value with the theoretical predictions are given in Appendix C, Section C.4.

The results of the test program based on the simple beam analysis and the plate analysis using Levy's Method are given in Table C-8 for shear forces and torsional moments and Table C-8a for flexural shear stresses (V_{obf}) and torsional shear stresses (τ_{obf}).

Nondimensional flexural and torsional stresses of the experimental results are given in Table C-8a and shown graphically on Figs. 3 and 4 for the simple beam analysis and the plate solution by Levy's Method respectively.

A comparison of the experimental shear/torsion values with the theoretical values are given in Tables C-9 and C-10 for the simple beam analysis and the plate solution by Levy's Method respectively.

A comparison of the interaction equation values are given in Table C-11 for the simple beam analysis and Table C-12 for the plate analysis by Levy's Method.

The comparison of the interaction equations values indicate that the interaction equation 2.1-B gives the best correlation between the measured and predicted data.

The interaction equation 2.1-B values are shown graphically in Fig. 5 and Fig. 6 for the simple beam analysis and the plate solution by Levy's Method.

4.3.2.1 LOAD CARRYING CAPACITY

As discussed before reinforced concrete plates with and without transverse reinforcement were cast and tested to determine their ultimate load carrying capacity.

Based on the observed failure loads and mode of failures of the test plates, the following observations are made:

a) The load carrying capacity of narrow plates, 7.5, 10 and 12.5 inches, decreased as eccentricity of the applied load was increased. This decrease was due to the combined effects of the shear load and the torsional moment.

b) The load carrying capcity of wide plates 25 inches, and extra wide plate, 50 inches wide, without transverse rebar did not decrease as eccentricity of the applied load increased except for the extreme case of edge strip loading applied to the extra wide plate. This was due to the presence of large positive transverse moment in the plates that were loaded at the center strip or middle strip. Both center strip and middle strip loaded plates basically failed by longitudinal cracks, as a result of positive transverse moment. While edge strip loaded plates failed by spiral diagonal crack, as a result of combined shear and torsion.

c) The load carrying capacity of the wide plates with transverse rebar did not increase for edge strip loading while there were increases for center strip and middle strip loading as follows:

1) Center strip loading

3 Top bars	30 to 40%
5 Top bars	40 to 50%
7 Top bars	40 to 50%
3 Bottom bars	30 to 35%
5 Bottom bars	40 to 50%
7 Bottom bars	55 to 65%

2) Middle strip loading

3 Top bars	None
5 Top bars	30%
7 Top bars	15%
3 Bottom bars	None
5 Bottom bars	25%
7 Bottom bars	30%

4.3.2.2 SIMPLE ANALYSIS (BEAM SOLUTION)

Simple analyses (see Section 2.3), are made for all fifty-four test plates. Details of the tests are given in Appendix C, Section C.4.

As may be seen from the Table C-11 and Fig. 3, all of the interaction equations give values much higher than unity for the simple beam analysis. These values for wide and extra wide plates are very high so that the comparison with unity is meaningless. This is due to the unrealistic assumption used to predict the torsional stress distribution in plates subjected to the non-symmetrical loadings.

The simple beam analysis assumption is based on the linear distribution of the torsional stresses with the maximum values occurring at the edges and zero value at the center of the plates. The typical stress distribution of this theory is depicted in Fig. 7.

While the interaction approach using simple beam analysis for plates is found to be unrealistic, the effective plate width approach can lead to realistic data. The effective width approach predicts load carrying capacity of non-symmetrically loaded plates based on the effective width and shear capacity of concrete only.

A comparison of experimental simple plate analysis results with the experimental beam shear results indicate that the effective shear width $Be = (V_{obf}/V_{fo})B$ was less than plate width (B) (see Table C-9 for Be/B ratios).

In plates subjected to non-symmetrical loading, as eccentricity increases and torsional stresses increase, the effective width decreases. As the plate width increases, the effective width increases for plates without transverse reinforcements and considerably for plates with transverse reinforcement.

The effective width increases with increasing plate width and supplying transverse reinforcement for center strip and middle strip loadings. Transverse reinforcement does not increase load carrying capacity of plates when the loads applied at edge strip. Effective width does not increase due to plate width increase after L/B ratio reaches "1". In another word, the load carrying capacity of wide and extra wide plates are almost identical.

Although the effective width approach was not the topic of this research study, it seems that based on the experimental results the following formulas can be taken under consideration for future research studies:

For plates without transverse reinforcement:

$$Be = \sqrt{(1-b/B)\ vL} \qquad (4.3\text{-}A)$$

$$vL \leq B^2$$

For plates with transverse reinforcement:

$$Be = \sqrt{(1-b/B)\ (1.56vL)} \qquad (4.3\text{-}B)$$

$$1.56vL \leq B^2$$

where:

Be = effective plate width

B = plate width

L = plate length

v = width of the partially distributed load, parallel to the supports

b = eccentricity of applied load about transverse "y" axis

For values of B, v and b see Tables C-7.

A comparison of experimental effective width to plate width ratios ($Be/B = V_{opf}/V_{fo}$) with suggested Be/B ratios based on the equation 4.3-A and 4.3-B is given in Table 1.

4.3.2.3 PLATE SOLUTION (LÉVY'S METHOD)

Plate solution by Lévy's Method are made for all fifty-four test plates. Computer programs were made to calculate shear forces and torsional moments induced by non-symmetrical loading. For computer programs and outputs see Appendix D.

A comparison of calculated values with theoretical values are given in Appendix C, Section C.4.

As may be seen in Table C-12, column 2, the interaction equation of the current ACI Code (eq. 2.2-3) gives values much higher than unity. In another word, this interaction equation underestimates the load carrying capacity of the non-symmetrically loaded one-way concrete plates even when the plate solution is applied.

The plate solution predicts the realistic distribution of the shear forces and torsional moments across the plate width. The shear and torsional moment distributions resulting from the application of this theory are shown in Figs. 8, 9 and 10 for center strip, middle strip and edge strip loadings of the wide plates (for numerical values see Appendix D).

There are two reasons that the ACI Code interaction equation is overly conservative. First, it underestimates the shear capacity of the heavily reinforced concrete beams and slabs. All of the plate specimens were cast with a reinforcement ratio (ρ max) to prevent failure due to the longitudinal bending moment.

In order to account for the true shear strength values in the interaction equations, the corresponding concrete beams were cast and tested to obtain the true shear strength values (for details see C.3.0 and Table C-6).

Secondly, it underestimates the torsional capacity of R. C. slabs.

In order to find appropriate torsional strength value of the concrete plates, the following values were considered:

1) $T_{opo} = T_{fo} = 2T_o = 1.6\sqrt{f'_c}\ x^2y$

2) $T_{opo} = T_{oro} = 2.5T_o = 2\sqrt{f'_c}\ x^2y$

The values of the interaction equation 2.1-A that considers $T_{opo} = T_{fo}$ is given in Table C-12, column 4 and values of the interaction equation 2.1-B that considers $T_{opo} = T_{oro}$ is given in Table C-12, column 5.

The results of the interaction equation 2.1-B for plate solution by Levy's Method are shown graphically in Figs. 4 and 6.

Observation of Figs. 4 and 6 reveal that the interaction equation 2.1-B based on the plate solution by Levy's Method is the best solution for predicting the load carrying capacity of the one-way concrete plates under non-symmetrical loading conditions.

5.0 CONCLUSION

This research study leads to the following conclusions:

a) Shear strength values of the concrete beams having reinforcement ratios equal to ρ_{max}, are higher than the values suggested by the ACI Code.

b) The load carrying capacity of one-way reinforced concrete plates loaded in the center strip or in the middle strip, increases when top and/or bottom transverse reinforcements are used. Use of the transverse reinforcement in concrete plates under edge strip loading does not increase the plate capacity.

c) Interaction equations for the combined effects of shear and torsion are not applicable for non-symmetrically loaded one-way concrete plates, when simple analysis (beam solution) is used to compute plate shear and torsions.

d) Interaction equation for the combined effects of shear and torsion are realistic when the plate solution (Levy's Method) is used to compute plate shear and torsion. It is found that, based on the plate solution, the torsional strength of the non-symmetrically loaded one-way concrete plates are at least 2.5 times higher than that recommended by the ACI Code.

The torsional strength of the reinforced concrete beams is found to be 2.5 times the recommended value by the ACI Code. This has also been reported by HSU (Ref. 9), see Section 2.2-2.

6.0 RECOMENDATION

Based on this research study, the interaction equation of shear/torsion to predict load carrying capacity of non-symmetrically loaded one-way concrete plates is presented in the following form:

$$\left(\frac{V_{cpfm}}{V_{cpo}}\right)^2 + \left(\frac{T_{cpfm}}{T_{cpo}}\right)^2 = 1 \qquad (6.1)$$

$$V_{cpfm} = \frac{V_{cpo}}{\sqrt{1 + \left(\frac{C_t T_u}{V_u}\right)^2}} \qquad (6.2)$$

$$T_{cpfm} = \frac{T_{cpo}}{\sqrt{1 + \left(\frac{V_u}{C_t T_u}\right)^2}} \qquad (6.3)$$

where:

V_{cpfm}, T_{cpfm}, V_u, T_u, C_t are defined in Section 2.0.

and

$$V_{opo} = V_o = \left(1.9\sqrt{f'_c} + 2500\,\frac{\rho V_u d}{M_u}\right) bd \leq 3.5\sqrt{f'_c}\, bd$$

$$v_{cpo} = 1.9\sqrt{f'_c} + 2500\,\frac{\rho V_u d}{M_u} \leq 3.5\sqrt{f'_c}$$

$$T_{opo} = 2.5T_o = 2\sqrt{f'_c}\, x^2 y = 2\sqrt{f'_c}\, h^2$$

$$\tau_{cpo} = \frac{3T_{cpo}}{x^2 y} = 6\sqrt{f'_c}$$

h = thickness of the plate

It must be noted that even higher shear strength values were observed in this research study but current ACI Code values are recommended. The reason for this is the recommendation of the ACI - ASCE Committee 326 "shear and diagonal torsion" that are based on a broad research study.

Therefore, the above recommended interaction equation is conservative even considering higher torsional strength capacity.

Note:

Load carrying capacity of the one-way concrete plates subjected to non-symmetrical loadings can be increased by providing transverse reinforcement and increasing thickness of the plates in the edge strips parallel to the free edges.

7.0 RECOMMENDATION FOR RESEARCH CONTINUATION

This research study indicates that concrete plates have higher load carrying capacity than predicted by the ACI. Load carrying capacity of the partially loaded one-way concrete plate is a function of the partially distributed load area, longitudinal reinforcement ratio, top and bottom transverse reinforcement ratio and thickness of the plates.

The following studies are recommended for continuation of this research study.

a) Partially Distributed Load Size Study

A series of identical concrete plates subject to various partially distributed load to study load width and length effect on the load carrying capacity.

b) Reinforcement Ratio Study

Series of identical concrete plates to be cast with various reinforcement ratios to study reinforcement ratio effect on the load carrying capacity.

c) Edge Strip Effect

A series of plate with various edge strip width and thickness to be cast and subjected to the identical load condition to study edge strip effect on the load carrying capacity of the concrete plates.

APPENDIX A

PLATE SOLUTION FOR ONE-WAY SLABS USING LÉVY'S METHOD

A.1 INTRODUCTION

For laterally loaded plates that have two opposite edges simply supported at x=o and x=a; M. Lévy suggested taking the solution in the form of a series. [Ref. A-1, A-2]

$$w(x,y) = \sum_{m=1}^{\infty} Y_m(y) \sin \frac{m\pi x}{a} \tag{A-1}$$

where w is deflection of the plate in the vertical (z) direction.

Eq. (A-1) satisfies the boundary conditions in the x direction (simple supports). It remains to determine Y_m (y) in such a form so as to satisfy the boundary conditions in the y direction and the equilibrium equations.

In applying this method to simply supported edges in the x direction and free edges in the y direction, with the lateral load only a function of x, a further simplification can be made by taking solution of Eq. (A-1) in the form of:

$$w(x,y) = w_H + w_P \tag{A-2}$$

Where w_H represents the solution of the homogeneous plate equation; that is, w_H must satisfy the equation [Ref. A-2]

$$\nabla^4 w_H = 0 \tag{A-3}$$

w_P is a particular solution of the plate subjected to lateral loads, and satisfies the equation [Ref. A-2]

$$\nabla^4 w_P = \frac{p_z(x)}{D} \tag{A-4}$$

where:

$$\nabla^4 w = \frac{\partial^4 w}{\partial x^4} + 2\frac{\partial^4 w}{\partial x^2 \partial y^2} + \frac{\partial^4 w}{\partial y^4}$$

$$D = \frac{E h^3}{12(1-\nu^2)}$$

h = Thickness of the plate, ν = Poissons Ratio.

For the particular solution, we expand the displacements in the form:

$$\omega_p(x) = \sum_{m=1}^{\infty} W_m \sin \frac{m\pi x}{a} \qquad \text{(A-5)}$$

This form satisfies the boundary conditions at the edges x=o and x=a. The applied load is expanded in a similar fashion as:

$$p_z(x) = \sum_{m=1}^{\infty} P_m \sin \frac{m\pi x}{a} \qquad \text{(A-6)}$$

substituting Eqs. (A-5) and (A-6) into Eq. (A-4) yields:

$$W_m = \left(\frac{a}{m\pi}\right)^4 \frac{P_m}{D} \qquad \text{(A-7)}$$

For the homogeneous solution, we define:

$$\omega_H(x, y) = \sum_{m=1}^{\infty} Y_m(y) \sin \frac{m\pi x}{a} \qquad \text{(A-8)}$$

This expression satisfies the assumed simply supported boundary conditions at x direction.

Substituting Eq. (A-8) into Eq. (A-3), yields:

$$Y_m^{IV}(y) - 2\left(\frac{m\pi}{a}\right)^2 Y_m''(y) + \left(\frac{m\pi}{a}\right)^4 Y_m(y) = 0 \qquad \text{(A-9)}$$

The integral solution of this linear, homogeneous, differential equation of the fourth order can be taken in the form of hyperbolic functions:

$$Y_m(y) = A_m \cosh\frac{m\pi y}{a} + B_m \frac{m\pi y}{a}\sinh\frac{m\pi y}{a}$$

$$+ C_m \sinh\frac{m\pi y}{a} + D_m \frac{m\pi y}{a}\cosh\frac{m\pi y}{a} \qquad \text{(A-10)}$$

The integration constants A_m, B_m, C_m, and D_m will be determined from boundary conditions in the y direction. With unsymmetrical load conditions with respect to y direction, all of the constants are nonzero.

Now by expressing Mx, My, Mxy, Qx, Qy, Vx and Vy in terms of deflection, one can find stresses developed in the plate at any point.

It has been found [Ref. A-1, A-2] that:

$$M_x = -D\left(\frac{\partial^2 w}{\partial x^2} + \nu \frac{\partial^2 w}{\partial y^2}\right) \qquad \text{(A-11)}$$

$$M_y = -D\left(\frac{\partial^2 w}{\partial y^2} + \nu \frac{\partial^2 w}{\partial x^2}\right) \qquad \text{(A-12)}$$

$$M_{xy} = M_{yx} = -D(1-\nu)\frac{\partial^2 w}{\partial x \partial y} \qquad \text{(A-13)}$$

$$Q_x = -D\frac{\partial}{\partial x}\left(\frac{\partial^2 w}{\partial x^2} + \frac{\partial^2 w}{\partial y^2}\right) \qquad \text{(A-14)}$$

$$Q_y = -D\frac{\partial}{\partial y}\left(\frac{\partial^2 w}{\partial x^2} + \frac{\partial^2 w}{\partial y^2}\right) \qquad \text{(A-15)}$$

$$V_x = -D\left[\frac{\partial^3 w}{\partial x^3} + (2-\nu)\frac{\partial^3 w}{\partial x \partial y^2}\right] \qquad \text{(A-16)}$$

$$V_y = -D\left[\frac{\partial^3 w}{\partial y^3} + (2-\nu)\frac{\partial^3 w}{\partial y \partial x^2}\right] \tag{A-17}$$

From these the corresponding stresses can be found as follows:

Normal flexural stresses:

$$\sigma_x = \frac{12 M_x z}{h^3} \tag{A-18}$$

$$\sigma_x \Big|_{max\,(z = h/2)} = \frac{6 M_x}{h^2} \tag{A-19}$$

$$\sigma_y = \frac{12 M_y z}{h^3} \tag{A-20}$$

$$\sigma_y \Big|_{max\,(z = h/2)} = \frac{6 M_y}{h^2} \tag{A-21}$$

Torsional stresses:

$$\tau_{xy} = \frac{12 M_{xy} z}{h^3} \tag{A-22}$$

$$\tau_{xy}\Big|_{max\,(z=h/2)} = \frac{6 M_{xy}}{h^2} \tag{A-23}$$

The shearing stresses τ_{xz} and τ_{yz} can now be determined by assuming that they are distributed across the thickness of the plate according to the parabolic law. Then:

$$\tau_{xz}\Big|_{max\,(z=0)} = \frac{3 Q_x}{2h} \tag{A-24}$$

$$\tau_{yz}\Big|_{max\,(z=0)} = \frac{3 Q_y}{2h} \tag{A-25}$$

and shearing stresses at supports:

$$\tau_{xz}\Big|_{max\,(z=0)} = \frac{3 V_x}{2h} \tag{A-26}$$

A.2 FOURIER EXPANSIONS OF PARTIALLY DISTRIBUTED LOADS

Fourier theorem states that any arbitrary function y=f(x) can be expressed by an infinite series, consisting of sine and cosine terms. Herein, we are interested in expanding the applied loads in terms of fourier sine series.

According to Fig. (A-1):

$$p_z(x) = q \quad \text{for } x_1 - \frac{u}{2} < x < x_1 + \frac{u}{2} \qquad \text{(a)}$$

$$p_z(x) = q \quad \text{for } x_2 - \frac{u}{2} < x < x_2 + \frac{u}{2} \qquad \text{(b)} \qquad \text{(A-27)}$$

$$p_z(x) = 0 \quad \text{otherwise} \qquad \text{(c)}$$

To express p_z (x) in terms of Fourier sine series, one can write:

$$p_z(x) = \sum_{m=1}^{\infty} P_m \sin \frac{m\pi x}{a} \qquad \text{(A-28)}$$

or

$$\int_0^a p_z(x)\,dx = \int_0^a P_m \sin \frac{m\pi x}{a}\,dx$$

multiply both sides with $\sin\frac{n\pi x}{a}$

$$\int_0^a p_z(x)\sin\frac{n\pi x}{a}\,dx = \int_0^a P_m \sin\frac{m\pi x}{a}\sin\frac{n\pi x}{a}$$

$$= 0 \quad \text{for} \quad n \neq m$$

$$= \frac{P_m a}{2} \quad \text{for} \quad n = m$$

Therefore:

$$\int_0^a p_z(x)\sin\frac{m\pi x}{a}\,dx = \frac{a P_m}{2}$$

or

$$P_m = \frac{2}{a}\int_0^a p_z(x)\sin\frac{m\pi x}{a}\,dx \qquad \text{(A-29)}$$

substituting Eq. (A-27) into Eq. (A-29), yields:

$$P_m = \frac{2}{a}\left[\int_{x_1-u/2}^{x_1+u/2} q\sin\frac{m\pi x}{a}\,dx + \int_{x_2-u/2}^{x_2+u/2} q\sin\frac{m\pi x}{a}\,dx\right] \qquad \text{(A-30)}$$

Integrating and simplyfing Eq. (A-30), yields:

$$P_m = \frac{4q}{\pi} \sum_{m=1}^{\infty} \frac{1}{m} \left(\sin \frac{m\pi x_1}{a} + \sin \frac{m\pi x_2}{a} \right) \sin \frac{m\pi U}{2a} \qquad \text{(A-31)}$$

Substituting Eq. (A-31) into Eq. (A-7), yields:

$$W_m = \frac{4qa^4}{D\pi^5} \sum_{m=1}^{\infty} \frac{1}{m^5} \left(\sin \frac{m\pi x_1}{a} + \sin \frac{m\pi x_2}{a} \right) \sin \frac{m\pi U}{2a} \qquad \text{(A-32)}$$

Substituting Eq. (A-31) into Eq. (A-28), yields:

$$p_z(x) = \frac{4q}{\pi} \sum_{m=1}^{\infty} \frac{1}{m} \left(\sin \frac{m\pi x_1}{a} + \sin \frac{m\pi x_2}{a} \right) \sin \frac{m\pi U}{2a} \sin \frac{m\pi x}{a} \qquad \text{(A-33)}$$

is shown in the following paragraphs that a total of 11 modes yields a good approximation to the applied pressure distribution. Therefore, for calculation of W_m and Integral constants A_m, B_m, C_m, and D_m, M=11 will be used.

A.3 DETERMINATION OF INTEGRAL CONSTANTS OF DEFLECTED SURFACE FOR EDGE STRIP LOADING

According to Fig. (A-1), there will be two different types of deflection surfaces for the partially loaded plate. For the unloaded portion of the plate above, the line ts, the deflection surface can be expressed in the form of:

$$W_1 = \sum_{m=1}^{\infty} \left(A_{m1} \cosh \frac{m\pi y}{a} + B_{m1} \frac{m\pi y}{a} \sinh \frac{m\pi y}{a} + C_{m1} \sinh \frac{m\pi y}{a} + D_{m1} \frac{m\pi y}{a} \cosh \frac{m\pi y}{a} \right) \sin \frac{m\pi x}{a} \qquad \text{(A-34)}$$

and for the loaded portion of the plate below the line ts, the deflection surface can be expressed in the form of:

$$W_2 = \sum_{m=1}^{\infty} \left(A_{m2} \cosh \frac{m\pi y}{a} + B_{m2} \frac{m\pi y}{a} \sinh \frac{m\pi y}{a} + C_{m2} \sinh \frac{m\pi y}{a} + D_{m2} \frac{m\pi y}{a} \cosh \frac{m\pi y}{a} + W_m \right) \sin \frac{m\pi x}{a} \qquad \text{(A-35)}$$

now, it is necessary to find the constants in the Eqs. (A-34) and (A-35) so as to satisfy boundary conditions in the y direction and continuity conditions along the line ts.

Continuity conditions along line ts, $y_1 = o$ and $y_2 = o$, are:

$$w_1 = w_2 , \frac{\partial w_1}{\partial y} = \frac{\partial w_2}{\partial y} , \frac{\partial^2 w_1}{\partial y^2} = \frac{\partial^2 w_2}{\partial y^2} \text{ and } \frac{\partial^3 w_1}{\partial y^3} = \frac{\partial^3 w_2}{\partial y^3}$$

$w_1 = w_2$ yields

$$A_{m1} - A_{m2} = W_m \qquad \text{(A-36)}$$

$\frac{\partial w_1}{\partial y} = \frac{\partial w_2}{\partial y}$ yields

$$C_{m1} + D_{m1} - C_{m2} - D_{m2} = 0 \qquad \text{(A-37)}$$

$\frac{\partial^2 w_1}{\partial y^2} = \frac{\partial^2 w_2}{\partial y^2}$ yields

$$A_{m1} + 2B_{m1} - A_{m2} - 2B_{m2} = 0 \qquad \text{(A-38)}$$

$\frac{\partial^3 w_1}{\partial y^3} = \frac{\partial^3 w_2}{\partial y^3}$ yields

$$C_{m1} + 3D_{m1} - C_{m2} - 3D_{m2} = 0 \qquad \text{(A-39)}$$

Conditions in the y direction.

B.C. at $y_1 = -b_1$, free edge, $My_1 = 0$ and $Vy_1 = 0$

$$My_1 = 0 \quad \frac{\partial^2 w_1}{\partial y_1^2} + \nu \frac{\partial^2 w_1}{\partial x^2} = 0 \quad \text{yields}$$

$$(1-\nu)A_{m1}\cosh m\alpha_1 + B_{m1}\left(2\cosh m\alpha_1 + (1-\nu)\, m\alpha_1 \sinh m\alpha_1\right)$$

$$-(1-\nu)C_{m1}\sinh m\alpha_1 + D_{m1}\left(-2\sinh m\alpha_1 - (1-\nu)\, m\alpha_1 \cosh m\alpha_1\right) = 0 \qquad \text{(A-40)}$$

$$Vy_1 = 0 \quad \frac{\partial^3 w_1}{\partial y_1^3} + (2-\nu)\frac{\partial^3 w_1}{\partial y_1 \partial x^2} = 0 \quad \text{yields}$$

$$(1-\nu)A_{m1}\sinh m\alpha_1 + B_{m1}\left(-(1+\nu)\sinh m\alpha_1 + (1-\nu)\, m\alpha_1 \cosh m\alpha_1\right)$$

$$+ (\nu-1)C_{m1}\cosh m\alpha_1 + D_{m1}\left((1+\nu)\cosh m\alpha_1 + (\nu-1)\, m\alpha_1 \sinh m\alpha_1\right) = 0 \qquad \text{(A-41)}$$

B.C. at $Y_2 = b_2$, free edge, $My_2 = 0$ and $Vy_2 = 0$

$$My_2 = 0 \quad \frac{\partial^2 w_2}{\partial y_2^2} + \nu \frac{\partial^2 w_2}{\partial x^2} = 0 \quad \text{yields}$$

$$(1-\nu)A_{m2}\cosh m\alpha_2 + B_{m2}\left(2\cosh m\alpha_2 + (1-\nu)\, m\alpha_2 \sinh m\alpha_2\right) + (1-\nu)C_{m2}$$

$$\sinh m\alpha_2 + D_{m2}\left(2\sinh m\alpha_2 + (1-\nu)\, m\alpha_2 \cosh m\alpha_2\right) = \nu W_m \qquad \text{(A-42)}$$

$$V_{y2}=0 \qquad \frac{\partial^3 w_2}{\partial y_2^3} + (2-\nu)\frac{\partial^3 w_2}{\partial y_2 \partial x^2} = 0 \quad \text{yields}$$

$$(\nu-1) A_{m2} \sinh m\alpha_2 + B_{m2}\left((1+\nu)\sinh m\alpha_2 + (\nu-1) m\alpha_2 \cosh m\alpha_2\right) + (\nu-1) C_{m2}$$

$$\cosh m\alpha_2 + D_{m2}\left((1+\nu)\cosh m\alpha_2 + (\nu-1) m\alpha_2 \sinh m\alpha_2\right) = 0 \qquad \text{(A-43)}$$

where, from Eq. (A-32)

$$W_m = \sum_{m=1}^{M} \frac{4qa^4}{Dm^5\pi^5}\left(\sin\frac{m\pi x_1}{a} + \sin\frac{m\pi x_2}{a}\right)\sin\frac{m\pi u}{2a}$$

and

$$\alpha_1 = \frac{\pi b_1}{a}$$

$$\alpha_2 = \frac{\pi b_2}{a}$$

Now we have to solve eight equations with eight unknown, which can be placed in the form:

$$[A]\left\{C\right\} = \left\{F\right\} \tag{A-44}$$

The coefficients of Eq. (A-44) are found as follows:

$$[A] = \begin{bmatrix} A_{1,1} & 0 & 0 & 0 & A_{1,5} & 0 & 0 & 0 \\ 0 & 0 & A_{2,3} & A_{2,4} & 0 & 0 & A_{2,7} & A_{2,8} \\ A_{3,1} & A_{3,2} & 0 & 0 & A_{3,5} & A_{3,6} & 0 & 0 \\ 0 & 0 & A_{4,3} & A_{4,4} & 0 & 0 & A_{4,7} & A_{4,8} \\ A_{5,1} & A_{5,2} & A_{5,3} & A_{5,4} & 0 & 0 & 0 & 0 \\ A_{6,1} & A_{6,2} & A_{6,3} & A_{6,4} & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & A_{7,5} & A_{7,6} & A_{7,7} & A_{7,8} \\ 0 & 0 & 0 & 0 & A_{8,5} & A_{8,6} & A_{8,7} & A_{8,8} \end{bmatrix}$$

Where:

A (1,1)	=	1	A (3,2)	=	2
A (1,5)	=	−1	A (3,5)	=	−1
A (2,3)	=	1	A (3,6)	=	−2
A (2,4)	=	1	A (4,3)	=	1
A (2,7)	=	−1	A (4,4)	=	3
A (2,8)	=	−1	A (4,7)	=	−1
A (3,1)	=	1	A (4,8)	=	−3

A (5,1) = $(1-\nu)\cosh m\alpha_1$

A (5,2) = $2\cosh m\alpha_1 + (1-\nu)(\sinh m\alpha_1)\, m\alpha_1$

A (5,3) = $(\nu-1)\sinh m\alpha_1$

A (5,4) = $-2\sinh m\alpha_1 - (1-\nu)\, m\alpha_1 \cosh m\alpha_1$

A (6,1) = $(1-\nu)\sinh m\alpha_1$

A (6,2) = $-(1+\nu)\sinh m\alpha_1 - (\nu-1)\, m\alpha_1 \cosh m\alpha_1$

A (6,3) = $(\nu-1)\cosh m\alpha_1$

A (6,4) = $(1+\nu)\cosh m\alpha_1 + (\nu-1)\, m\alpha_1 \sinh m\alpha_1$

A (7,5) = $(1-\nu)\cosh m\alpha_2$

A (7,7) = $(1-\nu)\sinh m\alpha_2$

A (7,6) = $2\cosh m\alpha_2 + (1-\nu)\, m\alpha_2 \sinh m\alpha_2$

A (7,8) = $2\sinh m\alpha_2 + (1-\nu)\, m\alpha_2 \cosh m\alpha_2$

A (8,5) = $(\nu-1)\sinh m\alpha_2$

A (8,6) = $(1+\nu)\sinh m\alpha_2 + (\nu-1)\, m\alpha_2 \cosh m\alpha_2$

A (8,7) = $(\nu-1)\cosh m\alpha_2$

A (8,8) = $(1+\nu)\cosh m\alpha_2 + (\nu-1)\, m\alpha_2 \sinh m\alpha_2$

$$\{C\} = \left\{ \begin{array}{c} A_{m1} \\ B_{m1} \\ C_{m1} \\ D_{m1} \\ \\ A_{m2} \\ B_{m2} \\ C_{m2} \\ D_{m2} \end{array} \right\} \quad \text{and} \quad \{F\} = \left\{ \begin{array}{c} W_m \\ 0 \\ 0 \\ 0 \\ \\ 0 \\ 0 \\ \nu W_m \\ 0 \end{array} \right\}$$

The poisson's ratio , ν , of .15 has been considered for normal concrete.

A.4 DETERMINATION OF INTEGRAL CONSTANT OF DEFLECTED SURFACE FOR MIDDLE AND CENTER STRIP LOADING

According to Fig. (A-1a), there will be three different types of deflection surfaces for the partially loaded plate. For the unloaded portions of the plate, above the line 'pr' and below the line 'ts', the deflection surface corresponds to the Eq. A-34.

For loaded portion of the plate, between lines 'pr' and 'ts', the deflection surface corresponds to the Eq. A-35.

Applying continuity conditions along lines 'pr' and 'ts' at $y = -b/2$ and $y=b/2$, respectively, and free edge boundry condition at $y = -b1$ and $y=b3$, the coefficients of Eq. A-44 are found as follows:

$$
[A] = \begin{bmatrix}
A_{1,1} & A_{1,2} & A_{1,3} & A_{1,4} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
A_{2,1} & A_{2,2} & A_{2,3} & A_{2,4} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
A_{3,1} & A_{3,2} & A_{3,3} & A_{3,4} & A_{3,5} & A_{3,6} & A_{3,7} & A_{3,8} & 0 & 0 & 0 & 0 \\
A_{4,1} & A_{4,2} & A_{4,3} & A_{4,4} & A_{4,5} & A_{4,6} & A_{4,7} & A_{4,8} & 0 & 0 & 0 & 0 \\
A_{5,1} & A_{5,2} & A_{5,3} & A_{5,4} & A_{5,5} & A_{5,6} & A_{5,7} & A_{5,8} & 0 & 0 & 0 & 0 \\
A_{6,1} & A_{6,2} & A_{6,3} & A_{6,4} & A_{6,5} & A_{6,6} & A_{6,7} & A_{6,8} & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & A_{7,5} & A_{7,6} & A_{7,7} & A_{7,8} & A_{7,9} & A_{7,10} & A_{7,11} & A_{7,12} \\
0 & 0 & 0 & 0 & A_{8,5} & A_{8,6} & A_{8,7} & A_{8,8} & A_{8,9} & A_{8,10} & A_{8,11} & A_{8,12} \\
0 & 0 & 0 & 0 & A_{9,5} & A_{9,6} & A_{9,7} & A_{9,8} & A_{9,9} & A_{9,10} & A_{9,11} & A_{9,12} \\
0 & 0 & 0 & 0 & A_{10,5} & A_{10,6} & A_{10,7} & A_{10,8} & A_{10,9} & A_{10,10} & A_{10,11} & A_{10,12} \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & A_{11,9} & A_{11,10} & A_{11,11} & A_{11,12} \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & A_{12,9} & A_{12,10} & A_{12,11} & A_{12,12}
\end{bmatrix}
$$

Where:

$A(1,1) = (1-\nu)\cosh\alpha 1$

$A(1,2) = 2\cosh\alpha 1 + (1-\nu)(\sinh\alpha 1)\alpha 1$

$A(1,3) = (\nu-1)\sinh\alpha 1$

$A(1,4) = -2\sinh\alpha_1 + (\nu-1)(\cosh\alpha 1)\alpha 1$

$A(2,1) = (1-\nu)\sinh\alpha 1$

$A(2,2) = -(1+\nu)\sinh\alpha 1 + (1-\nu)\alpha 1\cosh\alpha 1$

$A(2,3) = (\nu-1)\cosh\alpha 1$

$A(2,4) = (1+\nu)\cosh\alpha 1 + (\nu-1)\alpha 1\sinh\alpha 1$

$A(3,1) = \cosh\alpha 2$

$A(3,2) = \alpha 2\sinh\alpha 2$

$A(3,3) = -\sinh\alpha 2$

$A(3,4) = -\alpha 2\cosh\alpha 2$

$A(3,5) = -\cosh\alpha 2$

$A(3,6) = -\alpha 2\sinh\alpha 2$

$A(3,7) = \sinh\alpha 2$

$A(3,8) = \alpha 2\cosh\alpha 2$

$A(4,1) = -\sinh\alpha 2$

$A(4,2) = -(\sinh\alpha 2 + \alpha 2\cosh\alpha 2)$

$A(4,3) = \cosh\alpha 2$

$A(4,4) = \cosh\alpha 2 + \alpha 2\sinh\alpha 2$

$$A(4,5) = \sinh\alpha 2$$
$$A(4,6) = \sinh\alpha 2 + \alpha 2\cosh\alpha 2$$
$$A(4,7) = -\cosh\alpha 2$$
$$A(4,8) = -(\cosh\alpha 2 + \alpha 2\sinh\alpha 2)$$

$$A(5,1) = \cosh\alpha 2$$
$$A(5,2) = 2\cosh\alpha 2 + \alpha 2\sinh\alpha 2$$
$$A(5,3) = -\sinh\alpha 2$$
$$A(5,4) = -(2\sinh\alpha 2 + \alpha 2\cosh\alpha 2)$$
$$A(5,5) = -\cosh\alpha 2$$
$$A(5,6) = -(2\cosh\alpha 2 + \alpha 2\sinh\alpha 2)$$
$$A(5,7) = \sinh\alpha 2$$
$$A(5,8) = 2\sinh\alpha 2 + \alpha 2\cosh\alpha 2$$

$$A(6,1) = -\sinh\alpha 2$$
$$A(6,2) = -(3\sinh\alpha 2 + \alpha 2\cosh\alpha 2)$$
$$A(6,3) = \cosh\alpha 2$$
$$A(6,4) = 3\cosh\alpha 2 + \alpha 2\sinh\alpha 2$$
$$A(6,5) = \sinh\alpha 2$$
$$A(6,6) = 3\sinh\alpha 2 + \alpha 2\cosh\alpha 2$$
$$A(6,7) = -\cosh\alpha 2$$
$$A(6,8) = -(3\cosh\alpha 2 + \alpha 2\sinh\alpha 2)$$

$A(7,5) = \cosh \alpha 2$

$A(7,6) = \alpha 2 \sinh \alpha 2$

$A(7,7) = \sinh \alpha 2$

$A(7,8) = \alpha 2 \cosh \alpha 2$

$A(7,9) = -\cosh \alpha 2$

$A(7,10) = -\alpha 2 \sinh \alpha 2$

$A(7,11) = -\sinh \alpha 2$

$A(7,12) = -\alpha 2 \cosh \alpha 2$

$A(8,5) = \sinh \alpha 2$

$A(8,6) = \sinh \alpha 2 + \alpha 2 \cosh \alpha 2$

$A(8,7) = \cosh \alpha 2$

$A(8,8) = \cosh \alpha 2 + \alpha 2 \sinh \alpha 2$

$A(8,9) = -\sinh \alpha 2$

$A(8,10) = -(\sinh \alpha 2 + \alpha 2 \cosh \alpha 2)$

$A(8,11) = -\cosh \alpha 2$

$A(8,12) = -(\cosh \alpha 2 + \alpha 2 \sinh \alpha 2)$

$A(9,5) = \cosh \alpha 2$

$A(9,6) = 2 \cosh \alpha 2 + \alpha 2 \sinh \alpha 2$

$A(9,7) = \sinh \alpha 2$

$A(9,8) = 2 \sinh \alpha 2 + \alpha 2 \cosh \alpha 2$

$A(9,9) = -\cosh \alpha 2$

$A(9,10) = -(2 \cosh \alpha 2 + \alpha_2 \sinh \alpha 2)$

$A(9,11) = -\sinh \alpha 2$

$A(9,12) = -(2 \sinh \alpha_2 + \alpha_2 \cosh \alpha 2)$

$$A(10,5) = \sinh\alpha 2$$
$$A(10,6) = 3\sinh\alpha 2 + \alpha_2 \cosh\alpha 2$$
$$A(10,7) = \cosh\alpha 2$$
$$A(10,8) = 3\cosh\alpha 2 + \alpha_2 \sinh\alpha 2$$
$$A(10,9) = -\sinh\alpha 2$$
$$A(10,10) = -(3\sinh\alpha 2 + \alpha 2 \cosh\alpha 2)$$
$$A(10,11) = -\cosh\alpha 2$$
$$A(10,12) = -(3\cosh\alpha 2 + \alpha 2 \sinh\alpha 2)$$

$$A(11,9) = (1-\nu)\cosh\alpha_3$$
$$A(11,10) = 2\cosh\alpha_3 + (1-\nu)\alpha_3 \sinh\alpha_3$$
$$A(11,11) = (1-\nu)\sinh\alpha_3$$
$$A(11,12) = 2\sinh\alpha_3 + (1-\nu)\alpha_3 \cosh\alpha_3$$

$$A(12,9) = (\nu-1)\sinh\alpha_3$$
$$A(12,10) = (1+\nu)\sinh\alpha_3 + (\nu-1)\alpha_3 \cosh\alpha_3$$
$$A(12,11) = (\nu-1)\cosh\alpha_3$$
$$A(12,12) = (1+\nu)\cosh\alpha_3 + (\nu-1)\alpha_3 \sinh\alpha_3$$

and:

$$\alpha_1 = \frac{m\pi b_1}{a}$$

$$\alpha_2 = \frac{m\pi b_2}{a}$$

$$\alpha_3 = \frac{m\pi b_3}{a}$$

$$\{C\} = \begin{Bmatrix} A_{m1} \\ B_{m1} \\ C_{m1} \\ D_{m1} \\ \\ A_{m2} \\ B_{m2} \\ C_{m2} \\ D_{m2} \\ \\ A_{m3} \\ B_{m3} \\ C_{m3} \\ D_{m3} \end{Bmatrix} \quad \& \quad \{F\} = \begin{Bmatrix} 0 \\ 0 \\ W_m \\ 0 \\ \\ 0 \\ 0 \\ -W_m \\ 0 \\ \\ 0 \\ 0 \\ 0 \\ 0 \end{Bmatrix}$$

A.5 COMPARISON OF FOURIER EXPANSION TO ACTUAL APPLIED PRESSURE PROFILES

The theoretically applied pressure, $p_z(x)$, has been expanded in terms of Fourier sine series (see A.2). The Profile of the actual partially distributed pressures and the Fourier expansion of the applied load with 1, 3, 5, 7, and 9 terms are plotted in Figs. A-2, A-3, A-4, A-5, and A-6. It is observed that summation of 5 to 7 terms yields a reasonable approximation to the actual pressure.

Since the even terms of this sine series are equal to zero, summation of "m+1" terms is equal to summation of "m" terms, where m=odd.

APPENDIX B

PRELIMINARY EXPERIMENTAL STUDIES

B.1 INTRODUCTION

In order to observe the ultimate shear and torsional capacity of reinforced concrete plates without stirrups, non-symmetrical load conditions were imposed on a series of small plates in an attempt to estimate the load carrying capacity.

During this limited experimental program, six plates were cast and loaded until failure or major diagonal cracks occurred. All six test models were 2 inches thick, 10 inches wide and 22 inches long. Three of these plates were cast with one layer of wire mesh while the other three were cast with two layers of wire mesh.

B.2 MATERIAL DESCRIPTION

The wire mesh used as reinforcement in these plates was gage No. 20, with a wire diameter, d, of .037 inches and wire spacing, s, of 0.5 inches.

A concrete mix with 0.58 and 6.8 water-cement and sand-cement ratios by weight, respectively, was used for the plate test models. This mix had a slump of 2 to 3 inches.

Eighteen dog bone shape specimens with one inch square cross-section at the throat, were tested under a tensile loading yielding an ultimate tensile strength, f'_t, of 370 psi and a standard deviation of 35 psi (see table B-1 and Fig. B-1). Five cylinderical speciments 2" in diameter and 4" high, were tested under direct compressive loading yielding an ultimate compressive strength, f'_c, of 3800 psi and a standard deviation of 380 psi (see table B-2 and Fig. B-2). Five cylinderical specimens, 2" in diameter and 4" long, were tested by means of split tensile test yielding an ultimate splitting tesile strength, f'_{sp}, of 660 psi and a standard deviation of 84 psi (see table B-3 and Fig. B-2).

B.3 TEST SETUP

The concrete plates were loaded at two points with partially distributed loads. The load was transferred to the specimen through a distributing beam as shown in Fig. B-3. Distributed loads were symmetrial about the longitudinal "x" axis and non-symmetrical about the transverse "y" axis. Vertical deflections of test plates were measured at points A and B at different load levels. Point A was located at the center of the plates and point B was located at the middle of the loaded strip one inch from the free edge. Details of the test setup and location of points A and B are given in Figs. B-3 and B-4.

B.4 MODE OF FAILURE

The observed mode of failures of these plates are classified in three groups as follows:

a) Bending failure without presence of significant shear and torsion:

Plates No. I and III were cast with one layer of wire mesh. They failed by bending with no apparent significant shear and torsional stresses (see Figs. B-5 and B-8). For failure loads, shear forces and torsional moments at failure and comparison of theoretical and experiment values (see tables B-5 and B-6).

b) Bending failure with considerable shear and torsion:

Plate No. II was cast with two layers of wire mesh. This plate failed by bending with considerable shear and torsional stresses but without any diagonal shear and torsion cracks (See Figs. B-6, B-7 and Tables B-5 and B-6).

c) Shear and torsion failure:

1) Plates No. IV and VI were cast with two layers of wire mesh. First diagonal spiral cracks occurred at both ends of the loaded strip. These diagonal spiral cracks were propagated from the loaded edge up to about 1/5 to 1/4 of the plates width. These diagonal spiral cracks followed by a top longitudinal crack across the middle of the plates. These plates failed after the longitudinal crack was fully developed. The top longitudinal crack was the result of negative transverse moment after redistribution of stresses due to diagonal cracks. Therefore, these plates failed by shear and torsion with considerable positive longitudinal moment but without any visible transverse vertical cracks due to positive moment (See Figs. B-9, B-11, B-12 and tables B-5 and B-6).

2) Plate No. V was cast with one layer of wire mesh. This plate failed by combination of shear and torsion but without any longitudinal cracks. (See Fig. B-10 and table B-5 and B-6).

B.5 ANALYSIS OF TEST RESULTS

The observed load deflection behavior of plates II, IV and VI are compared with the predicted behavior on Figures B-13 to B-18. The predications are based on the plated solution developed in Appendix A. The effective plate stiffness is modified as discussed in section 2.5 to account for the reduced cross-sectional moment of inertia which occurs as the plate cracks. As may be seen, the stiffness prediction for the plates are in excellent agreement with the measured data up to loads approaching the failure load. This result supports the use of the plate equation to determine shear and moment distributions in the plate throughout the load history.

The predicted shear/torsional strength of the plates are compared with the observed failure loads on Tables B-5 and B-6. The data on Table B-5 are developed using the simple status relationship given in section 2.3 to compute the internal shear and torsional loads in the plates. The plate equation, developed in Appendix A and sumarized in section 2.4, is used to evaluate the internal shear and torsional loads used to develop the data in Table B-6.

In each of these tables the theoretical strength predictions are given in the upper portion of the table. The first three rows correspond to the standard combined shear/torsion equation in the ACI Code. The strength prediction is given in these forms. First, the predicted shear strength (Eq. 2.2-1), given the actual shear/torque ratio; second, the predicted torsional strength (Eq. 2.2-2), and third, the failure load based on the interaction equation (Eq. 2.2-3). The same set of predictions are made using the higher zero shear/torsional strength result. The corresponding equation numbers used for the calculation in the next three rows in the table are (2.2-5), (2.2-6) and (2.2-4). The lower portion of the table contains data developed from the experimental results (failure load, shear at the failure load, and torsion at the failure load).

It may readily be seen that the experimental values are significantly higher than those determined by the standard interaction and strength equation. The large conservation (and scatter) in prediction based on the interation equation can be seen in the last two rows of the tables. The sum of the interaction equation terms is much larger than unity as suggested in the ACI Code.

B.6 SUMMARY

A comparison of the theoretical and experimental values leads to the following conclusions:

a) Shear and torsional capacity of the test plates under combined torsion and shear were about 4 and 2.5 times higher than those predicted using the ACI Code 318-83 for simple, i.e., beam, and plate analyses, respectively.

b) Experimental values of the interaction formula of Eq. 2.2-3 were more than 14 and 6 times the theoretical values for simple and plate analyses, respectively.

c) Experimental values of the interaction formula of Eq. 2.2-4 were more than 2.5 times the theoretical values for both simple and plate analyses.

d) Observed deflections of the test plates were in agreement with plate analysis and contradicts simple analysis. Simple analysis considers uniform deflection across any transverse cross-section, where plate analysis predicts a non-uniform deflection due to non-symmetrical loading.

APPENDIX C

EXPERIMENTAL PROGRAM

C.1.0 INTRODUCTION

In order to study the ultimate capacity of reinforced concrete plates without shear reinforcement and subjected to loadings that introduce both shear and torsional effects, a series of beam and plate specimens were cast and tested. The loading patterns were varied to produce different ratios of shear to torsional effects.

A series of beam specimen with various widths were cast and tested to study the sensitivity of shear strength of the reinforced concrete beams to beam width. These beam specimens were subjected to symmetrically distributed loadings, with the load placement varied to give a range of shear spans. These data are also used to select a shear span/depth ratio for the plate testes so that shear failure rather than bending failure will develop. The shear span/depth (a/d) ratios of the tested load conditions number 1 through 6 were 5.94, 1.94, 2.67, 3.39, 4.36 and 4.85 respectively.

A series of reinforced concrete plates with the widths and transverse reinforcement varied were cast and tested to study the combined shear/torsion behavior of the one-way reinforced concrete plates. These plates were subjected to two concentrated loads, these loads placed at an equal distance from the free edge of the one-way plate. The distance from the edge of the plate was varied from test to test, one test series, the loads were located along the center of the plate, while for second test series the loads were at the free edge of the plate. For the third test series, the loads were placed midway between the locations for the first two test series.

C.2.0 MATERIALS DESCRIPTION

All reinforcement used for the beam and plate specimens were #3 deformed bars of grade 50, with yield point of 50 ksi. Concrete was purchased from the Bronx Ready Mix plant with specified compressive strength of f'_c = 3000 psi. Three different batches were used since the plates were cast over a period of several months.

Cylindrical specimens, 6" in diameter and 12" high, were cast and tested under direct compressive loading for each batch yielding ultimate compressive strengths, f'_c of 3600, 3700 and 3000 psi for batches No. I, No. II and No. III respectively (For test results see Table C-1).

Also cylinderical specimens, 6" in diameter and 12" high, were cast and tested by means of the split tensile test yielding ultimate splitting tensile strength, f'_{sp}, of 327, 344 and 300 psi for batches No. I, No. II and No. III respectively (For test results see Table C-2).

For batches No. II and No. III unreinforced beam specimens, 6" x 6" x 20" were cast and tested to obtain estimate of flexural strength, yielding the modulus of rupture, f_r, of 550 and 530 psi respectively (For test results see Table C-3). The ACI corresponding moduli of rupture predicted from the ACI Code formula ($f_r = 7.5\sqrt{f'_c}$) yields 455 and 410 psi respectively for Batches II and III. A comparison of the split tensile tests and flexural strength tests with ACI Code values are given in Table C-3a.

As one can see the test results of the split cylinder tests were lower, while the flexural test result were higher than the values predicted by ACI Code based on the compressive strength. Therefore, modulus of rupture from the ACI Code was used in the strength estimated for the beams and plates.

C.3.0 BEAM TEST PROGRAM

Forty beam specimens were cast and tested to study the shear strength of the reinforced concrete members of the experimental study.

Beam specimens were tested under the actin of two loads. Beam specimens data and load conditions are given in Table C-4.

C.3.1 BEAM TEST SETUP

The concrete beam specimens were simply supported at both ends with sepcimen lengths of 28 inches and span lengths of 26 inches. A concentrated load was applied by a hydraulic jack at the middle of the distributing steel beam.

The beam specimens were then tested under flexural shear and bending with no torsion (For test setup see Fig. C-1) applied to the cross-section.

C.3.2 MODE OF FAILURE

Beam specimens series with a/d ratio of 5.94 and 4.85, (load conditions 1 and 6), failed by bending or combined shear and bending (see Figs. C-3, C-8 and C-9).

Beam specimens series with a/d ration of 1.94 to 4.36, (load conditions 2, 3, 4 and 5), failed by shear. The diagonal shear cracks for these beams can be seen in Figs. C-4 to C-7 and C-8(a) to C-8(c).

Failure loads, shear strength of the tested beam specimens and comparison of experimental shear strength with predicted values obtained from ACI Code formula are given in Tables C-5 and C-5a.

C.3.3 BEAM TEST RESULTS

The observed failure loads and ultimate shear strengths calculated based on the simply supported beam solution are given in Table C-4 for all forty beam specimens.

C.3.4 SUMMARY

A comparison of the experimental values of the shear strength of heavily reinforced (ρ_{max}) test beams with theoretical values are given in Table C-5.

Non-dimensional values of ($1000\ Vd/M\sqrt{f'c}$) and $V/bd\sqrt{f'c}$ of the test results for comparison with ACI-ASCE committee 316 report values are given in Table C-5a.

It was found that the test beam specimens under load condition 4 and 5 failed due to diagonal tension with the obvious presence of the bending cracks. Since test beams under load condition 6 with slightly higher a/d ratios failed in bending, the shear-span/depth (a/d) ratio of load conditions 4 and 5 were chosen for the plate test study.

The experimental shear and torsion values used in the analysis of the plate specimens for load conditions 4 and 5 are given in Table C-6.

C.4.0 PLATE TEST PROGRAM

Fifty-four plate specimens were cast and tested under both symmetrical and non-symmetrical loadings to study the combined shear/torsion behavior of the one-way reinforced concrete plates.

Plate specimen data, eccentricity of the partially distributed applied load, and loading patterns are given in Table C-7.

C.4.1 PLATE TEST SETUP

The concrete plates were loaded at two points with partially distributed loads. The load was transferred to the test plates through a distributing beam at two points. The load was applied by a hydraulic jack placed at the midpoint of the distributing beam. The hydraulic jack was calibrated before the plate test, between individual plate tests, and after the tests. The conversion factor to convert the hydraulic jack pressure (psi) to applied beam load (lbs) was found to be 4.6. All distributed loads were symmetrical about the longitudinal "x" axis. Distributed loads were symmetrical and non-symmetrical about transverse "y" axis.

Eccentricities of the distributed load about y axis from the center of the plate, were 1.5, 1.75, 2.25, 3.5, 4.5, 4.75, 8.5, 12.5 and 21 inches. A sketch of the test setup and description of the load conditions is given on Fig. C-2 and Table C-7.

C.4.2 . MODE OF FAILURE

Adequate longitudinal reinforcements were provided in the test plates, so that no major transverse cracks due to the moment about the x axis, were observed.

The observed mode of failures of the test plates during this research study are classified in the following three groups:

a) <u>Failure due to the major shear cracks</u>

1. Plate Nos. C 1-1, C 1-2, C 1-3, 7.5 inches wide, D 1-1 and D 1-2, 10 inches wide, and without transverse reinforcement failed by shear but without any longitudinal cracks (See Figs. C-10 and C-11).

2. Plate Nos. H1, K1, 25 inches wide, 01 and 02, 50 inches wide, were cast with considerable bottom transverse reinforcements. Plate No. N1, 50 inches wide, was cast with considerable top reinforcement. In

these plates diagonal spiral cracks occurred without any major longitudinal cracks. These diagonal spiral cracks were propagated from the loaded area toward the corners and free edges. In plates H1 and K1, cracks extended over the full width of the plates, while in plates O1, O2, and N1 the cracks extended only up to half of the plates width. Failure of all of these plates was associated with major cracks near to and almost paralled to the supports, similar to those of the flexural shear and cracks failure (See Figs. C-12 to C-17).

3. Plate Nos. I1 and M1, 25 inches wide, and plate no. N2, 50 inches wide were cast with considerable top transverse reinforcements. In these plates, spiral diagonal and longitudinal cracks were observed to be parallel and about 8 inches apart, which corresponds to the width of the distributed load. The longitudinal cracks extended from the middle of the plates toward the supports with the crack

lengths being about two-thirds of the plates length. Failure of these plates was associated with major diagonal spiral cracks that followed the longitudinal cracks. Again, at failure major cracks near to and some sort parallel to the supports (See Figs. C-18 to C-20) were observed.

b) <u>Failure due to major longitudinal cracks followed by spiral diagonal cracks</u>

1. Plates Nos. E1-1 to E2-2, 12.5 inches wide, P121, F1, G1, P122, G2 and P123, 25 inches wide were cast without transverse reinforcements. Failure of these plates was associated with longitudinal cracks and diagonal spiral cracks immediately following the development of the longitudinal cracks (See Figs. C-21 to C-28).

2. Plates Nos. I2 and L2, 25 inches wide with top reinforcements. Failure of these plates was associated with longitudinal cracks followed by

the development of diagonal spiral cracks (See Figs. C-29 and C-30).

3. Plates No. J1 and L1, 25 inches wide, were cast with three bottom and top reinforcements respectively. Failure of these plates was associated with longitudinal cracks followed by the development of diagonal spiral cracks (See Figs. C-31 and C-32).

c) Failure due to the combined shear and torsional cracks

1. Plate Nos. C 3-1 to E 3-2 were cast without transverse reinforcements. Failure of plates was associated with diagonal spriral cracks, extending from outside of loaded areas toward the supports with about 45 degree angles with free edge and supports (See Figs. C-33 to C-35).

2. Plate Nos. H2, J2, K2, H3, J3, K3 and O3, were cast with bottom transverse reinforcements. Failure of these plates was associated with diagonal cracks

with presence of longitudinal cracks (See Figs. C-43 to C-48).

C.4.3 PLATE TEST RESULTS

Plate analyses based on the Levy's method and simple beam analysis were made for all fifty four plates.

The observed failure loads for each of the plates together with the shear and torsional loads calculated using the beam solution (Eqs. 2.3-4 and 2.3-5) and plate solution (Appendix A) are given in Table C-8. Non-dimensional values of the $v_{obf}/\sqrt{f'c}$, $\tau_{obf}/\sqrt{f'c}$ for the beam solutions and $v_{opfm}/\sqrt{f'c}$, $\tau_{opfm}/\sqrt{f'c}$ for the plate solutions are given in Table C-8a and were used in Figs. 3 and 4 for comparison with theoretical values.

A comparison of the shear and torsional values, consistent with the measured failure loads, with theoretical strength values of the experimental beam test results (V_{fo}) and assigned torsional strength value (T_{fo}) are made in Table C-9 and C-10 for both the simple analysis and Levy's method respectively.

A comparison of the interaction equation values based on the experimental shear/torsion results are made in Table C-11 and C-12 for both the simple beam analysis and Levy's method respectively.

In Tables C-11 and C-12, plate interaction equations 2.2-3, 2.2-4, 2.1-1A and 2.1-B are given in Columns 1, 2, 3, 4 and 5 respectively.

APPENDIX D

D.1.0

FOURIER EXPANSION PROGRAM

```
$JOB
      DIMENSION F(30)
      READ,X1,X2,U,Q,A,M
      PI=3.141592654
      IA=A
      DO 2 N=1,M,2
      TLAPPR=0.0
      WRITE (6,40) X1,X2,U,Q,A,M,IA
   40 FORMAT(1H1//12X,'X1=',F8.2/12X,'X2=',F8.2/12X,'U =',F8.2/
     112X,'Q =',F8.2/12X,'A =',F8.2/12X,'M =',I5/12X,'IA=',I5//)
      DO 1 J=1,IA
      X=FLOAT(J)
      FX=0.0
      DO 5 I=1,N
      FXI=(1/FLOAT(I))*(SIN(I*PI*X1/A)+SIN(I*PI*X2/A))*
     1SIN(I*PI*U/(2*A))*SIN(I*PI*X/A)
      IF(X.GE.2) GOTO 50
      TLI=((4*Q*A)/((I*PI)**2))*(SIN(I*PI*X1/A)+SIN(I*PI*X2/A))
     1*SIN(I*PI*U/(2*A))*(1-COS(I*PI))
      TLAPPR=TLAPPR+TLI
   50 CONTINUE
    5 FX=FX+FXI
      FX=FX*(4*Q/PI)
    1 F(J)=FX
      MODE=(N+1)/2
      WRITE(6,7) MODE,N
    7 FORMAT(12X,'MODE=',I3/12X,'NO. OF SERIES TERM USED=',I3)
      WRITE(6,11)
   11 FORMAT(12X,'X',15X,'FACT',8X,'FAPPROX')
      DO 12 I=1,IA
      X=FLOAT(I)
      IF(X.GE.(X1-U/2)) GOTO 10
   30 FACT=0.0
      GOTO 12
   10 IF(X.GT.(X1+U/2)) GOTO 20
   15 FACT=Q
      GOTO 12
   20 IF(X.LT.(X2-U/2)) GOTO 30
      IF(X.GT.(X2+U/2)) GOTO 30
      GOTO 15
   12 WRITE(6,14) X,FACT,F(I)
   14 FORMAT(12X,F5.2,5X,2F12.2)
      TLACT=2*U*Q
      WRITE(6,3) TLACT,TLAPPR
    3  FORMAT(4X///12X,'TOTAL LOAD ACTUAL=      ',F8.2//
     112X,'TOTAL LOAD APPROXIMATE=',F8.2)
    2 CONTINUE
      STOP
      END
$ENTRY
```

D.1.1

COMPUTER OUTPUT FOR FOURIER EXPANSION

```
X1=    7.00
X2=   19.00
U =    4.00
Q =  500.00
A =   26.00
M =   11
IA=   26
```

MODE= 1

NO. OF SERIES TERM USED= 1

X	FACT	FAPPROX
1.00	0.00	27.49
2.00	0.00	54.58
3.00	0.00	80.88
4.00	0.00	105.99
5.00	500.00	129.56
6.00	500.00	151.24
7.00	500.00	170.72
8.00	500.00	187.70
9.00	500.00	201.95
10.00	0.00	213.25
11.00	0.00	221.45
12.00	0.00	226.41
13.00	0.00	228.08
14.00	0.00	226.41
15.00	0.00	221.45
16.00	0.00	213.25
17.00	500.00	201.95
18.00	500.00	187.70
19.00	500.00	170.72
20.00	500.00	151.24
21.00	500.00	129.56
22.00	0.00	105.99
23.00	0.00	80.88
24.00	0.00	54.58
25.00	0.00	27.49
26.00	0.00	0.00

TOTAL LOAD ACTUAL= 4000.00

TOTAL LOAD APPROXIMATE= 3775.13

```
X1=    7.00
X2=   19.00
U =    4.00
Q =  500.00
A =   26.00
M =   11
IA=   26
```

MODE= 2

NO. OF SERIES TERM USED= 3

X	FACT	FAPPROX
1.00	0.00	84.18
2.00	0.00	160.60
3.00	0.00	222.44
4.00	0.00	264.70
5.00	500.00	284.79
6.00	500.00	282.82
7.00	500.00	261.54
8.00	500.00	225.96
9.00	500.00	182.68
10.00	0.00	138.96
11.00	0.00	101.78
12.00	0.00	76.93
13.00	0.00	68.20
14.00	0.00	76.93
15.00	0.00	101.78
16.00	0.00	138.96
17.00	500.00	182.68
18.00	500.00	225.96
19.00	500.00	261.54
20.00	500.00	282.82
21.00	500.00	284.79
22.00	0.00	264.70
23.00	0.00	222.44
24.00	0.00	160.60
25.00	0.00	84.18
26.00	0.00	0.00

TOTAL LOAD ACTUAL= 4000.00

TOTAL LOAD APPROXIMATE= 4657.22

```
X1=    7.00
X2=   19.00
U =    4.00
Q =  500.00
A =   26.00
M =   11
IA=   26
```

MODE= 3 .
NO. OF SERIES TERM USED= 5

X	FACT	FAPPROX
1.00	0.00	-35.58
2.00	0.00	-36.53
3.00	0.00	17.74
4.00	0.00	124.90
5.00	500.00	259.38
6.00	500.00	380.79
7.00	500.00	448.21
8.00	500.00	435.25
9.00	500.00	340.49
10.00	0.00	189.41
11.00	0.00	27.02
12.00	0.00	-96.58
13.00	0.00	-142.63
14.00	0.00	-96.58
15.00	0.00	27.02
16.00	0.00	189.41
17.00	500.00	340.49
18.00	500.00	435.25
19.00	500.00	448.21
20.00	500.00	380.79
21.00	500.00	259.38
22.00	0.00	124.90
23.00	0.00	17.74
24.00	0.00	-36.53
25.00	0.00	-35.58
26.00	0.00	-0.00

TOTAL LOAD ACTUAL= 4000.00

TOTAL LOAD APPROXIMATE= 3959.29

X1= 7.00
X2= 19.00
U = 4.00
Q = 500.00
A = 26.00
M = 11
IA= 26

MODE= 4
NO. OF SERIES TERM USED= 7

X	FACT	FAPPROX
1.00	0.00	-83.51
2.00	0.00	-100.09
3.00	0.00	-18.63
4.00	0.00	140.22
5.00	500.00	316.07
6.00	500.00	440.66
7.00	500.00	470.92
8.00	500.00	405.50
9.00	500.00	278.32
10.00	0.00	136.72
11.00	0.00	19.30
12.00	0.00	-54.12
13.00	0.00	-78.60
14.00	0.00	-54.12
15.00	0.00	19.30
16.00	0.00	136.72
17.00	500.00	278.32
18.00	500.00	405.50
19.00	500.00	470.92
20.00	500.00	440.66
21.00	500.00	316.07
22.00	0.00	140.22
23.00	0.00	-18.63
24.00	0.00	-100.09
25.00	0.00	-83.51
26.00	0.00	-0.00

TOTAL LOAD ACTUAL= 4000.00

TOTAL LOAD APPROXIMATE= 3807.89

```
X1=    7.00
X2=   19.00
U =    4.00
Q =  500.00
A =   26.00
M =   11
IA=   26
```

```
MODE=  5
NO. OF SERIES TERM USED=  9
```

X	FACT	FAPPROX
1.00	0.00	16.59
2.00	0.00	-7.06
3.00	0.00	-32.26
4.00	0.00	34.52
5.00	500.00	231.46
6.00	500.00	467.71
7.00	500.00	580.68
8.00	500.00	480.46
9.00	500.00	238.23
10.00	0.00	24.50
11.00	0.00	-44.92
12.00	0.00	-1.59
13.00	0.00	34.45
14.00	0.00	-1.59
15.00	0.00	-44.91
16.00	0.00	24.50
17.00	500.00	238.23
18.00	500.00	480.46
19.00	500.00	580.68
20.00	500.00	467.71
21.00	500.00	231.46
22.00	0.00	34.52
23.00	0.00	-32.26
24.00	0.00	-7.06
25.00	0.00	16.59
26.00	0.00	-0.00

```
TOTAL LOAD ACTUAL=      4000.00

TOTAL LOAD APPROXIMATE= 4015.80
```

```
X1=     7.00
X2=    19.00
U =     4.00
Q =   500.00
A =    26.00
M =    11
IA=    26
```

MODE= 6
NO. OF SERIES TERM USED= 11

X	FACT	FAPPROX
1.00	0.00	22.89
2.00	0.00	-4.04
3.00	0.00	-37.11
4.00	0.00	29.18
5.00	500.00	233.76
6.00	500.00	474.15
7.00	500.00	581.46
8.00	500.00	474.40
9.00	500.00	234.55
10.00	0.00	28.79
11.00	0.00	-39.17
12.00	0.00	-3.14
13.00	0.00	27.96
14.00	0.00	-3.14
15.00	0.00	-39.17
16.00	0.00	28.80
17.00	500.00	234.55
18.00	500.00	474.40
19.00	500.00	581.46
20.00	500.00	474.15
21.00	500.00	233.76
22.00	0.00	29.19
23.00	0.00	-37.11
24.00	0.00	-4.04
25.00	0.00	22.89
26.00	0.00	-0.00

TOTAL LOAD ACTUAL=   4000.00

TOTAL LOAD APPROXIMATE= 4025.55

D.2.0

COMPUTER PROGRAM FOR LEVY'S SOLUTION

D.2.1

MIDDLE AND CENTER STRIP LOADING

```
      DIMENSION AMAT(12,13),C(12),BMAT(12,13)
      REAL MXY1,MXYI,MXY2,MXYII,MX1,MXI,MX2,MXII,MY1,MYI,MY2,MYII
     1,MXY3,MXYIII,MX3,MXIII,MY3,MYIII
      READ,A1,B1,B2,B3,X1,X2,U,H,POIS,EFFI,FPRC,P,NMODES
      B=B1+B3
      BI=B1-B2/2
      BII=B2
      BIII=B3-B2/2  .
      Q=P/(2*(U*B2))
      E=57000*(FPRC**0.5)
      D=E*EFFI/(1-POIS*POIS)
      WRITE(6,2) A1,B,BI,BII,BIII,H,FPRC,EFFI,POIS,E,D
    2 FORMAT(1H1,15X,'LEVY SOLUTION FOR PLATE ANALYSIS'//
     15X,'PLAT DATA'//
     25X,'LENGTH OF PLATE                        (IN)',F12.2/
     35X,'WIDTH OF PLATE                         (IN)',F12.2/
     45X,'UNLOADED WIDTH OF PLATE                (IN)',F12.2/
     55X,'LOADED WIDTH OF PLATE                  (IN)',F12.2/
     55X,'UNLOADED WIDTH OF PLATE                (IN)',F12.2/
     65X,'THICKNESS OF PLATE                     (IN)',F12.2/
     65X,'FPRC IS COMP. STRENGHT OF CONC.       (PSI)',F12.2/
     65X,'EFFI IS EFF. MOM. OF INERTIA      (IN.**4)',F12.2/
     75X,'POISSON''S RATIO OF PLATE                  ',F12.2/
     85X,'ELASTIC MODOLUS OF PLATE              (PSI)',1PE12.2/
     95X,'FLEXURAL RIGIDITY OF PLAT           (#-IN)',1PE12.2/)
      WRITE(6,3) X1,X2,U,Q,P
    3 FORMAT(5X,'LOAD DATA'//
     15X,'CENTER LOCATION OF FIRST LOAD      (IN)',F12.2/
     25X,'CENTER LOCATION OF SECOND LOAD     (IN)',F12.2/
     35X,'LENGTH OF EACH DISTRIBUTED LOAD    (IN)',F12.2/
     45X,'INTENSITY OF DISTRIBUTED LOAD     (PSI)',F12.2/
     45X,'TOTATAL LOAD                        (#)',F12.2/)
      WRITE(6,4) NMODES
    4 FORMAT(5X,'NUMBER OF SERIES TERM USED           ',I12/
     15X,'X=0.0 & X=A1  ARE SIMPLY SUPPORTED EDGES'/
     35X,'Y1 AND Y3 ARE UNLOADED WIDTHS'/
     45X,'Y2 IS LODED WIDTH'/)
      K=A1+1
      K1=B1/2.5
      K2=B2/2+1
      K3=B3/2.5
      NROWS=12
      MCOLS=NROWS+1
      PI=3.141592654
```

```
      X=0.0
      DO 61 I=1,K
      WRITE(6,13)
 13   FORMAT(1H1//12X,'X',4X,'Y1',4X,'W1',8X,'QX1',7X,'VX1'
     1,7X,'MX1',7X,'MXY1'/33X,'QY1',7X,'VY1',7X,'MY1')
      Y1=-B1
      DO 51 J=1,K1
      W1=0.0
      QX1=0.0
      VX1=0.0
      MX1=0.0
      MXY1=0.0
      QY1=0.0
      VY1=0.0
      MY1=0.0
      DO 100 MODE=1,NMODES,2
      CALL EVAL(AMAT,A1,B1,B2,B3,X1,X2,U,H,POIS,E,D,Q,MODE,PI)
      CALL SOLVE(AMAT,NROWS,MCOLS,C)
      CALL EVAL(AMAT,A1,B1,B2,B3,X1,X2,U,H,POIS,E,D,Q,MODE,PI)
      ZETA=MODE*PI*Y1/A1
      WI=(C(1)*COSH(ZETA)+C(2)*ZETA*SINH(ZETA)+C(3)*SINH(ZETA)+
     1C(4)*ZETA*COSH(ZETA))*SIN(MODE*PI*X/A1)
      W1=W1+WI
      QXI=(-D*(MODE*PI/A1)**3)*(2*C(2)*COSH(ZETA)+2*C(4)*
     1SINH(ZETA))*COS(MODE*PI*X/A1)
      QX1=QXI+QX1
      VXI=(-D*(MODE*PI/A1)**3)*(C(1)*(1-POIS)*COSH(ZETA)
     1+C(2)*((4-2*POIS)*COSH(ZETA)+(1-POIS)*ZETA*
     1SINH(ZETA))+C(3)*(1-POIS)*SINH(ZETA)+C(4)*
     1((4-2*POIS)*SINH(ZETA)+(1-POIS)*ZETA*COSH(ZETA)))*
     1COS(MODE*PI*X/A1)
      VX1=VXI+VX1
      QYI=(-D*(MODE*PI/A1)**3)*(2*C(2)*SINH(ZETA)+2*C(4)*
     1COSH(ZETA))*SIN(MODE*PI*X/A1)
      QY1=QYI+QY1
      VYI=(-D*(MODE*PI/A1)**3)*(C(1)*(POIS-1)*SINH(ZETA)+C(2)
     1*((1+POIS)*SINH(ZETA)+(POIS-1)*ZETA*COSH(ZETA))+C(3)*
     1(POIS-1)*COSH(ZETA)+C(4)*((1+POIS)*COSH(ZETA)+(POIS-1)*
     1ZETA*SINH(ZETA)))*SIN(MODE*PI*X/A1)
      VY1=VYI+VY1
      MXI=(-D*(MODE*PI/A1)**2)*(C(1)*(POIS-1)*COSH(ZETA)
     1+C(2)*(2*POIS*COSH(ZETA)+(POIS-1)*ZETA*SINH(ZETA))
     1+C(3)*(POIS-1)*SINH(ZETA)+C(4)*(2*POIS*SINH(ZETA)+
     1(POIS-1)*ZETA*COSH(ZETA)))*SIN(MODE*PI*X/A1)
      MX1=MXI+MX1
      MYI=(-D*(MODE*PI/A1)**2)*(C(1)*(1-POIS)*COSH(ZETA)
     1+C(2)*(2*COSH(ZETA)+(1-POIS)*ZETA*SINH(ZETA))+
     1C(3)*(1-POIS)*SINH(ZETA)+C(4)*(2*SINH(ZETA)+
```

```
:    1(1-POIS)*ZETA*COSH(ZETA)))*SIN(MODE*PI*X/A1)
      MY1=MYI+MY1
      MXYI=(-D*(1-POIS)*(MODE*PI/A1)**2)*(C(1)*SINH(ZETA)
     1+C(2)*(SINH(ZETA)+ZETA*COSH(ZETA))+C(3)*COSH(ZETA)
     1+C(4)*(COSH(ZETA)+ZETA*SINH(ZETA)))*COS(MODE*PI*X/A1)
      MXY1=MXYI+MXY1
 100  CONTINUE
      WRITE(6,14) X,Y1,W1,QX1,VX1,MX1,MXY1,QY1,VY1,MY1
  14  FORMAT(11X,F4.1,1X,F5.1,1P5E10.2/31X,1P3E10.2)
      IF (ABS(Y1).LE.ABS(B2/2+1)) Y1=-6.5
  51  Y1=Y1+2.5
      WRITE(6,30)
  30  FORMAT(1H0,11X,'X',4X,'Y2',4X,'W2',8X,'QX2',7X,'VX2'
     1,7X,'MX2',7X,'MXY2'/33X,'QY2',7X,'VY2',7X,'MY2')
      Y2=-B2/2
      DO 71 L=1,K2
      W2=0.0
      QX2=0.0
      VX2=0.0
      MX2=0.0
      MXY2=0.0
      QY2=0.0
      VY2=0.0
      MY2=0.0
      DO 101 MODE=1,NMODES,2
      CALL EVAL(AMAT,A1,B1,B2,B3,X1,X2,U,H,POIS,E,D,Q,MODE,PI)
      CALL SOLVE(AMAT,NROWS,MCOLS,C)
      CALL EVAL(AMAT,A1,B1,B2,B3,X1,X2,U,H,POIS,E,D,Q,MODE,PI)
      ZETA=MODE*PI*Y2/A1
      WII=(AMAT(3,13)+C(5)*COSH(ZETA)+C(6)*ZETA*SINH(ZETA)+C(7)*
     1SINH(ZETA)+C(8)*ZETA*COSH(ZETA))*SIN(MODE*PI*X/A1)
      W2=W2+WII
      QXII=(-D*(MODE*PI/A1)**3)*((-AMAT(3,13))+C(6)*2*COSH(ZETA)+
     1C(8)*2*SINH(ZETA))*COS(MODE*PI*X/A1)
      QX2=QXII+QX2
      VXII=(-D*(MODE*PI/A1)**3)*(-AMAT(3,13)+C(5)*(1-POIS)*
     1COSH(ZETA)+C(6)*((4-2*POIS)*COSH(ZETA)+(1-POIS)*ZETA*
     1SINH(ZETA))+C(7)*(1-POIS)*SINH(ZETA)+C(8)*((4-2*POIS)*
     1SINH(ZETA)+(1-POIS)*ZETA*COSH(ZETA)))*COS(MODE*PI*X/A1)
      VX2=VXII+VX2
      QYII=(-D*(MODE*PI/A1)**3)*(2*C(6)*SINH(ZETA)+2*C(8)*
     1COSH(ZETA))*SIN(MODE*PI*X/A1)
      QY2=QYII+QY2
      VYII=(-D*(MODE*PI/A1)**3)*(C(5)*(POIS-1)*SINH(ZETA)+C(6)
     1*((1+POIS)*SINH(ZETA)+(POIS-1)*ZETA*COSH(ZETA))+C(7)*
     1(POIS-1)*COSH(ZETA)+C(8)*((1+POIS)*COSH(ZETA)+(POIS-1)*
     1ZETA*SINH(ZETA)))*SIN(MODE*PI*X/A1)
      VY2=VYII+VY2
```

```
:     MXII=(-D*(MODE*PI/A1)**2)*(-AMAT(3,13)+C(5)*(POIS-1)*COSH(ZETA)
     1+C(6)*(2*POIS*COSH(ZETA)+(POIS-1)*ZETA*SINH(ZETA))
     1+C(7)*(POIS-1)*SINH(ZETA)+C(8)*(2*POIS*SINH(ZETA)+
     1(POIS-1)*ZETA*COSH(ZETA)))*SIN(MODE*PI*X/A1)
      MX2=MXII+MX2
      MYII=(-D*(MODE*PI/A1)**2)*(-POIS*AMAT(3,13)+C(5)*(1-POIS)*
     1COSH(ZETA)+C(6)*(2*COSH(ZETA)+(1-POIS)*ZETA*SINH(ZETA))+
     1C(7)*(1-POIS)*SINH(ZETA)+C(8)*(2*SINH(ZETA)+
     1(1-POIS)*ZETA*COSH(ZETA)))*SIN(MODE*PI*X/A1)
      MY2=MYII+MY2
      MXYII=(-D*(1-POIS)*(MODE*PI/A1)**2)*(C(5)*SINH(ZETA)
     1+C(6)*(SINH(ZETA)+ZETA*COSH(ZETA))+C(7)*COSH(ZETA)
     1+C(8)*(COSH(ZETA)+ZETA*SINH(ZETA)))*COS(MODE*PI*X/A1)
      MXY2=MXYII+MXY2
 101  CONTINUE
      WRITE(6,31) X,Y2,W2,QX2,VX2,MX2,MXY2,QY2,VY2,MY2
  31  FORMAT(11X,F4.1,1X,F5.1,1P5E10.2/31X,1P3E10.2)
  71  Y2=Y2+2.0
      WRITE(6,15)
  15  FORMAT(1H0,11X,'X',4X,'Y3',4X,'W3',8X,'QX3',7X,'VX3'
     1,7X,'MX3',7X,'MXY3'/33X,'QY3',7X,'VY3',7X,'MY3')
      Y3=B2/2
      DO 81 J=1,K3
      W3=0.0
      QX3=0.0
      VX3=0.0
      MX3=0.0
      MXY3=0.0
      QY3=0.0
      VY3=0.0
      MY3=0.0
      DO 102 MODE=1,NMODES,2
      CALL EVAL(AMAT,A1,B1,B2,B3,X1,X2,U,H,POIS,E,D,Q,MODE,PI)
      CALL SOLVE(AMAT,NROWS,MCOLS,C)
      CALL EVAL(AMAT,A1,B1,B2,B3,X1,X2,U,H,POIS,E,D,Q,MODE,PI)
      ZETA=MODE*PI*Y3/A1
      WIII=(C(9)*COSH(ZETA)+C(10)*ZETA*SINH(ZETA)+C(11)*SINH(ZETA)+
     1C(12)*ZETA*COSH(ZETA))*SIN(MODE*PI*X/A1)
      W3=WIII+W3
      QXIII=(-D*(MODE*PI/A1)**3)*(2*C(10)*COSH(ZETA)+2*C(12)*
     1SINH(ZETA))*COS(MODE*PI*X/A1)
      QX3=QXIII+QX3
      VXIII=(-D*(MODE*PI/A1)**3)*(C(9)*(1-POIS)*COSH(ZETA)
     1+C(10)*((4-2*POIS)*COSH(ZETA)+(1-POIS)*ZETA*
     1SINH(ZETA))+C(11)*(1-POIS)*SINH(ZETA)+C(12)*
     1((4-2*POIS)*SINH(ZETA)+(1-POIS)*ZETA*COSH(ZETA)))*
     1COS(MODE*PI*X/A1)
      VX3=VXIII+VX3
```

```
:     QYIII=(-D*(MODE*PI/A1)**3)*(2*C(10)*SINH(ZETA)+2*C(12)*
     1COSH(ZETA))*SIN(MODE*PI*X/A1)
      QY3=QYIII+QY3
      VYIII=(-D*(MODE*PI/A1)**3)*(C(9)*(POIS-1)*SINH(ZETA)+C(10)
     1*((1+POIS)*SINH(ZETA)+(POIS-1)*ZETA*COSH(ZETA))+C(11)*
     1(POIS-1)*COSH(ZETA)+C(12)*((1+POIS)*COSH(ZETA)+(POIS-1)*
     1ZETA*SINH(ZETA)))*SIN(MODE*PI*X/A1)
      VY3=VYIII+VY3
      MXIII=(-D*(MODE*PI/A1)**2)*(C(9)*(POIS-1)*COSH(ZETA)
     1+C(10)*(2*POIS*COSH(ZETA)+(POIS-1)*ZETA*SINH(ZETA))
     1+C(11)*(POIS-1)*SINH(ZETA)+C(12)*(2*POIS*SINH(ZETA)+
     1(POIS-1)*ZETA*COSH(ZETA)))*SIN(MODE*PI*X/A1)
      MX3=MXIII+MX3
      MYIII=(-D*(MODE*PI/A1)**2)*(C(9)*(1-POIS)*COSH(ZETA)
     1+C(10)*(2*COSH(ZETA)+(1-POIS)*ZETA*SINH(ZETA))+
     1C(11)*(1-POIS)*SINH(ZETA)+C(12)*(2*SINH(ZETA)+
     1(1-POIS)*ZETA*COSH(ZETA)))*SIN(MODE*PI*X/A1)
      MY3=MYIII+MY3
      MXYIII=(-D*(1-POIS)*(MODE*PI/A1)**2)*(C(9)*SINH(ZETA)
     1+C(10)*(SINH(ZETA)+ZETA*COSH(ZETA))+C(11)*COSH(ZETA)
     1+C(12)*(COSH(ZETA)+ZETA*SINH(ZETA)))*COS(MODE*PI*X/A1)
      MXY3=MXYIII+MXY3
 102  CONTINUE
      WRITE(6,24) X,Y3,W3,QX3,VX3,MX3,MXY3,QY3,VY3,MY3
  24  FORMAT(11X,F4.1,1X,F5.1,1P5E10.2/31X,1P3E10.2)
      IF (Y3.GE.5) GO TO 81
      Y3=2.5
  81  Y3=Y3+2.5
  61  X=X+1
      STOP
      END
C==============================================================
      SUBROUTINE EVAL(A,A1,B1,B2,B3,X1,X2,U,H,POIS,E,D,Q,MODE,PI)
      DIMENSION A(12,13)
      ALPHA1=MODE*PI*B1/A1
      ALPHA2=MODE*PI*B2/(2*A1)
      ALPHA3=MODE*PI*B3/A1
      BETA1=MODE*PI*X1/A1
      BETA2=MODE*PI*X2/A1
      GAMMA=MODE*PI*U/(2*A1)
      DO 50 I=1,12
      DO 50 J=1,13
  50  A(I,J)=0.0
      A(1,1)=(1-POIS)*COSH(ALPHA1)
      A(1,2)=2*COSH(ALPHA1)+(1-POIS)*ALPHA1*SINH(ALPHA1)
      A(1,3)=-(1-POIS)*SINH(ALPHA1)
      A(1,4)=-2*SINH(ALPHA1)+(POIS-1)*ALPHA1*COSH(ALPHA1)
      A(2,1)=(1-POIS)*SINH(ALPHA1)
```

```
:      A(2,2)=-(1+POIS)*SINH(ALPHA1)+(1-POIS)*ALPHA1*COSH(ALPHA1)
       A(2,3)=(POIS-1)*COSH(ALPHA1)
       A(2,4)=(1+POIS)*COSH(ALPHA1)+(POIS-1)*ALPHA1*SINH(ALPHA1)
       A(3,1)=COSH(ALPHA2)
       A(3,2)=ALPHA2*SINH(ALPHA2)
       A(3,3)=-SINH(ALPHA2)
       A(3,4)=-ALPHA2*COSH(ALPHA2)
       A(3,5)=-A(3,1)
       A(3,6)=-A(3,2)
       A(3,7)=-A(3,3)
       A(3,8)=-A(3,4)
       A(3,13)=((4*Q*A1**4)/(D*(MODE*PI)**5))*(SIN(BETA1)
      1+SIN(BETA2))*SIN(GAMMA)
       A(4,1)=-SINH(ALPHA2)
       A(4,2)=-(SINH(ALPHA2)+ALPHA2*COSH(ALPHA2))
       A(4,3)=COSH(ALPHA2)
       A(4,4)=COSH(ALPHA2)+ALPHA2*SINH(ALPHA2)
       A(4,5)=-A(4,1)
       A(4,6)=-A(4,2)
       A(4,7)=-A(4,3)
       A(4,8)=-A(4,4)
       A(5,1)=COSH(ALPHA2)
       A(5,2)=2*COSH(ALPHA2)+ALPHA2*SINH(ALPHA2)
       A(5,3)=-SINH(ALPHA2)
       A(5,4)=-(2*SINH(ALPHA2)+ALPHA2*COSH(ALPHA2))
       A(5,5)=-A(5,1)
       A(5,6)=-A(5,2)
       A(5,7)=-A(5,3)
       A(5,8)=-A(5,4)
       A(6,1)=-SINH(ALPHA2)
       A(6,2)=-(3*SINH(ALPHA2)+ALPHA2*COSH(ALPHA2))
       A(6,3)=COSH(ALPHA2)
       A(6,4)=3*COSH(ALPHA2)+ALPHA2*SINH(ALPHA2)
       A(6,5)=-A(6,1)
       A(6,6)=-A(6,2)
       A(6,7)=-A(6,3)
       A(6,8)=-A(6,4)
       A(7,5)=A(3,1)
       A(7,6)=A(3,2)
       A(7,7)=-A(3,3)
       A(7,8)=-A(3,4)
       A(7,9)=A(3,5)
       A(7,10)=A(3,6)
       A(7,11)=-A(3,7)
       A(7,12)=-A(3,8)
       A(7,13)=-A(3,13)
       A(8,5)=-A(4,1)
       A(8,6)=-A(4,2)
```

```
:     A(8,7)=A(4,3)
      A(8,8)=A(4,4)
      A(8,9)=-A(4,5)
      A(8,10)=-A(4,6)
      A(8,11)=A(4,7)
      A(8,12)=A(4,8)
      A(9,5)=A(5,1)
      A(9,6)=A(5,2)
      A(9,7)=-A(5,3)
      A(9,8)=-A(5,4)
      A(9,9)=A(5,5)
      A(9,10)=A(5,6).
      A(9,11)=-A(5,7)
      A(9,12)=-A(5,8)
      A(10,5)=-A(6,1)
      A(10,6)=-A(6,2)
      A(10,7)=A(6,3)
      A(10,8)=A(6,4)
      A(10,9)=-A(6,5)
      A(10,10)=-A(6,6)
      A(10,11)=A(6,7)
      A(10,12)=A(6,8)
      A(11,9)=(1-POIS)*COSH(ALPHA3)
      A(11,10)=2*COSH(ALPHA3)+(1-POIS)*ALPHA3*SINH(ALPHA3)
      A(11,11)=(1-POIS)*SINH(ALPHA3)
      A(11,12)=2*SINH(ALPHA3)+(1-POIS)*ALPHA3*COSH(ALPHA3)
      A(12,9)=(POIS-1)*SINH(ALPHA3)
      A(12,10)=(1+POIS)*SINH(ALPHA3)+(POIS-1)*ALPHA3*COSH(ALPHA3)
      A(12,11)=(POIS-1)*COSH(ALPHA3)
      A(12,12)=(1+POIS)*COSH(ALPHA3)+(POIS-1)*ALPHA3*SINH(ALPHA3)
      RETURN
      END
C=================================================================
      SUBROUTINE SOLVE(A,N,M,X)
      DIMENSION A(12,13),X(12)
      L=N-1
      DO 22 K=1,L
      JJ=K
      BIG=ABS(A(K,K))
      KP1=K+1
C
C      SEARCH FOR LARGEST POSSIBLE PIVOT ELEMENT
      DO 17 I=KP1,N
      AB=ABS(A(I,K))
      IF(BIG-AB) 16,17,17
   16 BIG=AB
      JJ=I
   17 CONTINUE
```

```
C
C      DECISION ON NECESSITY OF ROW INTERCHANGE
      IF(JJ-K) 18,20,18
C
C      ROW INTERCHANGE
   18 DO 19 J=K,M
      TEMP=A(JJ,J)
      A(JJ,J)=A(K,J)
   19 A(K,J)=TEMP
C
C      CALCULATION OF ELEMENT OF NEW MATRIX
   20 DO 21 I=KP1,N
      QUAT=A(I,K)/A(K,K)
      DO 21 J=KP1,M
   21 A(I,J)=A(I,J)-QUAT*A(K,J)
      DO 22 I=KP1,N
   22 A(I,K)=0.0
C
C      FIRST STEP IN BACK-SUBSTITUTION
      X(N)=A(N,M)/A(N,N)
C
C      REMAINDER OF BACK-SUBSTITUTION
      DO 24 NN=1,L
      SUM=0.0
      I=N-NN
      IP1=I+1
      DO 23 J=IP1,N
   23 SUM=SUM+A(I,J)*X(J)
   24 X(I)=(A(I,M)-SUM)/A(I,I)
      RETURN
      END
C==============================================================
$ENTRY
```

D.2.2

EDGE STRIP LOADING

```
      DIMENSION AMAT(8,9),C(8),BMAT(8,9)
      REAL MXY1,MXYI,MXY2,MXYII,MX1,MXI,MX2,MXII,MY1,MYI,MY2,MYII
      READ,A1,B1,B2,X1,X2,U,H,POIS,EFFI,FPRC,P,NMODES
      B=B1+B2
      Q=P/(2*(U*B2))
      E=57000*(FPRC**0.5)
      D=E*EFFI/(1-POIS*POIS)
      WRITE(6,2) A1,B,B1,B2,H,FPRC,EFFI,POIS,E,D
    2 FORMAT(1H1,23X,'LEVY SOLUTION FOR PLATE ANALYSIS'//
     112X,'PLAT DATA'//
     212X,'LENGTH OF PLATE                         (IN)',F12.2/
     312X,'WIDTH OF PLATE                          (IN)',F12.2/
     412X,'UNLOADED WIDTH OF PLATE                 (IN)',F12.2/
     512X,'LOADED WIDTH OF PLATE                   (IN)',F12.2/
     612X,'THICKNESS OF PLATE                      (IN)',F12.2/
     612X,'FPRC IS COMP. STRENGHT OF CONC.       (PSI)',F12.2/
     612X,'EFFI IS EFF. MOM. OF INERTIA     (IN.**4)',F12.2/
     712X,'POISSON''S RATIO OF PLATE                  ',F12.2/
     812X,'ELASTIC MODOLUS OF PLATE              (PSI)',1PE12.2/
     912X,'FLEXURAL RIGIDITY OF PLAT            (#-IN)',1PE12.2/)
      WRITE(6,3) X1,X2,U,Q,P
    3 FORMAT(12X,'LOAD DATA'//
     112X,'CENTER LOCATION OF FIRST LOAD           (IN)',F12.2/
     212X,'CENTER LOCATION OF SECOND LOAD          (IN)',F12.2/
     312X,'LENGTH OF EACH DISTRIBUTED LOAD 1       (IN)',F12.2/
     412X,'INTENSITY OF DISTRIBUTED LOAD          (PSI)',F12.2/
     512X,'TOTAL LOAD                               (#)',F12.2/)
      WRITE(6,4) NMODES
    4 FORMAT(12X,'NUMBER OF SERIES TERM USED              ',I12/
     112X,'X=0.0 & X=A1  ARE SIMPLY SUPPORTED EDGES'/
     312X,'Y1 IS UNLOADED WIDTH'/
     412X,'Y2 IS LODED WIDTH'/)
      K=A1+1
      K1=B1/4+2
      K2=B2/2+1
      NROWS=8
      MCOLS=NROWS+1
      PI=3.141592654
      X=0.0
      DO 61 I=1,K
      WRITE(6,13)
   13 FORMAT(1H1//12X,'X',4X,'Y1',4X,'W1',8X,'QX1',7X,'VX1'
     1,7X,'MX1',7X,'MXY1'/33X,'QY1',7X,'VY1',7X,'MY1')
      Y1=-B1
```

```
      DO 51 J=1,K1
      W1=0.0
      QX1=0.0
      VX1=0.0
      MX1=0.0
      MXY1=0.0
      QY1=0.0
      VY1=0.0
      MY1=0.0
      DO 100 MODE=1,NMODES,2
      CALL EVAL(AMAT,A1,B1,B2,X1,X2,U,H,POIS,E,D,Q,MODE,PI)
      CALL SOLVE(AMAT,NROWS,MCOLS,C)
      CALL EVAL(AMAT,A1,B1,B2,X1,X2,U,H,POIS,E,D,Q,MODE,PI)
      ZETA=MODE*PI*Y1/A1
      WI=(C(1)*COSH(ZETA)+C(2)*ZETA*SINH(ZETA)+C(3)*SINH(ZETA)+
     1C(4)*ZETA*COSH(ZETA))*SIN(MODE*PI*X/A1)
      W1=W1+WI
      QXI=(-D*(MODE*PI/A1)**3)*(2*C(2)*COSH(ZETA)+2*C(4)*
     1SINH(ZETA))*COS(MODE*PI*X/A1)
      QX1=QXI+QX1
      VXI=(-D*(MODE*PI/A1)**3)*(C(1)*(1-POIS)*COSH(ZETA)
     1+C(2)*((4-2*POIS)*COSH(ZETA)+(1-POIS)*ZETA*
     1SINH(ZETA))+C(3)*(1-POIS)*SINH(ZETA)+C(4)*
     1((4-2*POIS)*SINH(ZETA)+(1-POIS)*ZETA*COSH(ZETA)))*
     1COS(MODE*PI*X/A1)
      VX1=VXI+VX1
      QYI=(-D*(MODE*PI/A1)**3)*(2*C(2)*SINH(ZETA)+2*C(4)*
     1COSH(ZETA))*SIN(MODE*PI*X/A1)
      QY1=QYI+QY1
      VYI=(-D*(MODE*PI/A1)**3)*(C(1)*(POIS-1)*SINH(ZETA)+C(2)
     1*((1+POIS)*SINH(ZETA)+(POIS-1)*ZETA*COSH(ZETA))+C(3)*
     1(POIS-1)*COSH(ZETA)+C(4)*((1+POIS)*COSH(ZETA)+(POIS-1)*
     1ZETA*SINH(ZETA)))*SIN(MODE*PI*X/A1)
      VY1=VYI+VY1
      MXI=(-D*(MODE*PI/A1)**2)*(C(1)*(POIS-1)*COSH(ZETA)
     1+C(2)*(2*POIS*COSH(ZETA)+(POIS-1)*ZETA*SINH(ZETA))
     1+C(3)*(POIS-1)*SINH(ZETA)+C(4)*(2*POIS*SINH(ZETA)+
     1(POIS-1)*ZETA*COSH(ZETA)))*SIN(MODE*PI*X/A1)
      MX1=MXI+MX1
      MYI=(-D*(MODE*PI/A1)**2)*(C(1)*(1-POIS)*COSH(ZETA)
     1+C(2)*(2*COSH(ZETA)+(1-POIS)*ZETA*SINH(ZETA))+
     1C(3)*(1-POIS)*SINH(ZETA)+C(4)*(2*SINH(ZETA)+
     1(1-POIS)*ZETA*COSH(ZETA)))*SIN(MODE*PI*X/A1)
      MY1=MYI+MY1
      MXYI=(-D*(1-POIS)*(MODE*PI/A1)**2)*(C(1)*SINH(ZETA)
     1+C(2)*(SINH(ZETA)+ZETA*COSH(ZETA))+C(3)*COSH(ZETA)
     1+C(4)*(COSH(ZETA)+ZETA*SINH(ZETA)))*COS(MODE*PI*X/A1)
      MXY1=MXYI+MXY1
```

```
:100  CONTINUE
      WRITE(6,14) X,Y1,W1,QX1,VX1,MX1,MXY1,QY1,VY1,MY1
  14  FORMAT(11X,F4.1,1X,F6.1,1P1E9.2,1P4E10.2/31X,1P3E10.2)
      IF (Y1.GE.-1) Y1=-4
  51  Y1=Y1+4
      WRITE(6,30)
  30  FORMAT(1H0,11X,'X',4X,'Y2',4X,'W2',8X,'QX2',7X,'VX2'
     .1,7X,'MX2',7X,'MXY2'/33X,'QY2',7X,'VY2',7X,'MY2')
      Y2=0.0
      DO 71 L=1,K2
      W2=0.0
      QX2=0.0
      VX2=0.0
      MX2=0.0
      MXY2=0.0
      QY2=0.0
      VY2=0.0
      MY2=0.0
      DO 101 MODE=1,NMODES,2
      CALL EVAL(AMAT,A1,B1,B2,X1,X2,U,H,POIS,E,D,Q,MODE,PI)
      CALL SOLVE(AMAT,NROWS,MCOLS,C)
      CALL EVAL(AMAT,A1,B1,B2,X1,X2,U,H,POIS,E,D,Q,MODE,PI)
      ZETA=MODE*PI*Y2/A1
      WII=(AMAT(1,9)+C(5)*COSH(ZETA)+C(6)*ZETA*SINH(ZETA)+C(7)*
     1SINH(ZETA)+C(8)*ZETA*COSH(ZETA))*SIN(MODE*PI*X/A1)
      W2=W2+WII
      QXII=(-D*(MODE*PI/A1)**3)*((-AMAT(1,9))+C(6)*2*COSH(ZETA)+
     1C(8)*2*SINH(ZETA))*COS(MODE*PI*X/A1)
      QX2=QXII+QX2
      VXII=(-D*(MODE*PI/A1)**3)*(-AMAT(1,9)+C(5)*(1-POIS)*
     1COSH(ZETA)+C(6)*((4-2*POIS)*COSH(ZETA)+(1-POIS)*ZETA*
     1SINH(ZETA))+C(7)*(1-POIS)*SINH(ZETA)+C(8)*((4-2*POIS)*
     1SINH(ZETA)+(1-POIS)*ZETA*COSH(ZETA)))*COS(MODE*PI*X/A1)
      VX2=VXII+VX2
      QYII=(-D*(MODE*PI/A1)**3)*(2*C(6)*SINH(ZETA)+2*C(8)*
     1COSH(ZETA))*SIN(MODE*PI*X/A1)
      QY2=QYII+QY2
      VYII=(-D*(MODE*PI/A1)**3)*(C(5)*(POIS-1)*SINH(ZETA)+C(6)
     1*((1+POIS)*SINH(ZETA)+(POIS-1)*ZETA*COSH(ZETA))+C(7)*
     1(POIS-1)*COSH(ZETA)+C(8)*((1+POIS)*COSH(ZETA)+(POIS-1)*
     1ZETA*SINH(ZETA)))*SIN(MODE*PI*X/A1)
      VY2=VYII+VY2
      MXII=(-D*(MODE*PI/A1)**2)*(-AMAT(1,9)+C(5)*(POIS-1)*COSH(ZETA)
     1+C(6)*(2*POIS*COSH(ZETA)+(POIS-1)*ZETA*SINH(ZETA))
     1+C(7)*(POIS-1)*SINH(ZETA)+C(8)*(2*POIS*SINH(ZETA)+
     1(POIS-1)*ZETA*COSH(ZETA)))*SIN(MODE*PI*X/A1)
      MX2=MXII+MX2
      MYII=(-D*(MODE*PI/A1)**2)*(-POIS*AMAT(1,9)+C(5)*(1-POIS)*
```

```
:     1COSH(ZETA)+C(6)*(2*COSH(ZETA)+(1-POIS)*ZETA*SINH(ZETA))+
      1C(7)*(1-POIS)*SINH(ZETA)+C(8)*(2*SINH(ZETA)+
      1(1-POIS)*ZETA*COSH(ZETA)))*SIN(MODE*PI*X/A1)
       MY2=MYII+MY2
       MXYII=(-D*(1-POIS)*(MODE*PI/A1)**2)*(C(5)*SINH(ZETA)
      1+C(6)*(SINH(ZETA)+ZETA*COSH(ZETA))+C(7)*COSH(ZETA)
      1+C(8)*(COSH(ZETA)+ZETA*SINH(ZETA)))*COS(MODE*PI*X/A1)
     . MXY2=MXYII+MXY2
 101   CONTINUE
       WRITE(6,31) X,Y2,W2,QX2,VX2,MX2,MXY2,QY2,VY2,MY2
  31   FORMAT(11X,F4.1,1X,F6.1,1P1E9.2,1P4E10.2,/31X,1P3E10.2)
  71   Y2=Y2+2
  61   X=X+1
       STOP
       END
C=================================================================
       SUBROUTINE EVAL(A,A1,B1,B2,X1,X2,U,H,POIS,E,D,Q,MODE,PI)
       DIMENSION A(8,9)
       ALPHA1=MODE*PI*B1/A1
       ALPHA2=MODE*PI*B2/A1
       BETA1=MODE*PI*X1/A1
       BETA2=MODE*PI*X2/A1
       GAMMA=MODE*PI*U/(2*A1)
       DO 50 I=1,8
       DO 50 J=1,9
  50   A(I,J)=0.0
       A(1,1)=1
       A(1,5)=-1
       A(1,9)=((4*Q*A1**4)/(D*(MODE*PI)**5))*(SIN(BETA1)
      1+SIN(BETA2))*SIN(GAMMA)
       A(2,3)=1
       A(2,4)=1
       A(2,7)=-1
       A(2,8)=-1
       A(3,1)=1
       A(3,2)=2
       A(3,5)=-1
       A(3,6)=-2
       A(4,3)=1
       A(4,4)=3
       A(4,7)=-1
       A(4,8)=-3
       A(5,1)=(1-POIS)*COSH(ALPHA1)
       A(5,2)=2*COSH(ALPHA1)+(1-POIS)*ALPHA1*SINH(ALPHA1)
       A(5,3)=(POIS-1)*SINH(ALPHA1)
       A(5,4)=-2*SINH(ALPHA1)-(1-POIS)*ALPHA1*COSH(ALPHA1)
       A(6,1)=(1-POIS)*SINH(ALPHA1)
       A(6,2)=-(1+POIS)*SINH(ALPHA1)-(POIS-1)*ALPHA1*COSH(ALPHA1)
```

```
:     A(6,3)=(POIS-1)*COSH(ALPHA1)
      A(6,4)=(1+POIS)*COSH(ALPHA1)+(POIS-1)*ALPHA1*SINH(ALPHA1)
      A(7,5)=(1-POIS)*COSH(ALPHA2)
      A(7,6)=2*COSH(ALPHA2)+(1-POIS)*ALPHA2*SINH(ALPHA2)
      A(7,7)=(1-POIS)*SINH(ALPHA2)
      A(7,8)=2*SINH(ALPHA2)+(1-POIS)*ALPHA2*COSH(ALPHA2)
      A(7,9)=POIS*A(1,9)
      A(8,5)=(POIS-1)*SINH(ALPHA2)
      A(8,6)=(POIS+1)*SINH(ALPHA2)+(POIS-1)*ALPHA2*COSH(ALPHA2)
      A(8,7)=(POIS-1)*COSH(ALPHA2)
      A(8,8)=(1+POIS)*COSH(ALPHA2)+(POIS-1)*ALPHA2*SINH(ALPHA2)
      RETURN
      END
C=================================================================
      SUBROUTINE SOLVE(A,N,M,X)
      DIMENSION A(8,9),X(8)
      L=N-1
      DO 22 K=1,L
      JJ=K
      BIG=ABS(A(K,K))
      KP1=K+1
C
C      SEARCH FOR LARGEST POSSIBLE PIVOT ELEMENT
      DO 17 I=KP1,N
      AB=ABS(A(I,K))
      IF(BIG-AB) 16,17,17
   16 BIG=AB
      JJ=I
   17 CONTINUE
C
C      DECISION ON NECESSITY OF ROW INTERCHANGE
      IF(JJ-K) 18,20,18
C
C      ROW INTERCHANGE
   18 DO 19 J=K,M
      TEMP=A(JJ,J)
      A(JJ,J)=A(K,J)
   19 A(K,J)=TEMP
C
C      CALCULATION OF ELEMENT OF NEW MATRIX
   20 DO 21 I=KP1,N
      QUAT=A(I,K)/A(K,K)
      DO 21 J=KP1,M
   21 A(I,J)=A(I,J)-QUAT*A(K,J)
      DO 22 I=KP1,N
   22 A(I,K)=0.0
C
C      FIRST STEP IN BACK-SUBSTITUTION
```

```
:       X(N)=A(N,M)/A(N,N)
C
C        REMAINDER OF BACK-SUBSTITUTION
        DO 24 NN=1,L
        SUM=0.0
        I=N-NN
        IP1=I+1
        DO 23 J=IP1,N
   23   SUM=SUM+A(I,J)*X(J)
   24   X(I)=(A(I,M)-SUM)/A(I,I)
        RETURN
        END
C=================================================================
$ENTRY
```

D.3.0

COMPUTER OUTPUT FOR WIDE PLATES

D.3.1

CENTER STRIP LOADED PLATES

LEVY SOLUTION FOR PLATE ANALYSIS

PLAT DATA

LENGTH OF PLATE	(IN)	26.00
WIDTH OF PLATE	(IN)	25.00
UNLOADED WIDTH OF PLATE	(IN)	8.50
LOADED WIDTH OF PLATE	(IN)	8.00
UNLOADED WIDTH OF PLATE	(IN)	8.50
THICKNESS OF PLATE	(IN)	3.00
FPRC IS COMP. STRENGHT OF CONC.	(PSI)	3600.00
EFFI IS EFF. MOM. OF INERTIA	(IN.**4)	0.83
POISSON'S RATIO OF PLATE		0.15
ELASTIC MODOLUS OF PLATE	(PSI)	3.42E 06
FLEXURAL RIGIDITY OF PLAT	(#-IN)	2.90E 06

LOAD DATA

CENTER LOCATION OF FIRST LOAD	(IN)	7.00
CENTER LOCATION OF SECOND LOAD	(IN)	19.00
LENGTH OF EACH DISTRIBUTED LOAD	(IN)	4.00
INTENSITY OF DISTRIBUTED LOAD	(PSI)	312.50
TOTATAL LOAD	(#)	20000.00

NUMBER OF SERIES TERM USED 5

X=0.0 & X=A1 ARE SIMPLY SUPPORTED EDGES

Y1 AND Y3 ARE UNLOADED WIDTHS

Y2 IS LODED WIDTH

X	Y1	W1	QX1	VX1	MX1	MXY1
			QY1	VY1	MY1	
0.0	-12.5	0.00E-01	3.12E 02	2.66E 02	0.00E-01	-1.66E 02
			0.00E-01	0.00E-01	0.00E-01	
0.0	-10.0	0.00E-01	3.20E 02	2.67E 02	0.00E-01	-2.94E 02
			0.00E-01	0.00E-01	0.00E-01	
0.0	-7.5	0.00E-01	3.64E 02	3.33E 02	0.00E-01	-4.05E 02
			0.00E-01	0.00E-01	0.00E-01	
0.0	-5.0	0.00E-01	4.38E 02	4.63E 02	0.00E-01	-4.21E 02
			0.00E-01	0.00E-01	0.00E-01	
0.0	-4.0	0.00E-01	4.65E 02	5.17E 02	0.00E-01	-3.82E 02
			0.00E-01	0.00E-01	0.00E-01	
X	Y2	W2	QX2	VX2	MX2	MXY2
			QY2	VY2	MY2	
0.0	-4.0	0.00E-01	4.65E 02	5.17E 02	0.00E-01	-3.82E 02
			0.00E-01	0.00E-01	0.00E-01	
0.0	-2.0	0.00E-01	5.13E 02	6.13E 02	0.00E-01	-2.28E 02
			0.00E-01	0.00E-01	0.00E-01	
0.0	0.0	0.00E-01	5.34E 02	6.54E 02	0.00E-01	4.37E-04
			0.00E-01	0.00E-01	0.00E-01	
0.0	2.0	0.00E-01	5.13E 02	6.13E 02	0.00E-01	2.28E 02
			0.00E-01	0.00E-01	0.00E-01	
0.0	4.0	0.00E-01	4.65E 02	5.17E 02	0.00E-01	3.82E 02
			0.00E-01	0.00E-01	0.00E-01	
X	Y3	W3	QX3	VX3	MX3	MXY3
			QY3	VY3	MY3	
0.0	4.0	0.00E-01	4.65E 02	5.17E 02	0.00E-01	3.82E 02
			0.00E-01	0.00E-01	0.00E-01	
0.0	5.0	0.00E-01	4.38E 02	4.63E 02	0.00E-01	4.21E 02
			0.00E-01	0.00E-01	0.00E-01	
0.0	7.5	0.00E-01	3.64E 02	3.33E 02	0.00E-01	4.05E 02
			0.00E-01	0.00E-01	0.00E-01	
0.0	10.0	0.00E-01	3.20E 02	2.68E 02	0.00E-01	2.94E 02
			0.00E-01	0.00E-01	0.00E-01	
0.0	12.5	0.00E-01	3.11E 02	2.66E 02	0.00E-01	1.65E 02
			0.00E-01	0.00E-01	0.00E-01	

X	Y1	W1	QX1	VX1	MX1	MXY1
			QY1	VY1	MY1	
1.0	-12.5	8.20E-03	3.09E 02	2.63E 02	3.54E 02	-1.64E 02
			-4.32E 00	-3.44E-01	5.75E-01	
1.0	-10.0	8.43E-03	3.17E 02	2.65E 02	3.71E 02	-2.90E 02
			1.06E 01	1.72E 01	-4.81E 00	
1.0	-7.5	8.79E-03	3.62E 02	3.29E 02	3.95E 02	-4.02E 02
			2.51E 01	3.15E 01	2.28E 01	
1.0	-5.0	9.22E-03	4.40E 02	4.62E 02	4.15E 02	-4.22E 02
			3.20E 01	3.08E 01	8.98E 01	
1.0	-4.0	9.38E-03	4.73E 02	5.24E 02	4.16E 02	-3.85E 02
			2.44E 01	2.02E 01	1.22E 02	
X	Y2	W2	QX2	VX2	MX2	MXY2
			QY2	VY2	MY2	
1.0	-4.0	9.38E-03	4.73E 02	5.24E 02	4.16E 02	-3.85E 02
			2.44E 01	2.02E 01	1.22E 02	
1.0	-2.0	9.63E-03	5.29E 02	6.30E 02	4.17E 02	-2.28E 02
			2.06E 01	1.90E 01	1.79E 02	
1.0	0.0	9.73E-03	5.51E 02	6.72E 02	4.19E 02	6.89E-04
			4.74E-04	9.64E-04	2.01E 02	
1.0	2.0	9.63E-03	5.29E 02	6.30E 02	4.17E 02	2.28E 02
			-2.06E 01	-1.90E 01	1.79E 02	
1.0	4.0	9.38E-03	4.73E 02	5.24E 02	4.16E 02	3.85E 02
			-2.44E 01	-2.02E 01	1.22E 02	
X	Y3	W3	QX3	VX3	MX3	MXY3
			QY3	VY3	MY3	
1.0	4.0	9.38E-03	4.73E 02	5.24E 02	4.16E 02	3.85E 02
			-2.44E 01	-2.02E 01	1.22E 02	
1.0	5.0	9.22E-03	4.40E 02	4.62E 02	4.15E 02	4.22E 02
			-3.20E 01	-3.08E 01	8.98E 01	
1.0	7.5	8.79E-03	3.62E 02	3.29E 02	3.95E 02	4.02E 02
			-2.51E 01	-3.15E 01	2.28E 01	
1.0	10.0	8.43E-03	3.17E 02	2.65E 02	3.71E 02	2.90E 02
			-1.05E 01	-1.72E 01	-3.66E 00	
1.0	12.5	8.20E-03	3.08E 02	2.63E 02	3.55E 02	1.63E 02
			3.97E 00	-3.04E-03	5.75E-01	

X	Y1	W1	QX1	VX1	MX1	MXY1
			QY1	VY1	MY1	
2.0	-12.5	1.63E-02	3.00E 02	2.55E 02	7.03E 02	-1.56E 02
			-8.47E 00	-5.65E-01	9.46E-01	
2.0	-10.0	1.67E-02	3.08E 02	2.57E 02	7.36E 02	-2.80E 02
			2.10E 01	3.45E 01	-9.79E 00	
2.0	-7.5	1.74E-02	3.53E 02	3.19E 02	7.86E 02	-3.92E 02
			5.09E 01	6.56E 01	4.36E 01	
2.0	-5.0	1.83E-02	4.41E 02	4.59E 02	8.35E 02	-4.21E 02
			7.12E 01	7.47E 01	1.76E 02	
2.0	-4.0	1.86E-02	4.89E 02	5.39E 02	8.46E 02	-3.88E 02
			6.40E 01	6.22E 01	2.45E 02	

X	Y2	W2	QX2	VX2	MX2	MXY2
			QY2	VY2	MY2	
2.0	-4.0	1.86E-02	4.89E 02	5.39E 02	8.46E 02	-3.88E 02
			6.40E 01	6.23E 01	2.44E 02	
2.0	-2.0	1.91E-02	5.67E 02	6.70E 02	8.62E 02	-2.29E 02
			4.45E 01	4.50E 01	3.63E 02	
2.0	0.0	1.93E-02	5.93E 02	7.14E 02	8.70E 02	1.36E-03
			7.70E-04	1.58E-03	4.08E 02	
2.0	2.0	1.91E-02	5.67E 02	6.70E 02	8.62E 02	2.29E 02
			-4.45E 01	-4.50E 01	3.63E 02	
2.0	4.0	1.86E-02	4.89E 02	5.39E 02	8.46E 02	3.88E 02
			-6.40E 01	-6.22E 01	2.45E 02	

X	Y3	W3	QX3	VX3	MX3	MXY3
			QY3	VY3	MY3	
2.0	4.0	1.86E-02	4.89E 02	5.39E 02	8.46E 02	3.88E 02
			-6.40E 01	-6.22E 01	2.45E 02	
2.0	5.0	1.83E-02	4.41E 02	4.59E 02	8.35E 02	4.21E 02
			-7.12E 01	-7.47E 01	1.76E 02	
2.0	7.5	1.74E-02	3.53E 02	3.19E 02	7.86E 02	3.92E 02
			-5.09E 01	-6.56E 01	4.35E 01	
2.0	10.0	1.67E-02	3.08E 02	2.57E 02	7.35E 02	2.80E 02
			-2.10E 01	-3.45E 01	-7.90E 00	
2.0	12.5	1.63E-02	3.00E 02	2.55E 02	7.04E 02	1.56E 02
			7.90E 00	-5.70E-03	9.46E-01	

X	Y1	W1	QX1 / QY1	VX1 / VY1	MX1 / MY1	MXY1
3.0	-12.5	2.41E-02	2.85E 02	2.42E 02	1.04E 03	-1.44E 02
			-1.23E 01	-5.85E-01	9.82E-01	
3.0	-10.0	2.48E-02	2.93E 02	2.44E 02	1.09E 03	-2.63E 02
			3.13E 01	5.18E 01	-1.48E 01	
3.0	-7.5	2.58E-02	3.38E 02	3.03E 02	1.17E 03	-3.72E 02
			7.75E 01	1.03E 02	6.12E 01	
3.0	-5.0	2.71E-02	4.36E 02	4.46E 02	1.26E 03	-4.12E 02
			1.21E 02	1.38E 02	2.56E 02	
3.0	-4.0	2.76E-02	5.00E 02	5.47E 02	1.29E 03	-3.85E 02
			1.27E 02	1.38E 02	3.67E 02	

X	Y2	W2	QX2 / QY2	VX2 / VY2	MX2 / MY2	MXY2
3.0	-4.0	2.76E-02	5.00E 02	5.47E 02	1.29E 03	-3.85E 02
			1.27E 02	1.38E 02	3.67E 02	
3.0	-2.0	2.83E-02	6.03E 02	7.06E 02	1.34E 03	-2.25E 02
			7.32E 01	8.17E 01	5.55E 02	
3.0	0.0	2.86E-02	6.33E 02	7.50E 02	1.37E 03	2.22E-03
			7.73E-04	1.63E-03	6.19E 02	
3.0	2.0	2.83E-02	6.03E 02	7.06E 02	1.34E 03	2.25E 02
			-7.32E 01	-8.17E 01	5.55E 02	
3.0	4.0	2.76E-02	5.00E 02	5.47E 02	1.29E 03	3.85E 02
			-1.27E 02	-1.38E 02	3.67E 02	

X	Y3	W3	QX3 / QY3	VX3 / VY3	MX3 / MY3	MXY3
3.0	4.0	2.76E-02	5.00E 02	5.47E 02	1.29E 03	3.85E 02
			-1.27E 02	-1.38E 02	3.67E 02	
3.0	5.0	2.71E-02	4.36E 02	4.46E 02	1.26E 03	4.12E 02
			-1.21E 02	-1.38E 02	2.56E 02	
3.0	7.5	2.58E-02	3.38E 02	3.03E 02	1.17E 03	3.72E 02
			-7.75E 01	-1.03E 02	6.11E 01	
3.0	10.0	2.48E-02	2.93E 02	2.44E 02	1.09E 03	2.63E 02
			-3.13E 01	-5.17E 01	-1.28E 01	
3.0	12.5	2.41E-02	2.85E 02	2.42E 02	1.04E 03	1.44E 02
			1.17E 01	-7.65E-03	9.83E-01	

X	Y1	W1	QX1	VX1	MX1	MXY1
			QY1	VY1	MY1	
4.0	-12.5	3.16E-02	2.65E 02	2.24E 02	1.36E 03	-1.28E 02
			-1.54E 01	-3.96E-01	6.71E-01	
4.0	-10.0	3.24E-02	2.73E 02	2.28E 02	1.42E 03	-2.39E 02
			4.09E 01	6.80E 01	-1.90E 01	
4.0	-7.5	3.38E-02	3.14E 02	2.81E 02	1.53E 03	-3.39E 02
			1.04E 02	1.43E 02	7.60E 01	
4.0	-5.0	3.54E-02	4.14E 02	4.19E 02	1.68E 03	-3.84E 02
			1.80E 02	2.19E 02	3.27E 02	
4.0	-4.0	3.61E-02	4.89E 02	5.31E 02	1.75E 03	-3.62E 02
			2.11E 02	2.45E 02	4.86E 02	
X	Y2	W2	QX2	VX2	MX2	MXY2
			QY2	VY2	MY2	
4.0	-4.0	3.61E-02	4.89E 02	5.31E 02	1.75E 03	-3.62E 02
			2.11E 02	2.45E 02	4.86E 02	
4.0	-2.0	3.71E-02	6.04E 02	7.02E 02	1.85E 03	-2.11E 02
			1.06E 02	1.27E 02	7.46E 02	
4.0	0.0	3.75E-02	6.35E 02	7.45E 02	1.89E 03	2.98E-03
			4.70E-04	1.09E-03	8.29E 02	
4.0	2.0	3.71E-02	6.04E 02	7.02E 02	1.85E 03	2.11E 02
			-1.06E 02	-1.27E 02	7.46E 02	
4.0	4.0	3.61E-02	4.89E 02	5.31E 02	1.75E 03	3.62E 02
			-2.11E 02	-2.45E 02	4.86E 02	
X	Y3	W3	QX3	VX3	MX3	MXY3
			QY3	VY3	MY3	
4.0	4.0	3.61E-02	4.89E 02	5.31E 02	1.75E 03	3.62E 02
			-2.11E 02	-2.45E 02	4.86E 02	
4.0	5.0	3.54E-02	4.14E 02	4.19E 02	1.68E 03	3.84E 02
			-1.80E 02	-2.19E 02	3.27E 02	
4.0	7.5	3.38E-02	3.14E 02	2.81E 02	1.53E 03	3.39E 02
			-1.04E 02	-1.43E 02	7.60E 01	
4.0	10.0	3.24E-02	2.73E 02	2.28E 02	1.42E 03	2.39E 02
			-4.09E 01	-6.80E 01	-1.77E 01	
4.0	12.5	3.16E-02	2.65E 02	2.24E 02	1.36E 03	1.29E 02
			1.50E 01	-8.64E-03	6.73E-01	

X	Y1	W1	QX1 / QY1	VX1 / VY1	MX1 / MY1	MXY1
5.0	-12.5	3.85E-02	2.40E 02	2.03E 02	1.65E 03	-1.11E 02
			-1.77E 01	-6.51E-02	1.23E-01	
5.0	-10.0	3.96E-02	2.47E 02	2.09E 02	1.72E 03	-2.09E 02
			4.95E 01	8.21E 01	-2.15E 01	
5.0	-7.5	4.12E-02	2.82E 02	2.54E 02	1.86E 03	-2.94E 02
			1.27E 02	1.79E 02	9.00E 01	
5.0	-5.0	4.32E-02	3.71E 02	3.74E 02	2.07E 03	-3.33E 02
			2.39E 02	3.03E 02	3.90E 02	
5.0	-4.0	4.40E-02	4.40E 02	4.77E 02	2.17E 03	-3.15E 02
			3.01E 02	3.62E 02	5.96E 02	
X	Y2	W2	QX2 / QY2	VX2 / VY2	MX2 / MY2	MXY2
5.0	-4.0	4.40E-02	4.40E 02	4.77E 02	2.17E 03	-3.15E 02
			3.01E 02	3.62E 02	5.96E 02	
5.0	-2.0	4.53E-02	5.48E 02	6.33E 02	2.34E 03	-1.82E 02
			1.37E 02	1.74E 02	9.25E 02	
5.0	0.0	4.57E-02	5.75E 02	6.69E 02	2.40E 03	3.39E-03
			-4.36E-05	1.22E-04	1.02E 03	
5.0	2.0	4.53E-02	5.48E 02	6.33E 02	2.34E 03	1.82E 02
			-1.37E 02	-1.74E 02	9.25E 02	
5.0	4.0	4.40E-02	4.40E 02	4.77E 02	2.17E 03	3.15E 02
			-3.01E 02	-3.62E 02	5.96E 02	
X	Y3	W3	QX3 / QY3	VX3 / VY3	MX3 / MY3	MXY3
5.0	4.0	4.40E-02	4.40E 02	4.77E 02	2.17E 03	3.15E 02
			-3.01E 02	-3.62E 02	5.96E 02	
5.0	5.0	4.32E-02	3.71E 02	3.74E 02	2.07E 03	3.33E 02
			-2.39E 02	-3.03E 02	3.90E 02	
5.0	7.5	4.12E-02	2.82E 02	2.54E 02	1.86E 03	2.94E 02
			-1.27E 02	-1.79E 02	9.00E 01	
5.0	10.0	3.96E-02	2.47E 02	2.08E 02	1.72E 03	2.09E 02
			-4.95E 01	-8.21E 01	-2.12E 01	
5.0	12.5	3.85E-02	2.40E 02	2.03E 02	1.65E 03	1.12E 02
			1.76E 01	-8.56E-03	1.25E-01	

X	Y1	W1	QX1	VX1	MX1	MXY1
			QY1	VY1	MY1	
6.0	-12.5	4.49E-02	2.11E 02	1.78E 02	1.91E 03	-9.31E 01
			-1.88E 01	2.91E-01	-4.68E-01	
6.0	-10.0	4.61E-02	2.18E 02	1.87E 02	1.99E 03	-1.74E 02
			5.64E 01	9.25E 01	-2.08E 01	
6.0	-7.5	4.80E-02	2.43E 02	2.24E 02	2.14E 03	-2.37E 02
			1.46E 02	2.07E 02	1.06E 02	
6.0	-5.0	5.03E-02	3.04E 02	3.10E 02	2.41E 03	-2.58E 02
			2.87E 02	3.71E 02	4.45E 02	
6.0	-4.0	5.12E-02	3.53E 02	3.83E 02	2.54E 03	-2.41E 02
			3.76E 02	4.61E 02	6.89E 02	
X	Y2	W2	QX2	VX2	MX2	MXY2
			QY2	VY2	MY2	
6.0	-4.0	5.12E-02	3.53E 02	3.83E 02	2.54E 03	-2.41E 02
			3.76E 02	4.61E 02	6.89E 02	
6.0	-2.0	5.26E-02	4.27E 02	4.92E 02	2.76E 03	-1.38E 02
			1.62E 02	2.12E 02	1.07E 03	
6.0	0.0	5.32E-02	4.46E 02	5.17E 02	2.83E 03	3.30E-03
			-5.99E-04	-9.47E-04	1.18E 03	
6.0	2.0	5.26E-02	4.27E 02	4.92E 02	2.76E 03	1.38E 02
			-1.62E 02	-2.12E 02	1.07E 03	
6.0	4.0	5.12E-02	3.53E 02	3.83E 02	2.54E 03	2.41E 02
			-3.76E 02	-4.61E 02	6.89E 02	
X	Y3	W3	QX3	VX3	MX3	MXY3
			QY3	VY3	MY3	
6.0	4.0	5.12E-02	3.53E 02	3.83E 02	2.54E 03	2.41E 02
			-3.76E 02	-4.61E 02	6.89E 02	
6.0	5.0	5.03E-02	3.04E 02	3.10E 02	2.41E 03	2.58E 02
			-2.87E 02	-3.71E 02	4.45E 02	
6.0	7.5	4.80E-02	2.43E 02	2.24E 02	2.14E 03	2.37E 02
			-1.46E 02	-2.07E 02	1.06E 02	
6.0	10.0	4.61E-02	2.18E 02	1.87E 02	1.99E 03	1.74E 02
			-5.64E 01	-9.25E 01	-2.17E 01	
6.0	12.5	4.49E-02	2.11E 02	1.78E 02	1.91E 03	9.39E 01
			1.91E 01	-7.43E-03	-4.66E-01	

X	Y1	W1	QX1 / QY1	VX1 / VY1	MX1 / MY1	MXY1
7.0	-12.5	5.07E-02	1.80E 02	1.52E 02	2.14E 03	-7.55E 01
			-1.87E 01	5.46E-01	-8.93E-01	
7.0	-10.0	5.20E-02	1.85E 02	1.64E 02	2.21E 03	-1.38E 02
			6.13E 01	9.80E 01	-1.61E 01	
7.0	-7.5	5.40E-02	1.98E 02	1.91E 02	2.38E 03	-1.74E 02
			1.57E 02	2.21E 02	1.26E 02	
7.0	-5.0	5.66E-02	2.21E 02	2.34E 02	2.66E 03	-1.68E 02
			3.13E 02	4.06E 02	4.94E 02	
7.0	-4.0	5.76E-02	2.36E 02	2.60E 02	2.81E 03	-1.51E 02
			4.17E 02	5.12E 02	7.61E 02	
X	Y2	W2	QX2 / QY2	VX2 / VY2	MX2 / MY2	MXY2
7.0	-4.0	5.75E-02	2.36E 02	2.60E 02	2.81E 03	-1.51E 02
			4.17E 02	5.12E 02	7.61E 02	
7.0	-2.0	5.91E-02	2.58E 02	2.98E 02	3.05E 03	-8.48E 01
			1.75E 02	2.31E 02	1.18E 03	
7.0	0.0	5.97E-02	2.64E 02	3.08E 02	3.13E 03	2.73E-03
			-1.01E-03	-1.77E-03	1.29E 03	
7.0	2.0	5.91E-02	2.58E 02	2.98E 02	3.05E 03	8.48E 01
			-1.75E 02	-2.31E 02	1.18E 03	
7.0	4.0	5.75E-02	2.36E 02	2.60E 02	2.81E 03	1.51E 02
			-4.17E 02	-5.12E 02	7.61E 02	
X	Y3	W3	QX3 / QY3	VX3 / VY3	MX3 / MY3	MXY3
7.0	4.0	5.75E-02	2.36E 02	2.60E 02	2.81E 03	1.51E 02
			-4.17E 02	-5.12E 02	7.61E 02	
7.0	5.0	5.66E-02	2.21E 02	2.34E 02	2.66E 03	1.68E 02
			-3.13E 02	-4.06E 02	4.94E 02	
7.0	7.5	5.40E-02	1.98E 02	1.91E 02	2.38E 03	1.74E 02
			-1.57E 02	-2.21E 02	1.26E 02	
7.0	10.0	5.20E-02	1.85E 02	1.64E 02	2.21E 03	1.38E 02
			-6.13E 01	-9.80E 01	-1.79E 01	
7.0	12.5	5.07E-02	1.80E 02	1.52E 02	2.14E 03	7.59E 01
			1.92E 01	-5.41E-03	-8.91E-01	

X	Y1	W1	QX1	VX1	MX1	MXY1
			QY1	VY1	MY1	
8.0	-12.5	5.56E-02	1.47E 02	1.25E 02	2.33E 03	-5.91E 01
			-1.74E 01	6.09E-01	-1.00E 00	
8.0	-10.0	5.71E-02	1.51E 02	1.40E 02	2.40E 03	-1.02E 02
			6.39E 01	9.82E 01	-7.22E 00	
8.0	-7.5	5.92E-02	1.53E 02	1.58E 02	2.55E 03	-1.13E 02
			1.60E 02	2.18E 02	1.51E 02	
8.0	-5.0	6.19E-02	1.34E 02	1.55E 02	2.82E 03	-7.77E 01
			3.10E 02	3.96E 02	5.37E 02	
8.0	-4.0	6.29E-02	1.11E 02	1.28E 02	2.96E 03	-5.80E 01
			4.11E 02	4.98E 02	8.07E 02	
X	Y2	W2	QX2	VX2	MX2	MXY2
			QY2	VY2	MY2	
8.0	-4.0	6.29E-02	1.11E 02	1.28E 02	2.96E 03	-5.80E 01
			4.11E 02	4.98E 02	8.07E 02	
8.0	-2.0	6.46E-02	7.49E 01	8.86E 01	3.19E 03	-3.12E 01
			1.74E 02	2.24E 02	1.23E 03	
8.0	0.0	6.52E-02	6.68E 01	8.36E 01	3.27E 03	1.85E-03
			-1.15E-03	-2.10E-03	1.35E 03	
8.0	2.0	6.46E-02	7.49E 01	8.86E 01	3.19E 03	3.12E 01
			-1.74E 02	-2.24E 02	1.23E 03	
8.0	4.0	6.29E-02	1.11E 02	1.28E 02	2.96E 03	5.80E 01
			-4.11E 02	-4.98E 02	8.07E 02	
X	Y3	W3	QX3	VX3	MX3	MXY3
			QY3	VY3	MY3	
8.0	4.0	6.29E-02	1.11E 02	1.28E 02	2.96E 03	5.80E 01
			-4.11E 02	-4.98E 02	8.07E 02	
8.0	5.0	6.19E-02	1.34E 02	1.55E 02	2.82E 03	7.77E 01
			-3.10E 02	-3.96E 02	5.37E 02	
8.0	7.5	5.92E-02	1.53E 02	1.58E 02	2.55E 03	1.13E 02
			-1.60E 02	-2.18E 02	1.51E 02	
8.0	10.0	5.71E-02	1.51E 02	1.40E 02	2.40E 03	1.02E 02
			-6.40E 01	-9.82E 01	-9.22E 00	
8.0	12.5	5.57E-02	1.47E 02	1.25E 02	2.33E 03	5.90E 01
			1.80E 01	-2.78E-03	-9.99E-01	

X	Y1	W1	QX1	VX1	MX1	MXY1
			QY1	VY1	MY1	
9.0	-12.5	5.98E-02	1.15E 02	9.83E 01	2.48E 03	-4.43E 01
			-1.52E 01	4.57E-01	-7.54E-01	
9.0	-10.0	6.13E-02	1.18E 02	1.14E 02	2.54E 03	-7.06E 01
			6.46E 01	9.39E 01	4.91E 00	
9.0	-7.5	6.36E-02	1.10E 02	1.24E 02	2.68E 03	-5.97E 01
			1.55E 02	2.01E 02	1.81E 02	
9.0	-5.0	6.63E-02	5.83E 01	8.48E 01	2.89E 03	-2.31E 00
			2.81E 02	3.44E 02	5.75E 02	
9.0	-4.0	6.73E-02	3.89E 00	1.51E 01	3.00E 03	1.85E 01
			3.58E 02	4.21E 02	8.29E 02	
X	Y2	W2	QX2	VX2	MX2	MXY2
			QY2	VY2	MY2	
9.0	-4.0	6.73E-02	3.89E 00	1.51E 01	3.00E 03	1.85E 01
			3.58E 02	4.21E 02	8.29E 02	
9.0	-2.0	6.90E-02	-8.02E 01	-8.79E 01	3.18E 03	1.27E 01
			1.58E 02	1.94E 02	1.23E 03	
9.0	0.0	6.96E-02	-9.94E 01	-1.05E 02	3.24E 03	9.31E-04
			-9.86E-04	-1.85E-03	1.35E 03	
9.0	2.0	6.90E-02	-8.02E 01	-8.79E 01	3.18E 03	-1.27E 01
			-1.58E 02	-1.94E 02	1.23E 03	
9.0	4.0	6.73E-02	3.90E 00	1.51E 01	3.00E 03	-1.85E 01
			-3.58E 02	-4.21E 02	8.29E 02	
X	Y3	W3	QX3	VX3	MX3	MXY3
			QY3	VY3	MY3	
9.0	4.0	6.73E-02	3.90E 00	1.51E 01	3.00E 03	-1.85E 01
			-3.58E 02	-4.21E 02	8.29E 02	
9.0	5.0	6.63E-02	5.83E 01	8.48E 01	2.89E 03	2.32E 00
			-2.81E 02	-3.44E 02	5.75E 02	
9.0	7.5	6.36E-02	1.10E 02	1.24E 02	2.68E 03	5.97E 01
			-1.55E 02	-2.01E 02	1.81E 02	
9.0	10.0	6.13E-02	1.18E 02	1.14E 02	2.54E 03	7.06E 01
			-6.46E 01	-9.39E 01	3.40E 00	
9.0	12.5	5.98E-02	1.15E 02	9.83E 01	2.48E 03	4.38E 01
			1.56E 01	1.30E-04	-7.52E-01	

X	Y1	W1	QX1	VX1	MX1	MXY1
			QY1	VY1	MY1	
10.0	-12.5	6.31E-02	8.40E 01	7.22E 01	2.59E 03	-3.13E 01
			-1.26E 01	1.43E-01	-2.40E-01	
10.0	-10.0	6.46E-02	8.57E 01	8.66E 01	2.64E 03	-4.46E 01
			6.39E 01	8.67E 01	1.84E 01	
10.0	-7.5	6.69E-02	7.27E 01	9.14E 01	2.75E 03	-2.19E 01
			1.44E 02	1.74E 02	2.11E 02	
10.0	-5.0	6.97E-02	5.28E 00	3.32E 01	2.89E 03	4.43E 01
			2.34E 02	2.64E 02	6.07E 02	
10.0	-4.0	7.07E-02	-6.41E 01	-5.74E 01	2.96E 03	6.41E 01
			2.75E 02	3.02E 02	8.33E 02	
X	Y2	W2	QX2	VX2	MX2	MXY2
			QY2	VY2	MY2	
10.0	-4.0	7.07E-02	-6.41E 01	-5.75E 01	2.96E 03	6.41E 01
			2.75E 02	3.02E 02	8.33E 02	
10.0	-2.0	7.23E-02	-1.71E 02	-1.91E 02	3.06E 03	3.85E 01
			1.34E 02	1.49E 02	1.20E 03	
10.0	0.0	7.29E-02	-1.95E 02	-2.14E 02	3.10E 03	2.04E-04
			-5.79E-04	-1.15E-03	1.31E 03	
10.0	2.0	7.23E-02	-1.71E 02	-1.91E 02	3.06E 03	-3.85E 01
			-1.34E 02	-1.49E 02	1.20E 03	
10.0	4.0	7.07E-02	-6.41E 01	-5.74E 01	2.96E 03	-6.41E 01
			-2.75E 02	-3.02E 02	8.33E 02	
X	Y3	W3	QX3	VX3	MX3	MXY3
			QY3	VY3	MY3	
10.0	4.0	7.07E-02	-6.41E 01	-5.74E 01	2.96E 03	-6.41E 01
			-2.75E 02	-3.02E 02	8.33E 02	
10.0	5.0	6.97E-02	5.29E 00	3.32E 01	2.89E 03	-4.43E 01
			-2.34E 02	-2.64E 02	6.07E 02	
10.0	7.5	6.69E-02	7.27E 01	9.14E 01	2.75E 03	2.19E 01
			-1.44E 02	-1.74E 02	2.11E 02	
10.0	10.0	6.46E-02	8.57E 01	8.72E 01	2.64E 03	4.46E 01
			-6.39E 01	-8.67E 01	1.79E 01	
10.0	12.5	6.31E-02	8.34E 01	7.22E 01	2.59E 03	3.05E 01
			1.27E 01	2.92E-03	-2.37E-01	

X	Y1	W1	QX1	VX1	MX1	MXY1
			QY1	VY1	MY1	
11.0	-12.5	6.55E-02	5.47E 01	4.73E 01	2.67E 03	-1.99E 01
			-1.01E 01	-2.22E-01	3.61E-01	
11.0	-10.0	6.70E-02	5.56E 01	5.85E 01	2.71E 03	-2.50E 01
			6.25E 01	7.90E 01	3.07E 01	
11.0	-7.5	6.94E-02	4.28E 01	5.99E 01	2.79E 03	-1.47E 00
			1.33E 02	1.45E 02	2.38E 02	
11.0	-5.0	7.21E-02	-1.90E 01	4.40E 00	2.86E 03	5.62E 01
			1.84E 02	1.79E 02	6.32E 02	
11.0	-4.0	7.31E-02	-8.21E 01	-7.87E 01	2.88E 03	7.19E 01
			1.86E 02	1.75E 02	8.26E 02	
X	Y2	W2	QX2	VX2	MX2	MXY2
			QY2	VY2	MY2	
11.0	-4.0	7.31E-02	-8.21E 01	-7.87E 01	2.88E 03	7.18E 01
			1.86E 02	1.75E 02	8.26E 02	
11.0	-2.0	7.47E-02	-1.79E 02	-2.01E 02	2.90E 03	4.25E 01
			1.08E 02	1.01E 02	1.15E 03	
11.0	0.0	7.52E-02	-2.01E 02	-2.22E 02	2.91E 03	-1.75E-04
			-9.01E-05	-2.79E-04	1.26E 03	
11.0	2.0	7.47E-02	-1.79E 02	-2.01E 02	2.90E 03	-4.25E 01
			-1.08E 02	-1.01E 02	1.15E 03	
11.0	4.0	7.31E-02	-8.21E 01	-7.87E 01	2.88E 03	-7.18E 01
			-1.86E 02	-1.75E 02	8.26E 02	
X	Y3	W3	QX3	VX3	MX3	MXY3
			QY3	VY3	MY3	
11.0	4.0	7.31E-02	-8.21E 01	-7.87E 01	2.88E 03	-7.18E 01
			-1.86E 02	-1.75E 02	8.26E 02	
11.0	5.0	7.21E-02	-1.90E 01	4.38E 00	2.86E 03	-5.62E 01
			-1.84E 02	-1.79E 02	6.32E 02	
11.0	7.5	6.94E-02	4.28E 01	6.00E 01	2.79E 03	1.47E 00
			-1.33E 02	-1.45E 02	2.38E 02	
11.0	10.0	6.70E-02	5.56E 01	5.91E 01	2.71E 03	2.50E 01
			-6.25E 01	-7.89E 01	3.14E 01	
11.0	12.5	6.55E-02	5.41E 01	4.73E 01	2.67E 03	1.91E 01
			9.90E 00	5.22E-03	3.63E-01	

D.3.2

MIDDLE STRIP LOADED PLATES

LEVY SOLUTION FOR PLATE ANALYSIS

PLAT DATA

LENGTH OF PLATE	(IN)	26.00
WIDTH OF PLATE	(IN)	25.00
UNLOADED WIDTH OF PLATE	(IN)	13.00
LOADED WIDTH OF PLATE	(IN)	8.00
UNLOADED WIDTH OF PLATE	(IN)	4.00
THICKNESS OF PLATE	(IN)	3.00
FPRC IS COMP. STRENGHT OF CONC.	(PSI)	3000.00
EFFI IS EFF. MOM. OF INERTIA	(IN.**4)	0.83
POISSON'S RATIO OF PLATE		0.15
ELASTIC MODOLUS OF PLATE	(PSI)	3.12E 06
FLEXURAL RIGIDITY OF PLAT	(#-IN)	2.65E 06

LOAD DATA

CENTER LOCATION OF FIRST LOAD	(IN)	9.00
CENTER LOCATION OF SECOND LOAD	(IN)	17.00
LENGTH OF EACH DISTRIBUTED LOAD	(IN)	4.00
INTENSITY OF DISTRIBUTED LOAD	(PSI)	312.50
TOTATAL LOAD	(#)	20000.00

NUMBER OF SERIES TERM USED 5
X=0.0 & X=A1 ARE SIMPLY SUPPORTED EDGES
Y1 AND Y3 ARE UNLOADED WIDTHS
Y2 IS LODED WIDTH

X	Y1	W1	QX1	VX1	MX1	MXY1
			QY1	VY1	MY1	
0.0	-17.0	0.00E-01	2.59E 02	2.22E 02	0.00E-01	-4.02E 02
			0.00E-01	0.00E-01	0.00E-01	
0.0	-13.0	0.00E-01	2.55E 02	1.92E 02	0.00E-01	-6.26E 02
			0.00E-01	0.00E-01	0.00E-01	
0.0	-9.0	0.00E-01	3.12E 02	2.69E 02	0.00E-01	-8.51E 02
			0.00E-01	0.00E-01	0.00E-01	
0.0	-5.0	0.00E-01	3.94E 02	4.21E 02	0.00E-01	-8.98E 02
			0.00E-01	0.00E-01	0.00E-01	
0.0	-4.0	0.00E-01	3.95E 02	4.34E 02	0.00E-01	-8.64E 02
			0.00E-01	0.00E-01	0.00E-01	
X	Y2	W2	QX2	VX2	MX2	MXY2
			QY2	VY2	MY2	
0.0	-4.0	0.00E-01	3.95E 02	4.34E 02	0.00E-01	-8.64E 02
			0.00E-01	0.00E-01	0.00E-01	
0.0	-3.0	0.00E-01	3.94E 02	4.43E 02	0.00E-01	-8.21E 02
			0.00E-01	0.00E-01	0.00E-01	
0.0	-2.0	0.00E-01	4.03E 02	4.66E 02	0.00E-01	-7.65E 02
			0.00E-01	0.00E-01	0.00E-01	
0.0	-1.0	0.00E-01	4.14E 02	4.87E 02	0.00E-01	-6.96E 02
			0.00E-01	0.00E-01	0.00E-01	
0.0	0.0	0.00E-01	4.23E 02	4.98E 02	0.00E-01	-6.22E 02
			0.00E-01	0.00E-01	0.00E-01	
0.0	1.0	0.00E-01	4.29E 02	4.97E 02	0.00E-01	-5.51E 02
			0.00E-01	0.00E-01	0.00E-01	
0.0	2.0	0.00E-01	4.33E 02	4.86E 02	0.00E-01	-4.90E 02
			0.00E-01	0.00E-01	0.00E-01	
0.0	3.0	0.00E-01	4.39E 02	4.74E 02	0.00E-01	-4.45E 02
			0.00E-01	0.00E-01	0.00E-01	
0.0	4.0	0.00E-01	4.55E 02	4.76E 02	0.00E-01	-4.18E 02
			0.00E-01	0.00E-01	0.00E-01	
X	Y3	W3	QX3	VX3	MX3	MXY3
			QY3	VY3	MY3	
0.0	4.0	0.00E-01	4.55E 02	4.76E 02	0.00E-01	-4.18E 02
			0.00E-01	0.00E-01	0.00E-01	
0.0	5.0	0.00E-01	4.69E 02	4.75E 02	0.00E-01	-4.04E 02
			0.00E-01	0.00E-01	0.00E-01	
0.0	6.0	0.00E-01	4.69E 02	4.50E 02	0.00E-01	-4.10E 02
			0.00E-01	0.00E-01	0.00E-01	
0.0	7.0	0.00E-01	4.61E 02	4.18E 02	0.00E-01	-4.41E 02
			0.00E-01	0.00E-01	0.00E-01	
0.0	8.0	0.00E-01	4.49E 02	3.82E 02	0.00E-01	-4.96E 02
			0.00E-01	0.00E-01	0.00E-01	

X	Y1	W1	QX1	VX1	MX1	MXY1
			QY1	VY1	MY1	
1.0	-17.0	7.61E-03	2.56E 02	2.19E 02	2.87E 02	-4.02E 02
			-1.09E 01	-4.83E-03	8.39E 00	
1.0	-13.0	8.52E-03	2.53E 02	1.90E 02	3.17E 02	-6.22E 02
			7.80E 00	1.61E 01	-2.47E 01	
1.0	-9.0	9.84E-03	3.11E 02	2.67E 02	3.56E 02	-8.48E 02
			2.08E 01	2.74E 01	2.83E 00	
1.0	-5.0	1.14E-02	4.01E 02	4.25E 02	3.71E 02	-9.02E 02
			1.21E 01	3.95E 00	8.54E 01	
1.0	-4.0	1.18E-02	4.10E 02	4.49E 02	3.61E 02	-8.69E 02
			-7.33E 00	-1.82E 01	9.89E 01	
X	Y2	W2	QX2	VX2	MX2	MXY2
			QY2	VY2	MY2	
1.0	-4.0	1.18E-02	4.10E 02	4.49E 02	3.61E 02	-8.69E 02
			-7.33E 00	-1.82E 01	9.89E 01	
1.0	-3.0	1.22E-02	4.16E 02	4.67E 02	3.52E 02	-8.25E 02
			7.68E 00	-1.92E-01	1.10E 02	
1.0	-2.0	1.26E-02	4.29E 02	4.95E 02	3.48E 02	-7.66E 02
			1.20E 01	9.59E 00	1.26E 02	
1.0	-1.0	1.29E-02	4.42E 02	5.17E 02	3.50E 02	-6.95E 02
			1.08E 01	1.41E 01	1.37E 02	
1.0	0.0	1.32E-02	4.51E 02	5.28E 02	3.58E 02	-6.18E 02
			7.35E 00	1.60E 01	1.40E 02	
1.0	1.0	1.34E-02	4.57E 02	5.27E 02	3.70E 02	-5.44E 02
			3.98E 00	1.80E 01	1.34E 02	
1.0	2.0	1.37E-02	4.58E 02	5.15E 02	3.87E 02	-4.80E 02
			2.96E 00	2.25E 01	1.21E 02	
1.0	3.0	1.39E-02	4.60E 02	4.98E 02	4.10E 02	-4.32E 02
			7.45E 00	3.24E 01	1.03E 02	
1.0	4.0	1.41E-02	4.69E 02	4.90E 02	4.39E 02	-4.04E 02
			2.26E 01	5.05E 01	9.01E 01	
X	Y3	W3	QX3	VX3	MX3	MXY3
			QY3	VY3	MY3	
1.0	4.0	1.41E-02	4.69E 02	4.90E 02	4.39E 02	-4.04E 02
			2.26E 01	5.05E 01	9.01E 01	
1.0	5.0	1.42E-02	4.76E 02	4.79E 02	4.67E 02	-3.91E 02
			3.20E 00	2.80E 01	7.51E 01	
1.0	6.0	1.44E-02	4.72E 02	4.51E 02	4.89E 02	-4.00E 02
			-5.83E 00	1.38E 01	5.10E 01	
1.0	7.0	1.46E-02	4.63E 02	4.18E 02	5.05E 02	-4.33E 02
			-1.00E 01	5.22E 00	2.55E 01	
1.0	8.0	1.48E-02	4.51E 02	3.84E 02	5.18E 02	-4.90E 02
			-1.31E 01	-2.00E-02	3.33E-02	

X	Y1	W1	QX1 / QY1	VX1 / VY1	MX1 / MY1	MXY1
2.0	-17.0	1.51E-02	2.46E 02	2.10E 02	5.70E 02	-3.99E 02
			-2.00E 01	-8.98E-03	1.38E 01	
2.0	-13.0	1.69E-02	2.48E 02	1.86E 02	6.30E 02	-6.09E 02
			1.56E 01	3.22E 01	-4.90E 01	
2.0	-9.0	1.95E-02	3.07E 02	2.61E 02	7.11E 02	-8.37E 02
			4.23E 01	5.71E 01	3.81E 00	
2.0	-5.0	2.27E-02	4.18E 02	4.36E 02	7.58E 02	-9.12E 02
			3.45E 01	2.51E 01	1.68E 02	
2.0	-4.0	2.35E-02	4.46E 02	4.85E 02	7.49E 02	-8.83E 02
			4.23E 00	-9.83E 00	2.02E 02	
X	Y2	W2	QX2 / QY2	VX2 / VY2	MX2 / MY2	MXY2
2.0	-4.0	2.35E-02	4.46E 02	4.85E 02	7.49E 02	-8.83E 02
			4.23E 00	-9.83E 00	2.02E 02	
2.0	-3.0	2.43E-02	4.73E 02	5.31E 02	7.39E 02	-8.34E 02
			2.55E 01	1.62E 01	2.31E 02	
2.0	-2.0	2.50E-02	4.96E 02	5.70E 02	7.39E 02	-7.68E 02
			2.90E 01	2.87E 01	2.64E 02	
2.0	-1.0	2.56E-02	5.14E 02	5.96E 02	7.47E 02	-6.89E 02
			2.37E 01	3.24E 01	2.87E 02	
2.0	0.0	2.62E-02	5.25E 02	6.09E 02	7.63E 02	-6.05E 02
			1.46E 01	3.19E 01	2.93E 02	
2.0	1.0	2.67E-02	5.28E 02	6.06E 02	7.86E 02	-5.23E 02
			5.73E 00	3.15E 01	2.82E 02	
2.0	2.0	2.72E-02	5.25E 02	5.89E 02	8.16E 02	-4.52E 02
			7.27E-01	3.55E 01	2.54E 02	
2.0	3.0	2.76E-02	5.17E 02	5.61E 02	8.56E 02	-3.97E 02
			4.83E 00	4.83E 01	2.17E 02	
2.0	4.0	2.79E-02	5.06E 02	5.27E 02	9.04E 02	-3.65E 02
			2.66E 01	7.47E 01	1.84E 02	
X	Y3	W3	QX3 / QY3	VX3 / VY3	MX3 / MY3	MXY3
2.0	4.0	2.79E-02	5.06E 02	5.27E 02	9.04E 02	-3.65E 02
			2.66E 01	7.47E 01	1.84E 02	
2.0	5.0	2.83E-02	4.93E 02	4.89E 02	9.52E 02	-3.56E 02
			-3.39E 00	3.97E 01	1.47E 02	
2.0	6.0	2.86E-02	4.79E 02	4.51E 02	9.89E 02	-3.72E 02
			-1.62E 01	1.84E 01	9.78E 01	
2.0	7.0	2.90E-02	4.66E 02	4.17E 02	1.02E 03	-4.12E 02
			-2.11E 01	6.36E 00	4.80E 01	
2.0	8.0	2.94E-02	4.56E 02	3.87E 02	1.04E 03	-4.71E 02
			-2.42E 01	-3.29E-02	5.50E-02	

X	Y1	W1	QX1	VX1	MX1	MXY1
			QY1	VY1	MY1	
3.0	-17.0	2.24E-02	2.32E 02	1.97E 02	8.45E 02	-3.92E 02
			-2.60E 01	-1.18E-02	1.43E 01	
3.0	-13.0	2.51E-02	2.39E 02	1.80E 02	9.33E 02	-5.89E 02
			2.35E 01	4.85E 01	-7.25E 01	
3.0	-9.0	2.90E-02	3.00E 02	2.51E 02	1.06E 03	-8.17E 02
			6.50E 01	9.06E 01	1.68E 00	
3.0	-5.0	3.37E-02	4.36E 02	4.47E 02	1.17E 03	-9.17E 02
			7.37E 01	7.46E 01	2.47E 02	
3.0	-4.0	3.49E-02	4.90E 02	5.29E 02	1.18E 03	-8.93E 02
			4.69E 01	4.25E 01	3.11E 02	
X	Y2	W2	QX2	VX2	MX2	MXY2
			QY2	VY2	MY2	
3.0	-4.0	3.49E-02	4.90E 02	5.29E 02	1.18E 03	-8.93E 02
			4.69E 01	4.25E 01	3.11E 02	
3.0	-3.0	3.61E-02	5.41E 02	6.08E 02	1.18E 03	-8.40E 02
			5.98E 01	6.00E 01	3.69E 02	
3.0	-2.0	3.71E-02	5.78E 02	6.61E 02	1.20E 03	-7.64E 02
			5.45E 01	6.34E 01	4.23E 02	
3.0	-1.0	3.81E-02	6.02E 02	6.93E 02	1.22E 03	-6.76E 02
			4.00E 01	5.76E 01	4.58E 02	
3.0	0.0	3.90E-02	6.14E 02	7.07E 02	1.24E 03	-5.84E 02
			2.18E 01	4.76E 01	4.67E 02	
3.0	1.0	3.97E-02	6.16E 02	7.03E 02	1.28E 03	-4.93E 02
			3.80E 00	3.77E 01	4.50E 02	
3.0	2.0	4.04E-02	6.06E 02	6.80E 02	1.31E 03	-4.13E 02
			-1.01E 01	3.26E 01	4.08E 02	
3.0	3.0	4.10E-02	5.85E 02	6.37E 02	1.36E 03	-3.49E 02
			-1.44E 01	3.68E 01	3.47E 02	
3.0	4.0	4.15E-02	5.49E 02	5.69E 02	1.41E 03	-3.12E 02
			-3.48E-01	5.54E 01	2.84E 02	
X	Y3	W3	QX3	VX3	MX3	MXY3
			QY3	VY3	MY3	
3.0	4.0	4.15E-02	5.49E 02	5.69E 02	1.41E 03	-3.12E 02
			-3.49E-01	5.54E 01	2.84E 02	
3.0	5.0	4.20E-02	5.11E 02	4.99E 02	1.46E 03	-3.08E 02
			-2.61E 01	2.43E 01	2.15E 02	
3.0	6.0	4.25E-02	4.85E 02	4.48E 02	1.50E 03	-3.33E 02
			-3.41E 01	7.58E 00	1.38E 02	
3.0	7.0	4.30E-02	4.67E 02	4.12E 02	1.54E 03	-3.80E 02
			-3.38E 01	7.77E-01	6.55E 01	
3.0	8.0	4.36E-02	4.58E 02	3.89E 02	1.56E 03	-4.42E 02
			-3.18E 01	-3.43E-02	5.76E-02	

X	Y1	W1	QX1	VX1	MX1	MXY1
			QY1	VY1	MY1	
4.0	-17.0	2.94E-02	2.16E 02	1.82E 02	1.11E 03	-3.78E 02
			-2.88E 01	-1.30E-02	9.79E 00	
4.0	-13.0	3.29E-02	2.26E 02	1.70E 02	1.22E 03	-5.59E 02
			3.12E 01	6.46E 01	-9.50E 01	
4.0	-9.0	3.80E-02	2.87E 02	2.37E 02	1.41E 03	-7.85E 02
			8.87E 01	1.28E 02	-3.79E 00	
4.0	-5.0	4.43E-02	4.46E 02	4.48E 02	1.61E 03	-9.06E 02
			1.30E 02	1.53E 02	3.19E 02	
4.0	-4.0	4.59E-02	5.21E 02	5.59E 02	1.65E 03	-8.87E 02
			1.22E 02	1.41E 02	4.26E 02	
X	Y2	W2	QX2	VX2	MX2	MXY2
			QY2	VY2	MY2	
4.0	-4.0	4.59E-02	5.21E 02	5.59E 02	1.65E 03	-8.87E 02
			1.22E 02	1.41E 02	4.26E 02	
4.0	-3.0	4.74E-02	5.93E 02	6.66E 02	1.68E 03	-8.30E 02
			1.11E 02	1.32E 02	5.25E 02	
4.0	-2.0	4.89E-02	6.41E 02	7.31E 02	1.72E 03	-7.48E 02
			8.86E 01	1.14E 02	6.02E 02	
4.0	-1.0	5.01E-02	6.70E 02	7.68E 02	1.76E 03	-6.53E 02
			5.98E 01	8.99E 01	6.49E 02	
4.0	0.0	5.13E-02	6.84E 02	7.83E 02	1.80E 03	-5.54E 02
			2.87E 01	6.28E 01	6.61E 02	
4.0	1.0	5.23E-02	6.84E 02	7.77E 02	1.84E 03	-4.57E 02
			-2.02E 00	3.61E 01	6.38E 02	
4.0	2.0	5.31E-02	6.69E 02	7.49E 02	1.88E 03	-3.69E 02
			-2.98E 01	1.30E 01	5.81E 02	
4.0	3.0	5.39E-02	6.35E 02	6.94E 02	1.92E 03	-2.99E 02
			-5.10E 01	-3.33E 00	4.95E 02	
4.0	4.0	5.45E-02	5.78E 02	5.98E 02	1.96E 03	-2.58E 02
			-5.95E 01	-9.37E 00	3.89E 02	
X	Y3	W3	QX3	VX3	MX3	MXY3
			QY3	VY3	MY3	
4.0	4.0	5.45E-02	5.78E 02	5.98E 02	1.96E 03	-2.58E 02
			-5.95E 01	-9.37E 00	3.89E 02	
4.0	5.0	5.51E-02	5.19E 02	5.00E 02	2.00E 03	-2.59E 02
			-6.57E 01	-1.95E 01	2.76E 02	
4.0	6.0	5.58E-02	4.82E 02	4.38E 02	2.03E 03	-2.92E 02
			-5.97E 01	-1.93E 01	1.70E 02	
4.0	7.0	5.64E-02	4.60E 02	4.01E 02	2.06E 03	-3.44E 02
			-4.81E 01	-1.19E 01	7.75E 01	
4.0	8.0	5.72E-02	4.52E 02	3.84E 02	2.09E 03	-4.08E 02
			-3.57E 01	-2.37E-02	4.04E-02	

X	Y1	W1	QX1	VX1	MX1	MXY1
			QY1	VY1	MY1	
5.0	-17.0	3.59E-02	1.98E 02	1.67E 02	1.36E 03	-3.56E 02
			-2.91E 01	-1.22E-02	1.78E 00	
5.0	-13.0	4.02E-02	2.11E 02	1.59E 02	1.50E 03	-5.22E 02
			3.88E 01	8.04E 01	-1.16E 02	
5.0	-9.0	4.65E-02	2.70E 02	2.21E 02	1.73E 03	-7.39E 02
			1.13E 02	1.67E 02	-1.18E 01	
5.0	-5.0	5.43E-02	4.36E 02	4.34E 02	2.05E 03	-8.68E 02
			1.98E 02	2.52E 02	3.86E 02	
5.0	-4.0	5.63E-02	5.21E 02	5.57E 02	2.13E 03	-8.53E 02
			2.19E 02	2.70E 02	5.42E 02	
X	Y2	W2	QX2	VX2	MX2	MXY2
			QY2	VY2	MY2	
5.0	-4.0	5.63E-02	5.21E 02	5.57E 02	2.13E 03	-8.53E 02
			2.19E 02	2.70E 02	5.42E 02	
5.0	-3.0	5.82E-02	6.04E 02	6.77E 02	2.21E 03	-7.95E 02
			1.74E 02	2.24E 02	6.89E 02	
5.0	-2.0	5.99E-02	6.56E 02	7.48E 02	2.28E 03	-7.11E 02
			1.28E 02	1.76E 02	7.92E 02	
5.0	-1.0	6.15E-02	6.87E 02	7.86E 02	2.35E 03	-6.15E 02
			8.18E 01	1.27E 02	8.51E 02	
5.0	0.0	6.29E-02	7.02E 02	8.01E 02	2.40E 03	-5.15E 02
			3.54E 01	7.74E 01	8.66E 02	
5.0	1.0	6.41E-02	7.00E 02	7.95E 02	2.44E 03	-4.18E 02
			-1.06E 01	2.88E 01	8.37E 02	
5.0	2.0	6.52E-02	6.82E 02	7.65E 02	2.47E 03	-3.29E 02
			-5.58E 01	-1.85E 01	7.66E 02	
5.0	3.0	6.60E-02	6.43E 02	7.03E 02	2.50E 03	-2.56E 02
			-9.97E 01	-6.37E 01	6.51E 02	
5.0	4.0	6.68E-02	5.75E 02	5.94E 02	2.52E 03	-2.15E 02
			-1.41E 02	-1.06E 02	4.95E 02	
X	Y3	W3	QX3	VX3	MX3	MXY3
			QY3	VY3	MY3	
5.0	4.0	6.68E-02	5.75E 02	5.94E 02	2.52E 03	-2.15E 02
			-1.41E 02	-1.06E 02	4.95E 02	
5.0	5.0	6.75E-02	5.06E 02	4.83E 02	2.53E 03	-2.19E 02
			-1.17E 02	-8.32E 01	3.32E 02	
5.0	6.0	6.83E-02	4.64E 02	4.17E 02	2.55E 03	-2.55E 02
			-9.03E 01	-5.74E 01	1.95E 02	
5.0	7.0	6.91E-02	4.41E 02	3.80E 02	2.57E 03	-3.09E 02
			-6.33E 01	-2.95E 01	8.50E 01	
5.0	8.0	7.00E-02	4.33E 02	3.68E 02	2.60E 03	-3.72E 02
			-3.67E 01	-4.96E-03	9.57E-03	

X	Y1	W1	QX1	VX1	MX1	MXY1
			QY1	VY1	MY1	
6.0	-17.0	4.19E-02	1.81E 02	1.52E 02	1.58E 03	-3.24E 02
			-2.88E 01	-9.62E-03	-6.86E 00	
6.0	-13.0	4.69E-02	1.92E 02	1.44E 02	1.75E 03	-4.76E 02
			4.59E 01	9.53E 01	-1.36E 02	
6.0	-9.0	5.43E-02	2.47E 02	2.01E 02	2.04E 03	-6.76E 02
			1.36E 02	2.05E 02	-2.07E 01	
6.0	-5.0	6.35E-02	4.02E 02	4.00E 02	2.47E 03	-7.98E 02
			2.68E 02	3.54E 02	4.47E 02	
6.0	-4.0	6.58E-02	4.82E 02	5.16E 02	2.60E 03	-7.84E 02
			3.19E 02	4.05E 02	6.53E 02	
X	Y2	W2	QX2	VX2	MX2	MXY2
			QY2	VY2	MY2	
6.0	-4.0	6.58E-02	4.82E 02	5.16E 02	2.60E 03	-7.84E 02
			3.19E 02	4.05E 02	6.53E 02	
6.0	-3.0	6.81E-02	5.59E 02	6.28E 02	2.73E 03	-7.31E 02
			2.39E 02	3.18E 02	8.48E 02	
6.0	-2.0	7.02E-02	6.09E 02	6.94E 02	2.83E 03	-6.53E 02
			1.68E 02	2.38E 02	9.76E 02	
6.0	-1.0	7.21E-02	6.38E 02	7.30E 02	2.92E 03	-5.63E 02
			1.04E 02	1.63E 02	1.05E 03	
6.0	0.0	7.37E-02	6.51E 02	7.44E 02	2.98E 03	-4.70E 02
			4.15E 01	9.11E 01	1.06E 03	
6.0	1.0	7.51E-02	6.50E 02	7.38E 02	3.03E 03	-3.78E 02
			-2.00E 01	1.95E 01	1.03E 03	
6.0	2.0	7.63E-02	6.32E 02	7.09E 02	3.06E 03	-2.95E 02
			-8.31E 01	-5.32E 01	9.45E 02	
6.0	3.0	7.73E-02	5.96E 02	6.52E 02	3.07E 03	-2.28E 02
			-1.51E 02	-1.29E 02	8.03E 02	
6.0	4.0	7.81E-02	5.32E 02	5.49E 02	3.06E 03	-1.89E 02
			-2.27E 02	-2.10E 02	5.97E 02	
X	Y3	W3	QX3	VX3	MX3	MXY3
			QY3	VY3	MY3	
6.0	4.0	7.81E-02	5.32E 02	5.49E 02	3.06E 03	-1.89E 02
			-2.27E 02	-2.10E 02	5.97E 02	
6.0	5.0	7.90E-02	4.67E 02	4.46E 02	3.04E 03	-1.93E 02
			-1.70E 02	-1.51E 02	3.82E 02	
6.0	6.0	7.98E-02	4.28E 02	3.84E 02	3.04E 03	-2.27E 02
			-1.22E 02	-9.81E 01	2.16E 02	
6.0	7.0	8.07E-02	4.06E 02	3.50E 02	3.05E 03	-2.77E 02
			-7.81E 01	-4.82E 01	9.03E 01	
6.0	8.0	8.18E-02	3.99E 02	3.39E 02	3.08E 03	-3.36E 02
			-3.64E 01	1.53E-02	-2.37E-02	

X	Y1	W1	QX1	VX1	MX1	MXY1
			QY1	VY1	MY1	
7.0	-17.0	4.73E-02	1.63E 02	1.38E 02	1.79E 03	-2.83E 02
			-2.95E 01	-5.42E-03	-1.31E 01	
7.0	-13.0	5.30E-02	1.71E 02	1.27E 02	1.97E 03	-4.23E 02
			5.23E 01	1.09E 02	-1.55E 02	
7.0	-9.0	6.13E-02	2.19E 02	1.79E 02	2.32E 03	-6.00E 02
			1.56E 02	2.40E 02	-2.88E 01	
7.0	-5.0	7.18E-02	3.47E 02	3.48E 02	2.85E 03	-6.98E 02
			3.27E 02	4.40E 02	5.03E 02	
7.0	-4.0	7.45E-02	4.07E 02	4.37E 02	3.02E 03	-6.84E 02
			4.03E 02	5.17E 02	7.52E 02	
X	Y2	W2	QX2	VX2	MX2	MXY2
			QY2	VY2	MY2	
7.0	-4.0	7.45E-02	4.07E 02	4.37E 02	3.02E 03	-6.84E 02
			4.03E 02	5.17E 02	7.52E 02	
7.0	-3.0	7.70E-02	4.65E 02	5.22E 02	3.18E 03	-6.38E 02
			2.94E 02	3.98E 02	9.89E 02	
7.0	-2.0	7.94E-02	5.03E 02	5.75E 02	3.31E 03	-5.73E 02
			2.03E 02	2.92E 02	1.14E 03	
7.0	-1.0	8.15E-02	5.27E 02	6.05E 02	3.42E 03	-4.96E 02
			1.23E 02	1.95E 02	1.22E 03	
7.0	0.0	8.34E-02	5.38E 02	6.17E 02	3.50E 03	-4.17E 02
			4.71E 01	1.03E 02	1.24E 03	
7.0	1.0	8.50E-02	5.37E 02	6.12E 02	3.55E 03	-3.39E 02
			-2.78E 01	1.24E 01	1.20E 03	
7.0	2.0	8.63E-02	5.24E 02	5.89E 02	3.57E 03	-2.68E 02
			-1.06E 02	-8.14E 01	1.10E 03	
7.0	3.0	8.74E-02	4.97E 02	5.44E 02	3.56E 03	-2.12E 02
			-1.93E 02	-1.82E 02	9.38E 02	
7.0	4.0	8.83E-02	4.51E 02	4.67E 02	3.53E 03	-1.79E 02
			-2.98E 02	-2.94E 02	6.88E 02	
X	Y3	W3	QX3	VX3	MX3	MXY3
			QY3	VY3	MY3	
7.0	4.0	8.83E-02	4.51E 02	4.67E 02	3.53E 03	-1.79E 02
			-2.98E 02	-2.94E 02	6.88E 02	
7.0	5.0	8.92E-02	4.04E 02	3.88E 02	3.50E 03	-1.81E 02
			-2.14E 02	-2.07E 02	4.29E 02	
7.0	6.0	9.02E-02	3.74E 02	3.39E 02	3.48E 03	-2.07E 02
			-1.48E 02	-1.32E 02	2.37E 02	
7.0	7.0	9.12E-02	3.57E 02	3.10E 02	3.49E 03	-2.49E 02
			-9.11E 01	-6.39E 01	9.59E 01	
7.0	8.0	9.24E-02	3.51E 02	2.98E 02	3.51E 03	-2.99E 02
			-3.67E 01	2.98E-02	-4.76E-02	

X	Y1	W1	QX1	VX1	MX1	MXY1
			QY1	VY1	MY1	
8.0	-17.0	5.20E-02	1.45E 02	1.23E 02	1.97E 03	-2.37E 02
			-3.24E 01	-1.61E-04	-1.47E 01	
8.0	-13.0	5.82E-02	1.47E 02	1.09E 02	2.17E 03	-3.63E 02
			5.79E 01	1.21E 02	-1.72E 02	
8.0	-9.0	6.74E-02	1.87E 02	1.54E 02	2.56E 03	-5.11E 02
			1.74E 02	2.67E 02	-3.45E 01	
8.0	-5.0	7.90E-02	2.76E 02	2.83E 02	3.16E 03	-5.77E 02
			3.68E 02	4.96E 02	5.54E 02	
8.0	-4.0	8.19E-02	3.08E 02	3.34E 02	3.35E 03	-5.61E 02
			4.56E 02	5.86E 02	8.34E 02	
X	Y2	W2	QX2	VX2	MX2	MXY2
			QY2	VY2	MY2	
8.0	-4.0	8.19E-02	3.08E 02	3.34E 02	3.35E 03	-5.61E 02
			4.56E 02	5.86E 02	8.34E 02	
8.0	-3.0	8.48E-02	3.39E 02	3.82E 02	3.53E 03	-5.26E 02
			3.31E 02	4.49E 02	1.10E 03	
8.0	-2.0	8.74E-02	3.62E 02	4.16E 02	3.68E 03	-4.77E 02
			2.28E 02	3.29E 02	1.27E 03	
8.0	-1.0	8.97E-02	3.77E 02	4.38E 02	3.80E 03	-4.19E 02
			1.37E 02	2.19E 02	1.36E 03	
8.0	0.0	9.18E-02	3.85E 02	4.47E 02	3.89E 03	-3.57E 02
			5.20E 01	1.14E 02	1.38E 03	
8.0	1.0	9.35E-02	3.86E 02	4.44E 02	3.94E 03	-2.97E 02
			-3.25E 01	1.09E 01	1.34E 03	
8.0	2.0	9.50E-02	3.80E 02	4.28E 02	3.97E 03	-2.44E 02
			-1.21E 02	-9.59E 01	1.23E 03	
8.0	3.0	9.62E-02	3.67E 02	4.00E 02	3.96E 03	-2.03E 02
			-2.20E 02	-2.11E 02	1.04E 03	
8.0	4.0	9.72E-02	3.46E 02	3.60E 02	3.92E 03	-1.79E 02
			-3.39E 02	-3.39E 02	7.62E 02	
X	Y3	W3	QX3	VX3	MX3	MXY3
			QY3	VY3	MY3	
8.0	4.0	9.72E-02	3.46E 02	3.60E 02	3.92E 03	-1.79E 02
			-3.39E 02	-3.39E 02	7.62E 02	
8.0	5.0	9.82E-02	3.25E 02	3.18E 02	3.88E 03	-1.76E 02
			-2.43E 02	-2.38E 02	4.72E 02	
8.0	6.0	9.92E-02	3.09E 02	2.85E 02	3.86E 03	-1.92E 02
			-1.67E 02	-1.51E 02	2.59E 02	
8.0	7.0	1.00E-01	2.98E 02	2.62E 02	3.86E 03	-2.22E 02
			-1.01E 02	-7.33E 01	1.04E 02	
8.0	8.0	1.02E-01	2.92E 02	2.48E 02	3.88E 03	-2.61E 02
			-3.89E 01	3.35E-02	-5.35E-02	

X	Y1	W1	QX1	VX1	MX1	MXY1
			QY1	VY1	MY1	
9.0	-17.0	5.60E-02	1.24E 02	1.06E 02	2.12E 03	-1.87E 02
			-3.79E 01	5.52E-03	-1.11E 01	
9.0	-13.0	6.27E-02	1.20E 02	8.87E 01	2.34E 03	-2.98E 02
			6.24E 01	1.31E 02	-1.86E 02	
9.0	-9.0	7.26E-02	1.51E 02	1.27E 02	2.75E 03	-4.13E 02
			1.87E 02	2.87E 02	-3.73E 01	
9.0	-5.0	8.50E-02	2.02E 02	2.14E 02	3.39E 03	-4.46E 02
			3.88E 02	5.19E 02	5.99E 02	
9.0	-4.0	8.82E-02	2.06E 02	2.26E 02	3.58E 03	-4.29E 02
			4.72E 02	6.03E 02	8.95E 02	
X	Y2	W2	QX2	VX2	MX2	MXY2
			QY2	VY2	MY2	
9.0	-4.0	8.82E-02	2.06E 02	2.26E 02	3.58E 03	-4.29E 02
			4.72E 02	6.03E 02	8.95E 02	
9.0	-3.0	9.12E-02	2.09E 02	2.37E 02	3.77E 03	-4.06E 02
			3.48E 02	4.68E 02	1.18E 03	
9.0	-2.0	9.41E-02	2.17E 02	2.53E 02	3.93E 03	-3.74E 02
			2.42E 02	3.46E 02	1.36E 03	
9.0	-1.0	9.66E-02	2.24E 02	2.66E 02	4.05E 03	-3.35E 02
			1.46E 02	2.32E 02	1.46E 03	
9.0	0.0	9.88E-02	2.29E 02	2.72E 02	4.14E 03	-2.92E 02
			5.61E 01	1.23E 02	1.48E 03	
9.0	1.0	1.01E-01	2.32E 02	2.71E 02	4.20E 03	-2.51E 02
			-3.33E 01	1.57E 01	1.43E 03	
9.0	2.0	1.02E-01	2.32E 02	2.63E 02	4.23E 03	-2.16E 02
			-1.26E 02	-9.42E 01	1.31E 03	
9.0	3.0	1.04E-01	2.32E 02	2.52E 02	4.23E 03	-1.90E 02
			-2.27E 02	-2.10E 02	1.11E 03	
9.0	4.0	1.05E-01	2.37E 02	2.48E 02	4.20E 03	-1.75E 02
			-3.45E 02	-3.37E 02	8.18E 02	
X	Y3	W3	QX3	VX3	MX3	MXY3
			QY3	VY3	MY3	
9.0	4.0	1.05E-01	2.37E 02	2.48E 02	4.20E 03	-1.75E 02
			-3.45E 02	-3.37E 02	8.18E 02	
9.0	5.0	1.06E-01	2.40E 02	2.42E 02	4.16E 03	-1.69E 02
			-2.52E 02	-2.40E 02	5.12E 02	
9.0	6.0	1.07E-01	2.38E 02	2.26E 02	4.15E 03	-1.74E 02
			-1.76E 02	-1.54E 02	2.82E 02	
9.0	7.0	1.08E-01	2.33E 02	2.09E 02	4.15E 03	-1.92E 02
			-1.08E 02	-7.54E 01	1.14E 02	
9.0	8.0	1.09E-01	2.28E 02	1.93E 02	4.18E 03	-2.20E 02
			-4.35E 01	2.49E-02	-3.91E-02	

X	Y1	W1	QX1	VX1	MX1	MXY1
			QY1	VY1	MY1	
10.0	-17.0	5.91E-02	9.87E 01	8.52E 01	2.24E 03	-1.37E 02
			-4.52E 01	1.09E-02	-3.53E 00	
10.0	-13.0	6.62E-02	9.18E 01	6.74E 01	2.48E 03	-2.27E 02
			6.59E 01	1.38E 02	-1.98E 02	
10.0	-9.0	7.66E-02	1.14E 02	9.76E 01	2.91E 03	-3.11E 02
			1.96E 02	3.00E 02	-3.74E 01	
10.0	-5.0	8.98E-02	1.33E 02	1.48E 02	3.54E 03	-3.18E 02
			3.88E 02	5.12E 02	6.38E 02	
10.0	-4.0	9.31E-02	1.18E 02	1.33E 02	3.73E 03	-3.02E 02
			4.57E 02	5.79E 02	9.37E 02	
X	Y2	W2	QX2	VX2	MX2	MXY2
			QY2	VY2	MY2	
10.0	-4.0	9.31E-02	1.18E 02	1.33E 02	3.73E 03	-3.02E 02
			4.57E 02	5.79E 02	9.37E 02	
10.0	-3.0	9.63E-02	1.03E 02	1.17E 02	3.90E 03	-2.89E 02
			3.46E 02	4.59E 02	1.22E 03	
10.0	-2.0	9.93E-02	9.90E 01	1.19E 02	4.05E 03	-2.71E 02
			2.45E 02	3.45E 02	1.41E 03	
10.0	-1.0	1.02E-01	1.00E 02	1.25E 02	4.18E 03	-2.49E 02
			1.51E 02	2.37E 02	1.51E 03	
10.0	0.0	1.04E-01	1.03E 02	1.29E 02	4.27E 03	-2.23E 02
			5.94E 01	1.30E 02	1.54E 03	
10.0	1.0	1.06E-01	1.06E 02	1.29E 02	4.34E 03	-1.99E 02
			-3.09E 01	2.56E 01	1.49E 03	
10.0	2.0	1.08E-01	1.10E 02	1.27E 02	4.38E 03	-1.79E 02
			-1.23E 02	-7.96E 01	1.36E 03	
10.0	3.0	1.09E-01	1.20E 02	1.29E 02	4.39E 03	-1.66E 02
			-2.19E 02	-1.87E 02	1.15E 03	
10.0	4.0	1.10E-01	1.41E 02	1.50E 02	4.38E 03	-1.58E 02
			-3.24E 02	-2.98E 02	8.56E 02	
X	Y3	W3	QX3	VX3	MX3	MXY3
			QY3	VY3	MY3	
10.0	4.0	1.10E-01	1.41E 02	1.50E 02	4.38E 03	-1.58E 02
			-3.24E 02	-2.98E 02	8.56E 02	
10.0	5.0	1.12E-01	1.62E 02	1.69E 02	4.36E 03	-1.50E 02
			-2.46E 02	-2.19E 02	5.46E 02	
10.0	6.0	1.13E-01	1.69E 02	1.66E 02	4.36E 03	-1.47E 02
			-1.76E 02	-1.44E 02	3.06E 02	
10.0	7.0	1.14E-01	1.68E 02	1.55E 02	4.37E 03	-1.55E 02
			-1.12E 02	-7.13E 01	1.26E 02	
10.0	8.0	1.16E-01	1.64E 02	1.39E 02	4.40E 03	-1.74E 02
			-4.97E 01	7.08E-03	-9.49E-03	

X	Y1	W1	QX1 QY1	VX1 VY1	MX1 MY1	MXY1
11.0	-17.0	6.14E-02	6.92E 01	6.00E 01	2.32E 03	-8.90E 01
			-5.24E 01	1.53E-02	5.24E 00	
11.0	-13.0	6.87E-02	6.21E 01	4.53E 01	2.58E 03	-1.54E 02
			6.83E 01	1.44E 02	-2.08E 02	
11.0	-9.0	7.96E-02	7.58E 01	6.63E 01	3.01E 03	-2.08E 02
			2.03E 02	3.07E 02	-3.60E 01	
11.0	-5.0	9.32E-02	7.70E 01	9.02E 01	3.63E 03	-2.01E 02
			3.78E 02	4.89E 02	6.68E 02	
11.0	-4.0	9.67E-02	5.61E 01	6.59E 01	3.80E 03	-1.89E 02
			4.27E 02	5.33E 02	9.62E 02	

X	Y2	W2	QX2 QY2	VX2 VY2	MX2 MY2	MXY2
11.0	-4.0	9.67E-02	5.60E 01	6.59E 01	3.80E 03	-1.89E 02
			4.27E 02	5.33E 02	9.62E 02	
11.0	-3.0	1.00E-01	3.45E 01	4.04E 01	3.96E 03	-1.82E 02
			3.35E 02	4.35E 02	1.24E 03	
11.0	-2.0	1.03E-01	2.63E 01	3.54E 01	4.10E 03	-1.74E 02
			2.42E 02	3.35E 02	1.43E 03	
11.0	-1.0	1.06E-01	2.44E 01	3.67E 01	4.22E 03	-1.64E 02
			1.51E 02	2.35E 02	1.54E 03	
11.0	0.0	1.08E-01	2.53E 01	3.85E 01	4.31E 03	-1.51E 02
			6.17E 01	1.36E 02	1.57E 03	
11.0	1.0	1.10E-01	2.81E 01	3.93E 01	4.38E 03	-1.38E 02
			-2.70E 01	3.70E 01	1.51E 03	
11.0	2.0	1.12E-01	3.39E 01	4.05E 01	4.43E 03	-1.29E 02
			-1.15E 02	-5.94E 01	1.38E 03	
11.0	3.0	1.13E-01	4.59E 01	4.84E 01	4.46E 03	-1.25E 02
			-2.03E 02	-1.53E 02	1.17E 03	
11.0	4.0	1.15E-01	7.13E 01	7.68E 01	4.47E 03	-1.22E 02
			-2.89E 02	-2.42E 02	8.78E 02	

X	Y3	W3	QX3 QY3	VX3 VY3	MX3 MY3	MXY3
11.0	4.0	1.15E-01	7.13E 01	7.68E 01	4.47E 03	-1.22E 02
			-2.89E 02	-2.42E 02	8.78E 02	
11.0	5.0	1.16E-01	9.59E 01	1.04E 02	4.48E 03	-1.14E 02
			-2.31E 02	-1.86E 02	5.73E 02	
11.0	6.0	1.17E-01	1.06E 02	1.08E 02	4.49E 03	-1.08E 02
			-1.72E 02	-1.27E 02	3.27E 02	
11.0	7.0	1.18E-01	1.08E 02	1.02E 02	4.52E 03	-1.10E 02
			-1.13E 02	-6.43E 01	1.37E 02	
11.0	8.0	1.20E-01	1.05E 02	8.89E 01	4.56E 03	-1.21E 02
			-5.62E 01	-1.37E-02	2.49E-02	

X	Y1	W1	QX1	VX1	MX1	MXY1
			QY1	VY1	MY1	
12.0	-17.0	6.28E-02	3.57E 01	3.11E 01	2.38E 03	-4.36E 01
			-5.78E 01	1.82E-02	1.22E 01	
12.0	-13.0	7.03E-02	3.13E 01	2.28E 01	2.64E 03	-7.74E 01
			6.98E 01	1.47E 02	-2.13E 02	
12.0	-9.0	8.14E-02	3.79E 01	3.35E 01	3.08E 03	-1.04E 02
			2.06E 02	3.09E 02	-3.43E 01	
12.0	-5.0	9.53E-02	3.43E 01	4.21E 01	3.67E 03	-9.66E 01
			3.67E 02	4.66E 02	6.87E 02	
12.0	-4.0	9.88E-02	1.99E 01	2.48E 01	3.83E 03	-8.95E 01
			3.99E 02	4.92E 02	9.75E 02	
X	Y2	W2	QX2	VX2	MX2	MXY2
			QY2	VY2	MY2	
12.0	-4.0	9.88E-02	1.99E 01	2.48E 01	3.83E 03	-8.95E 01
			3.99E 02	4.92E 02	9.75E 02	
12.0	-3.0	1.02E-01	5.26E 00	6.85E 00	3.97E 03	-8.70E 01
			3.23E 02	4.12E 02	1.25E 03	
12.0	-2.0	1.05E-01	-8.80E-01	2.08E 00	4.10E 03	-8.49E 01
			2.38E 02	3.25E 02	1.44E 03	
12.0	-1.0	1.08E-01	-2.83E 00	1.88E 00	4.22E 03	-8.10E 01
			1.51E 02	2.32E 02	1.55E 03	
12.0	0.0	1.11E-01	-2.65E 00	2.57E 00	4.31E 03	-7.59E 01
			6.31E 01	1.39E 02	1.58E 03	
12.0	1.0	1.13E-01	-9.45E-01	3.17E 00	4.39E 03	-7.11E 01
			-2.36E 01	4.61E 01	1.52E 03	
12.0	2.0	1.14E-01	2.90E 00	4.70E 00	4.44E 03	-6.81E 01
			-1.08E 02	-4.25E 01	1.39E 03	
12.0	3.0	1.16E-01	1.09E 01	1.09E 01	4.49E 03	-6.74E 01
			-1.88E 02	-1.24E 02	1.18E 03	
12.0	4.0	1.17E-01	2.75E 01	3.03E 01	4.52E 03	-6.67E 01
			-2.58E 02	-1.95E 02	8.89E 02	
X	Y3	W3	QX3	VX3	MX3	MXY3
			QY3	VY3	MY3	
12.0	4.0	1.17E-01	2.75E 01	3.03E 01	4.52E 03	-6.67E 01
			-2.58E 02	-1.95E 02	8.89E 02	
12.0	5.0	1.18E-01	4.37E 01	4.90E 01	4.54E 03	-6.19E 01
			-2.17E 02	-1.59E 02	5.90E 02	
12.0	6.0	1.20E-01	5.06E 01	5.31E 01	4.57E 03	-5.77E 01
			-1.67E 02	-1.12E 02	3.41E 02	
12.0	7.0	1.21E-01	5.24E 01	5.03E 01	4.60E 03	-5.75E 01
			-1.14E 02	-5.81E 01	1.45E 02	
12.0	8.0	1.23E-01	5.06E 01	4.30E 01	4.65E 03	-6.21E 01
			-6.10E 01	-3.00E-02	5.20E-02	

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X	Y1	W1	QX1 / QY1	VX1 / VY1	MX1 / MY1	MXY1
13.0	-17.0	6.32E-02	3.43E-04	2.95E-04	2.39E 03	-4.99E-04
			-5.98E 01	1.92E-02	1.48E 01	
13.0	-13.0	7.08E-02	3.27E-04	2.42E-04	2.66E 03	-8.08E-04
			7.02E 01	1.48E 02	-2.15E 02	
13.0	-9.0	8.20E-02	4.05E-04	3.46E-04	3.10E 03	-1.11E-03
			2.07E 02	3.10E 02	-3.36E 01	
13.0	-5.0	9.59E-02	4.98E-04	5.42E-04	3.69E 03	-1.16E-03
			3.62E 02	4.57E 02	6.93E 02	
13.0	-4.0	9.95E-02	4.74E-04	5.27E-04	3.83E 03	-1.10E-03
			3.88E 02	4.76E 02	9.79E 02	
X	Y2	W2	QX2 / QY2	VX2 / VY2	MX2 / MY2	MXY2
13.0	-4.0	9.95E-02	4.74E-04	5.27E-04	3.83E 03	-1.10E-03
			3.88E 02	4.76E 02	9.79E 02	
13.0	-3.0	1.03E-01	4.47E-04	5.07E-04	3.97E 03	-1.05E-03
			3.18E 02	4.03E 02	1.25E 03	
13.0	-2.0	1.06E-01	4.48E-04	5.28E-04	4.10E 03	-9.81E-04
			2.36E 02	3.20E 02	1.44E 03	
13.0	-1.0	1.09E-01	4.58E-04	5.53E-04	4.21E 03	-8.93E-04
			1.50E 02	2.31E 02	1.55E 03	
13.0	0.0	1.11E-01	4.69E-04	5.67E-04	4.31E 03	-7.95E-04
			6.36E 01	1.40E 02	1.58E 03	
13.0	1.0	1.13E-01	4.78E-04	5.66E-04	4.38E 03	-7.01E-04
			-2.23E 01	4.95E 01	1.53E 03	
13.0	2.0	1.15E-01	4.88E-04	5.54E-04	4.44E 03	-6.23E-04
			-1.05E 02	-3.60E 01	1.39E 03	
13.0	3.0	1.17E-01	5.07E-04	5.48E-04	4.49E 03	-5.69E-04
			-1.82E 02	-1.13E 02	1.18E 03	
13.0	4.0	1.18E-01	5.55E-04	5.84E-04	4.53E 03	-5.37E-04
			-2.46E 02	-1.77E 02	8.93E 02	
X	Y3	W3	QX3 / QY3	VX3 / VY3	MX3 / MY3	MXY3
13.0	4.0	1.18E-01	5.55E-04	5.84E-04	4.53E 03	-5.37E-04
			-2.46E 02	-1.77E 02	8.93E 02	
13.0	5.0	1.19E-01	6.00E-04	6.15E-04	4.56E 03	-5.12E-04
			-2.12E 02	-1.48E 02	5.96E 02	
13.0	6.0	1.21E-01	6.11E-04	5.93E-04	4.59E 03	-5.13E-04
			-1.65E 02	-1.06E 02	3.46E 02	
13.0	7.0	1.22E-01	6.05E-04	5.52E-04	4.63E 03	-5.49E-04
			-1.14E 02	-5.57E 01	1.48E 02	
13.0	8.0	1.24E-01	5.89E-04	5.01E-04	4.68E 03	-6.19E-04
			-6.28E 01	-3.62E-02	6.23E-02	

X	Y1	W1	QX1	VX1	MX1	MXY1
			QY1	VY1	MY1	
14.0	-17.0	6.28E-02	-3.57E 01	-3.11E 01	2.38E 03	4.36E 01
			-5.78E 01	1.82E-02	1.22E 01	
14.0	-13.0	7.03E-02	-3.13E 01	-2.28E 01	2.64E 03	7.74E 01
			6.98E 01	1.47E 02	-2.13E 02	
14.0	-9.0	8.14E-02	-3.79E 01	-3.35E 01	3.08E 03	1.04E 02
			2.06E 02	3.09E 02	-3.43E 01	
14.0	-5.0	9.53E-02	-3.43E 01	-4.21E 01	3.67E 03	9.66E 01
			3.67E 02	4.66E 02	6.87E 02	
14.0	-4.0	9.88E-02	-1.99E 01	-2.48E 01	3.83E 03	8.95E 01
			3.99E 02	4.92E 02	9.75E 02	

X	Y2	W2	QX2	VX2	MX2	MXY2
			QY2	VY2	MY2	
14.0	-4.0	9.88E-02	-1.99E 01	-2.48E 01	3.83E 03	8.95E 01
			3.99E 02	4.92E 02	9.75E 02	
14.0	-3.0	1.02E-01	-5.26E 00	-6.85E 00	3.97E 03	8.70E 01
			3.23E 02	4.12E 02	1.25E 03	
14.0	-2.0	1.05E-01	8.81E-01	-2.07E 00	4.10E 03	8.49E 01
			2.38E 02	3.25E 02	1.44E 03	
14.0	-1.0	1.08E-01	2.83E 00	-1.87E 00	4.22E 03	8.10E 01
			1.51E 02	2.32E 02	1.55E 03	
14.0	0.0	1.11E-01	2.65E 00	-2.57E 00	4.31E 03	7.59E 01
			6.31E 01	1.39E 02	1.58E 03	
14.0	1.0	1.13E-01	9.46E-01	-3.16E 00	4.39E 03	7.11E 01
			-2.36E 01	4.61E 01	1.52E 03	
14.0	2.0	1.14E-01	-2.90E 00	-4.69E 00	4.44E 03	6.81E 01
			-1.08E 02	-4.25E 01	1.39E 03	
14.0	3.0	1.16E-01	-1.09E 01	-1.09E 01	4.49E 03	6.73E 01
			-1.88E 02	-1.24E 02	1.18E 03	
14.0	4.0	1.17E-01	-2.75E 01	-3.03E 01	4.52E 03	6.67E 01
			-2.58E 02	-1.95E 02	8.89E 02	

X	Y3	W3	QX3	VX3	MX3	MXY3
			QY3	VY3	MY3	
14.0	4.0	1.17E-01	-2.75E 01	-3.03E 01	4.52E 03	6.67E 01
			-2.58E 02	-1.95E 02	8.89E 02	
14.0	5.0	1.18E-01	-4.37E 01	-4.90E 01	4.54E 03	6.19E 01
			-2.17E 02	-1.59E 02	5.90E 02	
14.0	6.0	1.20E-01	-5.06E 01	-5.31E 01	4.57E 03	5.77E 01
			-1.67E 02	-1.12E 02	3.41E 02	
14.0	7.0	1.21E-01	-5.24E 01	-5.03E 01	4.60E 03	5.75E 01
			-1.14E 02	-5.81E 01	1.45E 02	
14.0	8.0	1.23E-01	-5.06E 01	-4.30E 01	4.65E 03	6.21E 01
			-6.10E 01	-3.00E-02	5.20E-02	

D.3.3

EDGE STRIP LOADED PLATES

LEVY SOLUTION FOR PLATE ANALYSIS

PLAT DATA

LENGTH OF PLATE	(IN)	26.00
WIDTH OF PLATE	(IN)	25.00
UNLOADED WIDTH OF PLATE	(IN)	17.00
LOADED WIDTH OF PLATE	(IN)	8.00
THICKNESS OF PLATE	(IN)	3.00
FPRC IS COMP. STRENGHT OF CONC.	(PSI)	3700.00
EFFI IS EFF. MOM. OF INERTIA	(IN.**4)	0.83
POISSON'S RATIO OF PLATE		0.15
ELASTIC MODOLUS OF PLATE	(PSI)	3.47E 06
FLEXURAL RIGIDITY OF PLAT	(#-IN)	2.94E 06

LOAD DATA

CENTER LOCATION OF FIRST LOAD	(IN)	7.00
CENTER LOCATION OF SECOND LOAD	(IN)	19.00
LENGTH OF EACH DISTRIBUTED LOAD 1	(IN)	4.00
INTENSITY OF DISTRIBUTED LOAD	(PSI)	312.50
TOTAL LOAD	(#)	20000.00

NUMBER OF SERIES TERM USED 5
X=0.0 & X=A1 ARE SIMPLY SUPPORTED EDGES
Y1 IS UNLOADED WIDTH
Y2 IS LODED WIDTH

X	Y1	W1	QX1	VX1	MX1	MXY1
			QY1	VY1	MY1	
0.0	-17.0	0.00E-01	1.66E 02	1.40E 02	0.00E-01	-4.31E 02
			0.00E-01	0.00E-01	0.00E-01	
0.0	-13.0	0.00E-01	1.59E 02	9.69E 01	0.00E-01	-6.13E 02
			0.00E-01	0.00E-01	0.00E-01	
0.0	-9.0	0.00E-01	1.93E 02	1.11E 02	0.00E-01	-9.07E 02
			0.00E-01	0.00E-01	0.00E-01	
0.0	-5.0	0.00E-01	2.81E 02	1.99E 02	0.00E-01	-1.25E 03
			0.00E-01	0.00E-01	0.00E-01	
0.0	-1.0	0.00E-01	4.38E 02	4.08E 02	0.00E-01	-1.50E 03
			0.00E-01	0.00E-01	0.00E-01	
0.0	0.0	0.00E-01	4.78E 02	4.67E 02	0.00E-01	-1.52E 03
			0.00E-01	0.00E-01	0.00E-01	

X	Y2	W2	QX2	VX2	MX2	MXY2
			QY2	VY2	MY2	
0.0	0.0	0.00E-01	4.78E 02	4.67E 02	0.00E-01	-1.52E 03
			0.00E-01	0.00E-01	0.00E-01	
0.0	2.0	0.00E-01	5.53E 02	5.73E 02	0.00E-01	-1.51E 03
			0.00E-01	0.00E-01	0.00E-01	
0.0	4.0	0.00E-01	6.05E 02	6.24E 02	0.00E-01	-1.46E 03
			0.00E-01	0.00E-01	0.00E-01	
0.0	6.0	0.00E-01	6.17E 02	5.98E 02	0.00E-01	-1.45E 03
			0.00E-01	0.00E-01	0.00E-01	
0.0	8.0	0.00E-01	5.91E 02	5.03E 02	0.00E-01	-1.56E 03
			0.00E-01	0.00E-01	0.00E-01	

X	Y1	W1	QX1	VX1	MX1	MXY1
			QY1	VY1	MY1	
1.0	-17.0	4.49E-03	1.65E 02	1.39E 02	1.91E 02	-4.28E 02
			-6.92E 00	-1.03E 00	-5.49E-01	
1.0	-13.0	5.30E-03	1.58E 02	9.63E 01	2.21E 02	-6.08E 02
			3.23E 00	1.30E 01	-3.83E 01	
1.0	-9.0	6.50E-03	1.92E 02	1.10E 02	2.75E 02	-9.00E 02
			1.44E 01	2.98E 01	-5.35E 01	
1.0	-5.0	8.22E-03	2.79E 02	1.97E 02	3.63E 02	-1.24E 03
			3.06E 01	5.21E 01	-4.05E 01	
1.0	-1.0	1.04E-02	4.40E 02	4.08E 02	4.70E 02	-1.49E 03
			4.45E 01	6.13E 01	3.50E 01	
1.0	0.0	1.10E-02	4.85E 02	4.75E 02	4.92E 02	-1.51E 03
			3.73E 01	5.22E 01	6.12E 01	

X	Y2	W2	QX2	VX2	MX2	MXY2
			QY2	VY2	MY2	
1.0	0.0	1.10E-02	4.85E 02	4.75E 02	4.92E 02	-1.51E 03
			3.73E 01	5.22E 01	6.12E 01	
1.0	2.0	1.23E-02	5.68E 02	5.90E 02	5.38E 02	-1.50E 03
			3.49E 01	5.53E 01	1.04E 02	
1.0	4.0	1.34E-02	6.22E 02	6.42E 02	5.91E 02	-1.45E 03
			1.66E 01	4.07E 01	1.11E 02	
1.0	6.0	1.46E-02	6.34E 02	6.15E 02	6.42E 02	-1.44E 03
			-3.88E 00	2.10E 01	7.46E 01	
1.0	8.0	1.58E-02	6.07E 02	5.16E 02	6.86E 02	-1.55E 03
			-2.18E 01	-3.69E-03	9.43E-04	

X	Y1	W1	QX1	VX1	MX1	MXY1
			QY1	VY1	MY1	
2.0	-17.0	8.91E-03	1.61E 02	1.36E 02	3.79E 02	-4.19E 02
			-1.36E 01	-1.69E 00	-8.97E-01	
2.0	-13.0	1.05E-02	1.54E 02	9.43E 01	4.38E 02	-5.94E 02
			6.39E 00	2.56E 01	-7.58E 01	
2.0	-9.0	1.29E-02	1.87E 02	1.08E 02	5.46E 02	-8.77E 02
			2.84E 01	5.89E 01	-1.06E 02	
2.0	-5.0	1.63E-02	2.72E 02	1.91E 02	7.21E 02	-1.21E 03
			6.09E 01	1.04E 02	-8.08E 01	
2.0	-1.0	2.07E-02	4.41E 02	4.06E 02	9.44E 02	-1.46E 03
			9.60E 01	1.35E 02	6.75E 01	
2.0	0.0	2.19E-02	5.01E 02	4.91E 02	9.96E 02	-1.49E 03
			8.95E 01	1.26E 02	1.24E 02	
X	Y2	W2	QX2	VX2	MX2	MXY2
			QY2	VY2	MY2	
2.0	0.0	2.19E-02	5.01E 02	4.91E 02	9.96E 02	-1.49E 03
			8.95E 01	1.26E 02	1.24E 02	
2.0	2.0	2.43E-02	6.05E 02	6.30E 02	1.10E 03	-1.47E 03
			7.30E 01	1.17E 02	2.15E 02	
2.0	4.0	2.67E-02	6.62E 02	6.84E 02	1.21E 03	-1.41E 03
			3.35E 01	8.27E 01	2.28E 02	
2.0	6.0	2.90E-02	6.75E 02	6.56E 02	1.31E 03	-1.40E 03
			-8.27E 00	4.17E 01	1.54E 02	
2.0	8.0	3.13E-02	6.44E 02	5.47E 02	1.40E 03	-1.51E 03
			-4.62E 01	-5.96E-03	1.22E-03	

X	Y1	W1	QX1	VX1	MX1	MXY1
			QY1	VY1	MY1	
3.0	-17.0	1.32E-02	1.54E 02	1.31E 02	5.60E 02	-4.04E 02
			-1.98E 01	-1.74E 00	-9.13E-01	
3.0	-13.0	1.56E-02	1.48E 02	9.11E 01	6.48E 02	-5.70E 02
			9.40E 00	3.77E 01	-1.12E 02	
3.0	-9.0	1.91E-02	1.79E 02	1.04E 02	8.06E 02	-8.39E 02
			4.18E 01	8.67E 01	-1.56E 02	
3.0	-5.0	2.41E-02	2.59E 02	1.82E 02	1.07E 03	-1.15E 03
			9.03E 01	1.56E 02	-1.20E 02	
3.0	-1.0	3.07E-02	4.35E 02	3.96E 02	1.42E 03	-1.41E 03
			1.58E 02	2.27E 02	9.57E 01	
3.0	0.0	3.24E-02	5.11E 02	5.01E 02	1.51E 03	-1.44E 03
			1.65E 02	2.32E 02	1.90E 02	
X	Y2	W2	QX2	VX2	MX2	MXY2
			QY2	VY2	MY2	
3.0	0.0	3.24E-02	5.11E 02	5.01E 02	1.51E 03	-1.44E 03
			1.65E 02	2.32E 02	1.90E 02	
3.0	2.0	3.60E-02	6.38E 02	6.67E 02	1.70E 03	-1.41E 03
			1.15E 02	1.89E 02	3.36E 02	
3.0	4.0	3.95E-02	6.98E 02	7.20E 02	1.87E 03	-1.35E 03
			5.06E 01	1.26E 02	3.52E 02	
3.0	6.0	4.29E-02	7.09E 02	6.90E 02	2.03E 03	-1.34E 03
			-1.34E 01	6.16E 01	2.39E 02	
3.0	8.0	4.64E-02	6.75E 02	5.74E 02	2.16E 03	-1.45E 03
			-7.43E 01	-5.87E-03	4.26E-04	

X	Y1	W1	QX1 / QY1	VX1 / VY1	MX1 / MY1	MXY1
4.0	-17.0	1.73E-02	1.45E 02	1.25E 02	7.32E 02	-3.82E 02
			-2.54E 01	-1.17E 00	-5.88E-01	
4.0	-13.0	2.04E-02	1.40E 02	8.66E 01	8.47E 02	-5.37E 02
			1.22E 01	4.89E 01	-1.45E 02	
4.0	-9.0	2.50E-02	1.68E 02	9.86E 01	1.05E 03	-7.87E 02
			5.43E 01	1.12E 02	-2.02E 02	
4.0	-5.0	3.16E-02	2.41E 02	1.70E 02	1.39E 03	-1.07E 03
			1.18E 02	2.05E 02	-1.57E 02	
4.0	-1.0	4.01E-02	4.13E 02	3.72E 02	1.89E 03	-1.32E 03
			2.27E 02	3.34E 02	1.19E 02	
4.0	0.0	4.25E-02	4.98E 02	4.88E 02	2.03E 03	-1.35E 03
			2.59E 02	3.66E 02	2.56E 02	

X	Y2	W2	QX2 / QY2	VX2 / VY2	MX2 / MY2	MXY2
4.0	0.0	4.25E-02	4.98E 02	4.88E 02	2.03E 03	-1.35E 03
			2.59E 02	3.66E 02	2.56E 02	
4.0	2.0	4.71E-02	6.36E 02	6.65E 02	2.31E 03	-1.32E 03
			1.60E 02	2.67E 02	4.61E 02	
4.0	4.0	5.17E-02	6.94E 02	7.15E 02	2.55E 03	-1.26E 03
			6.73E 01	1.69E 02	4.79E 02	
4.0	6.0	5.61E-02	7.04E 02	6.85E 02	2.76E 03	-1.25E 03
			-1.92E 01	7.97E 01	3.27E 02	
4.0	8.0	6.07E-02	6.69E 02	5.68E 02	2.94E 03	-1.36E 03
			-1.05E 02	-3.36E-03	-1.40E-03	

X	Y1	W1	QX1 / QY1	VX1 / VY1	MX1 / MY1	MXY1
5.0	-17.0	2.11E-02	1.34E 02	1.16E 02	8.92E 02	-3.55E 02
			-3.04E 01	-1.59E-01	-3.40E-02	
5.0	-13.0	2.50E-02	1.29E 02	8.08E 01	1.03E 03	-4.97E 02
			1.48E 01	5.90E 01	-1.76E 02	
5.0	-9.0	3.06E-02	1.54E 02	9.21E 01	1.28E 03	-7.23E 02
			6.54E 01	1.35E 02	-2.44E 02	
5.0	-5.0	3.86E-02	2.18E 02	1.55E 02	1.69E 03	-9.78E 02
			1.42E 02	2.49E 02	-1.90E 02	
5.0	-1.0	4.89E-02	3.69E 02	3.31E 02	2.32E 03	-1.20E 03
			2.96E 02	4.41E 02	1.38E 02	
5.0	0.0	5.18E-02	4.47E 02	4.38E 02	2.52E 03	-1.22E 03
			3.59E 02	5.08E 02	3.18E 02	

X	Y2	W2	QX2 / QY2	VX2 / VY2	MX2 / MY2	MXY2
5.0	0.0	5.18E-02	4.47E 02	4.38E 02	2.52E 03	-1.22E 03
			3.59E 02	5.08E 02	3.18E 02	
5.0	2.0	5.75E-02	5.74E 02	5.99E 02	2.89E 03	-1.19E 03
			2.03E 02	3.43E 02	5.81E 02	
5.0	4.0	6.30E-02	6.25E 02	6.41E 02	3.20E 03	-1.15E 03
			8.22E 01	2.08E 02	5.97E 02	
5.0	6.0	6.84E-02	6.32E 02	6.15E 02	3.45E 03	-1.14E 03
			-2.49E 01	9.53E 01	4.09E 02	
5.0	8.0	7.40E-02	6.00E 02	5.10E 02	3.68E 03	-1.24E 03
			-1.35E 02	7.76E-04	-3.77E-03	

X	Y1	W1	QX1	VX1	MX1	MXY1
			QY1	VY1	MY1	
6.0	-17.0	2.47E-02	1.22E 02	1.05E 02	1.04E 03	-3.22E 02
			-3.49E 01	9.18E-01	5.52E-01	
6.0	-13.0	2.91E-02	1.17E 02	7.39E 01	1.20E 03	-4.49E 02
			1.70E 01	6.79E 01	-2.03E 02	
6.0	-9.0	3.57E-02	1.39E 02	8.45E 01	1.49E 03	-6.49E 02
			7.50E 01	1.54E 02	-2.80E 02	
6.0	-5.0	4.50E-02	1.90E 02	1.39E 02	1.95E 03	-8.64E 02
			1.63E 02	2.84E 02	-2.16E 02	
6.0	-1.0	5.70E-02	3.01E 02	2.72E 02	2.69E 03	-1.03E 03
			3.52E 02	5.29E 02	1.55E 02	
6.0	0.0	6.03E-02	3.58E 02	3.49E 02	2.93E 03	-1.05E 03
			4.43E 02	6.27E 02	3.69E 02	

X	Y2	W2	QX2	VX2	MX2	MXY2
			QY2	VY2	MY2	
6.0	0.0	6.03E-02	3.58E 02	3.49E 02	2.93E 03	-1.05E 03
			4.43E 02	6.27E 02	3.69E 02	
6.0	2.0	6.69E-02	4.47E 02	4.63E 02	3.39E 03	-1.04E 03
			2.37E 02	4.04E 02	6.79E 02	
6.0	4.0	7.33E-02	4.83E 02	4.92E 02	3.75E 03	-1.01E 03
			9.37E 01	2.39E 02	6.93E 02	
6.0	6.0	7.95E-02	4.88E 02	4.72E 02	4.03E 03	-1.02E 03
			-2.98E 01	1.07E 02	4.77E 02	
6.0	8.0	8.60E-02	4.64E 02	3.94E 02	4.30E 03	-1.09E 03
			-1.61E 02	5.14E-03	-5.93E-03	

X	Y1	W1	QX1	VX1	MX1	MXY1
			QY1	VY1	MY1	
7.0	-17.0	2.78E-02	1.07E 02	9.21E 01	1.17E 03	-2.84E 02
			-3.88E 01	1.68E 00	9.60E-01	
7.0	-13.0	3.29E-02	1.03E 02	6.58E 01	1.35E 03	-3.95E 02
			1.88E 01	7.53E 01	-2.27E 02	
7.0	-9.0	4.02E-02	1.21E 02	7.57E 01	1.66E 03	-5.66E 02
			8.30E 01	1.69E 02	-3.10E 02	
7.0	-5.0	5.06E-02	1.60E 02	1.22E 02	2.17E 03	-7.37E 02
			1.77E 02	3.08E 02	-2.34E 02	
7.0	-1.0	6.41E-02	2.18E 02	2.01E 02	2.97E 03	-8.47E 02
			3.85E 02	5.80E 02	1.71E 02	
7.0	0.0	6.77E-02	2.39E 02	2.31E 02	3.24E 03	-8.60E 02
			4.91E 02	6.94E 02	4.06E 02	

X	Y2	W2	QX2	VX2	MX2	MXY2
			QY2	VY2	MY2	
7.0	0.0	6.77E-02	2.39E 02	2.31E 02	3.24E 03	-8.60E 02
			4.91E 02	6.94E 02	4.06E 02	
7.0	2.0	7.51E-02	2.72E 02	2.74E 02	3.74E 03	-8.63E 02
			2.57E 02	4.40E 02	7.43E 02	
7.0	4.0	8.23E-02	2.87E 02	2.87E 02	4.13E 03	-8.60E 02
			1.01E 02	2.58E 02	7.56E 02	
7.0	6.0	8.93E-02	2.90E 02	2.75E 02	4.44E 03	-8.72E 02
			-3.31E 01	1.15E 02	5.21E 02	
7.0	8.0	9.65E-02	2.78E 02	2.36E 02	4.73E 03	-9.25E 02
			-1.76E 02	8.23E-03	-7.10E-03	

X	Y1	W1	QX1	VX1	MX1	MXY1
			QY1	VY1	MY1	
8.0	-17.0	3.06E-02	9.20E 01	7.80E 01	1.29E 03	-2.42E 02
			-4.23E 01	1.86E 00	1.04E 00	
8.0	-13.0	3.61E-02	8.81E 01	5.66E 01	1.48E 03	-3.37E 02
			2.04E 01	8.14E 01	-2.47E 02	
8.0	-9.0	4.42E-02	1.02E 02	6.57E 01	1.82E 03	-4.77E 02
			8.93E 01	1.81E 02	-3.34E 02	
8.0	-5.0	5.56E-02	1.28E 02	1.04E 02	2.34E 03	-6.04E 02
			1.87E 02	3.20E 02	-2.43E 02	
8.0	-1.0	7.01E-02	1.31E 02	1.28E 02	3.16E 03	-6.51E 02
			3.88E 02	5.82E 02	1.88E 02	
8.0	0.0	7.41E-02	1.12E 02	1.05E 02	3.42E 03	-6.55E 02
			4.89E 02	6.92E 02	4.25E 02	

X	Y2	W2	QX2	VX2	MX2	MXY2
			QY2	VY2	MY2	
8.0	0.0	7.41E-02	1.12E 02	1.05E 02	3.42E 03	-6.55E 02
			4.89E 02	6.92E 02	4.25E 02	
8.0	2.0	8.21E-02	8.30E 01	7.05E 01	3.92E 03	-6.79E 02
			2.59E 02	4.43E 02	7.64E 02	
8.0	4.0	8.99E-02	7.73E 01	6.76E 01	4.32E 03	-7.01E 02
			1.02E 02	2.62E 02	7.78E 02	
8.0	6.0	9.75E-02	7.67E 01	6.50E 01	4.64E 03	-7.21E 02
			-3.43E 01	1.19E 02	5.35E 02	
8.0	8.0	1.05E-01	7.80E 01	6.63E 01	4.93E 03	-7.46E 02
			-1.80E 02	8.98E-03	-6.77E-03	

X	Y1	W1	QX1	VX1	MX1	MXY1
			QY1	VY1	MY1	
9.0	-17.0	3.29E-02	7.53E 01	6.28E 01	1.38E 03	-1.96E 02
			-4.54E 01	1.38E 00	7.56E-01	
9.0	-13.0	3.89E-02	7.18E 01	4.65E 01	1.59E 03	-2.74E 02
			2.15E 01	8.61E 01	-2.64E 02	
9.0	-9.0	4.75E-02	8.22E 01	5.45E 01	1.94E 03	-3.84E 02
			9.40E 01	1.88E 02	-3.53E 02	
9.0	-5.0	5.97E-02	9.75E 01	8.51E 01	2.47E 03	-4.72E 02
			1.91E 02	3.22E 02	-2.44E 02	
9.0	-1.0	7.51E-02	5.46E 01	6.40E 01	3.24E 03	-4.66E 02
			3.63E 02	5.38E 02	2.06E 02	
9.0	0.0	7.93E-02	3.32E 00	-2.71E 00	3.48E 03	-4.62E 02
			4.41E 02	6.22E 02	4.26E 02	

X	Y2	W2	QX2	VX2	MX2	MXY2
			QY2	VY2	MY2	
9.0	0.0	7.93E-02	3.32E 00	-2.71E 00	3.48E 03	-4.62E 02
			4.41E 02	6.22E 02	4.26E 02	
9.0	2.0	8.78E-02	-7.69E 01	-1.01E 02	3.94E 03	-5.01E 02
			2.46E 02	4.15E 02	7.45E 02	
9.0	4.0	9.60E-02	-9.94E 01	-1.16E 02	4.31E 03	-5.42E 02
			9.93E 01	2.55E 02	7.62E 02	
9.0	6.0	1.04E-01	-1.02E 02	-1.11E 02	4.63E 03	-5.68E 02
			-3.33E 01	1.19E 02	5.22E 02	
9.0	8.0	1.13E-01	-8.98E 01	-7.63E 01	4.92E 03	-5.69E 02
			-1.73E 02	7.15E-03	-4.92E-03	

X	Y1	W1	QX1	VX1	MX1	MXY1
			QY1	VY1	MY1	
10.0	-17.0	3.48E-02	5.76E 01	4.72E 01	1.46E 03	-1.48E 02
			-4.80E 01	4.13E-01	2.02E-01	
10.0	-13.0	4.10E-02	5.46E 01	3.56E 01	1.68E 03	-2.08E 02
			2.24E 01	8.95E 01	-2.76E 02	
10.0	-9.0	5.01E-02	6.18E 01	4.21E 01	2.04E 03	-2.89E 02
			9.73E 01	1.93E 02	-3.65E 02	
10.0	-5.0	6.29E-02	6.91E 01	6.50E 01	2.56E 03	-3.44E 02
			1.91E 02	3.16E 02	-2.40E 02	
10.0	-1.0	7.90E-02	1.93E 00	1.80E 01	3.26E 03	-3.05E 02
			3.19E 02	4.63E 02	2.23E 02	
10.0	0.0	8.33E-02	-6.54E 01	-7.02E 01	3.45E 03	-2.97E 02
			3.60E 02	5.07E 02	4.16E 02	

X	Y2	W2	QX2	VX2	MX2	MXY2
			QY2	VY2	MY2	
10.0	0.0	8.33E-02	-6.54E 01	-7.02E 01	3.45E 03	-2.97E 02
			3.60E 02	5.07E 02	4.16E 02	
10.0	2.0	9.21E-02	-1.71E 02	-1.99E 02	3.84E 03	-3.43E 02
			2.21E 02	3.68E 02	6.99E 02	
10.0	4.0	1.01E-01	-2.02E 02	-2.21E 02	4.17E 03	-3.91E 02
			9.33E 01	2.39E 02	7.20E 02	
10.0	6.0	1.09E-01	-2.05E 02	-2.12E 02	4.48E 03	-4.18E 02
			-3.10E 01	1.17E 02	4.90E 02	
10.0	8.0	1.18E-01	-1.87E 02	-1.59E 02	4.75E 03	-4.04E 02
			-1.57E 02	3.37E-03	-2.01E-03	

X	Y1	W1	QX1	VX1	MX1	MXY1
			QY1	VY1	MY1	
11.0	-17.0	3.61E-02	3.89E 01	3.14E 01	1.51E 03	-9.96E 01
			-5.00E 01	-7.09E-01	-4.32E-01	
11.0	-13.0	4.26E-02	3.67E 01	2.41E 01	1.74E 03	-1.40E 02
			2.29E 01	9.18E 01	-2.85E 02	
11.0	-9.0	5.20E-02	4.12E 01	2.88E 01	2.10E 03	-1.93E 02
			9.94E 01	1.96E 02	-3.74E 02	
11.0	-5.0	6.52E-02	4.37E 01	4.39E 01	2.62E 03	-2.23E 02
			1.89E 02	3.06E 02	-2.33E 02	
11.0	-1.0	8.17E-02	-2.15E 01	-5.49E 00	3.23E 03	-1.77E 02
			2.70E 02	3.81E 02	2.38E 02	
11.0	0.0	8.62E-02	-8.35E 01	-8.68E 01	3.38E 03	-1.69E 02
			2.72E 02	3.81E 02	4.00E 02	

X	Y2	W2	QX2	VX2	MX2	MXY2
			QY2	VY2	MY2	
11.0	0.0	8.62E-02	-8.35E 01	-8.68E 01	3.38E 03	-1.69E 02
			2.72E 02	3.81E 02	4.00E 02	
11.0	2.0	9.51E-02	-1.80E 02	-2.06E 02	3.68E 03	-2.09E 02
			1.94E 02	3.15E 02	6.44E 02	
11.0	4.0	1.04E-01	-2.09E 02	-2.26E 02	3.98E 03	-2.52E 02
			8.65E 01	2.20E 02	6.70E 02	
11.0	6.0	1.13E-01	-2.12E 02	-2.16E 02	4.26E 03	-2.73E 02
			-2.81E 01	1.13E 02	4.53E 02	
11.0	8.0	1.22E-01	-1.95E 02	-1.66E 02	4.52E 03	-2.55E 02
			-1.40E 02	-1.01E-03	1.09E-03	

X	Y1	W1	QX1	VX1	MX1	MXY1
			QY1	VY1	MY1	
12.0	-17.0	3.69E-02	1.96E 01	1.57E 01	1.55E 03	-4.99E 01
			-5.13E 01	-1.59E 00	-9.30E-01	
12.0	-13.0	4.35E-02	1.85E 01	1.22E 01	1.78E 03	-7.01E 01
			2.32E 01	9.32E 01	-2.91E 02	
12.0	-9.0	5.32E-02	2.06E 01	1.46E 01	2.14E 03	-9.62E 01
			1.01E 02	1.97E 02	-3.78E 02	
12.0	-5.0	6.66E-02	2.10E 01	2.22E 01	2.65E 03	-1.09E 02
			1.87E 02	2.98E 02	-2.27E 02	
12.0	-1.0	8.34E-02	-1.86E 01	-8.72E 00	3.19E 03	-7.97E 01
			2.33E 02	3.19E 02	2.48E 02	
12.0	0.0	8.79E-02	-5.54E 01	-5.71E 01	3.31E 03	-7.43E 01
			2.05E 02	2.86E 02	3.86E 02	

X	Y2	W2	QX2	VX2	MX2	MXY2
			QY2	VY2	MY2	
12.0	0.0	8.79E-02	-5.54E 01	-5.71E 01	3.31E 03	-7.43E 01
			2.05E 02	2.86E 02	3.86E 02	
12.0	2.0	9.69E-02	-1.13E 02	-1.28E 02	3.55E 03	-9.77E 01
			1.73E 02	2.75E 02	6.00E 02	
12.0	4.0	1.06E-01	-1.30E 02	-1.40E 02	3.82E 03	-1.23E 02
			8.12E 01	2.06E 02	6.30E 02	
12.0	6.0	1.15E-01	-1.32E 02	-1.34E 02	4.09E 03	-1.35E 02
			-2.58E 01	1.10E 02	4.23E 02	
12.0	8.0	1.24E-01	-1.22E 02	-1.03E 02	4.33E 03	-1.23E 02
			-1.26E 02	-4.46E-03	3.45E-03	

X	Y1	W1	QX1	VX1	MX1	MXY1
			QY1	VY1	MY1	
13.0	-17.0	3.72E-02	2.07E-04	1.72E-04	1.56E 03	-5.36E-04
			-5.17E 01	-1.92E 00	-1.12E 00	
13.0	-13.0	4.39E-02	1.97E-04	1.26E-04	1.79E 03	-7.52E-04
			2.33E 01	9.36E 01	-2.93E 02	
13.0	-9.0	5.36E-02	2.28E-04	1.48E-04	2.16E 03	-1.07E-03
			1.01E 02	1.97E 02	-3.80E 02	
13.0	-5.0	6.71E-02	2.80E-04	2.37E-04	2.66E 03	-1.33E-03
			1.87E 02	2.95E 02	-2.25E 02	
13.0	-1.0	8.39E-02	1.83E-04	2.08E-04	3.18E 03	-1.34E-03
			2.19E 02	2.95E 02	2.51E 02	
13.0	0.0	8.84E-02	4.12E-05	2.52E-05	3.28E 03	-1.33E-03
			1.80E 02	2.50E 02	3.81E 02	

X	Y2	W2	QX2	VX2	MX2	MXY2
			QY2	VY2	MY2	
13.0	0.0	8.84E-02	4.12E-05	2.52E-05	3.28E 03	-1.33E-03
			1.80E 02	2.50E 02	3.81E 02	
13.0	2.0	9.75E-02	-1.76E-04	-2.37E-04	3.50E 03	-1.44E-03
			1.65E 02	2.60E 02	5.84E 02	
13.0	4.0	1.07E-01	-2.29E-04	-2.68E-04	3.75E 03	-1.54E-03
			7.92E 01	2.01E 02	6.15E 02	
13.0	6.0	1.16E-01	-2.33E-04	-2.57E-04	4.02E 03	-1.60E-03
			-2.49E 01	1.09E 02	4.12E 02	
13.0	8.0	1.25E-01	-2.01E-04	-1.71E-04	4.26E 03	-1.61E-03
			-1.21E 02	-5.77E-03	4.32E-03	

X	Y1	W1	QX1	VX1	MX1	MXY1
			QY1	VY1	MY1	
14.0	-17.0	3.69E-02	-1.96E 01	-1.57E 01	1.55E 03	4.99E 01
			-5.13E 01	-1.59E 00	-9.30E-01	
14.0	-13.0	4.35E-02	-1.85E 01	-1.22E 01	1.78E 03	7.01E 01
			2.32E 01	9.32E 01	-2.91E 02	
14.0	-9.0	5.32E-02	-2.06E 01	-1.46E 01	2.14E 03	9.62E 01
			1.01E 02	1.97E 02	-3.78E 02	
14.0	-5.0	6.66E-02	-2.10E 01	-2.22E 01	2.65E 03	1.09E 02
			1.87E 02	2.98E 02	-2.27E 02	
14.0	-1.0	8.34E-02	1.86E 01	8.72E 00	3.19E 03	7.97E 01
			2.33E 02	3.19E 02	2.48E 02	
14.0	0.0	8.79E-02	5.54E 01	5.71E 01	3.31E 03	7.43E 01
			2.05E 02	2.86E 02	3.86E 02	
X	Y2	W2	QX2	VX2	MX2	MXY2
			QY2	VY2	MY2	
14.0	0.0	8.79E-02	5.54E 01	5.71E 01	3.31E 03	7.43E 01
			2.05E 02	2.86E 02	3.86E 02	
14.0	2.0	9.69E-02	1.13E 02	1.28E 02	3.55E 03	9.77E 01
			1.73E 02	2.75E 02	6.00E 02	
14.0	4.0	1.06E-01	1.30E 02	1.40E 02	3.82E 03	1.23E 02
			8.12E 01	2.06E 02	6.30E 02	
14.0	6.0	1.15E-01	1.32E 02	1.34E 02	4.09E 03	1.35E 02
			-2.58E 01	1.10E 02	4.23E 02	
14.0	8.0	1.24E-01	1.22E 02	1.03E 02	4.33E 03	1.23E 02
			-1.26E 02	-4.46E-03	3.45E-03	

X	Y1	W1	QX1	VX1	MX1	MXY1
			QY1	VY1	MY1	
15.0	-17.0	3.61E-02	-3.89E 01	-3.14E 01	1.51E 03	9.96E 01
			-5.00E 01	-7.09E-01	-4.32E-01	
15.0	-13.0	4.26E-02	-3.67E 01	-2.41E 01	1.74E 03	1.40E 02
			2.29E 01	9.18E 01	-2.85E 02	
15.0	-9.0	5.20E-02	-4.12E 01	-2.88E 01	2.10E 03	1.93E 02
			9.94E 01	1.96E 02	-3.74E 02	
15.0	-5.0	6.52E-02	-4.37E 01	-4.39E 01	2.62E 03	2.23E 02
			1.89E 02	3.06E 02	-2.33E 02	
15.0	-1.0	8.17E-02	2.15E 01	5.49E 00	3.23E 03	1.77E 02
			2.70E 02	3.81E 02	2.38E 02	
15.0	0.0	8.62E-02	8.35E 01	8.68E 01	3.38E 03	1.69E 02
			2.72E 02	3.81E 02	4.00E 02	
X	Y2	W2	QX2	VX2	MX2	MXY2
			QY2	VY2	MY2	
15.0	0.0	8.62E-02	8.35E 01	8.68E 01	3.38E 03	1.69E 02
			2.72E 02	3.81E 02	4.00E 02	
15.0	2.0	9.51E-02	1.80E 02	2.06E 02	3.68E 03	2.09E 02
			1.94E 02	3.15E 02	6.44E 02	
15.0	4.0	1.04E-01	2.09E 02	2.26E 02	3.98E 03	2.52E 02
			8.65E 01	2.20E 02	6.70E 02	
15.0	6.0	1.13E-01	2.12E 02	2.16E 02	4.26E 03	2.73E 02
			-2.81E 01	1.13E 02	4.53E 02	
15.0	8.0	1.22E-01	1.95E 02	1.66E 02	4.52E 03	2.55E 02
			-1.40E 02	-1.01E-03	1.09E-03	

TABLE 1: COMPARISON OF THE TEST RESULTS WITH THE SUGGESTED EFFECTIVE WIDTH TO PLATE WIDTH RATIO

PLATE NO.	$\frac{Be}{B} = \frac{V_{fbo}}{V_{fo}}$	Be/B (Eq. 4.3-A)	Be/B (Eq. 4.3-B)
C1-1	0.94	1.00	-
C1-2	1.00	1.00	-
C1-3	1.05	1.00	-
D1-1	0.85	0.88	-
D1-2	0.97	0.88	-
E1-1	0.80	0.71	-
E1-2	0.72	0.71	-
E1-3	0.96	1.00	-
P121	0.57	0.58	-
F1	0.56	0.58	-
G1	0.53	0.58	-
H1-b	0.85	-	0.72
I1	0.79	-	0.72
J1-b	0.73	-	0.72
K1-b	0.87	-	0.72
L1	0.77	-	0.72
M1	0.79	-	0.72
P131	0.33	0.29	-
P232	0.34	0.29	-
N1	0.41	-	0.36
01-b	0.42	-	0.36
D2-1	0.91	0.81	-
D2-2	0.85	0.81	-
E2-1	0.83	0.66	-
E2-2	0.82	0.66	-
P122	0.52	0.52	-
G2	0.59	0.52	-
H2	0.60	-	0.65
I2	0.72	-	0.65
J2	0.71	-	0.65
K2	0.74	-	0.65
L2	0.59	-	0.65
M2	0.65	-	0.65

TABLE 1: CONTINUED

PLATE NO.	$\frac{Be}{B} = \frac{V_{fbo}}{V_{fo}}$	Be/B (Eq. 4.3-A)	Be/B (Eq. 4.3-B)
P132	0.31	.25	-
N2	0.45	-	0.31
O2	0.49	-	0.31
C3-1	0.77	0.84	-
C3-2	0.71	0.84	-
D3-1	0.72	0.71	-
D3-2	0.72	0.71	-
E3-1	0.44	0.56	-
E3-2	0.47	0.56	-
P123	0.51	0.41	-
G3	0.57	0.41	-
H3	0.55	-	0.51
I3	0.61	-	0.51
J3	0.58	-	0.51
K3	0.60	-	0.51
L3	0.57	-	0.51
M3	0.57	-	0.51
P133	0.22	0.22	-
P233	0.22	0.22	-
N3	0.25	-	0.28
D3	0.28	-	0.28

TABLE B-1: DIRECT TENSILE TEST RESULTS

Test No.	Area (In.²)	Failure Load (lbs.)	f't (psi)
1	1	430	430
2	1	355	355
3	1	320	320
4	1	420	420
5	1	340	340
6	1	375	375
7	1	385	385
8	1	380	380
9	1	430	430
10	1	340	340
11	1	350	350
12	1	345	345
13	1	325	325
14	1	375	375
15	1	335	335
16	1	355	355
17	1	375	375
18	1	410	410

$(f'_t)_{ave}$ = 370 psi, σ = 35 psi,

σ = standard deviation

TABLE B-2: COMPRESSIVE TEST RESULTS

Test No.	Dimension of Test Cylinder (In.)	Failure Load (lbs.)	f'o (psi)
1	2 x 4	12,500	3,978
2	2 x 4	14,000	4,456
3	2 x 4	10,600	3,374
4	2 x 4	11,000	3,501
5	2 x 4	12,000	3,820

(f'o) ave. = 3825 psi

σ = 382 psi

TABLE B-3: SPLIT CYLINDER TEST RESULTS

Test No.	Dimension of Test Cylinder (In.)	Failure Load (lbs.)	f'_{sp} (psi)
1	2 x 4	9,925	789
2	2 x 4	8,500	676
3	2 x 4	8,500	676
4	2 x 4	8,000	636
5	2 x 4	6,625	527

(f'_{sp}) ave. = 660 psi

σ = 84 psi

TABLE B-4: TEST PLATES DATA AND LOADING PATTERNS

Plate No.	I	II	III	IV	V	VI
Size (In.)	22x10x2	22x10x2	22x10x2	22x10x2	22x10x2	22x10x2
Layer of Wire Mesh	1	2	1	2	1	2
Span Length (In.)	20	20	16	16	18	18
Partial Loads Span Length (In.)	10	10	10	10	10	10

TABLE B-5: COMPARISON OF THEORETICAL AND EXPERIMENTAL VALUES BASED ON THE OBSERVED FAILURE LOADS FOR SIMPLE ANALYSIS

	PLATE NO.	I	II	III	IV	V	VI
THEORETICAL VALUES	Vc (lb/in) Eq. 2.2-1	48	48	48	48	48	48
	Tc (in-lb/in) Eq. 2.2-2	192	192	192	192	192	192
	Pult (lbs)	960	960	960	960	960	960
	Vcr (lb/in) Eq. 2.2-5	106	106	106	106	106	106
	Ter (in-lb/in) Eq. 2.2-6	424	424	424	424	424	424
	Pult (lbs)	2120	2120	2120	2120	2120	2120
EXPERIMENTAL VALUES	Pf (lbs)	1,975	3,700	2,850	4,200	3,600	3,740
	Vc (lb-in)	98.75	185	142.5	210	180	187
	Tc (in-lb/in)	395	740	570	840	720	748
	Interaction Eq. 2.2-3	=4.2>1	=14>>1	=8.8>1	=19>>1	=14>>1	=15>>1
	Interaction Eq. 2.2-4	=0.8<1	=3.0>1	=1.8>1	=3.9>1	=2.8>1	=3.1>1

TABLE B-6: COMPARISON OF THEORETICAL AND EXPERIMENTAL VALUES BASED ON THE OBSERVED FAILURE LOADS FOR PLATE ANALYSIS

	PLATE NO.	I	II	III	IV	V	VI
THEORETICAL VALUES	Vc (lb/in) Eq. 2.2-1	121	121	128	128	117	117
	Tc (in-lb/in) Eq. 2.2-2	161	161	156	156	164	164
	Pult (lbs)	1418	1418	1456	1456	1464	1464
	Vcr (lb/in) Eq. 2.2-5	186	186	190	184	184	409.2
	Tcr (in-lb/in) Eq. 2.2-6	249	249	234	234	258	258
	Pult (lbs)	2180	2180	2161	2161	2303	2303
EXPERIMENTAL VALUES	Pf (lbs)	1,975	3,700	2,850	4,200	3,600	3,740
	Vc (lb-in)	168.5	315.5	250.5	369.2	287.6	298.8
	Tc (in-lb/in)	224	419.8	305.3	449.9	401.6	417.2
	Interaction Eq. 2.2-3	=1.9>1	=6.8>1	=3.8>1	=8.3>1	=6>1	6.5>1
	Interaction Eq. 2.2-4	=.85<1	=3.0>1	=1.8>1	=3.9>1	=2.6>1	=2.7>1

TABLE C-1 COMPRESSIVE TEST RESULTS

BATCH NO. I

TEST NO.	AGE (DAYS)	FAILURE LOAD (lbs)	f'c (psi)
1	28	100,000	3,537
2	28	91,000	3,218
3	28	103,000	3,643
4	28	102,000	3,608
		AVE.	3,496
5	34	103,000	3,640
6	34	112,000	3,958
		AVE.	3,799

Note: Compressive strength of f'c = 3600 psi is adapted for batch No. I.

TABLE C-1 COMPRESSIVE TEST RESULTS (CONTINUED)

BATCH NO. II

TEST NO.	AGE (DAYS)	FAILURE LOAD (lbs)	f'c (psi)
1	28	101,000	3,572
2	28	107,000	3,784
3	28	91,000	3,236
4	28	103,400	3,657
		AVE.	3,562
5	51	112,400	3,975
6	51	107,000	3,784
7	51	115,500	4,085
		AVE.	3,948

Note: Compressive strength of f'c = 3700 psi is adapted for batch No. II.

TABLE C-1 COMPRESSIVE TEST RESULTS (CONTINUED)

BATCH NO. III

TEST NO.	AGE (DAYS)	FAILURE LOAD (lbs)	f'c (psi)
1	28	84,000	2,970
2	28	75,000	2,652
3	28	91,000	3,218
4	28	90,000	3,183
		AVE.	3,005
5	41	85,000	3,006
6	41	91,000	3,218
7	41	85,000	3,006
		AVE.	3,077

Note: Compressive strength of f'c = 3000 psi is adapted for batch No. III.

TABLE C-2 SPLIT CYLINDER TEST RESULTS

TEST NO.	AGE (DAYS)	FAILURE LOAD (lbs)	f'sp (psi)
BATCH NO. I			
1	28	35,000	309
2	28	39,000	345
BATCH NO. II			
1	28	39,000	345
2	28	38,000	336
3	51	39,600	348
4	51	39,400	348
BATCH NO. III			
1	28	31,000	274
2	28	34,000	300
3	41	31,000	274
4	41	33,000	292
5	41	34,000	362

TABLE C-3 TENSILE STRENGTH TEST RESULTS MODULUS OF RUPTURE

BATCH NO. I

TEST NO.	AGE (DAYS)	FAILURE LOAD (lbs)	f_r (psi)
–	–	–	–

BATCH NO. II

TEST NO.	AGE (DAYS)	FAILURE LOAD (lbs)	f_r (psi)
1	14	6,725	560
2	14	5,425	452
3	28	6,775	565
4	28	7,450	620

BATCH NO. III

TEST NO.	AGE (DAYS)	FAILURE LOAD (lbs)	f_r (psi)
1	14	6,600	550
2	14	6,650	554
3	28	6,500	542
4	28	5,700	475

TABLE C-3a COMPARISON OF TEST RESULTS WITH ACI CODE VALUES

BATCH NO.	f'sp (psi)		fr (psi)	
	Actual	ACI Code	Actual	ACI Code
I	327	402	-	450
II	344	407	550	455
III	300	367	530	410

TABLE C-4 TEST BEAM DATA

LOAD CONDITION 1

BEAM NO.	LENGTH (in.)	SPAN (in.)	WIDTH (in.)	a/d RATIO	f'c (psi)
A 11	28	26	2.5	5.94	3,700
A 12	28	26	2.5	5.94	3,700
A 12	28	26	2.5	5.94	3,700
A 13	28	26	2.5	5.94	3,700
A 14	28	26	2.5	5.94	3,700
B 11	28	26	5.0	5.94	3,000
E 11	28	26	12.5	5.94	3,600
E 12	28	26	12.5	5.94	3,700
F 11	28	26	25.0	5.94	3,700
LOAD CONDITION 2					
A 21	28	26	2.5	1.94	3,000
B 21	28	26	5.0	1.94	3,000
B 22	28	26	5.0	1.94	3,000
LOAD CONDITION 3					
A 31	28	26	2.5	2.67	3,600
A 32	28	26	2.5	2.67	3,000

TABLE C-4 TEST BEAM DATA

LOAD CONDITION 3

BEAM NO.	LENGTH (in.)	SPAN (in.)	WIDTH (in.)	a/d RATIO	f'c (psi)
B 31	28	26	5.0	2.67	3,600
B 32	28	26	5.0	2.67	3,000
E 31	28	26	12.5	2.67	3,600

LOAD CONDITION 4

A 41	28	26	2.5	3.39	3,600
A 42	28	26	2.5	3.39	3,700
A 43	28	26	2.5	3.39	3,000
B 41	28	26	5.0	3.39	3,600
B 42	28	26	5.0	3.39	3,700
B 43	28	26	5.0	3.39	3,000
D 41	28	26	10.0	3.39	3,600
D 42	28	26	10.0	3.39	3,700
E 41	28	26	12.5	3.39	3,600
E 42	28	26	12.5	3.39	3,700

LOAD CONDITION 5

A 51	28	26	2.5	4.36	3,000

TABLE C-4 TEST BEAM DATA

LOAD CONDITION 5

BEAM NO.	LENGTH (in.)	SPAN (in.)	WIDTH (in.)	a/d RATIO	f'c (psi)
B 51	28	26	5.0	4.36	3,700
B 52	28	26	5.0	4.36	3,000
B 53	28	26	5.0	4.36	3,000
B 54	28	26	5.0	4.36	3,000
C 51	28	26	7.5	4.36	3,700
C 52	28	26	7.5	4.36	3,000
C 53	28	26	7.5	4.36	3,000
D 51	28	26	10.0	4.36	3,700
D 52	28	26	10.0	4.36	3,000
E 51	28	26	12.5	4.36	3,000

LOAD CONDITION 6

BEAM NO.	LENGTH (in.)	SPAN (in.)	WIDTH (in.)	a/d RATIO	f'c (psi)
A 61	28	26	2.5	4.85	3,000
B 61	28	26	5.0	4.85	3,000
C 61	28	26	7.5	4.85	3,700
D 61	28	26	10.0	4.85	3,000

TABLE C-5 BEAM TEST RESULTS AND COMPARISON WITH CODE VALUES

LOAD CONDITION 1

TEST NO.	FAILURE LOAD, P_f (lbs)	a/d Ratio	V_{fo}* lbs/in.	V_{oo}** lbs/in.	V_{fo}/V_{oo}
A11	2,530	5.94	490.7	276.5	1.77
A12	2,668	5.94	517.4	276.5	1.87
A13	2,990	5.94	579.9	276.5	2.10
A14	2,300	5.94	446.1	276.5	1.61
B11	5,428	5.94	526.4	252.8	2.08
E11	12,880	5.94	499.6	273.3	1.83
E12	13,110	5.94	508.5	276.5	1.84
F11	26,220	5.94	508.5	276.5	1.84
				AVE.	1.87

LOAD CONDITION 2

TEST NO.	FAILURE LOAD, P_f (lbs)	a/d Ratio	V_{fo}* lbs/in.	V_{oo}** lbs/in.	V_{fo}/V_{oo}
A21	7,268	1.94	1,409.5	324.5	4.34
B21	9,200	1.94	892.1	324.5	2.75
B22	9,200	1.94	892.1	324.5	2.75
				AVE.	3.28

LOAD CONDITION 3

TEST NO.	FAILURE LOAD, P_f (lbs)	a/d Ratio	V_{fo}* lbs/in.	V_{oo}** lbs/in.	V_{fo}/V_{oo}
A31	5,520	2.67	1,070.5	320.0	3.35

TABLE C-5 BEAM TEST RESULTS AND COMPARISON WITH CODE VALUES

LOAD CONDITION 3

TEST NO.	FAILURE LOAD, P_f (lbs)	a/d Ratio	V_{fo}* lbs/in.	V_{oo}** lbs/in.	V_{fo}/V_{oo}
A32	4,692	2.67	910.0	299.5	3.04
B31	9,890	2.67	959.0	320.0	3.00
B32	7,360	2.67	713.7	299.5	2.38
E31	23,000	2.67	892.1	320.0	2.79
				AVE.	2.91

LOAD CONDITION 4

TEST NO.	FAILURE LOAD, P_f (lbs)	a/d Ratio	V_{fo}* lbs/in.	V_{oo}** lbs/in.	V_{fo}/V_{oo}
A41	4,600	3.39	892.1	302.0	2.95
A42	4,600	3.39	892.1	305.2	2.92
A43	4,370	3.39	847.5	281.5	3.01
B41	9,200	3.39	892.1	302.0	2.95
B42	8,280	3.39	802.9	305.2	2.63
B43	8,050	3.39	780.6	281.5	2.77
D41	17,940	3.39	869.8	302.0	2.88
D42	14,720	3.39	713.7	305.2	2.34
E41	20,700	3.39	802.9	302.0	2.66
E42	15,640	3.39	606.6	305.2	1.99
				AVE.	2.71

TABLE C-5 BEAM TEST RESULTS AND COMPARISON WITH CODE VALUES

LOAD CONDITION 5

TEST NO.	FAILURE LOAD, P_f (lbs)	a/d Ratio	V_{fo}* lbs/in.	V_{oo}** lbs/in.	V_{fo}/V_{oo}
A51	3,818	4.36	740.5	266.6	2.78
B51	6,900	4.36	669.1	290.3	2.30
B52	6,348	4.36	615.6	266.6	2.31
B53	5,980	4.36	579.9	266.6	2.24
B54	6,210	4.36	602.2	290.3	2.26
C51	9,200	4.36	594.8	290.3	2.05
C52	8,165	4.36	527.8	266.6	1.98
C53	7,498	4.36	484.7	266.6	1.82
D51	12,328	4.36	597.7	290.3	2.06
D52	12,374	4.36	599.9	266.6	2.25
E51	16,100	4.36	624.5	266.6	2.34
				AVE.	2.22

LOAD CONDITION 6

TEST NO.	FAILURE LOAD, P_f (lbs)	a/d Ratio	V_{fo}* lbs/in.	V_{oo}** lbs/in.	V_{fo}/V_{oo}
A61	2,990	4.85	579.9	261.3	2.22
B61	6,072	4.85	588.8	261.3	2.25

*$V_{fo} = P_f/2b$
**V_{oo}, see section 2.2-1

TABLE C-5a BEAM TEST RESULTS

BEAM NO.	BEAM WIDTH IN.	$1000\rho Vd/M\sqrt{f'_c}$	$V/bd\sqrt{f'_c}$
A11	2.5	0.122	4.033
A12	2.5	0.122	4.253
A13	2.5	0.122	4.767
A14	2.5	0.122	3.667
B11	5.0	0.122	4.327
E11	12.5	0.122	4.107
E12	12.5	0.122	4.180
F11	25.0	0.122	4.18
A21	2.5	4.13	12.867
B21	5.0	4.13	5.488
B22	5.0	4.13	5.488
A31	2.5	.274	8.921
A32	2.5	.300	9.773
B31	5.0	.274	7.992
B32	5.0	.300	6.515
E31	12.5	.274	7.434
A41	2.5	.216	7.434
A42	2.5	.213	7.333
A43	2.5	.237	7.737

TABLE C-5a BEAM TEST RESULTS

BEAM NO.	BEAM WIDTH IN.	$1000\rho Vd/M\sqrt{f'_c}$	$V/bd\sqrt{f'_c}$
B41	5.0	.216	7.434
B42	5.0	.213	6.600
B43	5.0	.237	7.126
D41	10.0	.216	7.248
D42	10.0	.213	5.867
E41	12.5	.216	6.691
E42	12.5	.213	4.987
A51	2.5	.184	6.759
B51	5.0	.166	5.500
B52	5.0	.184	5.619
B53	5.0	.184	5.294
B54	5.0	.184	5.487
C51	7.5	.166	4.889
C52	7.5	.184	4.818
C53	7.5	.184	4.425
D51	10.0	.166	4.913
D52	10.0	.184	5.477
E51	12.5	.184	5.701

TABLE C-5a BEAM TEST RESULTS

BEAM NO.	BEAM WIDTH IN.	1000 $\rho Vd/M\sqrt{f'_c}$	$V/bd\sqrt{f'_c}$
A61	2.5	.165	5.294
B61	5.0	.165	5.375
C61	7.5	.165	4.889
D61	10.0	.165	4.888

TABLE C-6 SHEAR AND TORSION VALUES OF CONCRETE

BATCH NO.	LOAD CONDITION	THEORETICAL V_o lbs	THEORETICAL T_o lbs-in	THEORETICAL T_{cro} in-lb	EXPERIMENTAL V_{fo} lbs	EXPERIMENTAL T_{fo} in-lb
I	4	302	432	1080	818	864
	5	287	432	1080	637	864
II	4	305	438	1095	826	876
	5	290	438	1095	643	876
III	4	281	394	985	761	788
	5	267	394	985	592	788

Note: $T_{fo} = 2T_o = 1.6\sqrt{f'c}\,x^2y$
based on the study by Marti, P. and et al (Ref. 8), for heavily reinforced concrete plates.

TABLE C-7 TEST PLATE DATA AND LOADING PATTERN

CENTER STRIP LOADING

PLATE NO.	B in.	R% * TOP	BOTT.	a/d Ratio	b in	u x v in.xin.	Load Condition No.	f'c psi
C1-1	7.5	0	0	4.36	0	3x3	5	3,000
C1-2	7.5	0	0	4.36	0	3x3	5	3,000
C1-3	7.5	0	0	4.36	0	3x3	5	3,000
D1-1	10.0	0	0	4.36	0	3x3	5	3,000
D1-2	10.0	0	0	4.36	0	3x3	5	3,000
E1-1	12.5	0	0	4.36	0	3x3	5	3,000
E1-2	12.5	0	0	4.36	0	3x3	5	3,000
E1-3	12.5	0	0	4.36	0	3x6	5	3,000
P121	25.0	0	0	3.39	0	4x8	4	3,600
F1	25.0	0	0	4.36	0	4x8	5	3,700
G1	25.0	0	0	4.36	0	4x8	5	3,000
H1	25.0	0	50	4.36	0	4x8	5	3,700
I1	25.0	50	0	4.36	0	4x8	5	3,700
J1	25.0	0	30	4.36	0	4x8	5	3,700
K1	25.0	0	70	4.36	0	4x8	5	3,700
L1	25.0	30	0	4.36	0	4x8	5	3,700
M1	25.0	70	0	4.36	0	4x8	5	3,700

TABLE C-7 TEST PLATE DATA AND LOADING PATTERN

CENTER STRIP LOADING

PLATE NO.	B in.	R% * TOP	BOTT.	a/d Ratio	b in	u x v in.xin.	Load Condition No.	f'c psi
P131	50	0	0	3.39	0	4x8	4	3,600
P231	50	0	0	3.39	0	4x8	4	3,600
N1	50	50	0	4.36	0	4x8	5	3,700
01	50	0	50	4.36	0	4x8	5	3,700

MIDDLE STRIP LOADING

PLATE NO.	B in.	R% * TOP	BOTT.	a/d Ratio	b in	u x v in.xin.	Load Condition No.	f'c psi
D2-1	10.0	0	0	4.36	1.5	3x3	5	3,000
D2-2	10.0	0	0	4.36	1.5	3x3	5	3,000
E2-1	12.5	0	0	4.36	1.5	3x3	5	3,000
E2-2	12.5	0	0	4.36	1.5	3x3	5	3,000
P122	25.0	0	0	3.39	4.5	4x8	5	3,600
G2	25.0	0	0	4.36	4.5	4x8	5	3,000
H2	25.0	0	50	4.36	4.5	4x8	5	3,000
I2	25.0	50	0	4.36	4.5	4x8	5	3,000
J2	25.0	0	30	4.36	4.5	4x8	5	3,000
K2	25.0	0	70	4.36	4.5	4x8	5	3,000
L2	25.0	30	0	4.36	4.5	4x8	5	3,000

TABLE C-7 TEST PLATE DATA AND LOADING PATTERN

MIDDLE STRIP LOADING

PLATE NO.	B in.	R% * TOP	BOTT.	a/d Ratio	b in	u x v in.xin.	Load Condition No.	f'c psi
M2	25.0	70	0	4.36	4.5	4x8	5	3,000
P132	50.0	0	0	3.39	12.5	4x8	4	3,600
N2	50.0	50	0	4.36	12.5	4x8	5	3,000
O2	50.0	0	50	4.36	12.5	4x8	5	3,000

EDGE STRIP LOADING

PLATE NO.	B in.	R% * TOP	BOTT.	a/d Ratio	b in	u x v in.xin.	Load Condition No.	f'c psi
C3-1	7.5	0	0	4.36	2.25	3x3	5	3,000
C3-2	7.5	0	0	4.36	2.25	3x3	5	3,000
D3-1	10.0	0	0	4.36	3.50	3x3	5	3,000
D3-2	10.0	0	0	4.36	3.50	3x3	5	3,000
E3-1	12.5	0	0	4.36	4.75	3x3	5	3,000
E3-2	12.5	0	0	4.36	4.75	3x3	5	3,000
P123	25.0	0	0	3.39	8.50	4x8	4	3,600
G3	25.0	0	0	4.36	8.50	4x8	5	3,700
H3	25.0	0	50	4.36	8.50	4x8	5	3,700
I3	25.0	50	0	4.36	8.50	4x8	5	3,700
J3	25.0	0	30	4.36	8.50	4x8	5	3,700
K3	25.0	0	70	4.36	8.50	4x8	5	3,700
L3	25.0	30	0	4.36	8.50	4x8	5	3,700

TABLE C-7 TEST PLATE DATA AND LOADING PATTERN

EDGE STRIP LOADING

PLATE NO.	B in.	R% * TOP	R% * BOTT.	a/d Ratio	b in	u x v in.xin.	Load Condition No.	f'c psi
M3	25.0	70	0	4.36	8.50	4x8	5	3,700
P133	50.0	0	0	3.39	21.00	4x8	4	3,600
P233	50.0	0	50	4.36	21.00	4x8	5	3,600
N3	50.0	50	0	4.36	21.00	4x8	5	3,700
O3	50.0	0	50	4.36	21.00	4x8	5	3,700

$$*R\% = \frac{\text{Transverse } \rho}{\text{Longitudinal } \rho} \times 100$$

f'_c (Batch No. I) = 3600 psi

f'_c (Batch No. II) = 3700 psi

f'_c (Batch No. III) = 3000 psi

TABLE C-8: EXPERIMENTAL TEST PLATE RESULTS

PLATE NO.	Failure Load P_f (lbs)	Simple Analysis V_{obf} lb/in	T_{obf} in-lb/in	Lévy's Method V_{opfm} lb/in	T_{opfm} in-lb/in
C1-1	8,372	558	0	639	0
C1-2	8,855	590	0	676	0
C1-3	9,338	622	0	713	0
D1-1	10,120	506	0	664	0
D1-2	11,500	575	0	754	0
E1-1	11,868	475	0	710	0
E1-2	10,948	437	0	754	0
E1-3	14,260	570	0	573	0
P121	23,460	469	0	803	0
F1	18,170	363	0	622	0
G1	17,020	340	0	583	0
H1	27,600	552	0	745	0
I1	25,484	509	0	873	0
J1	23,460	469	0	803	0
K1	28,060	561	0	961	0
L1	24,840	496	0	351	0
M1	25,576	511	0	876	0
P131	27,600	276	0	669	0
P231	28,060	280	0	680	0
N1	26,680	266	0	645	0
O1	30,360	303	0	736	0
D2-1	10,810	540	811	722	337
D2-2	10,120	506	759	676	316
E2-1	12,420	496	868	747	346
E2-2	12,190	487	852	734	340
P122	21,620	432	1,944	638	668
G2	17,020	340	1,530	562	525

TABLE C-8: CONTINUED

PLATE NO.	Failure Load P_f (lbs)	Simple Analysis V_{obf} lb/in	Simple Analysis T_{obf} in-lb/in	Lévy's Method V_{opfm} lb/in	Lévy's Method T_{opfm} in-lb/in
H2	17,940	358	1,611	529	554
J2	22,448	449	2,020	662	604
J2	21,160	423	1,903	624	654
K2	22,080	441	1,984	651	682
L2	17,480	349	1,570	515	540
M2	19,320	386	1,737	570	597
P132	25,300	253	3,162	793	360
N2	26,680	266	3,325	836	380
02	28,980	289	3,612	908	413
C3-1	6,808	453	1,019	424	719
C3-2	5,980	399	897	373	631
D3-1	8,510	425	1,489	541	928
D3-2	8,510	425	1,489	541	928
E3-1	6,532	261	1,241	379	712
E3-2	6,900	276	1,311	401	752
P123	20,700	414	3,519	667	1563
G3	18,400	368	3,128	438	989
H3	17,710	354	3,010	624	1408
J3	19,780	395	3,362	696	1573
J3	18,768	375	3,190	661	1492
K3	19,320	386	3,284	680	1536
L3	18,400	368	3,128	648	1463
M3	18,400	368	3,128	648	1463
P133	17,940	179	3,767	573	1,623
P233	17,940	179	3,767	573	1,623
N3	15,870	159	3,332	507	1,436
03	17,710	177	3,719	565	1,602

TABLE C-8a EXPERIMENT TEST PLATE RESULT

PLATE NO.	SIMPLE ANALYSIS $\frac{v_{cbf}}{\sqrt{f'_c}}$	SIMPLE ANALYSIS $\frac{\tau_{cbf}}{\sqrt{f'_c}}$	LÉVY'S METHOD $\frac{v_{cpfm}}{\sqrt{f'_c}}$	LÉVY'S METHOD $\frac{\tau_{cpfm}}{\sqrt{f'_c}}$
C1-1	4.94	0	5.64	0
C1-2	5.22	0	5.97	0
C1-3	5.50	0	6.30	0
D1-1	4.47	0	5.80	0
D-2	5.08	0	6.66	0
E1-1	4.20	0	6.28	0
E1-2	3.85	0	6.28	0
E1-3	5.04	0	5.06	0
P121	3.78	0	6.48	0
F1	2.89	0	5.02	0
G1	3.01	0	4.65	0
H1	4.46	0	7.53	0
I1	4.11	0	6.95	0
J1	3.79	0	6.40	0
K1	4.53	0	7.66	0
L1	4.01	0	6.77	0
M1	4.13	0	6.99	0
P131	2.23	0	5.40	0
P231	2.26	0	5.48	0
N1	2.12	0	5.13	0
01	2.42	0	5.41	0
D2-1	4.78	4.94	6.39	2.04
D2-2	4.47	4.62	5.99	1.92
E2-1	4.38	5.28	6.61	2.10
E2-2	4.31	5.19	6.50	2.06
P122	3.48	10.80	5.15	3.72
G2	2.99	9.31	4.97	3.20
H2	3.17	9.80	4.67	3.36
I2	3.97	12.29	5.86	3.67
J2	3.74	11.58	5.51	3.98
K2	3.90	12.07	5.77	4.14
L2	3.09	9.55	4.56	3.29
M2	3.42	10.57	5.04	3.63
P132	2.04	17.57	6.40	2.19
N2	2.35	11.08	7.40	2.32
02	2.56	12.04	8.03	2.52
C3-1	4.01	6.20	3.75	4.38

TABLE C-8a CONTINUED

PLATE NO.	SIMPLE ANALYSIS $\frac{V_{cbf}}{\sqrt{f'_c}}$	SIMPLE ANALYSIS $\frac{\tau_{cbf}}{\sqrt{f'_c}}$	LÉVY'S METHOD $\frac{V_{cpfm}}{\sqrt{f'_c}}$	LÉVY'S METHOD $\frac{\tau_{cpfm}}{\sqrt{f'_c}}$
C3-2	3.53	5.46	3.01	3.84
D3-1	3.76	9.06	4.79	5.65
D3-2	3.76	9.06	4.79	5.65
E3-1	2.31	7.55	3.35	4.33
E3-2	2.44	7.98	3.55	4.58
P123	3.35	19.55	5.38	8.68
G3	2.93	17.14	3.49	5.42
H3	2.82	16.49	4.96	7.71
I3	3.15	18.42	5.54	8.61
J3	2.99	17,48	5.61	8.17
K3	3.08	18.00	5.43	8.42
L3	2.93	17.14	5.16	8.02
M3	2.93	17.14	5.16	8.02
P133	1.45	20.93	4.63	9.02
P233	1.45	20.93	4.63	9.02
N3	1.27	18.26	4.04	7.87
O3	1.41	20.38	4.50	8.78

TABLE C-9: COMPARISON OF THE EXPERIMENTAL SHEAR/ TORSION VALUES WITH THE THEORETICAL VALUES BASED ON THE SIMPLE ANALYSIS

PLATE NO.	$\frac{V_{obf}}{V_o}$	$\frac{T_{obf}}{T_o}$	$\frac{T_{obf}}{T_{oro}}$	$\frac{V_{obf}}{V_{fo}}$	$\frac{T_{obf}}{T_{fo}}$	Be/B
CENTER STRIP LOADING						
Narrow plates without transverse reinforcement						
C1-1	2.09	0	0	0.94	0	0.94
C1-2	2.22	0	0	1.00	0	1.00
C1-3	2.33	0	0	1.05	0	1.05
D1-1	1.90	0	0	0.85	0	0.85
D1-2	2.16	0	0	0.97	0	0.97
Intermediate plates without transverse reinforcement						
E1-1	1.76	0	0	0.8	0	0.8
E1-2	1.64	0	0	0.72	0	0.72
E1-3	2.14	0	0	0.96	0	0.96
Wide plates without transverse reinforcement						
P121	1.55	0	0	0.57	0	0.57
F1	1.25	0	0	0.56	0	0.56
G1	1.17	0	0	0.53	0	0.53
Wide plates with transverse reinforcement						
H1	1.90	0	0	0.85	0	0.85
J1	1.75	0	0	0.79	0	0.79
J1	1.67	0	0	0.73	0	0.73
K1	1.93	0	0	0.87	0	0.87
L1	1.71	0	0	0.77	0	0.77
M1	1.76	0	0	0.79	0	0.79
Extra wide plates without transverse reinforcement						
P131	0.91	0	0	0.33	0	0.33
P231	0.92	0	0	0.34	0	0.34

TABLE C-9: CONTINUED

PLATE NO.	$\frac{V_{obf}}{V_o}$	$\frac{T_{obf}}{T_o}$	$\frac{T_{obf}}{T_{oro}}$	$\frac{V_{obf}}{V_{fo}}$	$\frac{T_{obf}}{T_{fo}}$	Be/B
Extra wide plates with transverse reinforcement						
N1	0.91	0	0	0.41	0	0.41
O1	1.04	0	0	0.47	0	0.47
MIDDLE STRIP LOADING						
Narrow plates without transverse reinforcement						
D2-1	2.02	2.05	0.82	0.91	1.03	0.91
D2-2	1.90	1.92	0.77	0.85	0.96	0.85
Intermediate plates without transverse reinforcement						
E2-1	1.86	2.20	0.88	0.83	1.10	0.83
E2-2	1.83	2.16	0.86	0.82	1.08	0.82
Wide plates without transverse reinforcement						
P122	1.43	4.5	1.8	0.52	2.25	0.52
G2	1.27	3.88	1.55	0.59	1.94	0.59
Wide plates with transverse reinforcement						
H2	1.35	4.09	1.64	0.60	2.05	0.60
I2	1.69	5.13	2.05	0.72	2.57	0.72
J2	1.59	4.83	1.93	0.71	2.41	0.71
K2	1.66	5.04	2.02	0.74	2.52	0.74
L2	1.31	3.98	1.59	0.59	1.99	0.59
M2	1.45	4.41	1.76	0.65	2.20	0.65
Extra wide plates without transverse reinforcement						
P132	0.84	7.33	2.93	0.31	3.67	0.31
Extra wide plates with transverse reinforcement						
M2	1.00	8.44	3.38	0.45	4.22	0.45
O2	1.09	9.17	3.67	0.49	4.58	0.49

TABLE C-9: CONTINUED

PLATE NO.	$\frac{V_{obf}}{V_o}$	$\frac{T_{obf}}{T_o}$	$\frac{T_{obf}}{T_{oro}}$	$\frac{V_{obf}}{V_{fo}}$	$\frac{T_{obf}}{T_{fo}}$	Be/B
			EDGE STRIP LOADING			
Narrow plates without transverse reinforcement						
C3-1	1.70	2.59	1.03	0.77	1.29	0.77
C3-2	1.50	2.28	0.91	0.67	1.14	0.67
D3-1	1.60	3.78	1.51	0.72	1.89	0.72
D3-2	1.60	3.78	1.51	0.72	1.89	0.72
Intermediate plates without transverse reinforcement						
E3-1	0.98	3.15	1.26	0.44	1.58	0.44
E3-2	1.04	3.33	1.33	0.47	1.66	0.47
Wide plates without transverse reinforcement						
P123	1.37	8.15	3.26	0.51	4.08	0.51
G3	1.27	7.14	2.86	0.57	3.58	0.57
Wide plates with transverse reinforcement						
H3	1.22	6.87	2.75	0.55	3.44	0.55
I3	1.36	7.68	3.07	0.61	3.84	0.61
J3	1.29	7.28	2.91	0.58	3.64	0.58
K3	1.33	7.50	3.00	0.60	3.75	0.60
L3	1.27	7.14	2.86	0.57	3.57	0.57
M3	1.27	7.14	2.86	0.57	3.57	0.57
Extra wide plates without transverse reinforcement						
P133	0.59	8.72	3.49	0.22	4.36	0.22
P233	0.59	8.72	3.49	0.22	4.36	0.22
Extra wide plates with transverse reinforcement						
N3	0.55	7.61	3.04	0.25	3.80	0.25
O3	0.61	8.49	3.40	0.28	4.25	0.28

B_e = Effective with = $(V_{fo}/V_{obf})B$

TABLE C-10: COMPARISON OF THE EXPERIMENTAL SHEAR/ TORSION VALUES WITH THEORETICAL VALUES BASED ON THE PLATE SOLUTION BY LÉVY'S METHOD

PLATE NO.	$\frac{V_{obf}}{V_o}$	$\frac{T_{obf}}{T_o}$	$\frac{T_{opfm}}{T_{oro}}$	$\frac{V_{opfm}}{V_{fo}}$	$\frac{T_{opfm}}{T_{fo}}$
CENTER STRIP LOADING					
Narrow plates without transverse reinforcement					
C1-1	2.40	0	0	1.08	0
C1-2	2.54	0	0	1.14	0
C1-3	2.68	0	0	1.20	0
D1-1	2.50	0	0	1.12	0
D1-2	2.83	0	0	1.27	0
Intermediate plates without transverse reinforcement					
E1-1	2.67	0	0	1.20	0
E1-2	2.45	0	0	1.11	0
E1-3	2.15	0	0	0.97	0
Wide plates without transverse reinforcement					
P121	2.66	0	0	0.98	0
F1	2.14	0	0	0.97	0
G1	2.01	0	0	0.91	0
Wide plates with transverse reinforcement					
H1	3.26	0	0	1.47	0
I1	3.01	0	0	1.36	0
J1	2.77	0	0	1.25	0
K1	3.31	0	0	1.49	0
L1	2.93	0	0	1.32	0
M1	3.02	0	0	1.36	0
Extra wide plates without transverse reinforcement					
P131	2.22	0	0	0.82	0
P231	2.25	0	0	0.83	0

TABLE C-10: CONTINUED

PLATE NO.	$\frac{V_{obf}}{V_o}$	$\frac{T_{obf}}{T_o}$	$\frac{T_{opfm}}{T_{oro}}$	$\frac{V_{opfm}}{V_{fo}}$	$\frac{T_{opfm}}{T_{fo}}$
Extra wide plates with transverse reinforcement					
N1	2.22	0	0	1.00	0
01	2.54	0	0	1.14	0

MIDDLE STRIP LOADING

PLATE NO.	$\frac{V_{obf}}{V_o}$	$\frac{T_{obf}}{T_o}$	$\frac{T_{opfm}}{T_{oro}}$	$\frac{V_{opfm}}{V_{fo}}$	$\frac{T_{opfm}}{T_{fo}}$
Narrow plates without transverse reinforcement					
D2-1	2.71	0.86	0.34	1.22	0.45
D2-2	2.54	0.80	0.32	1.14	0.40
Intermediate plates without transverse reinforcement					
E2-1	2.81	0.88	0.35	1.26	0.44
E2-2	2.76	0.86	0.34	1.24	0.43
Wide plates without transverse reinforcement					
P122	2.11	1.55	0.62	0.78	0.78
G2	1.89	1.34	0.54	0.85	0.67
Wide plates with transverse reinforcement					
H2	1.99	1.41	0.56	0.89	0.71
I2	2.41	1.71	0.68	1.08	0.86
J2	2.35	1.66	0.66	1.05	0.83
K2	2.45	1.73	0.69	1.10	0.87
L2	1.94	1.37	0.55	0.87	0.69
M2	2.14	1.52	0.61	0.96	0.76
Extra wide plates without transverse reinforcement					
P132	2.63	0.83	0.33	0.97	0.42
Extra wide plates with transverse reinforcement					
N2	3.14	0.96	0.39	1.41	0.48
02	3.14	1.05	0.42	1.53	0.53

TABLE C-10: CONTINUED

PLATE NO.	$\frac{V_{obf}}{V_o}$	$\frac{T_{obf}}{T_o}$	$\frac{T_{opfm}}{T_{oro}}$	$\frac{V_{opfm}}{V_{fo}}$	$\frac{T_{opfm}}{T_{fo}}$
EDGE STRIP LOADING					
Narrow plates without transverse reinforcement					
C3-1	1.97	1.82	0.73	0.72	0.91
C3-2	1.40	1.60	0.64	0.63	0.80
D3-1	2.03	2.36	0.94	0.91	1.18
D3-2	2.03	2.36	0.94	0.91	1.18
Intermediate pltes without transverse reinforcement					
E3-1	1.42	1.81	0.72	0.64	0.91
E3-2	1.51	1.91	0.76	0.68	0.96
Wide plates without transverse reinforcement					
P123	2.21	3.62	1.45	0.82	1.81
G3	2.23	3.34	1.34	1.01	1.67
Wide plates with transverse reinforcement					
H3	2.15	3.21	1.29	0.97	1.67
I3	2.39	3.59	1.44	1.08	1.80
J3	2.28	3.41	1.36	1.03	1.70
K3	2.34	3.51	1.40	1.06	1.75
L3	2.23	3.34	1.34	1.01	1.67
M3	2.23	3.34	1.34	1.01	1.67
Extra wide plates without transverse reinforcement.					
P133	1.90	3.76	1.50	0.70	1.88
P233	1.90	3.76	1.50	0.70	1.88
Extra wide plates with transverse reinforcement					
N3	1.91	3.64	1.46	0.85	1.83
O3	2.21	4.07	1.63	0.95	1.83

TABLE C-11: COMPARISON OF THE INTERACTION EQUATION VALUES BASED ON THE SIMPLE ANALYSIS

CENTER STRIP LOADING

PLATE NO.	Eq. 2.2-3	Eq. 2.2-4	Eq. 2.1-1(A)	Eq. 2.1-1(B)
C1-1	-	-	-	-
C1-2	-	-	-	-
C1-3	-	-	-	-
D1-1	-	-	-	-
D1-2	-	-	-	-
E1-1	-	-	-	-
E1-2	-	-	-	-
E1-3	-	-	-	-
P121	-	-	-	-
F1	-	-	-	-
G1	-	-	-	-
H1	-	-	-	-
I1	-	-	-	-
J1	-	-	-	-
L1	-	-	-	-
M1	-	-	-	-
P131	-	-	-	-
P231	-	-	-	-
N1	-	-	-	-
O1	-	-	-	-

MIDDLE STRIP LOADING

PLATE NO.	Eq. 2.2-3	Eq. 2.2-4	Eq. 2.1-1(A)	Eq. 2.1-1(B)
D2-1	8.32	5.16	1.89	1.87
D2-2	7.29	4.20	1.60	1.32
E2-1	8.3	4.23	1.89	1.46
E2-2	8.01	4.08	1.84	1.41
P122	22.3	5.28	5.33	3.51
G2	16.7	4.02	4.11	2.75
H2	18.5	4.51	4.56	3.05
I2	29.15	7.06	7.18	4.78
J2	25.86	6.25	6.31	2.43
K2	28.16	6.84	6.90	4.63
L2	17.56	4.24	4.31	2.88
M2	21.55	5.20	5.26	3.52
P132	54.43	9.29	13.57	8.68
N2	72.23	12.42	18.01	11.63
O2	85.28	14.66	21.22	13.71

TABLE C-11: CONTINUED

EDGE STRIP LOADING

PLATE NO.	Eq. 2.2-3	Eq. 2.2-4	Eq. 2.1-1(A)	Eq. 2.1-1(B)
C3-1	9.60	3.95	2.26	1.65
C3-2	7.45	3.08	1.75	1.28
D3-1	16.85	4.84	4.09	2.80
D3-2	16.85	4.84	4.09	2.80
E3-1	10.88	2.55	2.69	1.78
E3-2	12.17	2.85	2.98	1.99
P123	68.30	12.50	16.91	10.89
G3	52.59	9.79	13.14	8.50
M3	48.69	9.05	12.14	7.87
I3	60.83	11.27	15.12	9.80
J3	54.66	10.13	13.59	8.8
K3	58.02	10.77	14.42	9.36
L3	52.59	9.79	13.07	8.48
M3	52.59	9.79	13.07	8.48
P133	76.39	12.53	19.06	12.23
P233	76.39	12.53	19.06	12.23
N3	58.21	9.54	14.50	9.30
O3	72.45	11.93	18.18	11.64

TABLE C-12: COMPARISON OF THE INTERACTION EQUATION VALUES BASED ON THE PLATE SOLUTION (LEVY'S METHOD)

CENTER STRIP LOADING

PLATE NO.	Eq. 2.2-3	Eq. 2.2-4	Eq. 2.1-1(A)	Eq. 2.1-1(B)
C1-1	-	-	-	-
C1-2	-	-	-	-
C1-3	-	-	-	-
D1-1	-	-	-	-
D1-2	-	-	-	-
E1-1	-	-	-	-
E1-2	-	-	-	-
E1-3	-	-	-	-
P121	-	-	-	-
F1	-	-	-	-
G1	-	-	-	-
H1	-	-	-	-
I1	-	-	-	-
J1	-	-	-	-
L1	-	-	-	-
M1	-	-	-	-
P131	-	-	-	-
P231	-	-	-	-
N1	-	-	-	-
O1	-	-	-	-

MIDDLE STRIP LOADING

PLATE NO.	Eq. 2.2-3	Eq. 2.2-4	Eq. 2.1-1(A)	Eq. 2.1-1(B)
D2-1	8.08	7.46	1.69	1.60
D2-2	7.09	6.55	1.46	1.40
E2-1	8.67	8.02	1.78	1.71
E2-2	8.36	7.73	1.72	1.65
P122	6.85	4.84	1.22	0.99
G2	5.37	3.86	1.17	1.01
H2	5.95	4.22	1.30	1.11
I2	8.73	6.30	2.03	1.74
J2	8.28	5.96	1.79	1.54
K2	9.00	6.48	1.97	1.69
L2	5.64	4.07	1.23	1.06
M2	6.89	4.95	1.50	1.29
P132	7.61	7.03	1.12	1.05
N2	10.78	10.01	2.22	2.14
O2	12.73	11.80	2.62	2.52

TABLE C-12: CONTINUED

EDGE STRIP LOADING

PLATE NO.	Eq. 2.2-3	Eq. 2.2-4	Eq. 2.1-1(A)	Eq. 2.1-1(B)
C3-1	7.19	4.41	1.35	1.05
C3-2	4.52	2.37	1.04	0.81
D3-1	9.69	5.00	2.22	1.71
D3-2	9.69	5.00	2.22	1.71
E3-1	5.29	2.53	1.24	0.93
E3-2	5.93	2.86	1.38	1.04
P123	17.99	6.99	3.95	2.77
G3	16.13	9.77	3.81	2.82
M3	14.93	6.29	3.53	2.61
I3	18.60	7.79	4.41	3.24
J3	16.83	7.05	3.95	2.91
K3	17.80	7.44	4.19	3.08
L3	16.13	6.77	3.81	2.82
M3	16.13	6.77	3.81	2.82
P133	17.75	5.86	4.23	2.74
P233	17.75	5.86	4.23	2.74
N3	16.90	5.78	4.07	2.85
03	21.45	7.54	4.25	3.56

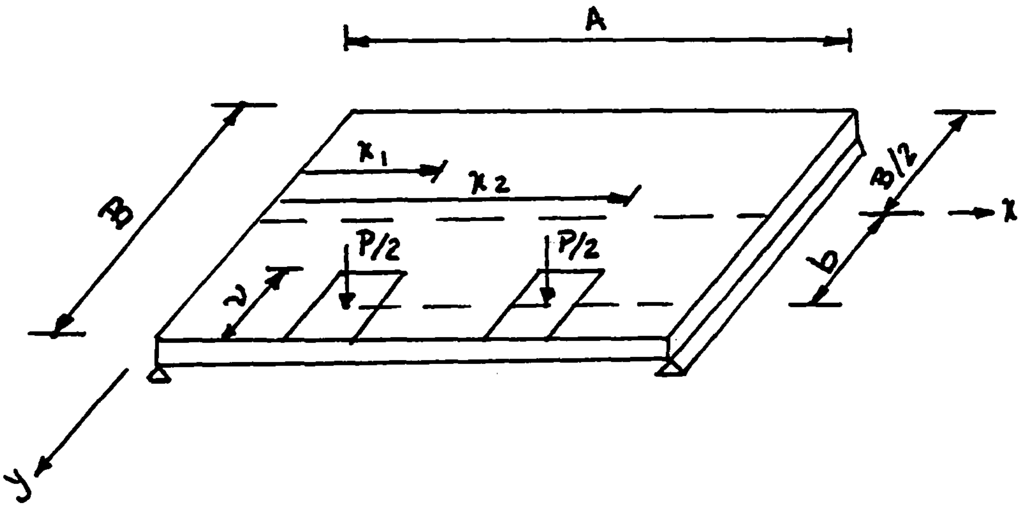

Fig. 1

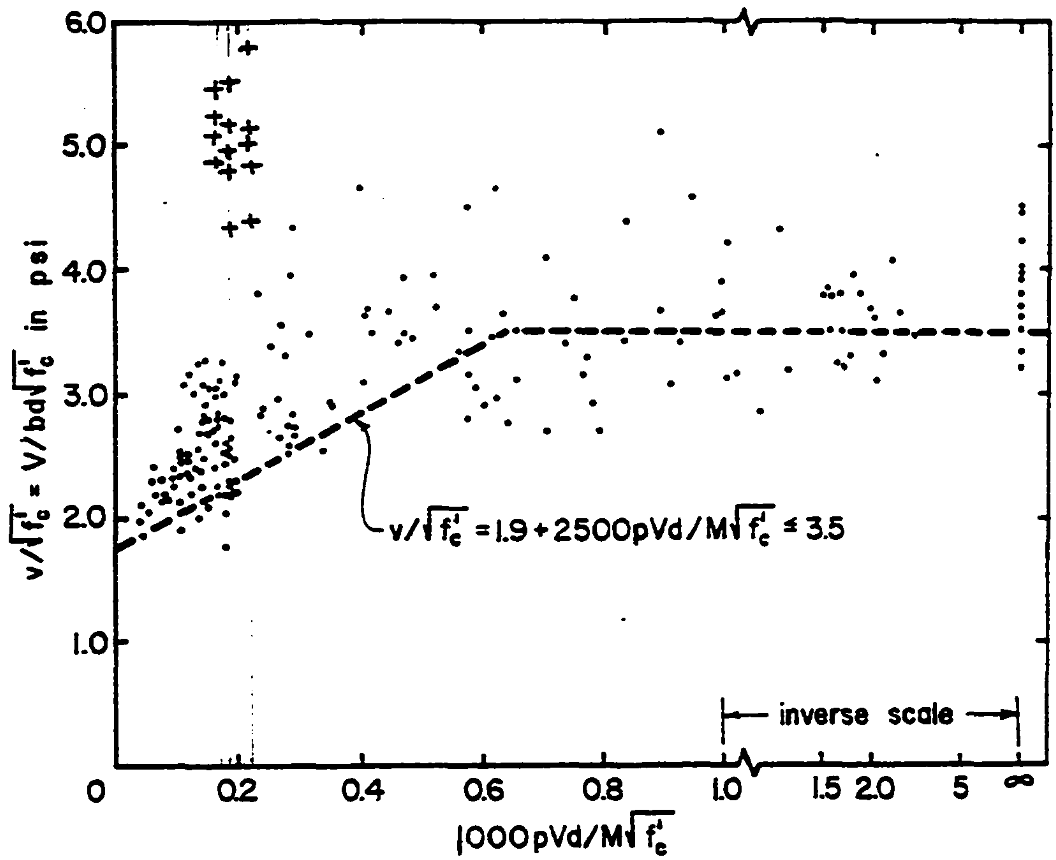

Fig. 2

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+ Experimental Results for concrete beams that were cast with ρ_{max}

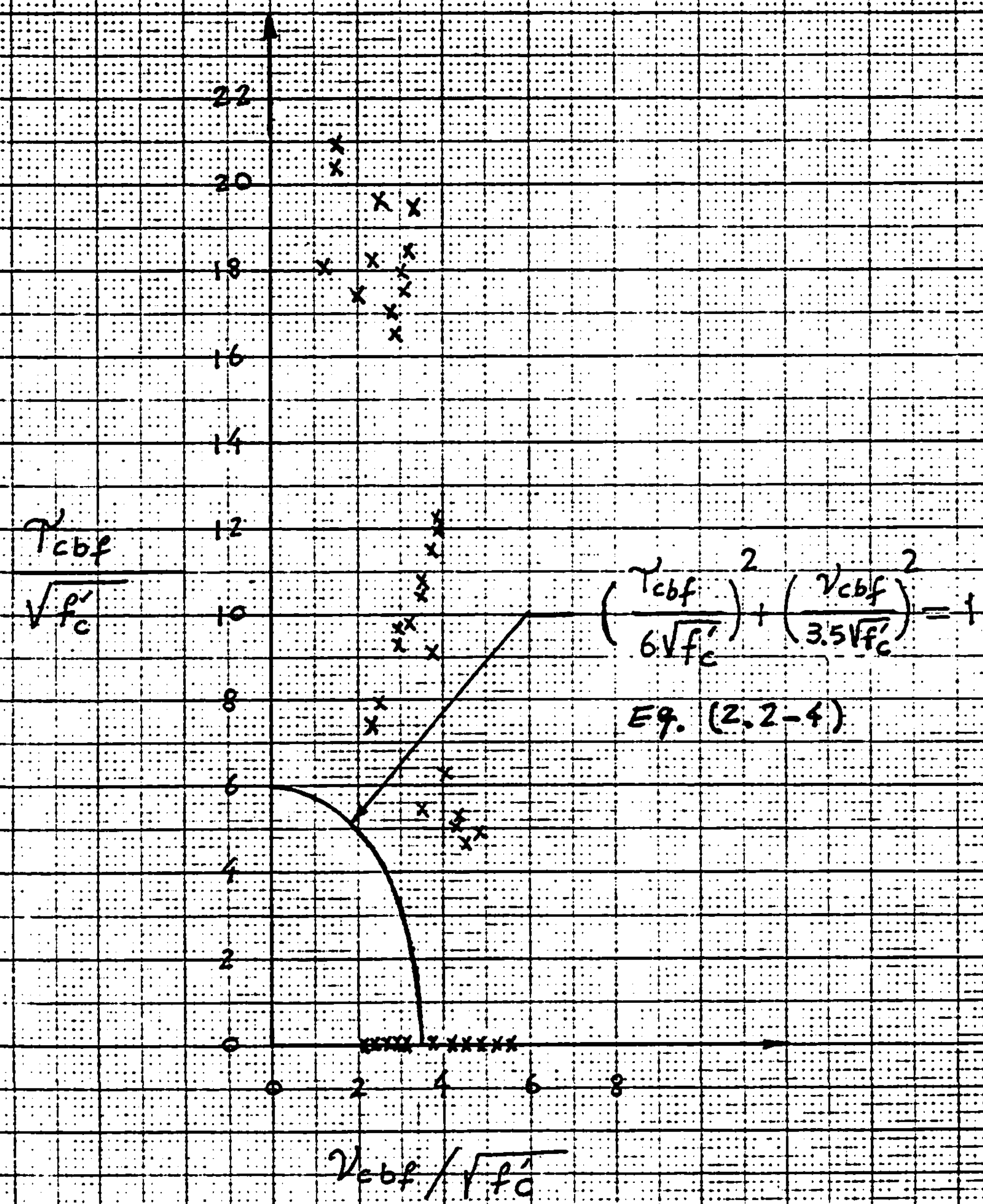

22
20
18
16
14
12
10
8
6
4
2
0
0
2
4
6
8
$\tau_{cbf}/\sqrt{f'_c}$
$\left(\frac{\tau_{cbf}}{6\sqrt{f'_c}}\right)^2+\left(\frac{\nu_{cbf}}{3.5\sqrt{f'_c}}\right)^2=1$
Eq. (2.2-4)
$\nu_{cbf}/\sqrt{f'_c}$

Fig. 3

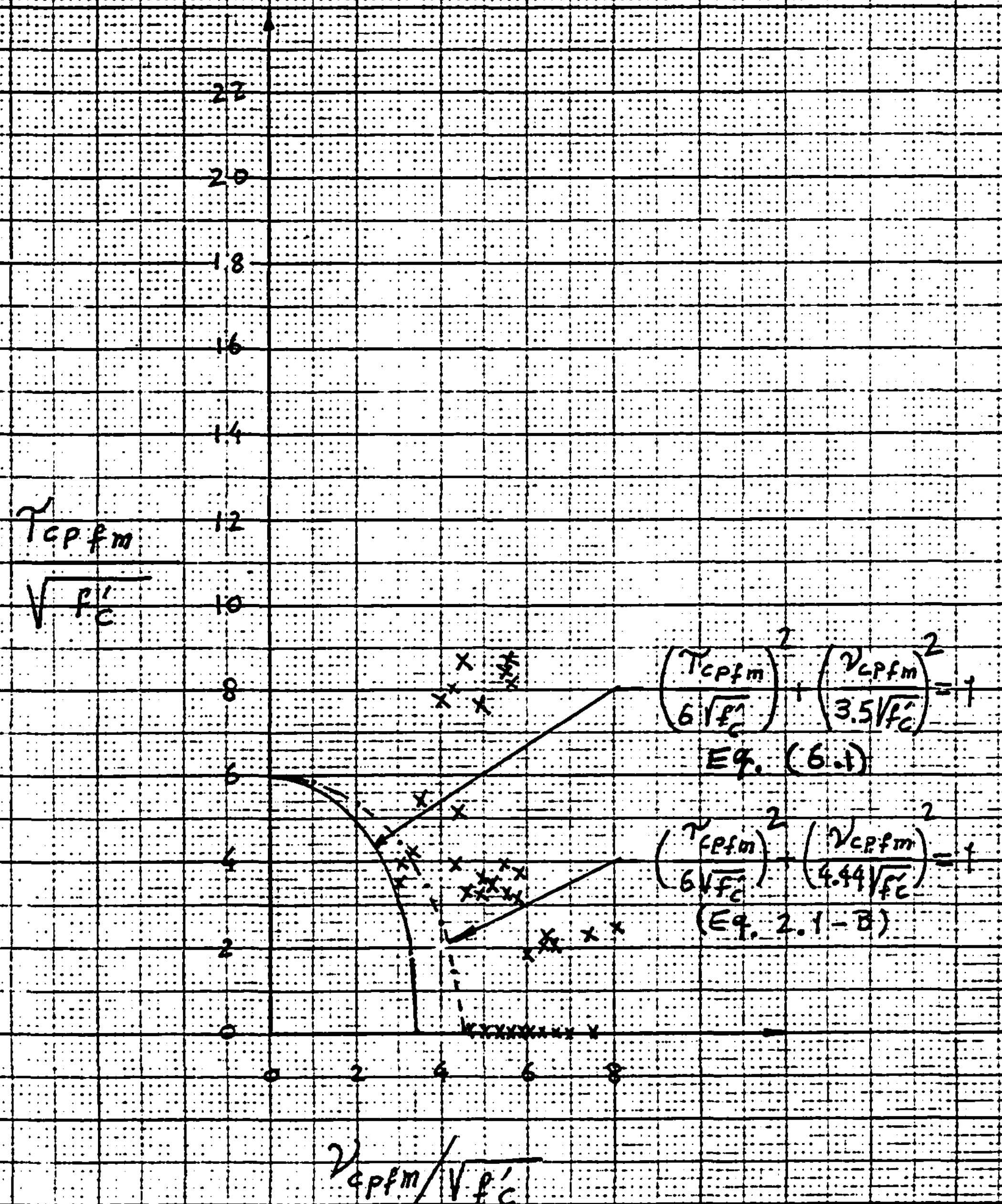

22
20
18
16
14
12
10
8
6
4
2
0
$\frac{\tau_{cpfm}}{\sqrt{f'_c}}$
0
2
4
6
8
$\nu_{cpfm}/\sqrt{f'_c}$
$\left(\frac{\tau_{cpfm}}{6\sqrt{f'_c}}\right)^2 + \left(\frac{\nu_{cpfm}}{3.5\sqrt{f'_c}}\right)^2 = 1$
Eq. (6.1)
$\left(\frac{\tau_{cpfm}}{6\sqrt{f'_c}}\right)^2 + \left(\frac{\nu_{cpfm}}{4.44\sqrt{f'_c}}\right)^2 = 1$
(Eq. 2.1-B)

Fig. 4

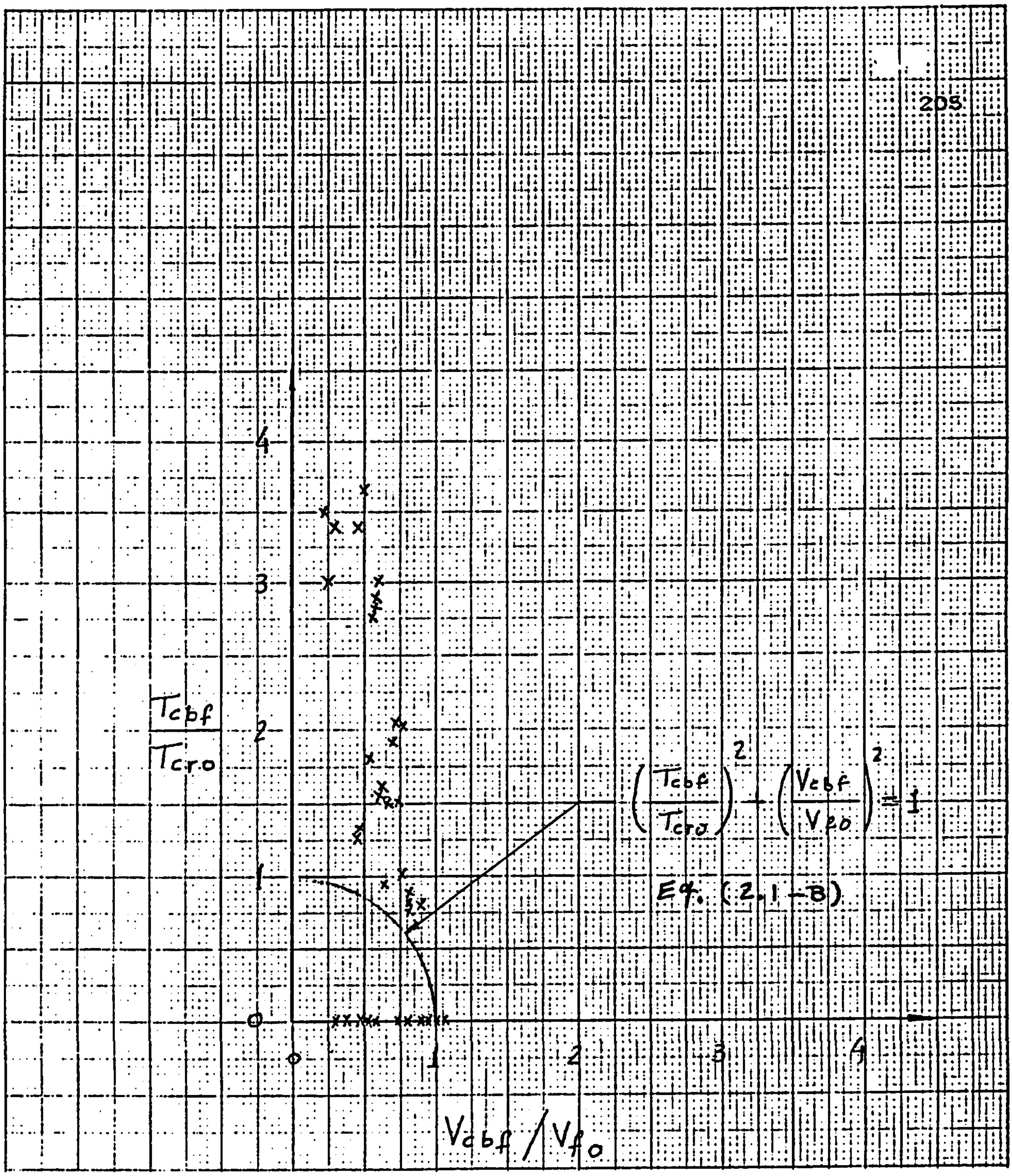
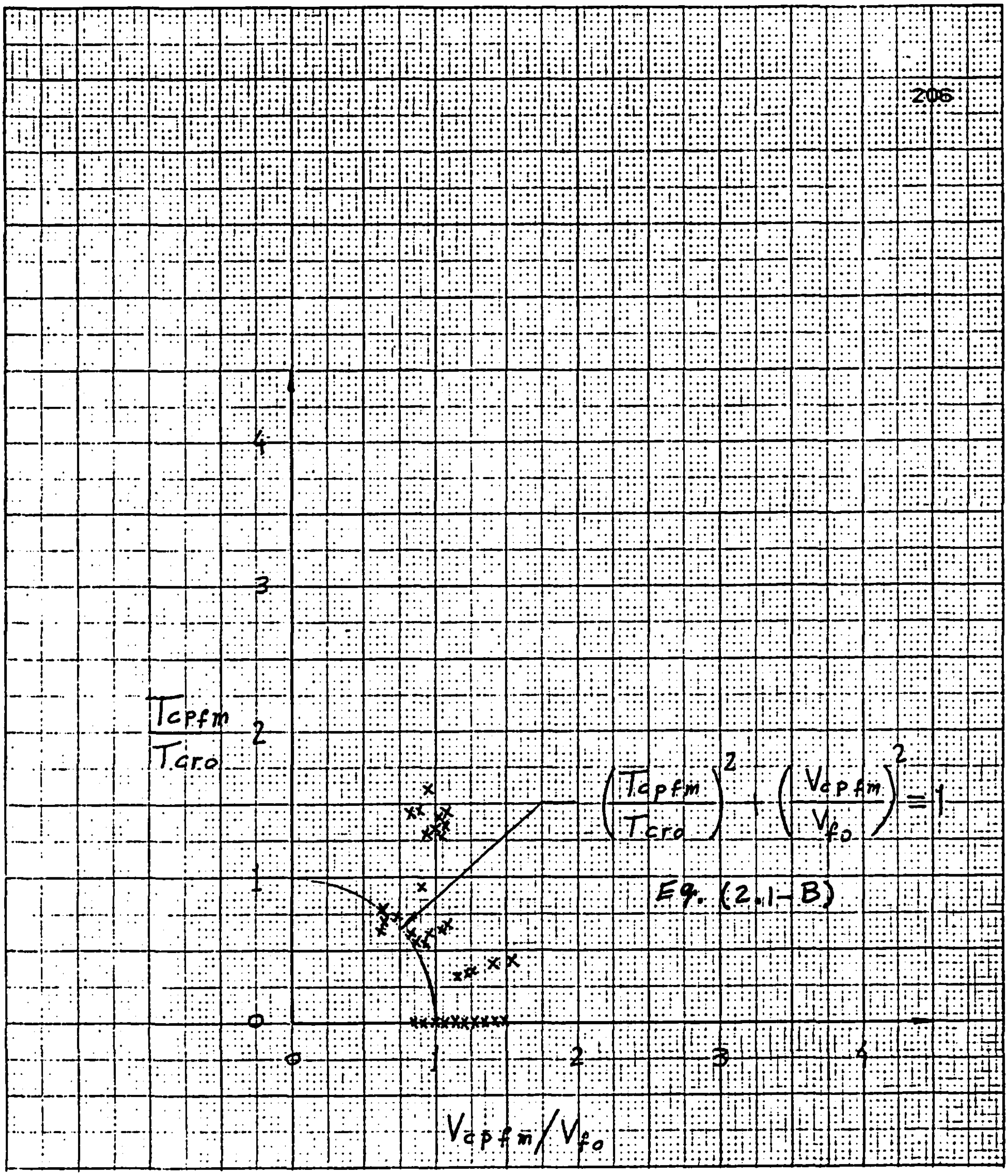

4
3
2
1
0
$\frac{T_{cbf}}{T_{cro}}$
0
1
2
3
4
V_{cbf}/V_{fo}
$\left(\frac{T_{cbf}}{T_{cro}}\right)^2+\left(\frac{V_{cbf}}{V_{fo}}\right)^2=1$
Eq. (2.1-B)

Fig. 5



Tcpfm / Tcro
4
3
2
1
0
0
1
2
3
4
(Tcpfm / Tcro)^2 + (Vcpfm / Vfo)^2 = 1
Eq. (2.1-B)
Vcpfm / Vfo

Fig. 6

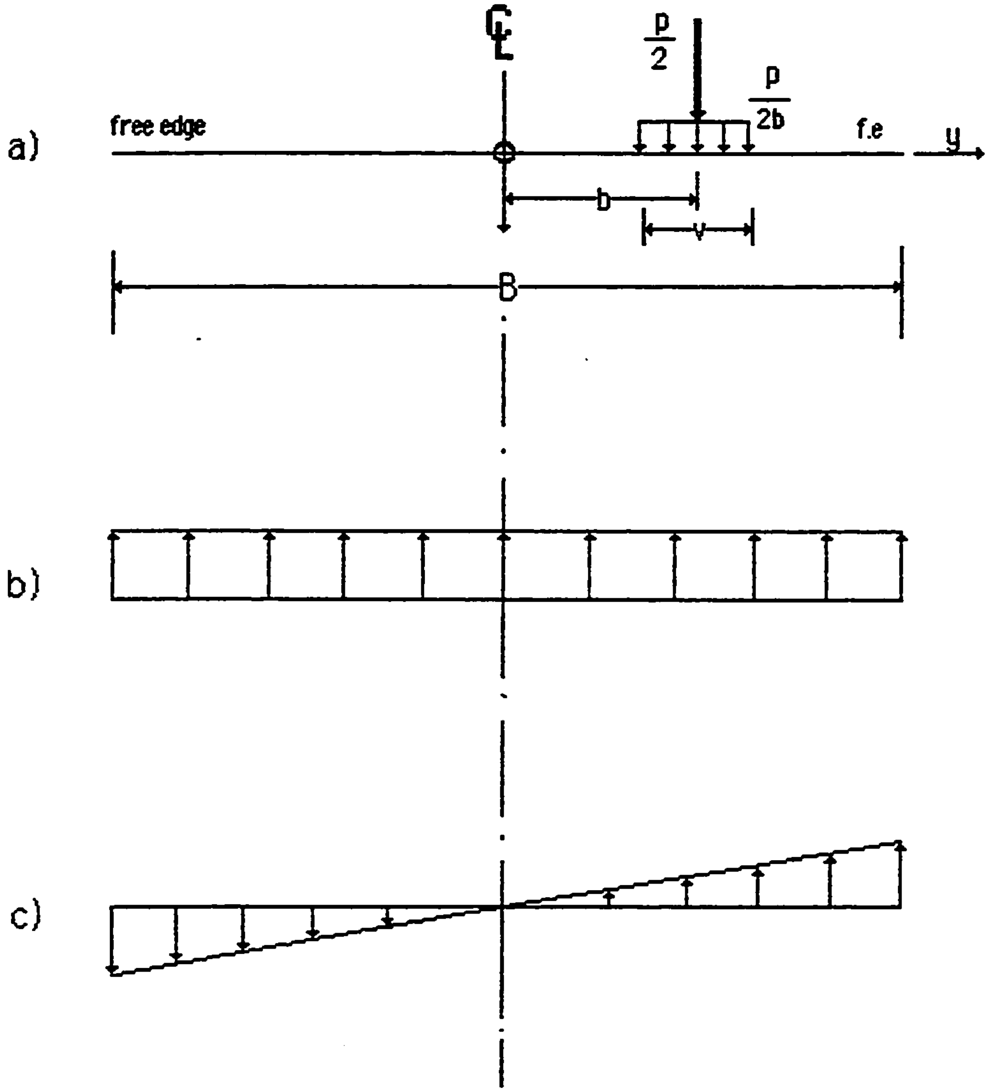


Fig. 7

a=Applied Non Symmetrical Load
b=Shear Reaction
c=Torsion Reaction
* For Interaction of Combined Shear&Torsional Reactions See Figs. 3 & 5.

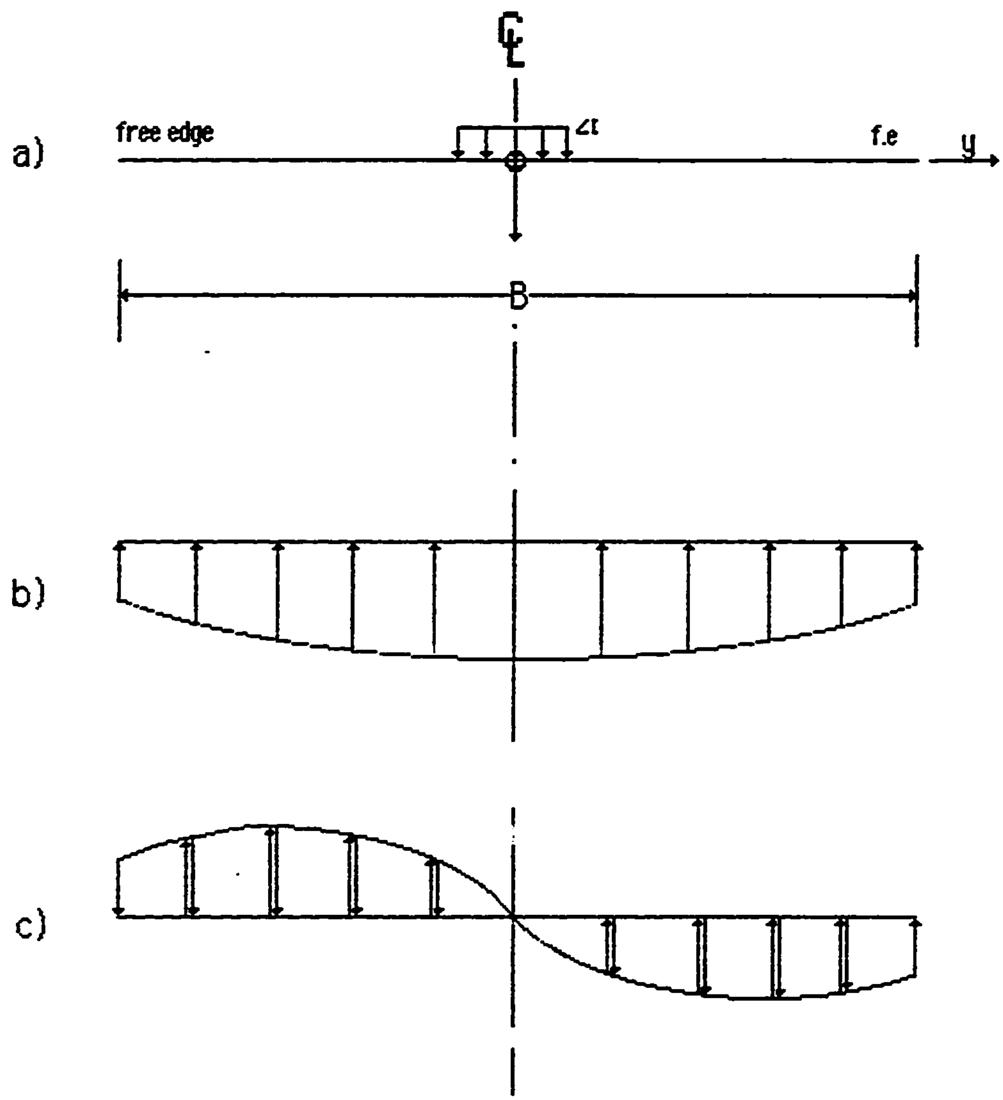


Fig. 8

a=Applied Symmetrical Load
b=Shear Reaction
c=Torsion Reaction
* For Interaction of Combined Shear&Torsional
Reactions See Fig. 4 & 6.

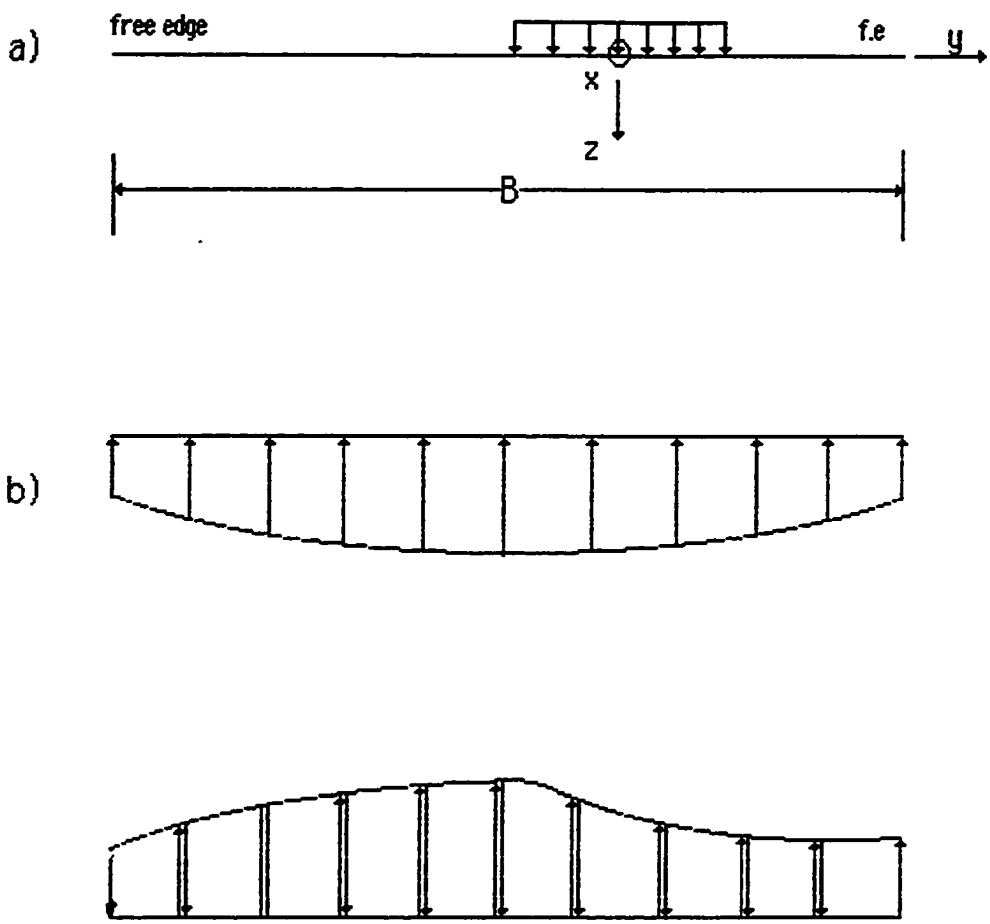


Fig. 9

a=Applied Non Symmetrical Load
b=Shear Reaction
c=Torsion Reaction
* For Interaction of Combined Shear&Torsional
Reactions See Fig. 4 & 6.

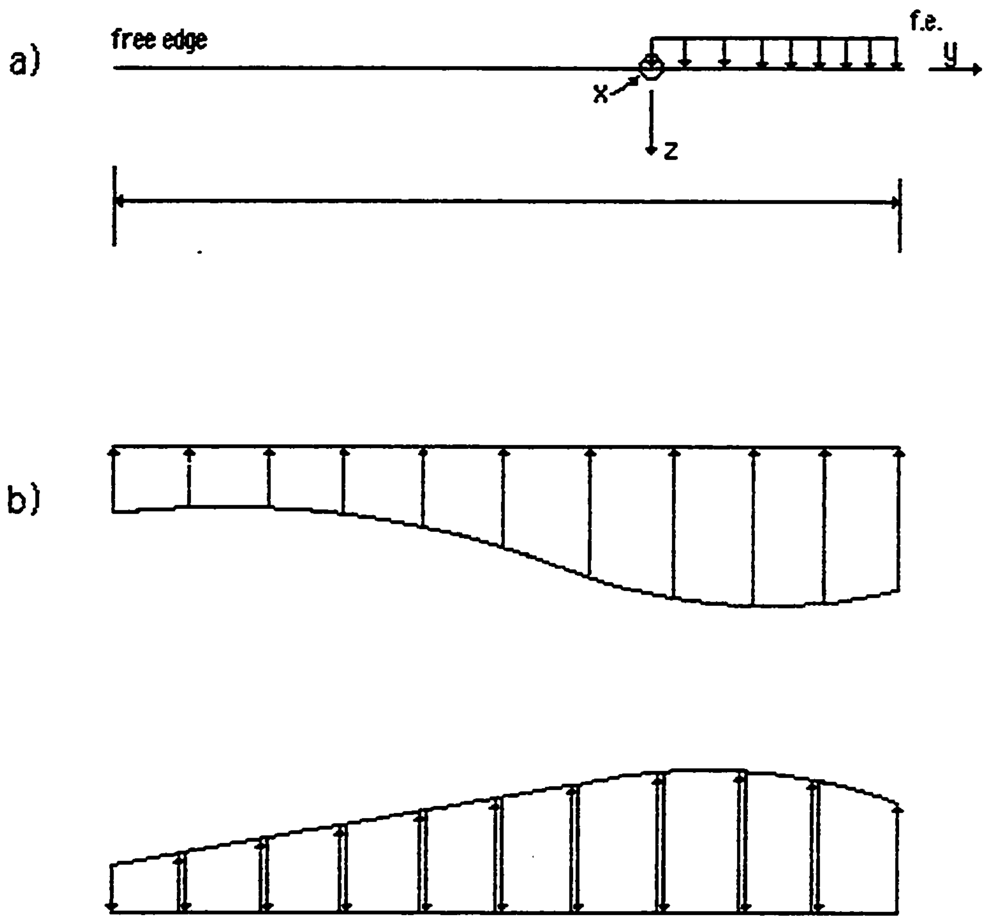


Fig 10

a=Applied Non Symmetrical Load
b=Shear Reaction
c=Torsion Reaction
* For Interaction of Combined Shear&Torsional Reactions See Fig. 4 & 6.

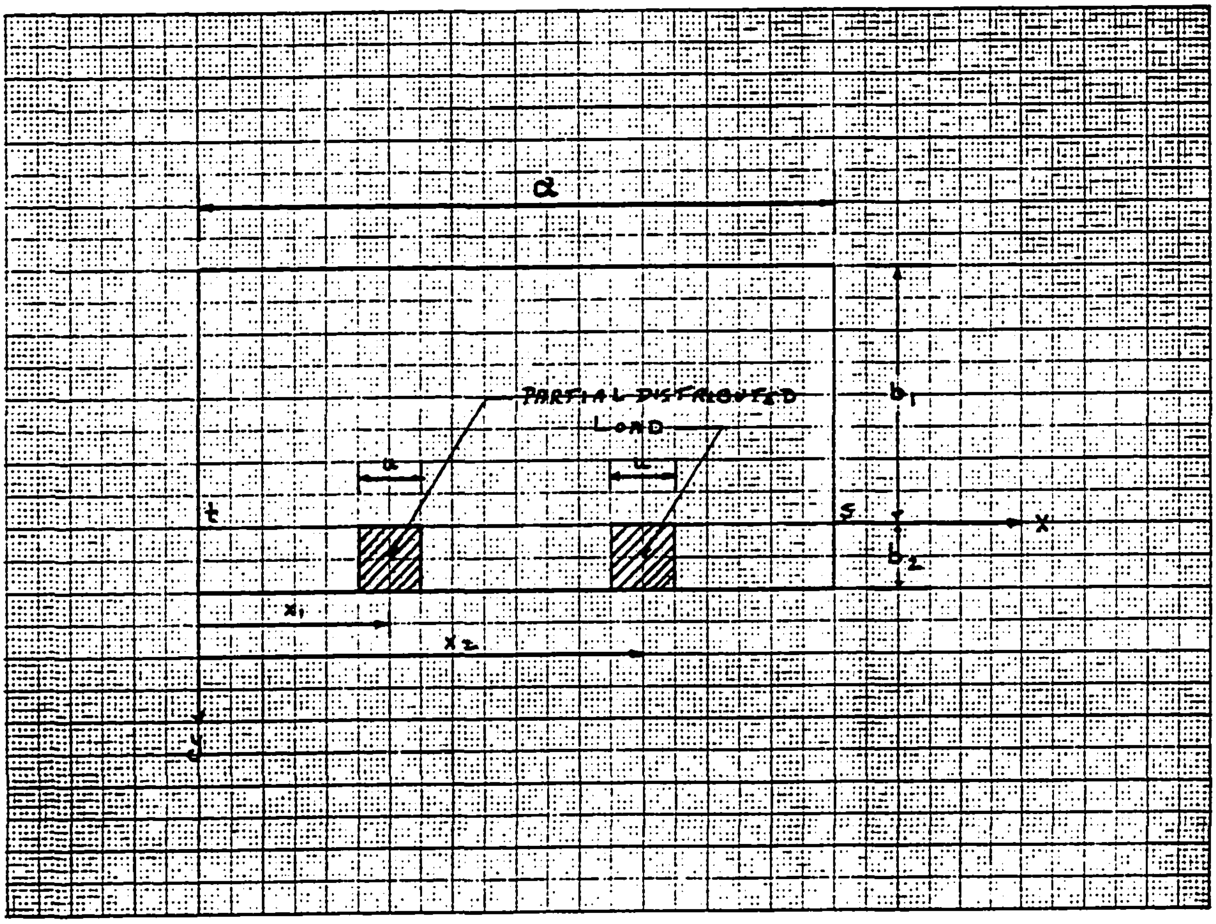


FIG. A-1

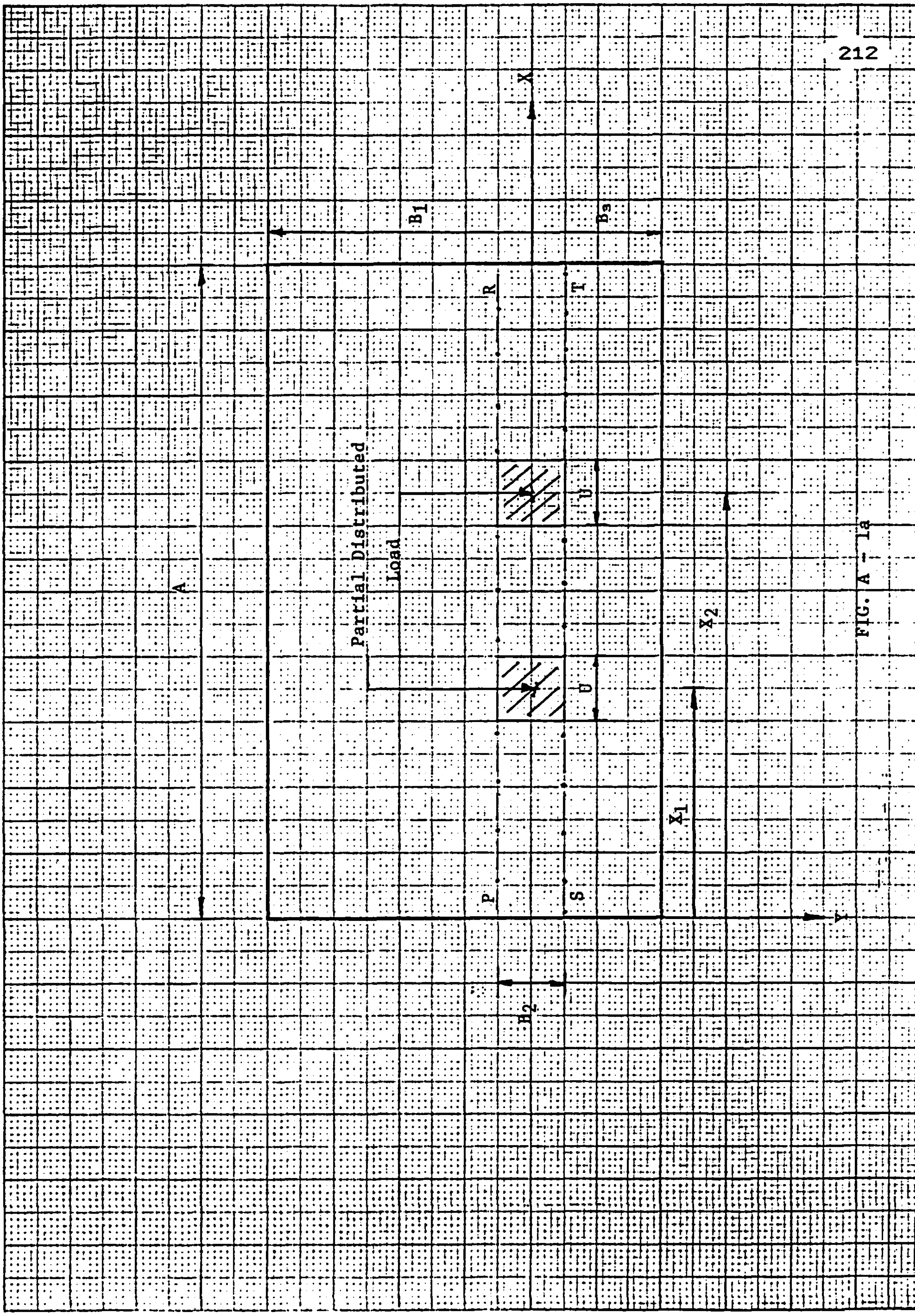


FIG. A - 1a

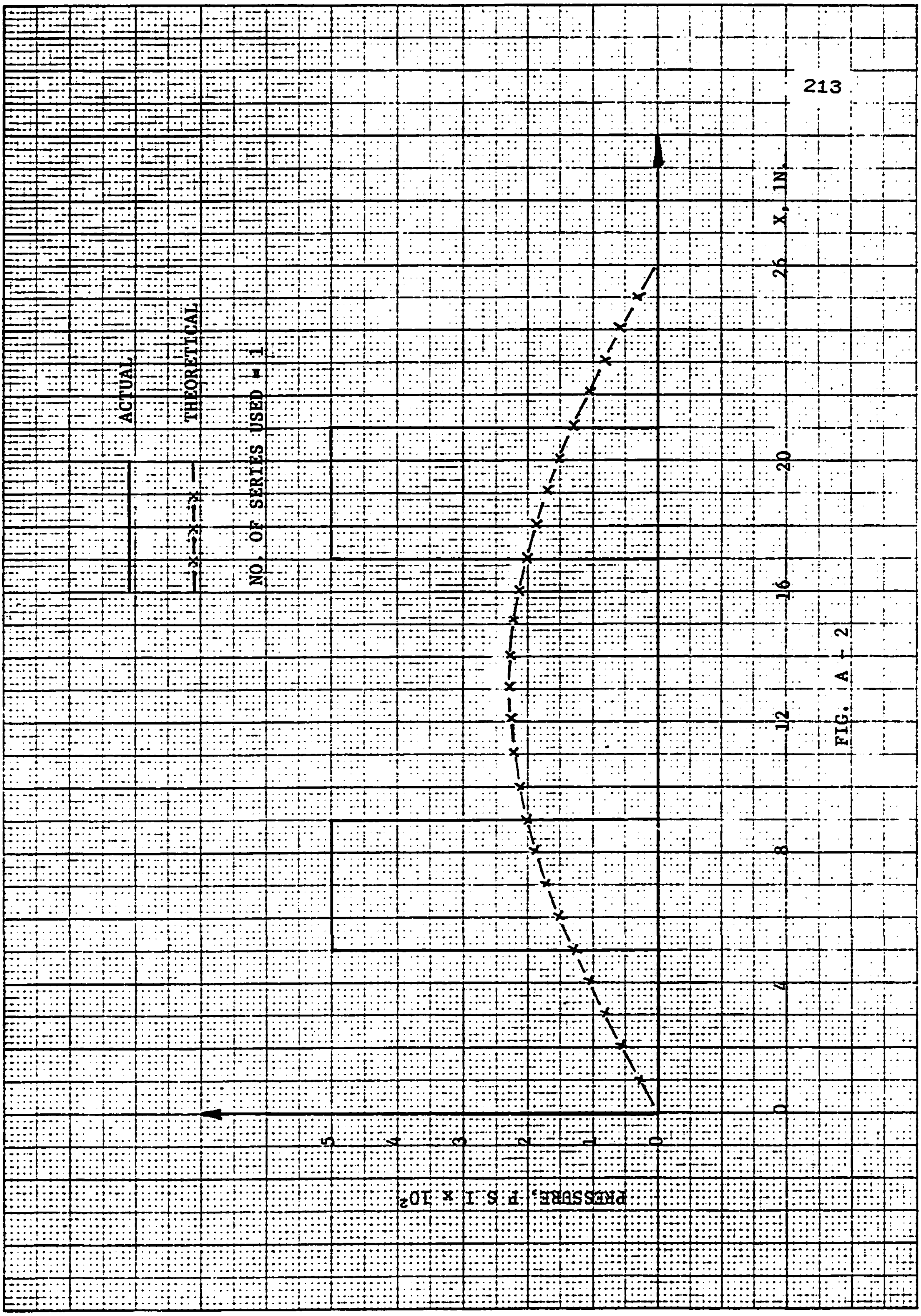

ACTUAL
THEORETICAL
NO. OF SERIES USED = 1
X, IN.
0
4
8
12
16
20
24
PRESSURE, P.S.I × 10²
0
1
2
3
4
5

FIG. A - 2

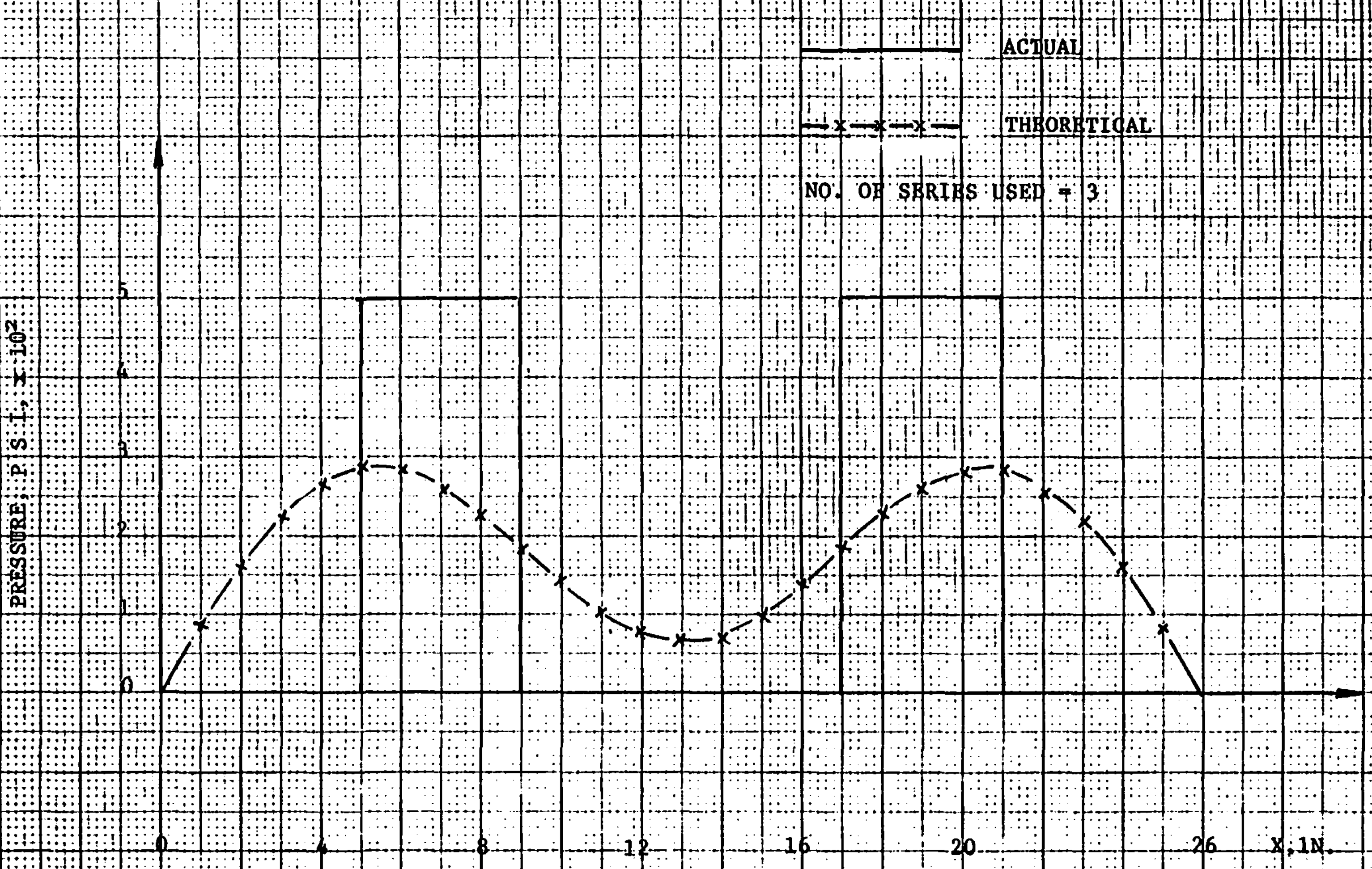

ACTUAL
THEORETICAL
NO. OF SERIES USED = 3
PRESSURE, P S I, x 10^2
0
1
2
3
4
5
0
4
8
12
16
20
26
X, IN.

FIG. A - 3

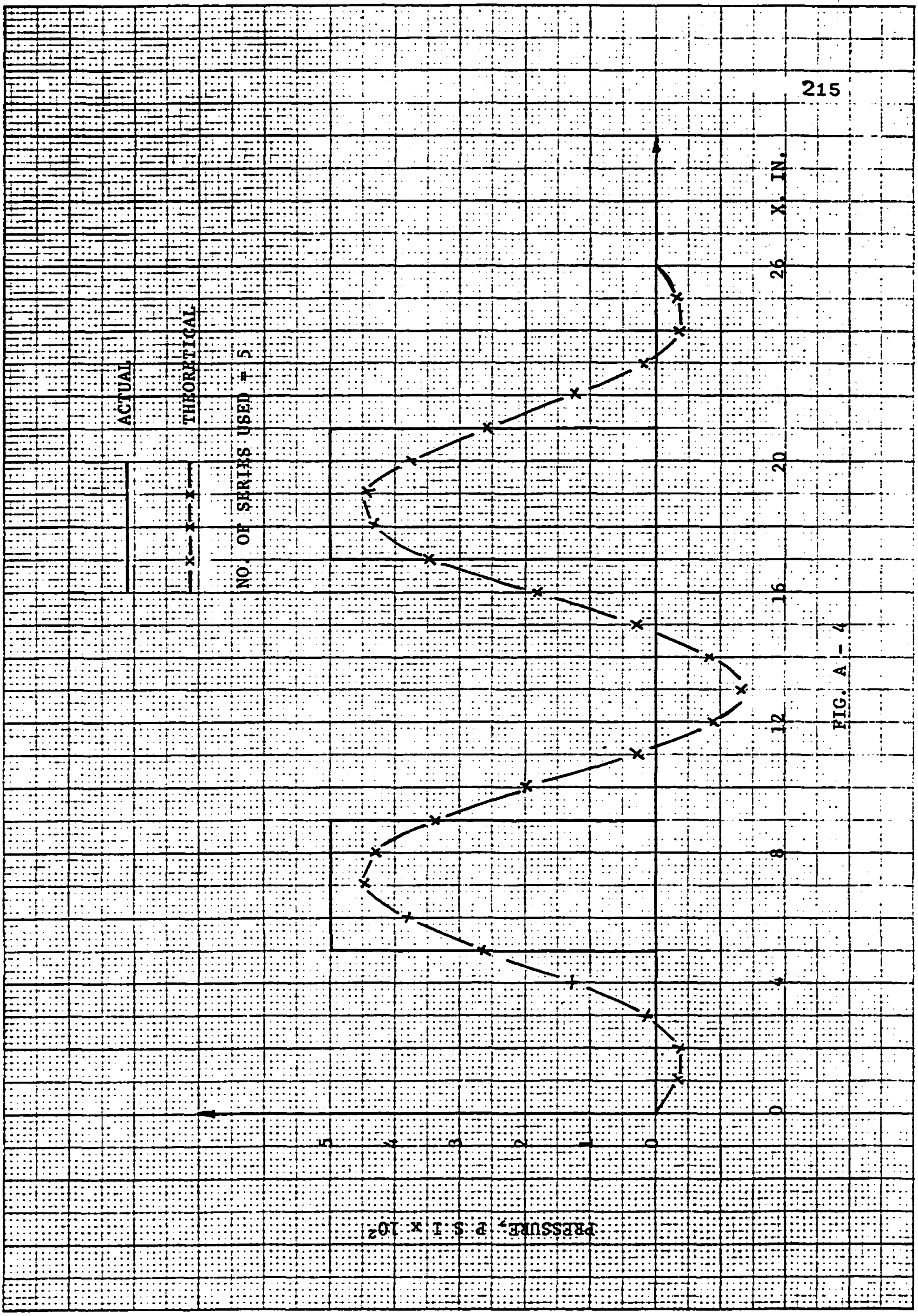

ACTUAL
THEORETICAL
NO. OF SERIES USED = 5
X, IN.
0
4
8
12
16
20
26
0
1
2
3
4
5
PRESSURE, P S I x 10²

FIG. A - 4

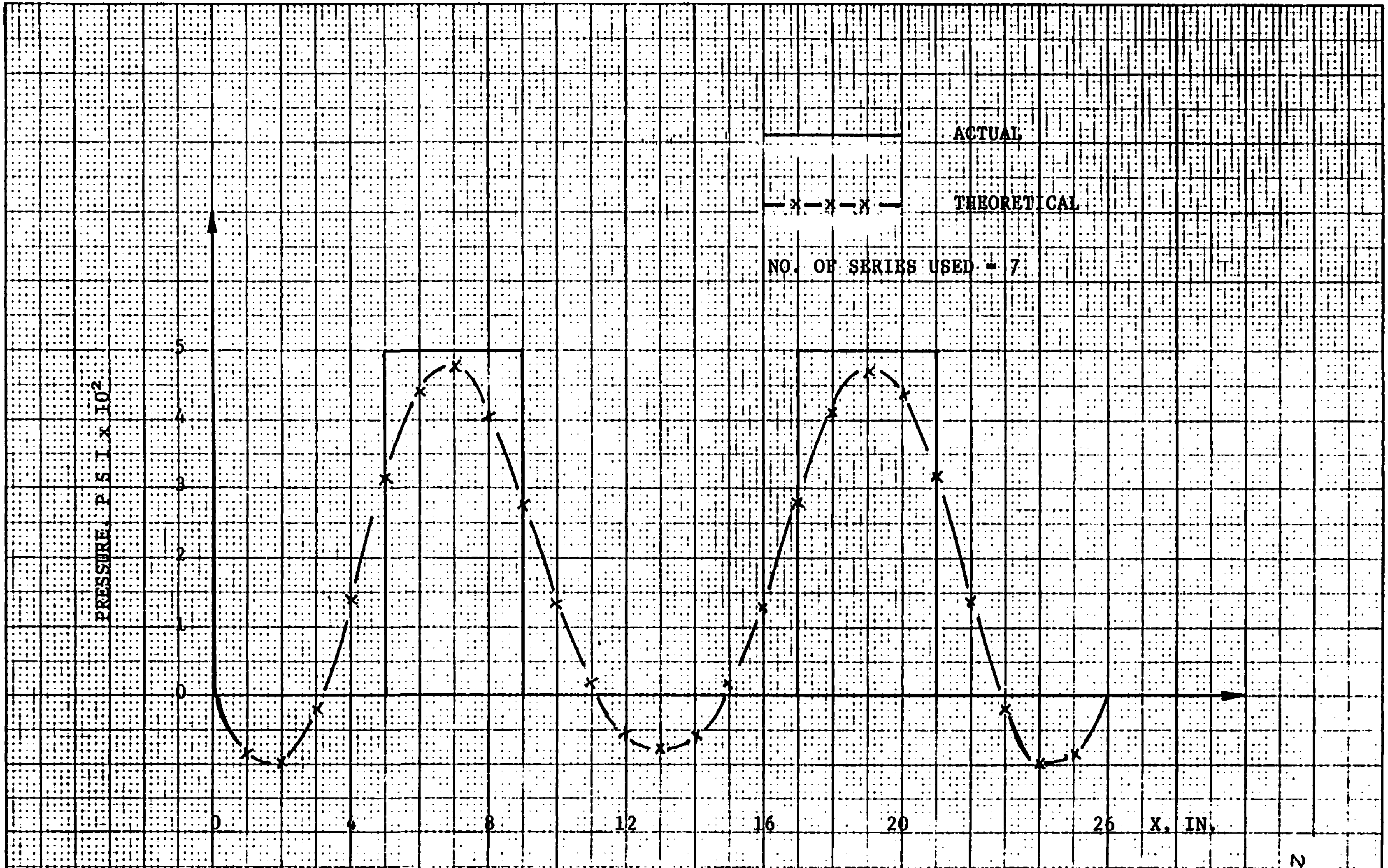

ACTUAL
THEORETICAL
NO. OF SERIES USED = 7
PRESSURE, P S I x 10²
5
4
3
2
1
0
0
4
8
12
16
20
26
X, IN.

FIG. A - 5

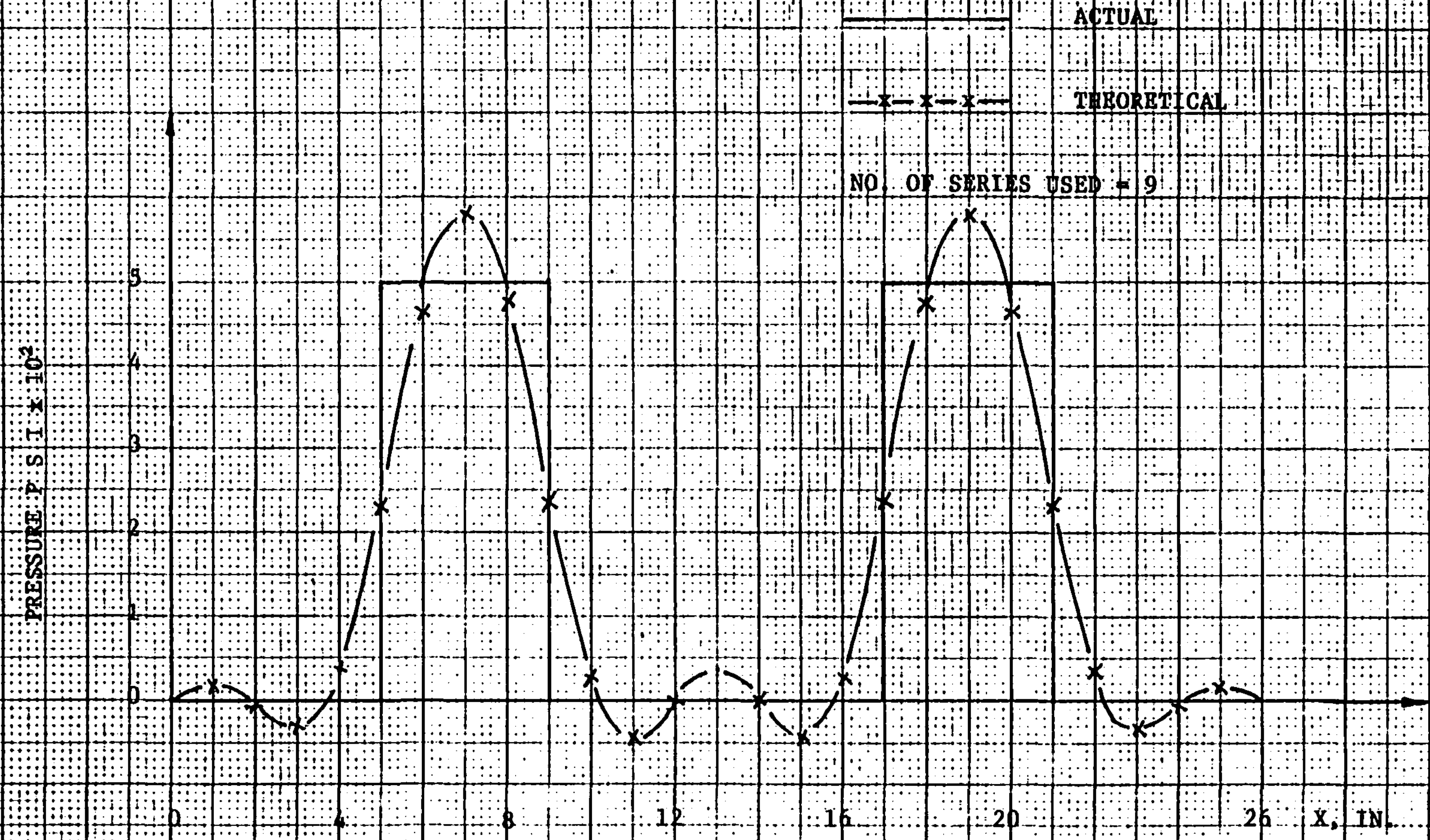

ACTUAL
THEORETICAL
NO. OF SERIES USED = 9
PRESSURE P S I x 10^2
0
1
2
3
4
5
0
4
8
12
16
20
26
X, IN.

FIG. A - 6

Fig. B-1 Direct tensile test specimens

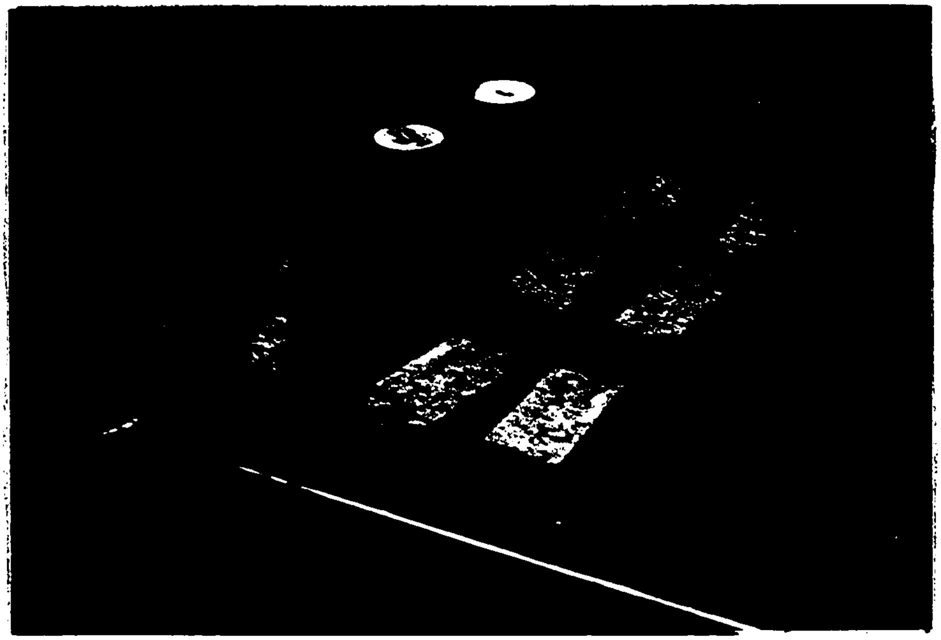


Fig. B-2 Compressive & split tensile test specimens

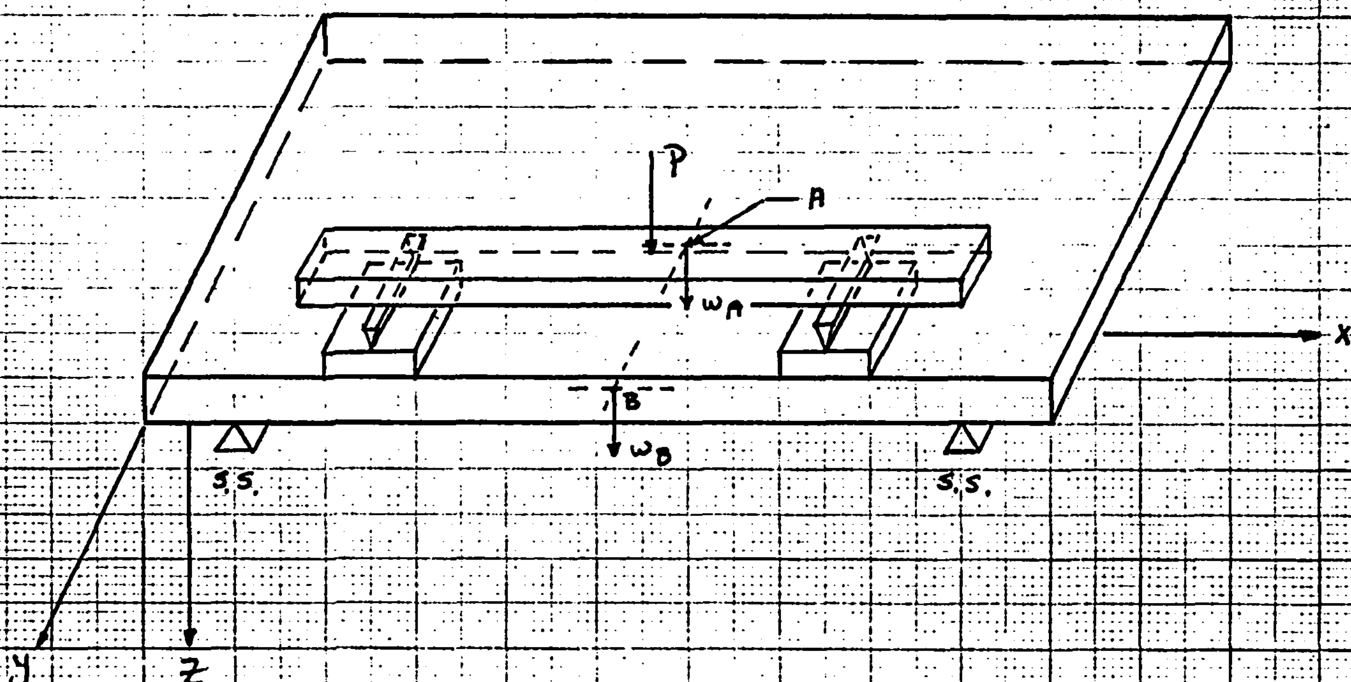


Fig. B-3 Test set up for non-symmetrical londing

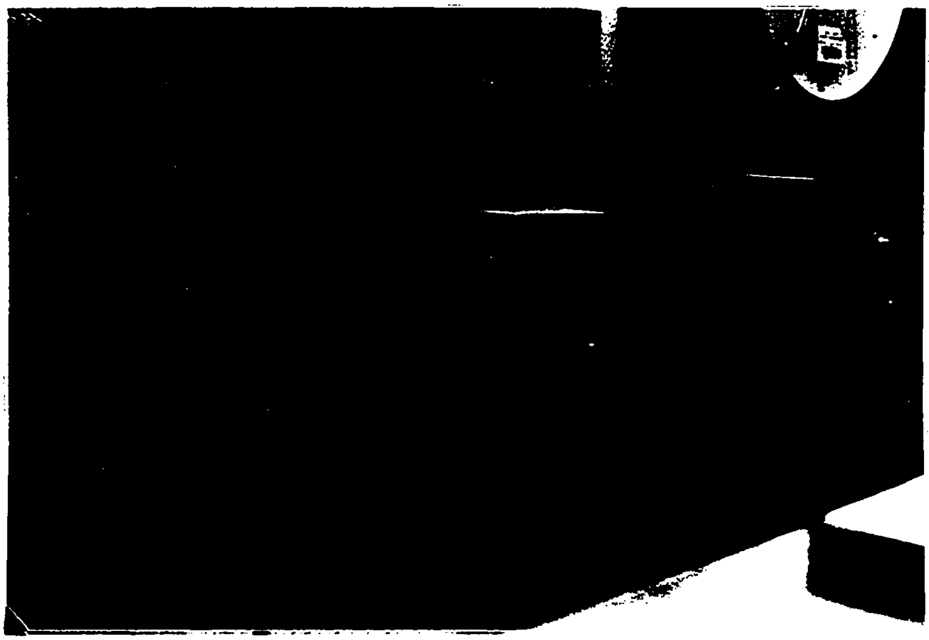


Fig. B-4 Photograph of test set-up

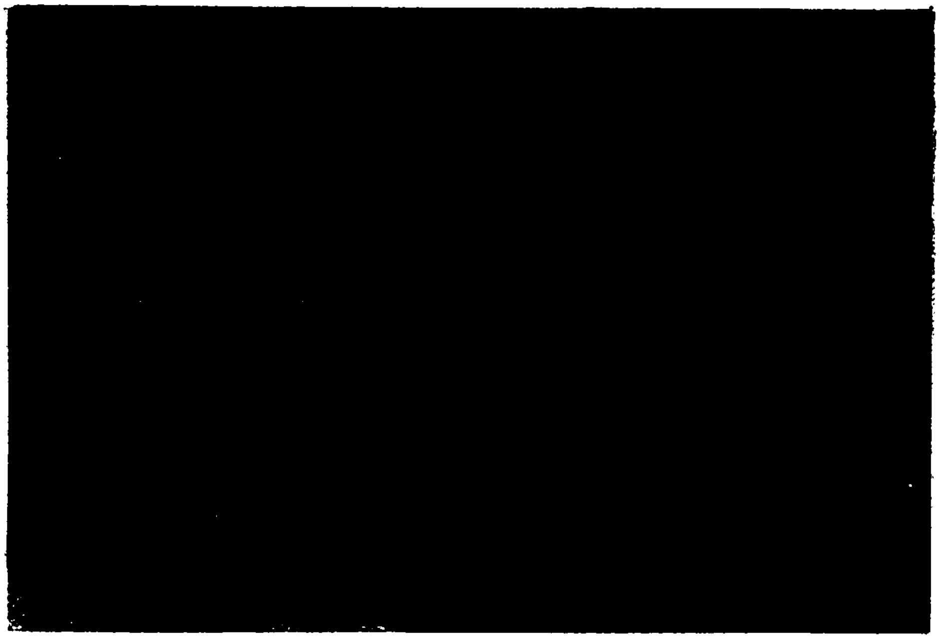


Fig. B-5 Bending failure, Plate No. I

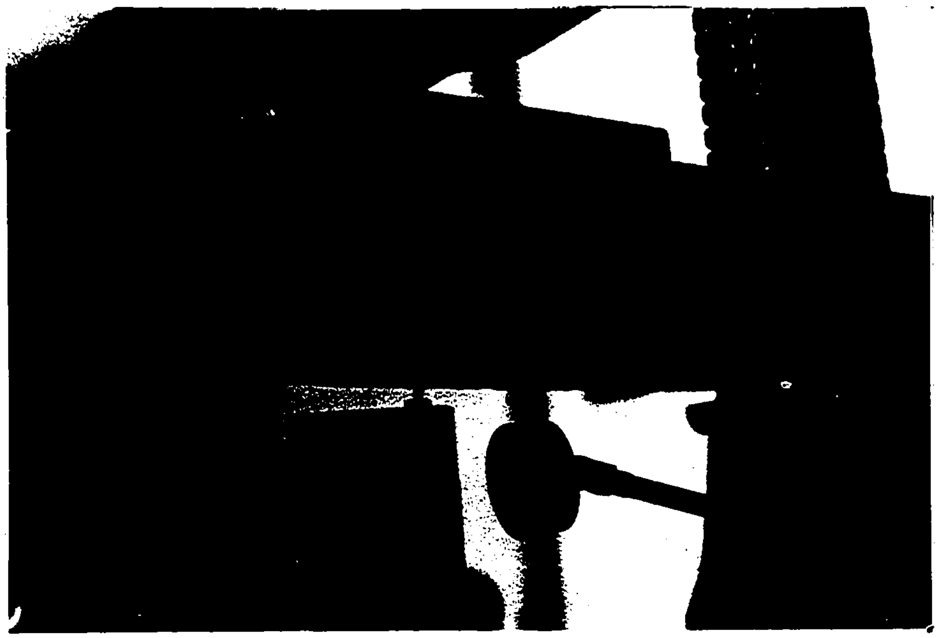


Fig. B-6 Bending failure, Plate No. II

Fig. B-7 Bending failure, Plate No.II

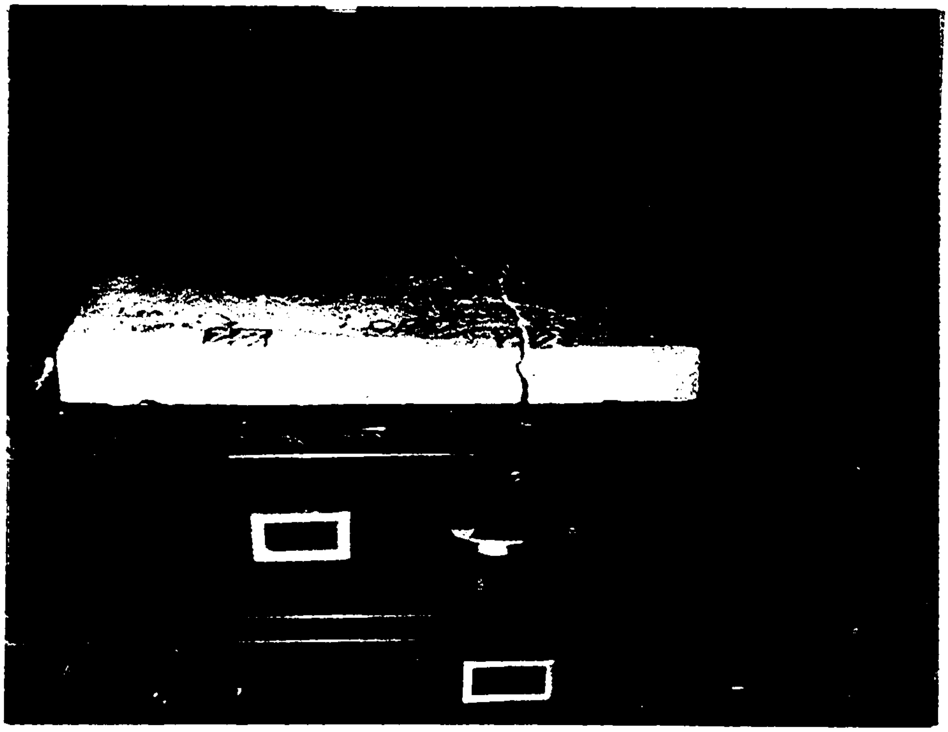


Fig. B-8 Bending failure, Plate No. III

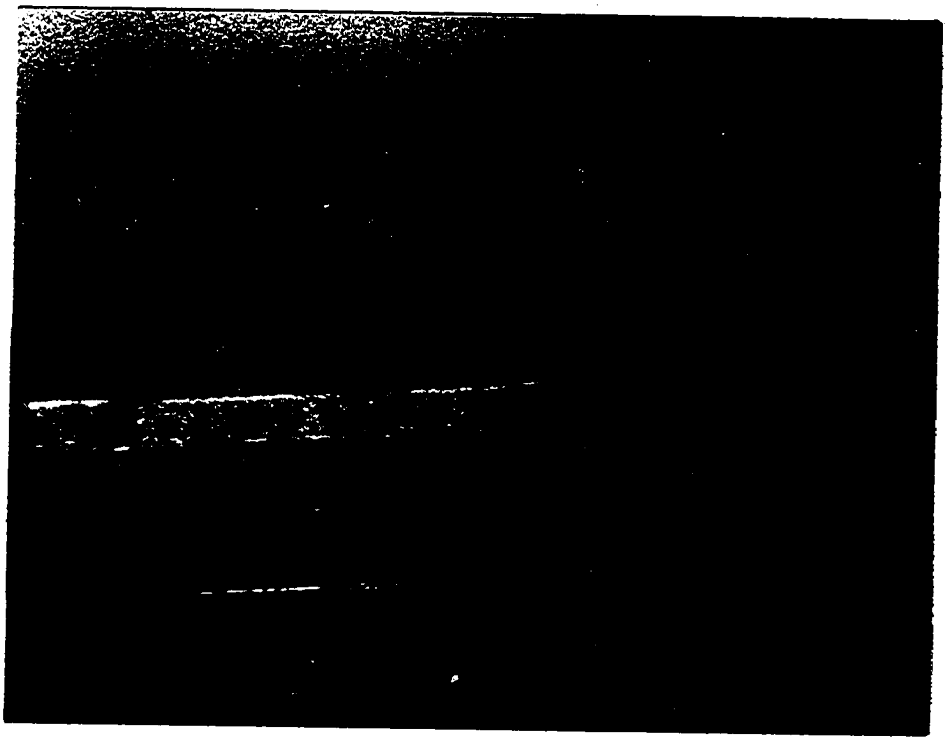


Fig. B-9 Combined shear & torsion failure, Plate No. IV

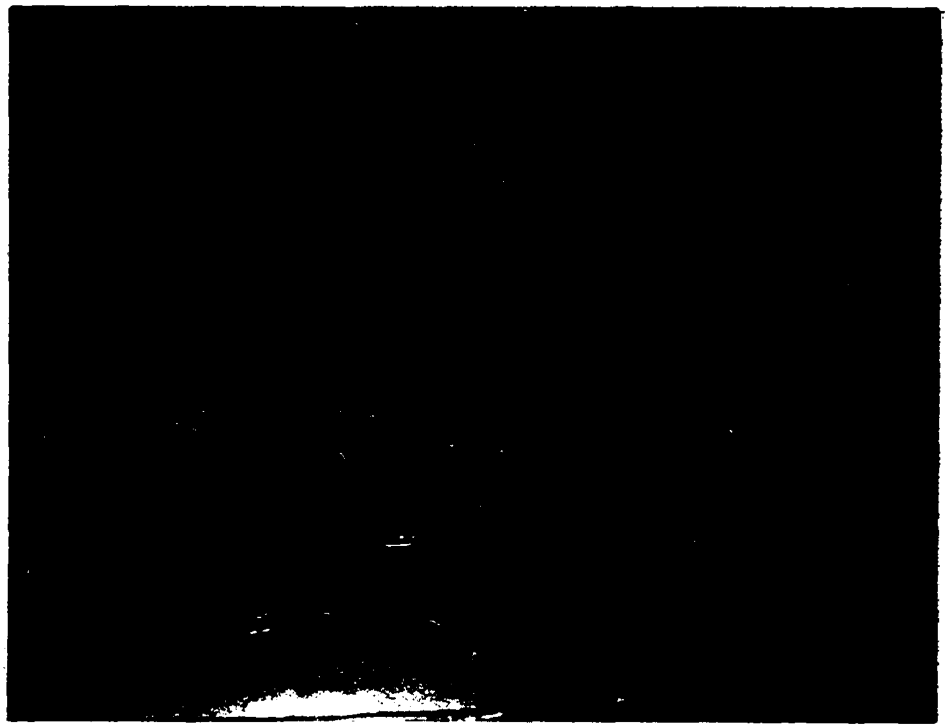


Fig. B-10 Combined shear & torsion failure Plate No. V

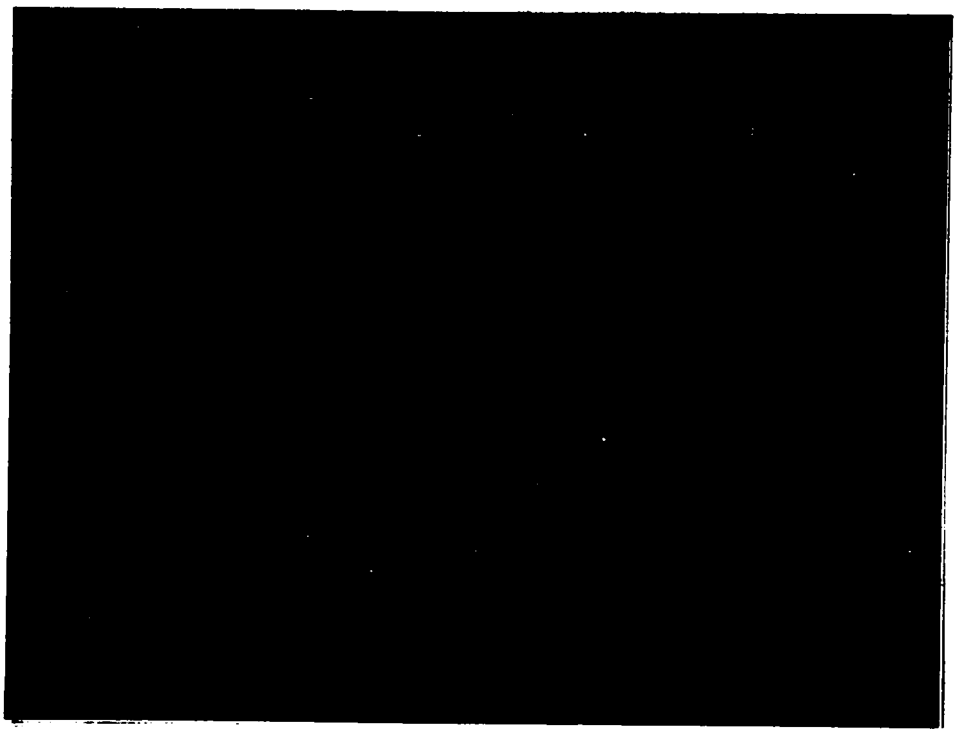


Fig. B-11 Combined shear & torsion failure, Plate No. VI

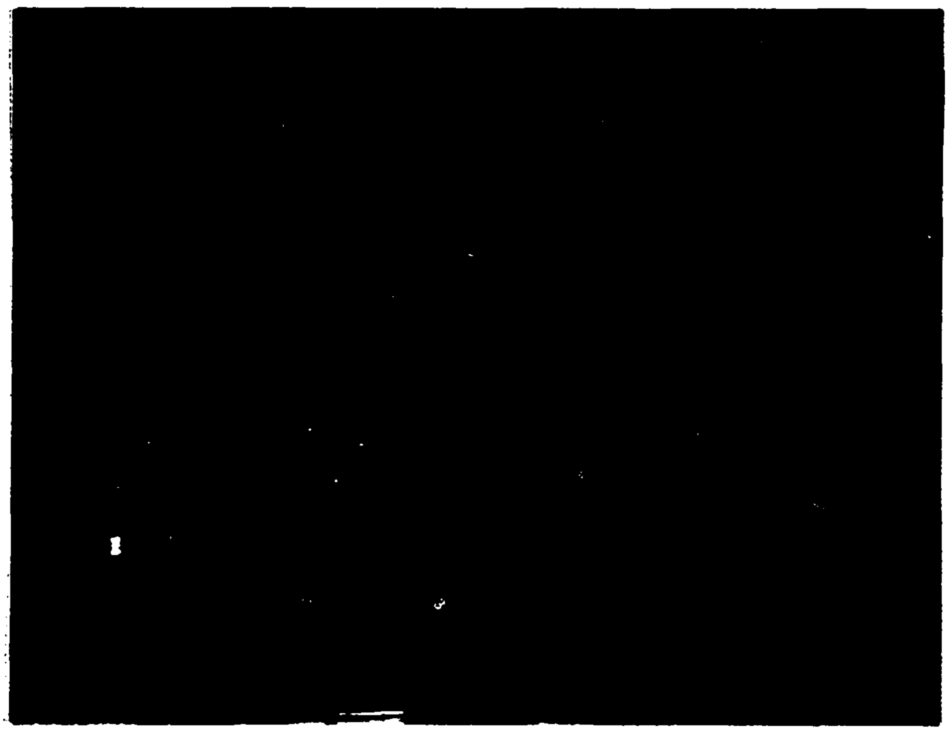


Fig. B-12 Combined shear & torsion failure, Plate No. VI

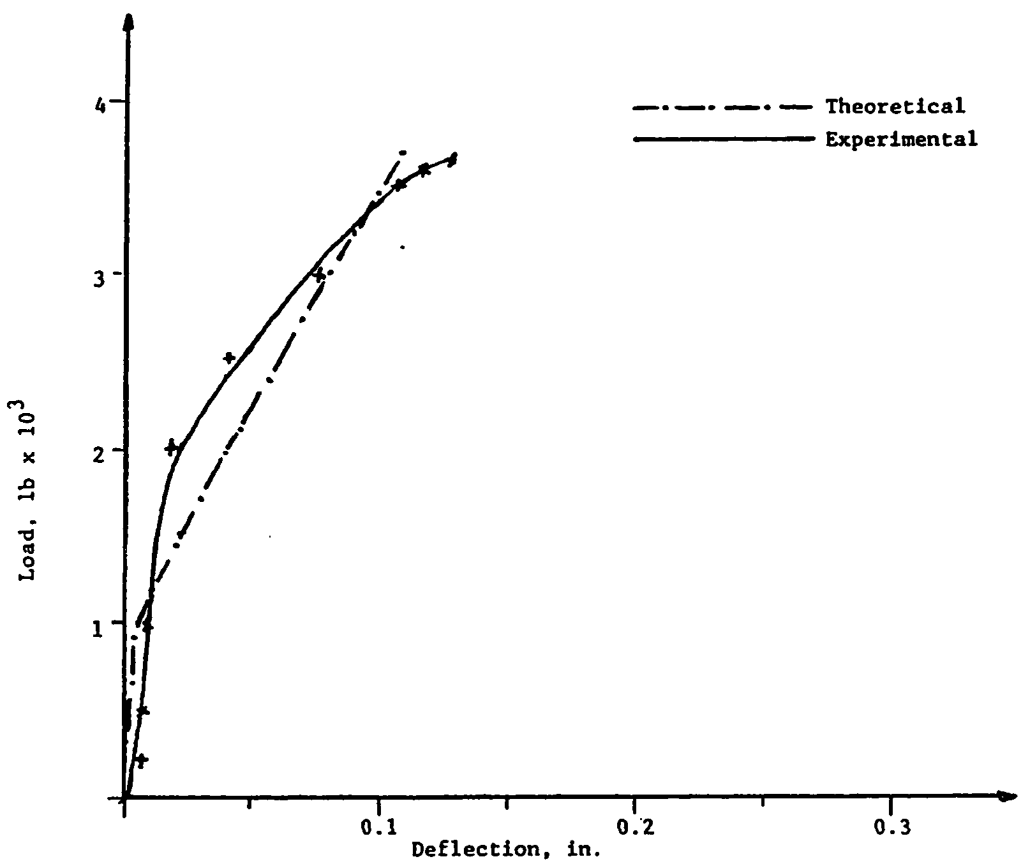


FIG. B-13 LOAD DEFLECTION CURVE, PLATE NO. II, POINT A

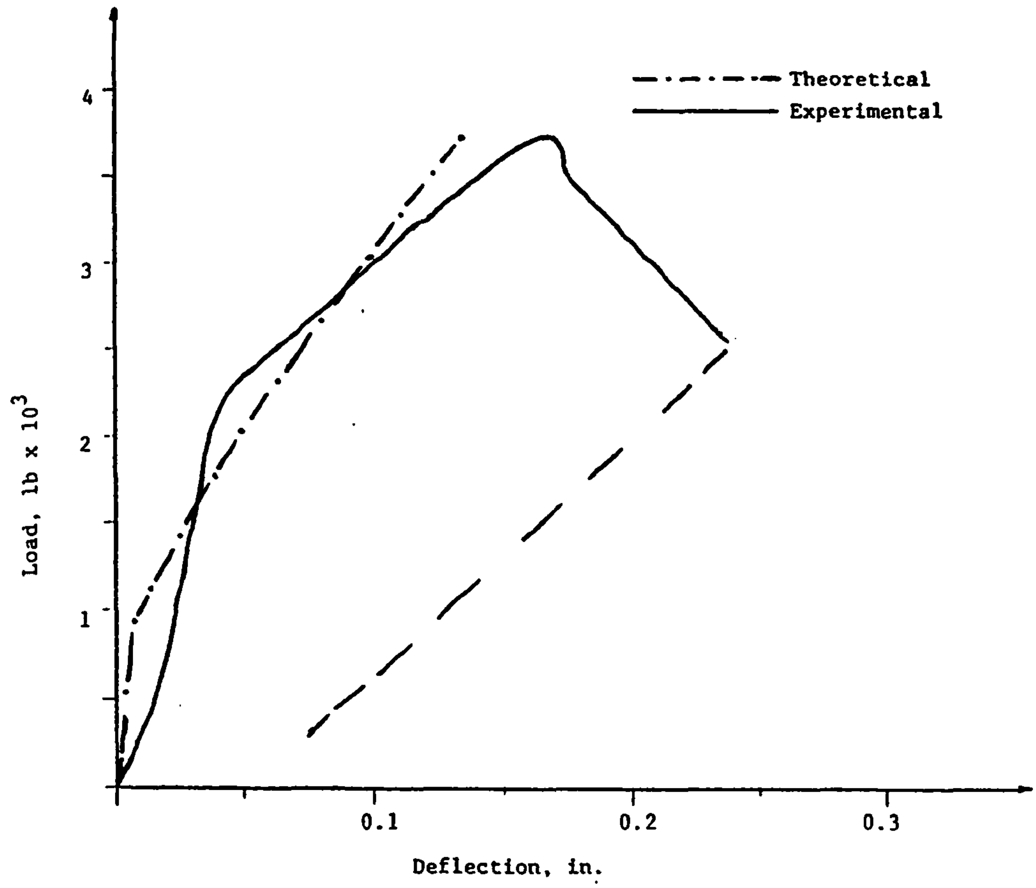


FIG. B-14 LOAD DEFLECTION CURVE, PLATE NO. II, POINT B

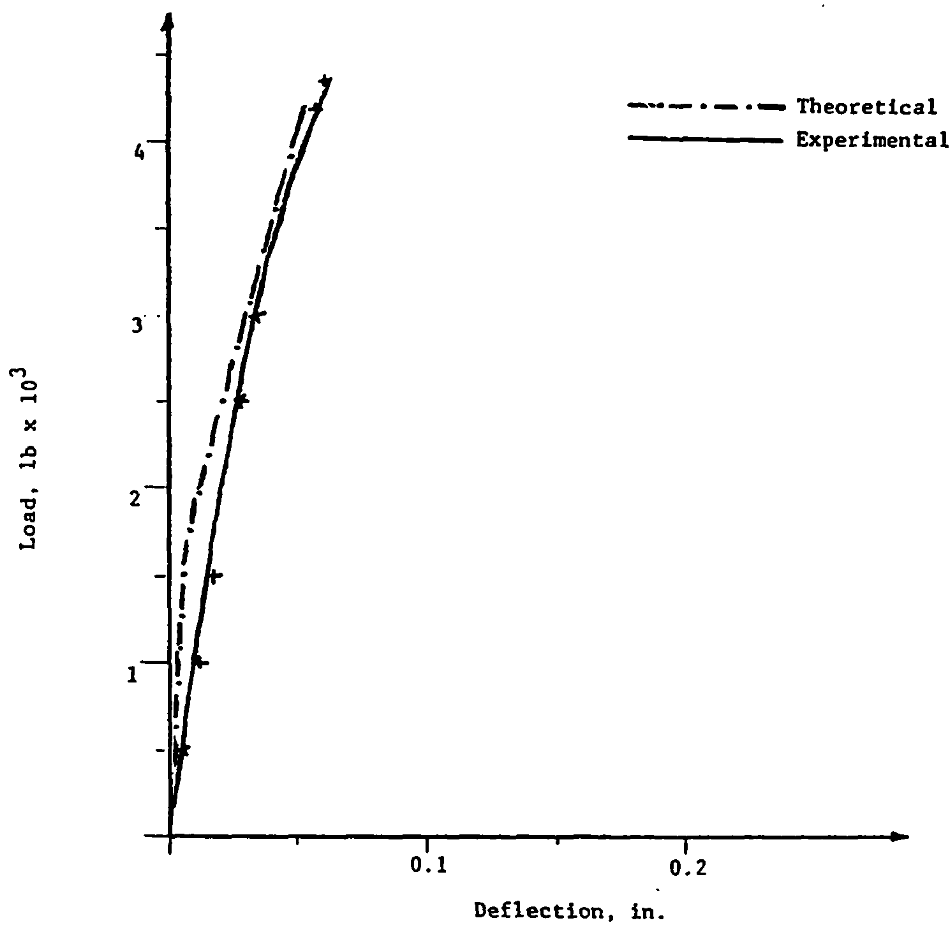


FIG. B-15 LOAD DEFLECTION CURVE, PLATE NO. IV, POINT A

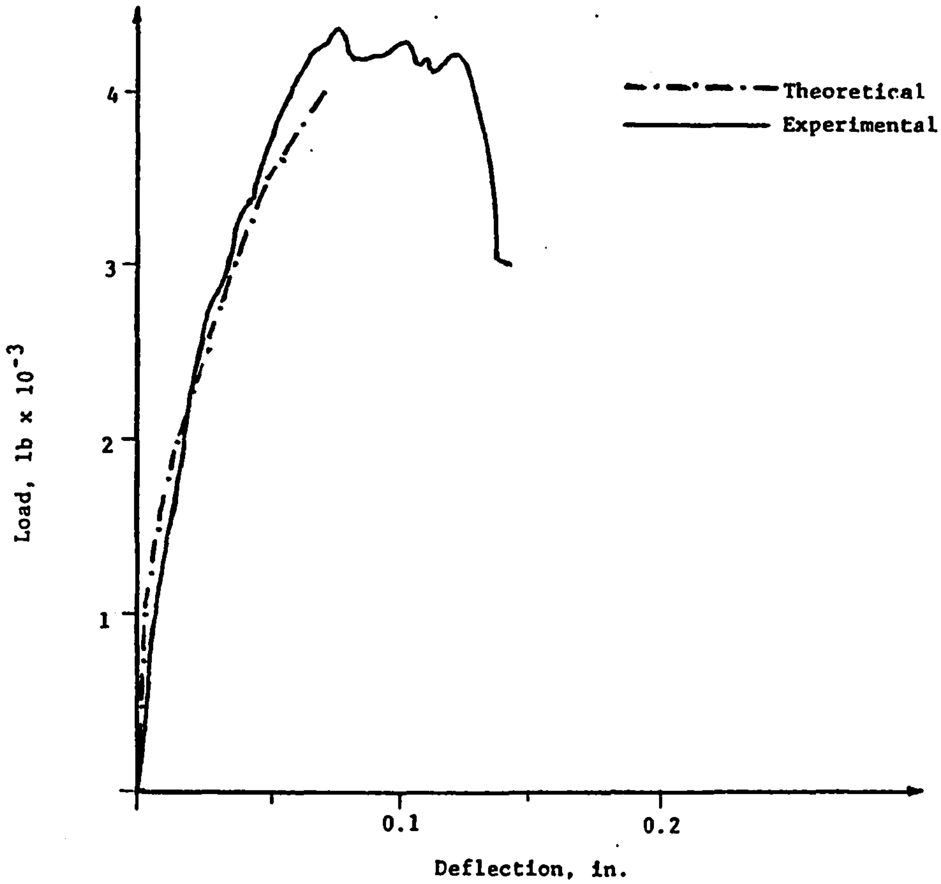


FIG. B-16 LOAD DEFLECTION CURVE, PLATE NO. IV, POINT B

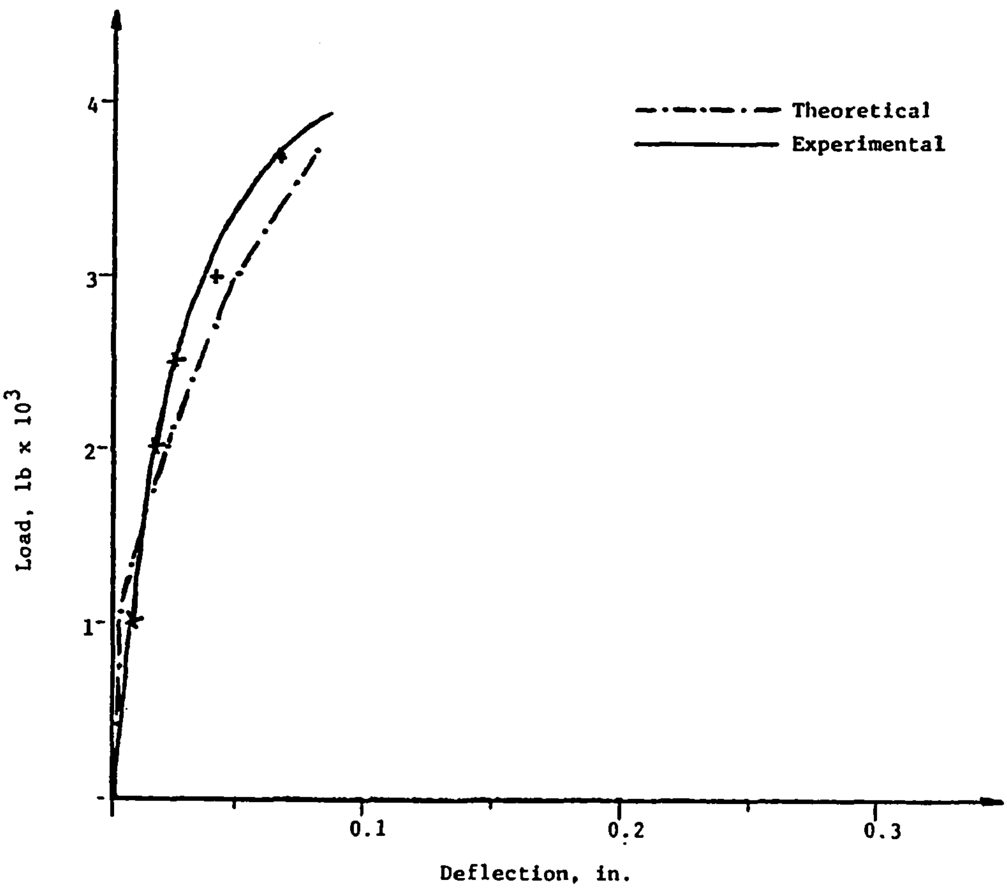


FIG. B -17 LOAD DEFLECTION CURVE, PLATE NO. VI, POINT A

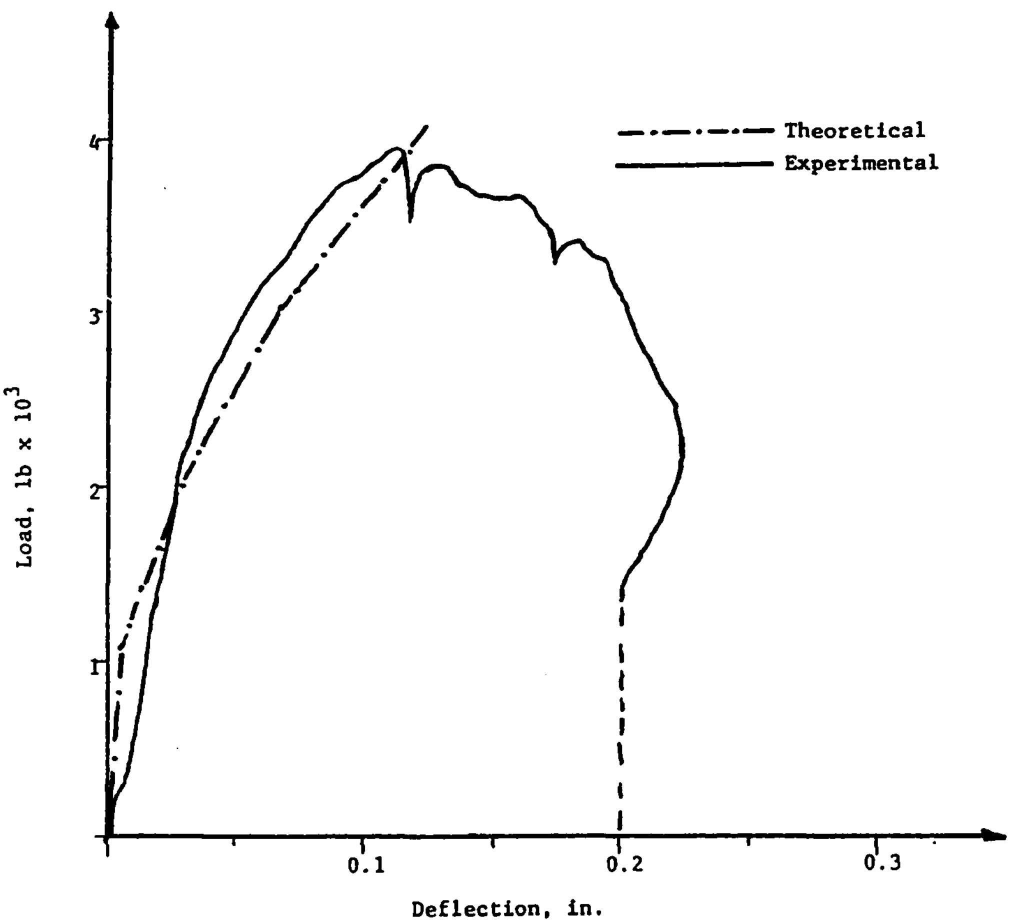


FIG B-18 LOAD DEFLECTION CURVE, PLATE NO. VI, POINT B

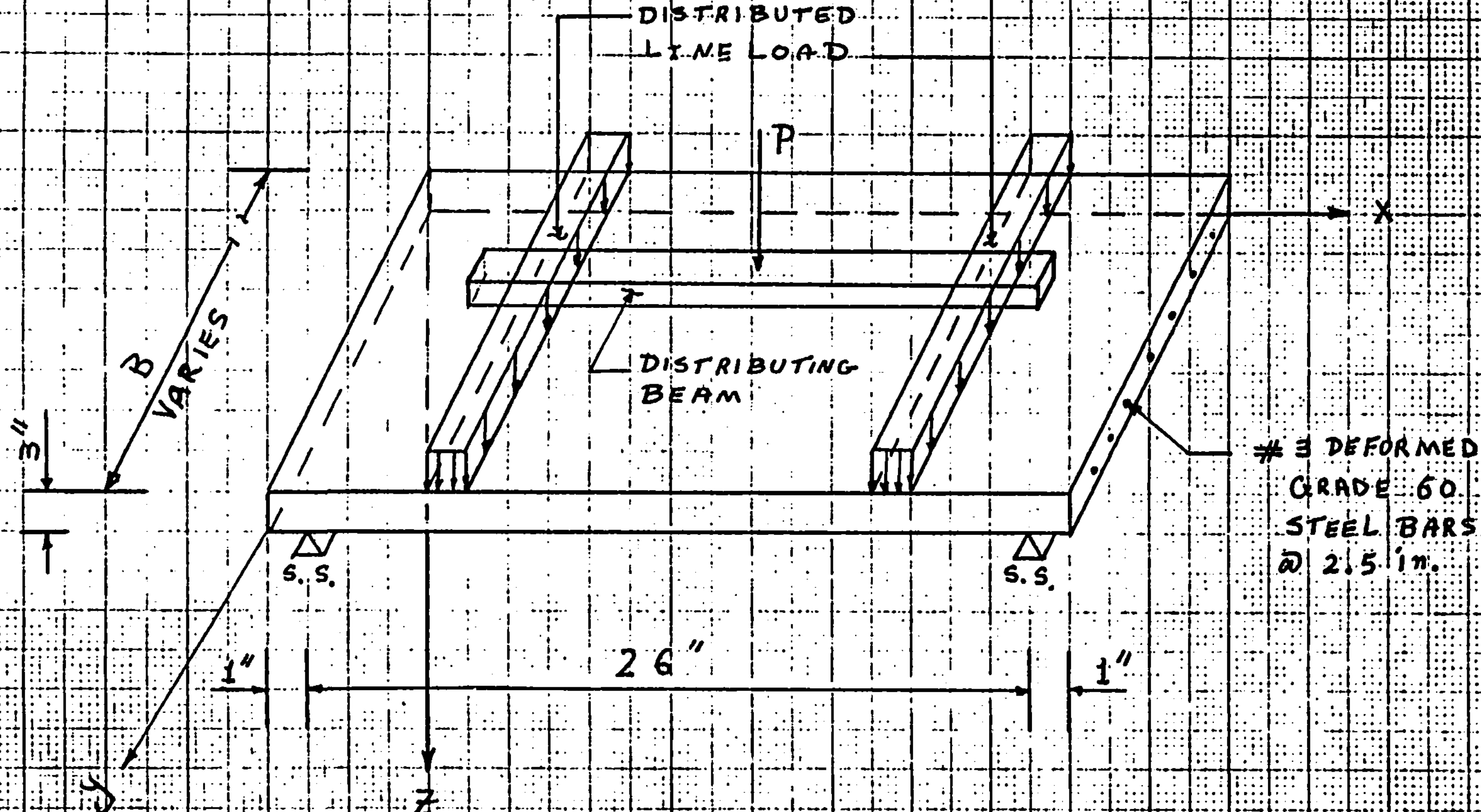

DISTRIBUTED
LINE LOAD
P
X
DISTRIBUTING
BEAM
B
VARIES
3"
3 DEFORMED
GRADE 60
STEEL BARS
@ 2.5 in.
S. S.
S. S.
1"
26"
1"
y
Z

Fig. C-1

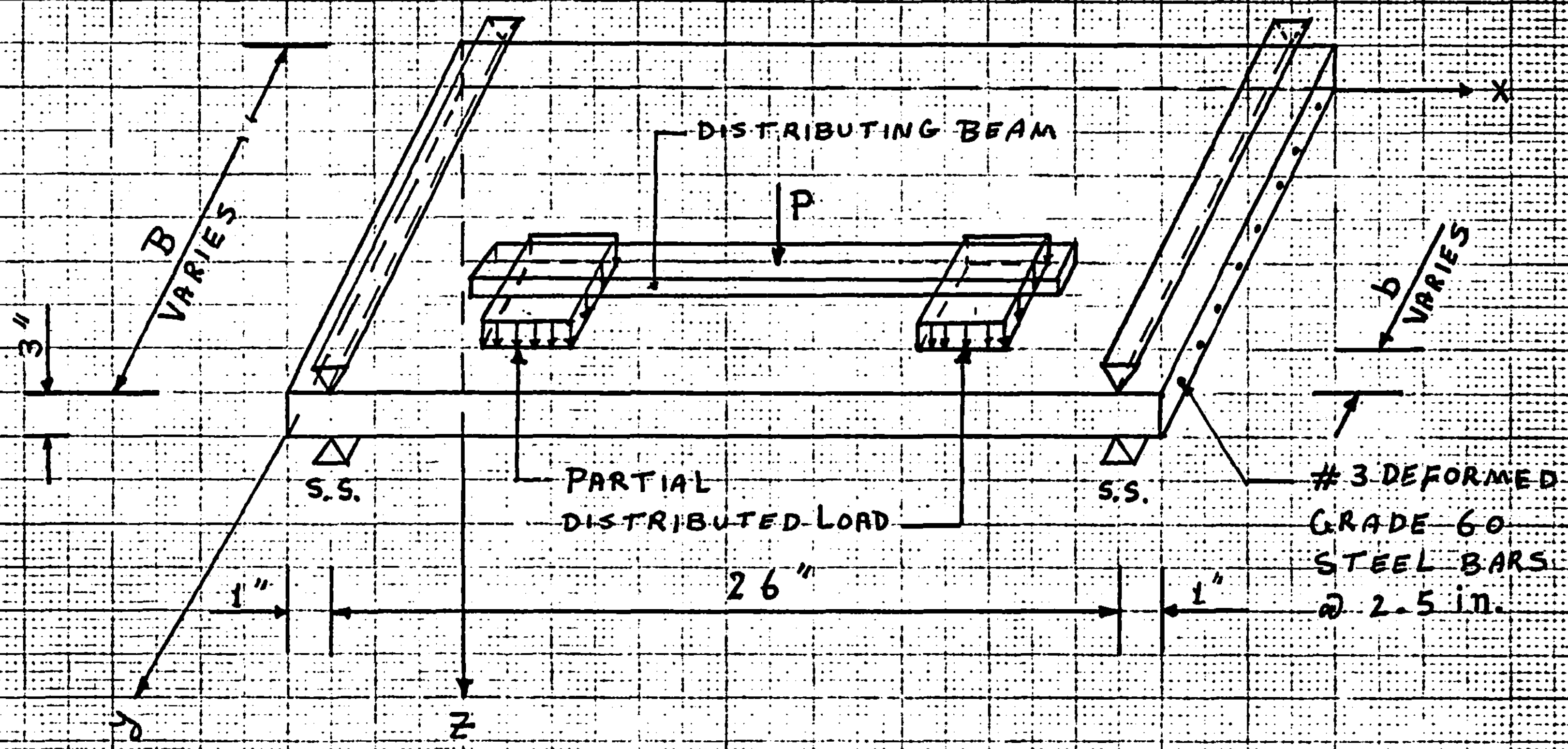

DISTRIBUTING BEAM
P
B
VARIES
3"
b
VARIES
X
S.S.
S.S.
PARTIAL
DISTRIBUTED LOAD
3 DEFORMED
GRADE 60
STEEL BARS
@ 2.5 in.
1"
26"
1"
Z

Fig. C-2

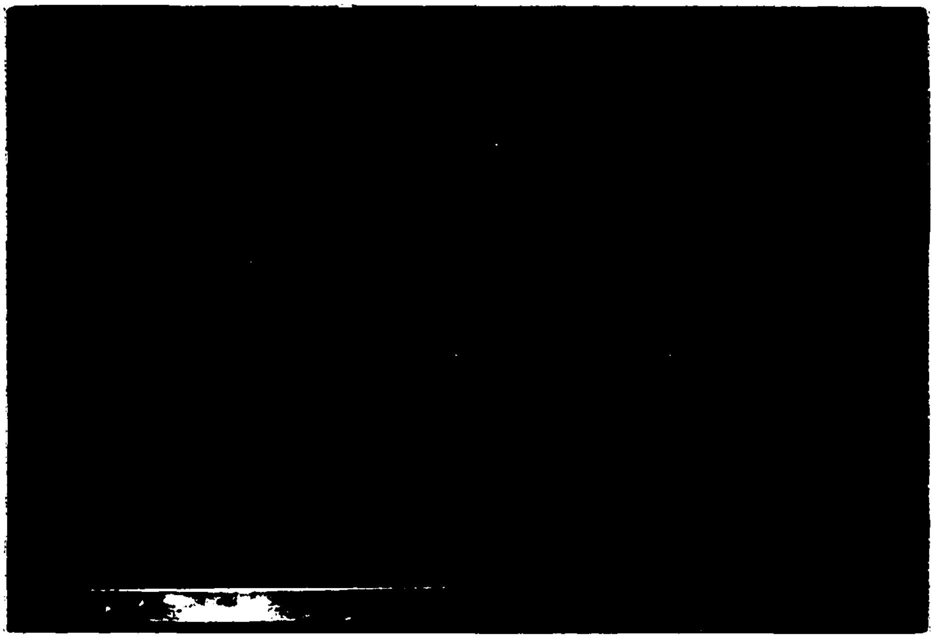


Fig. C-3 Bending failure of beams A11 to E12

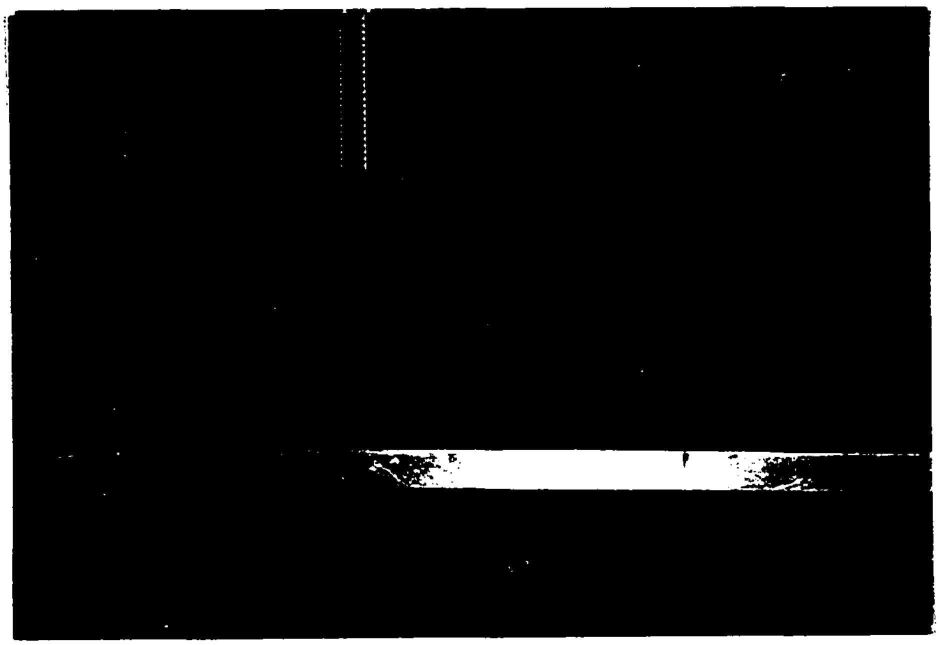


FIG. C-4 Shear failure of beams A21 to B22.

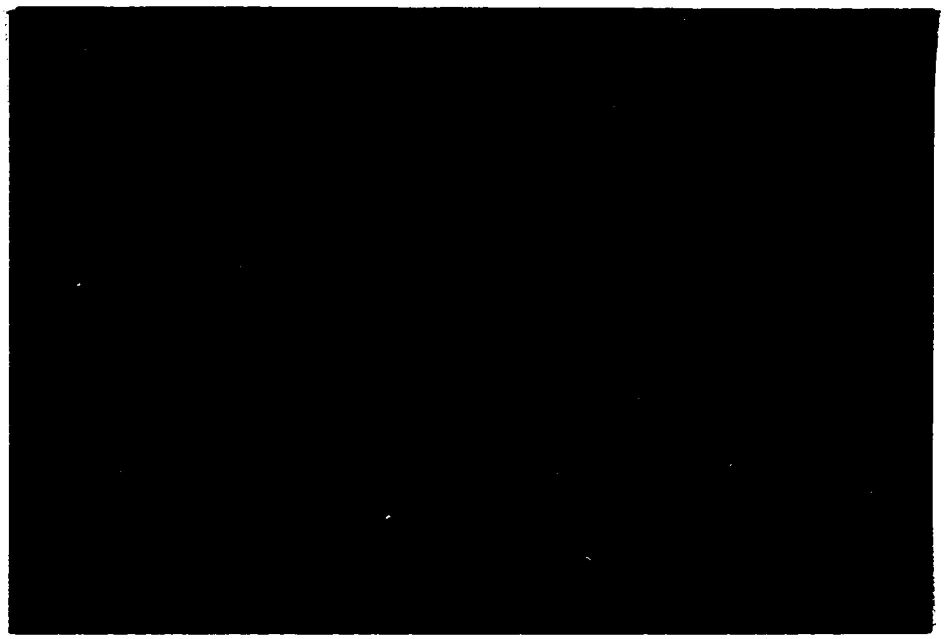


FIG. C-5 Shear failure of beams A31 to E31.

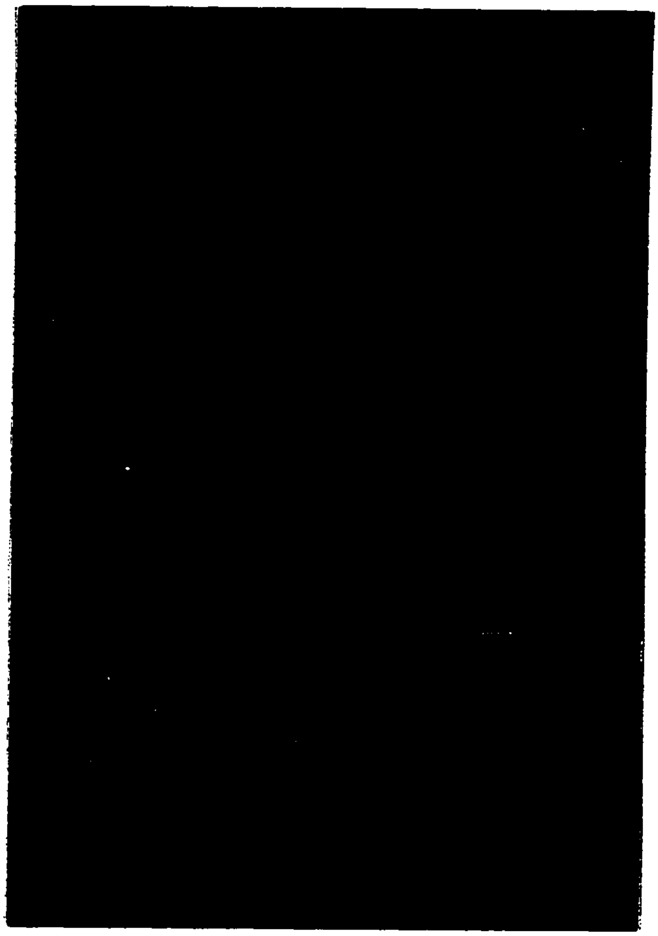


FIG. C-6 Shear failure of beams B41 to E42.

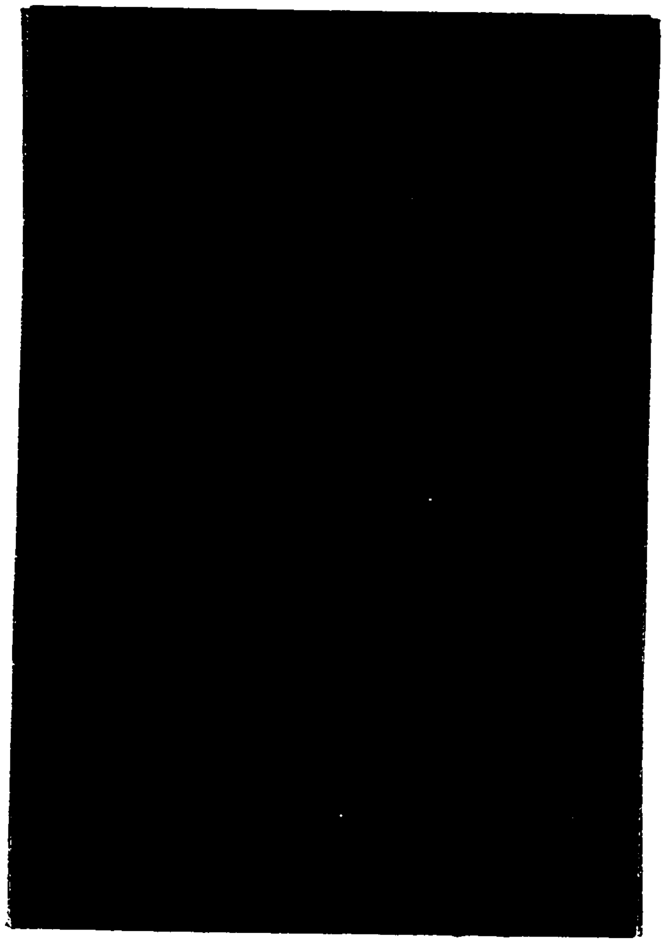


FIG. C-7 Shear failure of beams A51 to E51.

Fig. C-8 Bending failure of beams B61, C61, D61.

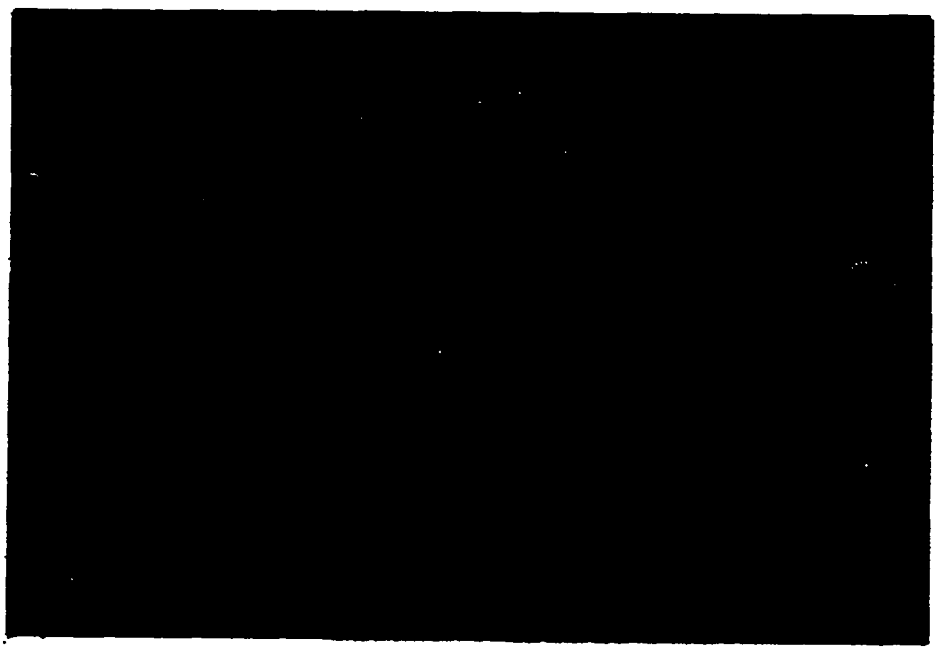


FIG. C-8(a) Photograph of tested beams.

FIG. C-8(b) Photograph of tested beams.

FIG. C-8(c) Photograph of tested beams.

FIG. C-9 Combined shear & compression failure beam F11.

FIG. C-10 Shear failure, plates C1-1, C1-2 & C1-3.

FIG. C-11 Shear failure, plates D1-1 & D-2.

FIG. C-12 Shear failure, plate No. H1.

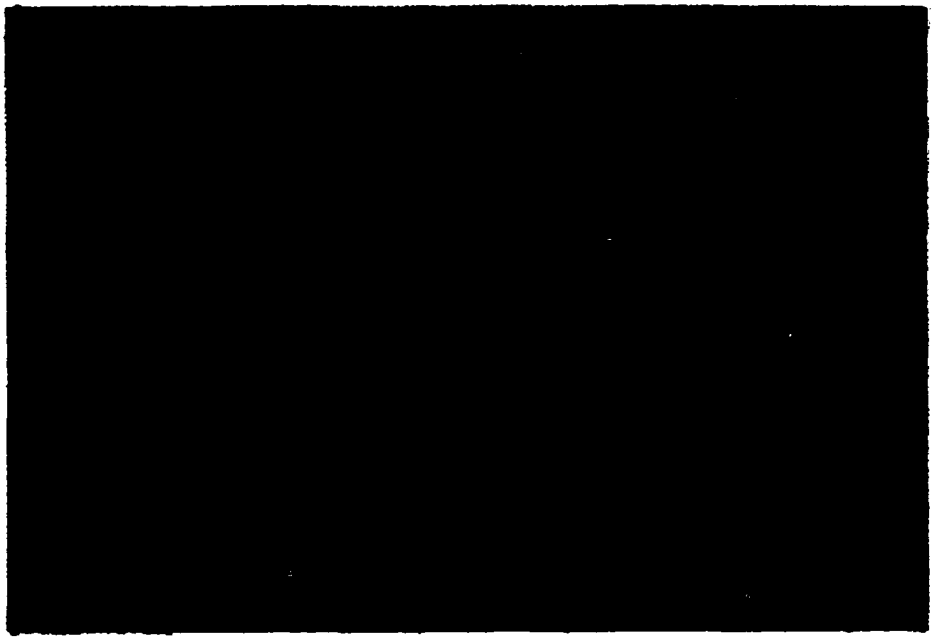


FIG. C-13 Shear failure, plate No. K1.

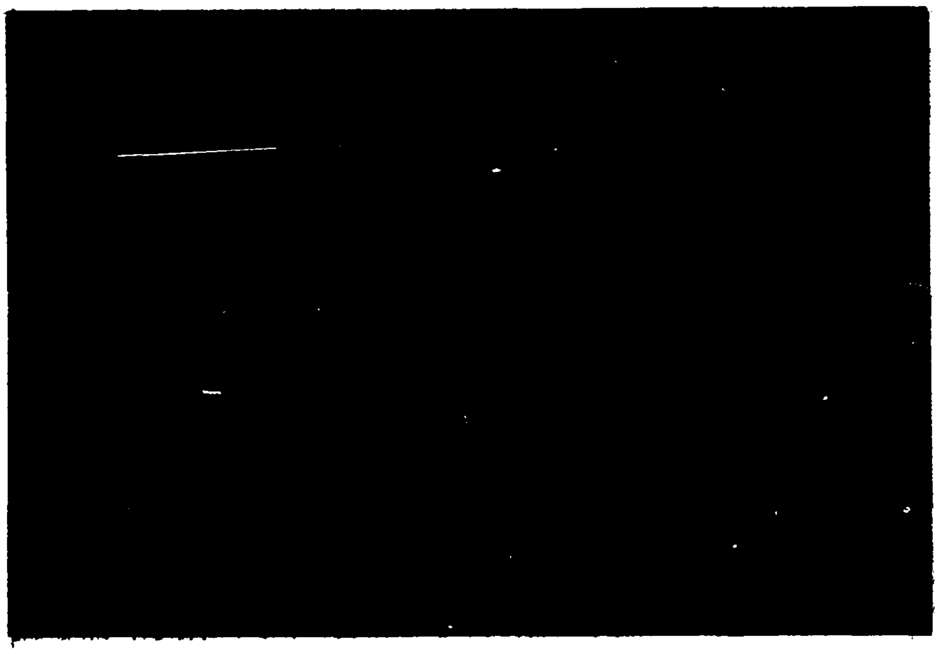


FIG. C-14 Shear failure, plate No. O1.

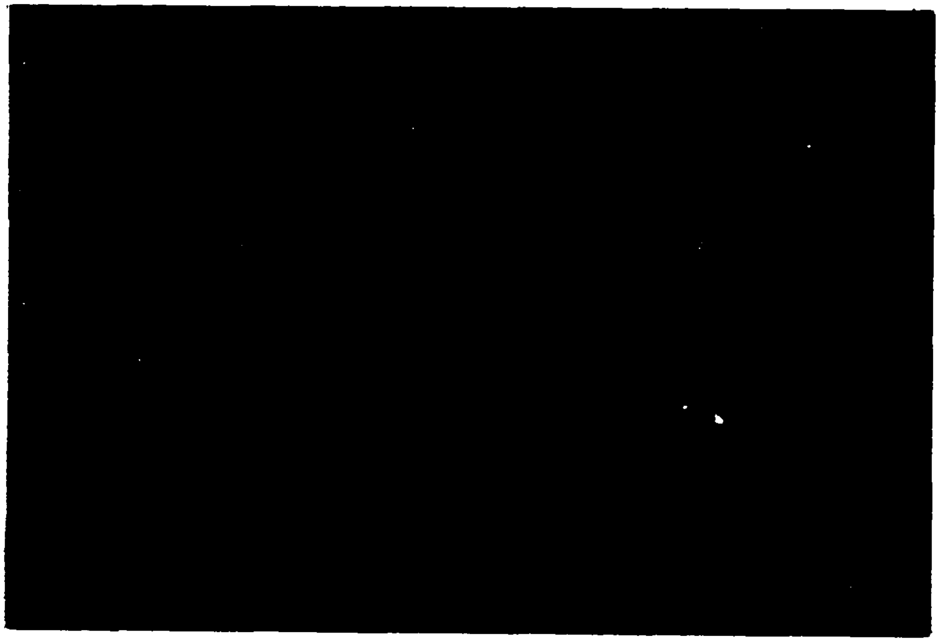


FIG. C-15 Crack patterns of plate 01, 03 & N3.

FIG. C-16 Shear failure, plate No. 02.

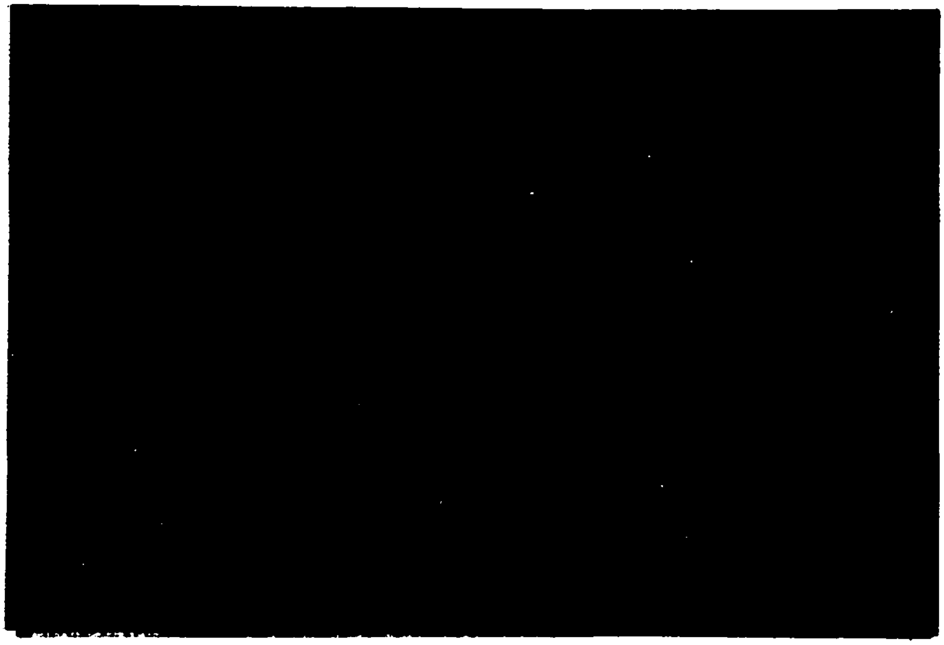


FIG. C-17 Shear failure, plate No. N1.

FIG. C-18 Shear failure, plate No. I1.

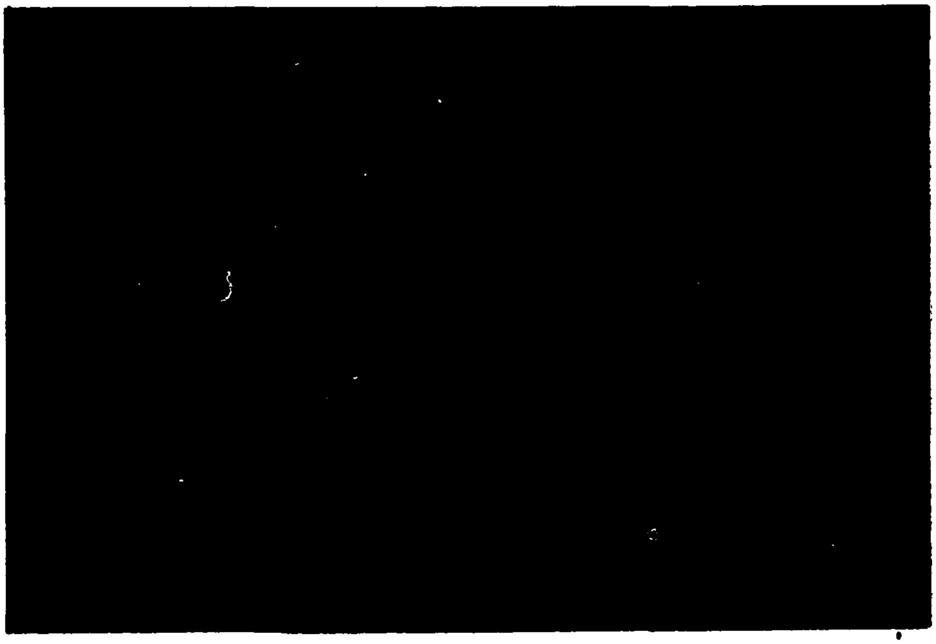


FIG. C-19 Shear Failure, Plate No. M1

FIG. C-20 Shear failure, plate No. N2.

FIG. C-21 Combined transverse moment & shear failure, plates No. E1-1, E1-2 & E1-3.

FIG. C-22 Combined transverse moment & shear failure plate No. E2-1 & E2-2.

FIG. C-22(a) Combined transverse moment & shear failure plated No. E2-1 & E2-2.

FIG. C-23 Combined transverse moment & shear failure plate No. P121.

FIG. C-24 Combined transverse moment & shear failure plate No. F1.

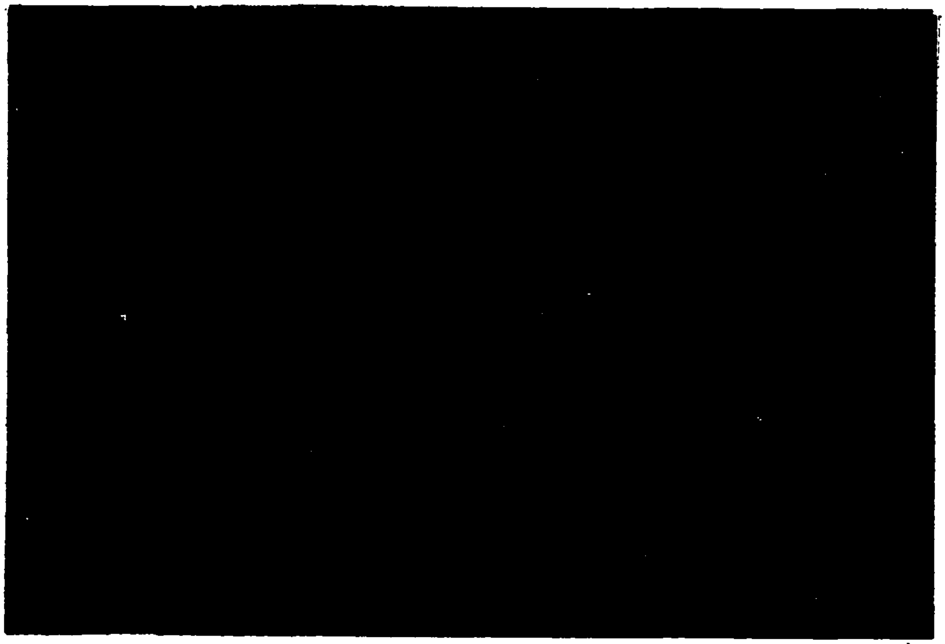


FIG. C-25 Combined transverse moment & shear failure plate No. G1.

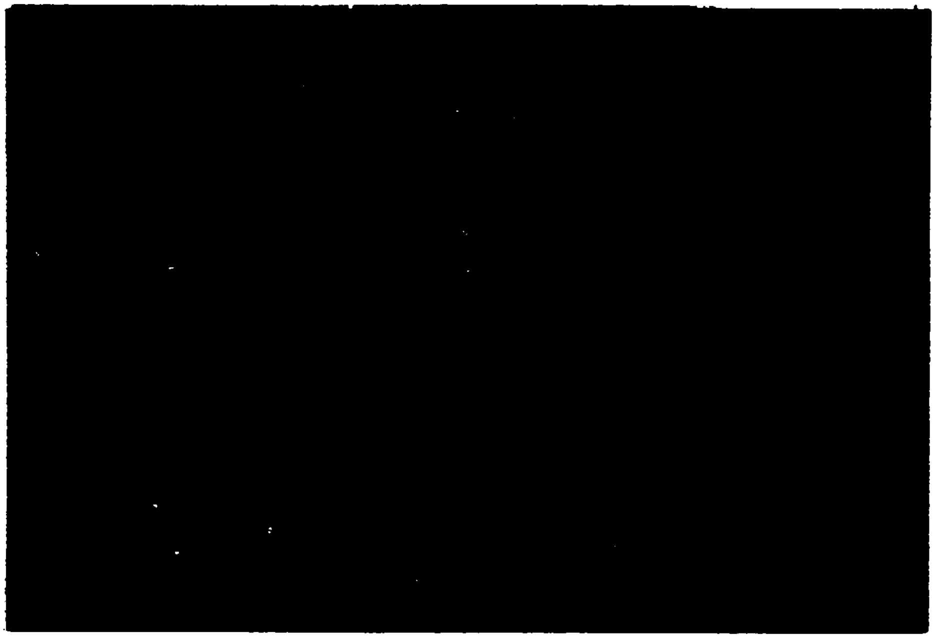


FIG. C-26 Combined transverse moment & shear failure plate No. P122.

FIG. C-27 Combined transverse moment & shear failure plate No. G2.

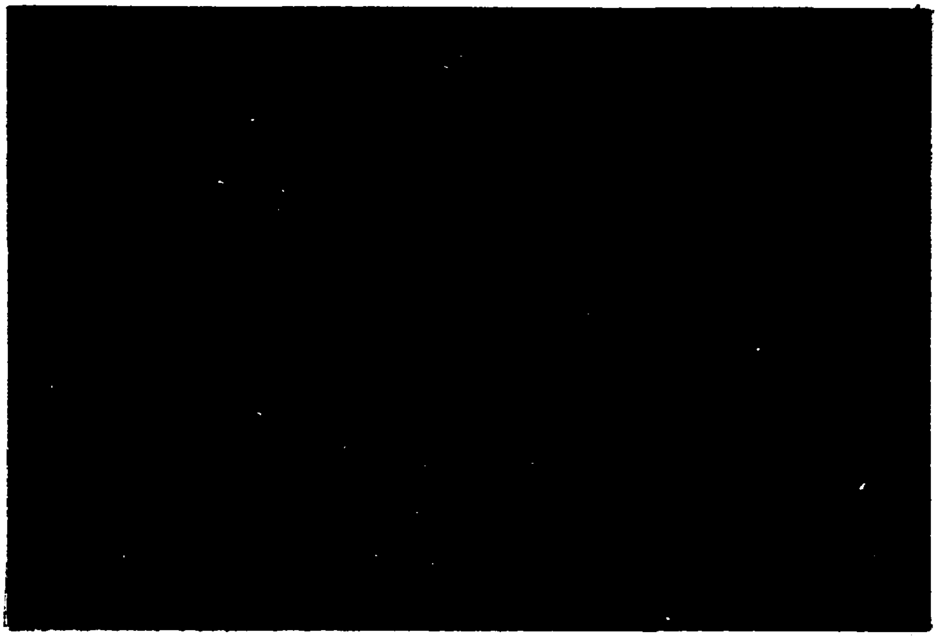


FIG. C-28 Combined transverse moment & shear failure plate No. P123.

FIG. C-29 Combined transverse moment & shear failure plate No. I2.

FIG. C-30 Combined transverse moment & shear failure plate No. L2.

FIG. C-31 Combined transverse moment & shear failure plate No. J1.

FIG. C-32 Combined transverse moment & shear failure plate No. L1.

FIG. C-33 Combined shear and torsion failure plate No. C-3-1 & C3-2.

FIG. C-33(a) Combined shear and torsion failure plate No. C3-1 & C3-2.

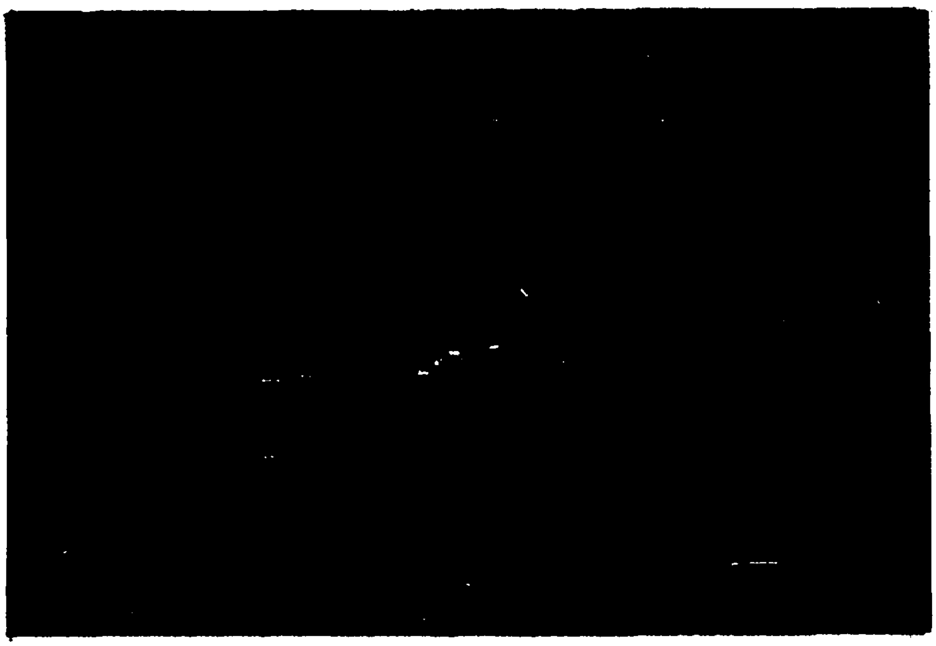


FIG. C-34 Combined shear and torsion failure plate No. D3-1 & D3-2.

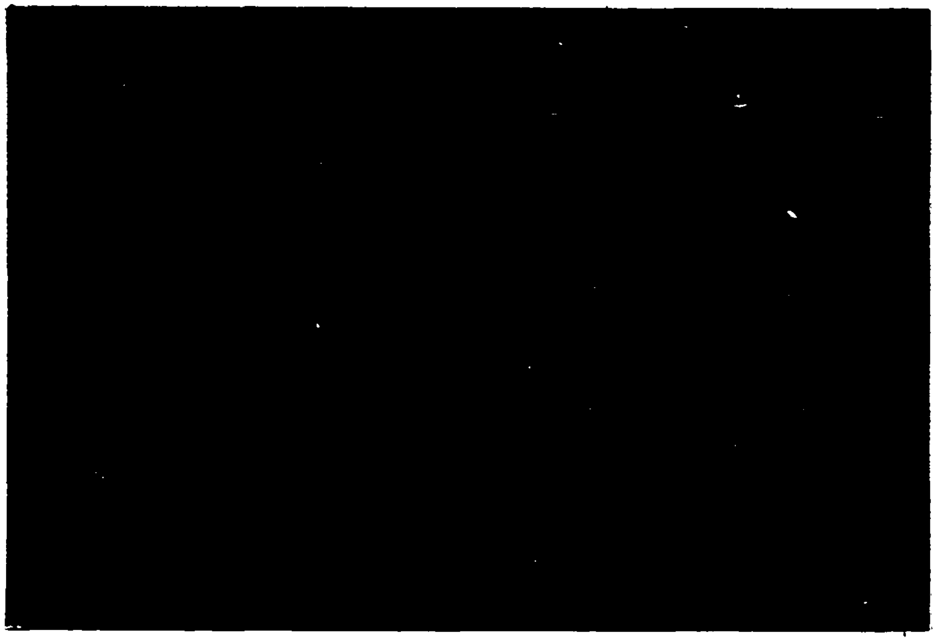


FIG. C-34(a) Combined shear and torsion failure plate No. D3-1 & D3-2.

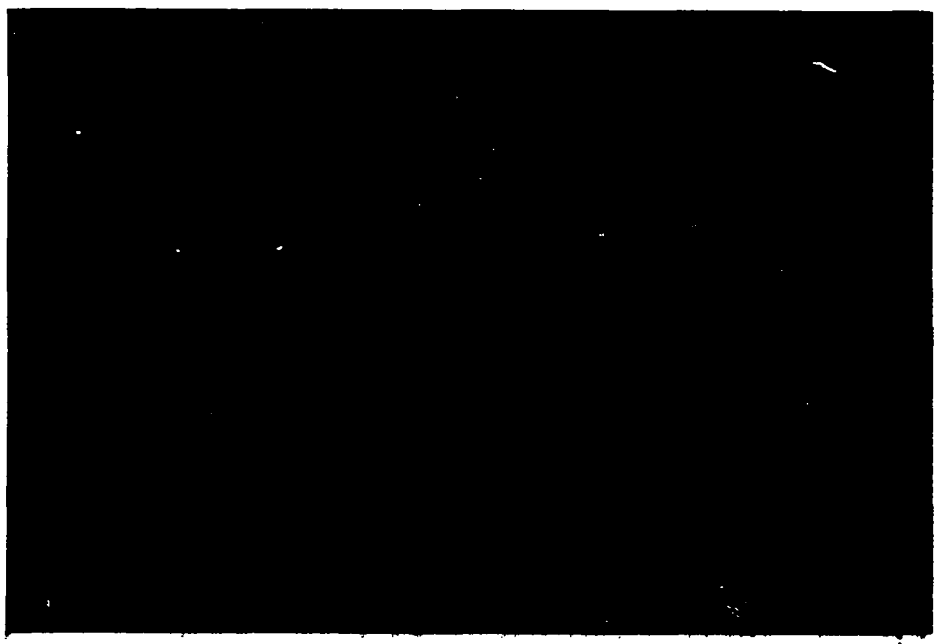


FIG. C-35 Combined shear and torsion failure plate No. E3-1 & E-32.

FIG. C-36 Combined shear and torsion failure plate No. H2.

FIG. C-37 Combined shear and torsion failure plate No. J2.

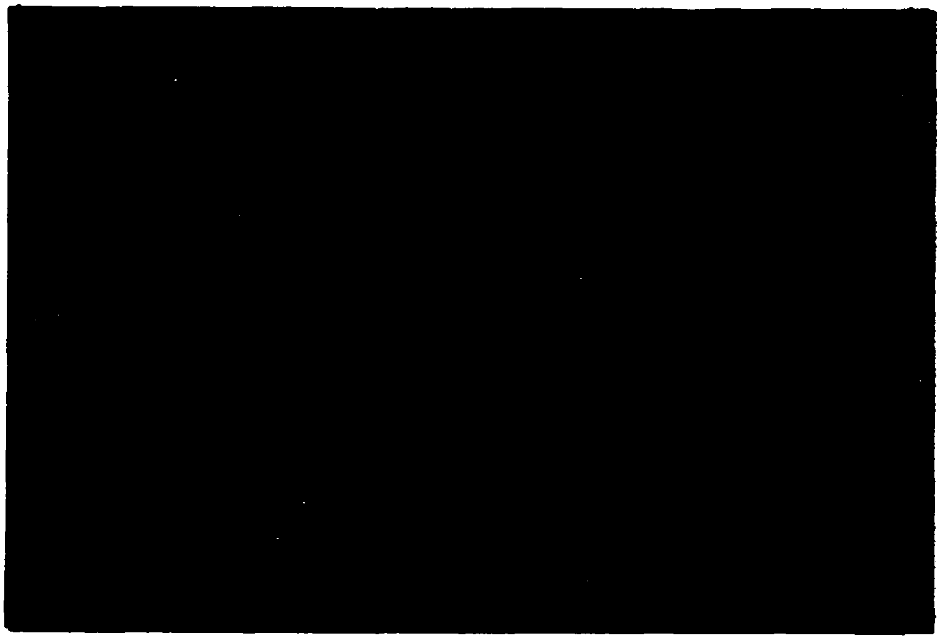


FIG. C-38 Combined shear torsion failure plate No. K2.

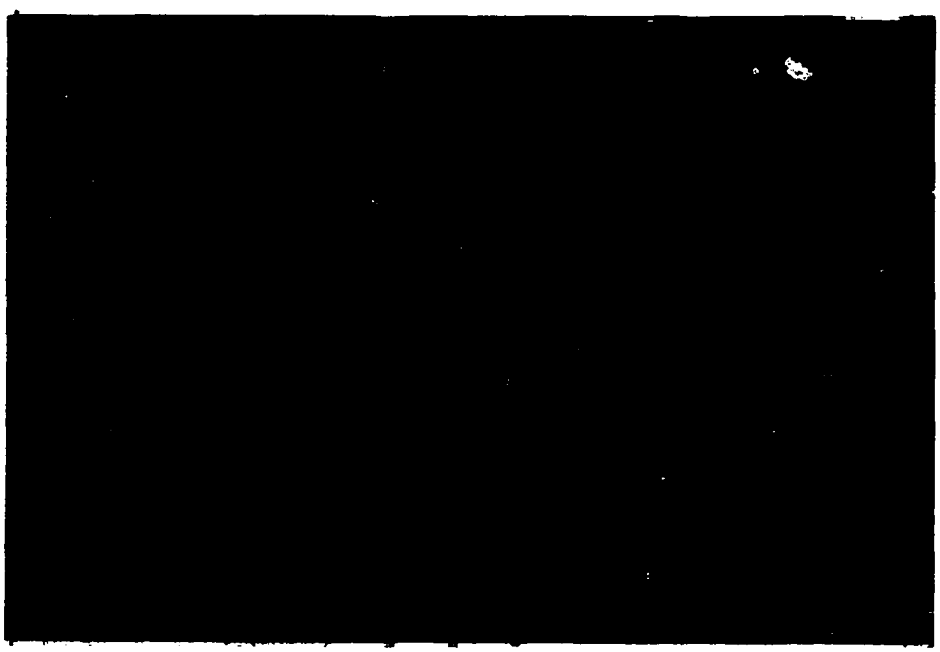


FIG. C-39 Combined shear and torsion failure plate No. H3.

FIG. C-40 Combined shear and torsion failure plate No. J3.

FIG. C-41 Combined shear & torsion failure plate No. K3.

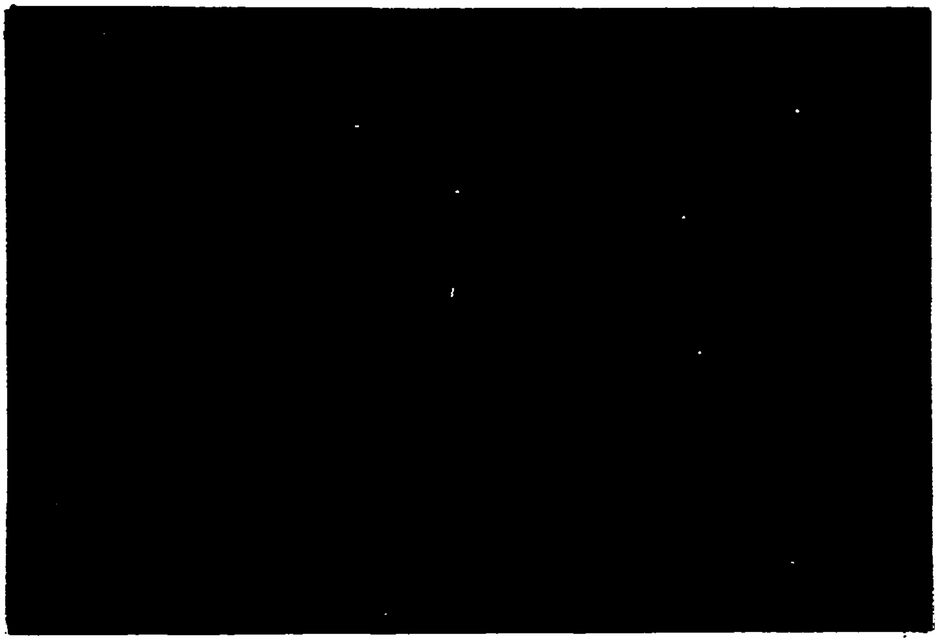


FIG. C-42 Combined shear & torsion failure plate No. 03.

FIG. C-43 Combined shear & torsion failure plate No. G3.

FIG. C-43(a) Photograph of crack patterns.

FIG. C-44 Combined shear & torsion failure plate No. M2.

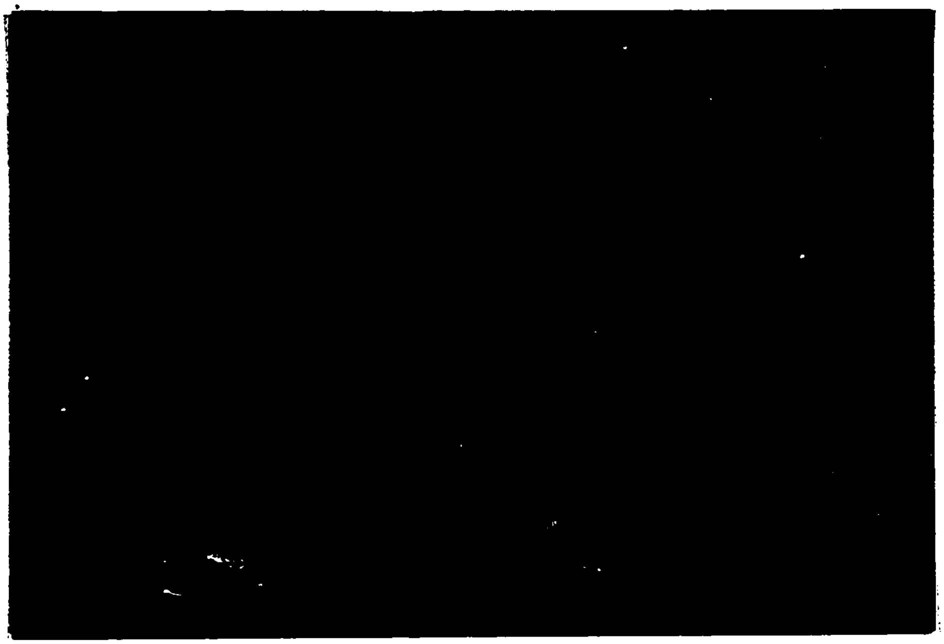


FIG. C-45 Combined shear & torsion failure plate No. I3.

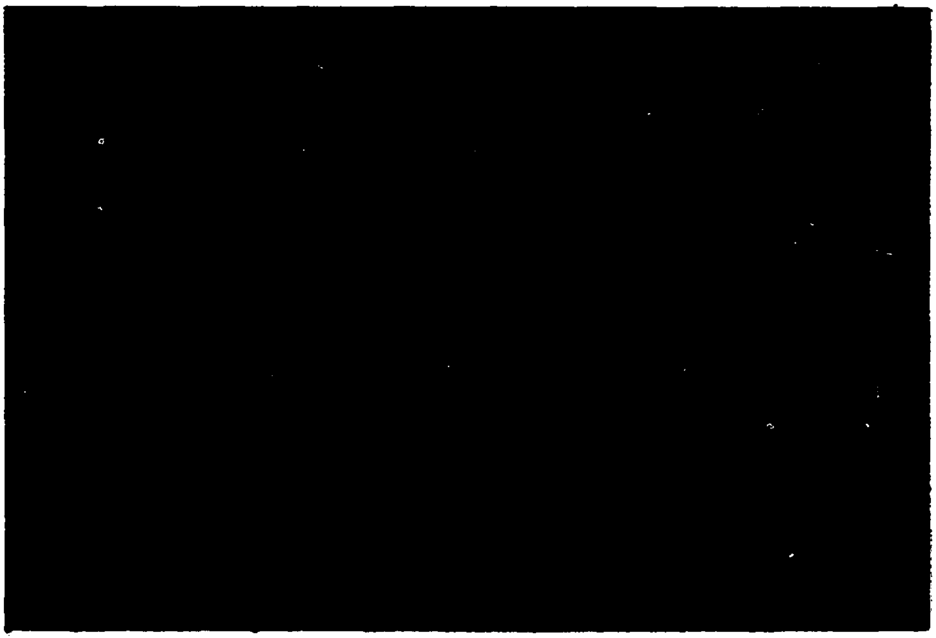


FIG. C-46 Combined shear & torsion failure plate No. L3.

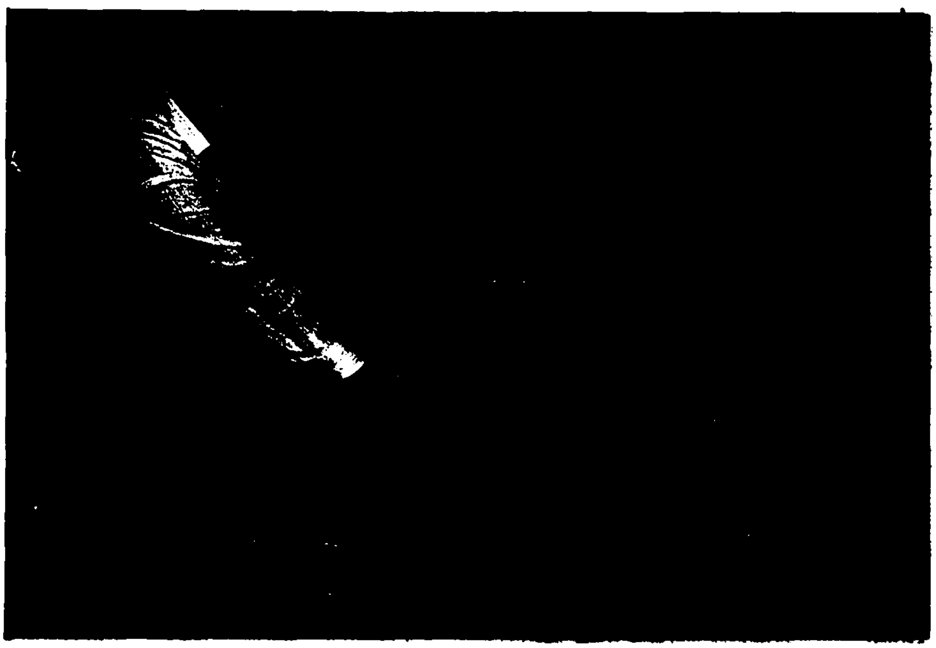


FIG. C-46(a) Photograph of crack patterns.

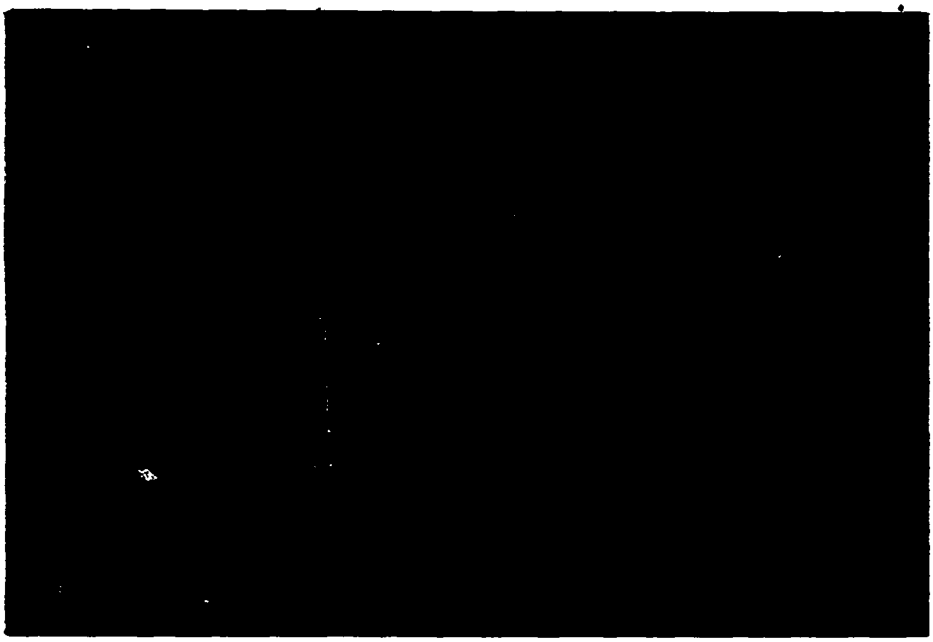


FIG. C-47 Combined shear & torsion failure plate No. M3.

FIG. C-48 Combined shear & torsion failure plate No. N3.

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4. Ersoy, U. and P. M. Ferguson, "Behavior and Strength of Concrete L-Beams under combined Torsion and Shear", Journal of the American Concrete Institute, Proc., Vol. 64, No. 12 December 1967.

5. Syamal, P. K., and M. S. Mirza and D. P. Ray, "Plain and Reinforced Concrete L-Beam under Combined Flexure, Shear and Torsion", Journal of the American Concrete Institute, Proc., Vol. 68, No. 11 November 1971.

6. ACI 318-83; Building Code Requirement for Reinforced Concrete, American Concrete Institute, Detroit, 1983 and 1986 Supplement to ACI 318-83.

7. Hwang C. S. and Thomas T. C. HSU, "Mixed Torsion Analysis of Reinforced Concrete Channel Beams-A Fourier Series Approach", Journal of the American Concrete Institute, Proc., Vol. 80, No. 5 September-October 1983.

8. Marti, P., Leesti, P., and Khalifa, W. V., "Torsion Tests on Reinforced Concrete Slab Element", ASCE, Journal of Structural Engineering, Vol. 113, No. 5, May 1987.

9. HSU, T. T. C. "Torsion of Reinforced Concrete", Van Nostrand, New York 1984.

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