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LONGITUDINAL JOINT SYSTEMS IN SLIP-FORMED RIGID PAVEMENTS

Volume III - User's Manual

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University of Illinois
Urbana, Illinois

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Interim Report
November 1979

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16. Abstract This is the third volume of a three volume series on the design and construction of longitudinal joint systems in slip-form concrete pavements. Volume I (Literature Survey and Field Inspection) and Volume II (Analysis of Load Transfer Systems for Concrete Pavements) have been already published. Long a subject of major concern, the determination of the affects that joints and/or cracks have on the stress and deflection of concrete pavements has lead to the development of several methods of analysis. The authors have selected the finite element modeling technique and with the aid of the high-speed computer their method is capable of structurally analyzing concrete pavement systems with joints and/or cracks. The computer program can be used for the analysis of a number of problems which can be summarized as follows:

(1) Concrete pavements with load transfer systems at the joints.
(2) Jointed reinforced concrete pavements with cracks having reinforcement steel at the cracks.
(3) Continuously reinforced concrete pavements.
(4) Concrete shoulders with or without tie bars.
(5) Concrete pavements with a stabilized base or an overlay and assuming either a perfect bond or no bond between two layers.
(6) Concrete slabs of varying thicknesses and modulus of elasticities, and subgrades with varying modulus of supports.

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METRIC CONVERSION FACTORS

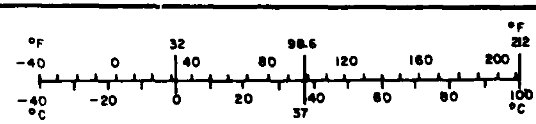
Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in ≡ 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.

Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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INTRODUCTION

The determination of stresses and deflections in concrete pavements with joints and/or cracks has been a subject of major concern for several years. Since all of the analytical (closed form) solutions were based on an infinitely large slab with no, or at most one discontinuity, they could not be applied to analysis of jointed or cracked concrete slabs of finite dimensions, or with various load transfer systems used at the joints and cracks.

With the development of high-speed computers and the powerful finite-element method, it is possible to analyze concrete pavements in a more realistic manner. Various models have been developed for analyzing pavement systems using the finite-element modeling techniques. However, little was done in modeling joints and/or cracks with load transfer systems.

The finite-element computer program presented here is based on the classical theory of meidum-thick plate on Winkler foundation, and is capable of evaluating the structural response of the concrete pavement system with joints and/or cracks. The model, which provides several options, can be used for analysis of a number of problems which can be summarized as:

1. Jointed concrete pavements with load transfer systems at the joints.
2. Jointed reinforced concrete pavements with cracks having reinforcement steel at the cracks.
3. Continuously reinforced concrete pavements.
4. Concrete shoulders with or without tie bars.
5. Concrete pavements with a stabilized base or an overlay, by assuming either a perfect bond or no bond between two layers.
6. Concrete slabs of varying thicknesses and modulus of elasticities, and subgrades with varying modulus of supports.

GENERAL ASSUMPTIONS

The assumptions regarding the concrete slab, stabilized base, overlay, subgrade, dowel bar, keyway, and aggregate interlock can be briefly summarized as follows:

1. The small-deformation theory of an elastic, homogenous medium-thick plate can be employed for the concrete slab, stabilized base and overlay. Such a plate is thick enough to carry transverse load by flexure, rather than in plane force (as would be the case for a thin membrane), and yet is not so thick that transverse shear deformation becomes important. In this theory it is assumed that lines normal to the middle surface in the undeformed plate remain straight, unstretched and normal to the middle surface in the deformed plate, each lamina parallel to middle surface is in a state of plane stress, and no axial or in-plane shear stress develops due to loading.
2. The subgrade behaves as a Winkler foundation.
3. In case of a bonded stabilized base or overlay, full strain compatibility exists at the interface, or for the unbonded case shear stresses at the interface are neglected.
4. Dowel bars at joints behave linearly elastic, and are located at the neutral axis of the slab.
5. When aggregate interlock or keyway is used for load transfer system, load is transferred from one slab to an adjacent slab by means of shear. However, with dowel bars some moment as well as shear may be transferred across the joints.

MODELING TECHNIQUE

For modeling the concrete pavement slab, the rectangular plate element with 12 degrees of freedom was used. Figure 1-a shows that at each node there are three displacement components: a vertical deflection (W) in the Z-direction, a rotation (θ_X) about the X-axis, and a rotation (θ_Y) about the Y-axis. Corresponding to these displacement components there are three force components: a vertical force (P_W), a couple about the X-axis ($P_{\theta X}$) and a couple about the Y-axis ($P_{\theta Y}$), respectively. For each element, these forces and displacement can be related by matrix notation:

$$\{P\}_e = [K_{top} + K_{bottom} + K_{sub}]_e \{D\}_e \tag{1}$$

where $[K_{top}]_e$, $[K_{bottom}]_e$, and $[K_{sub}]_e$ are the stiffness matrices of the top layer, bottom layer, and subgrade, respectively. $\{P\}_e$ is the force vector and $\{D\}_e$ is the displacement vector of the slab element. For the case where two layers (slab and stabilized base or slab and overlay) are bonded, an equivalent layer based on the transformed section concept is used to determine the location of the neutral axis of the element. The following equations give the location of neutral axis for bonded two layer system using the first moment of the equilvalent area of the transformed cross section.

$$\alpha = \frac{\frac{1}{2}(h_t + h_b)h_t}{h_t + \frac{E_b}{E_t} h_b} \tag{2}$$

$$\beta = \frac{1}{2}(h_t + h_b) - \alpha \tag{3}$$

where α is the distance from the middle surface of the bottom layer to

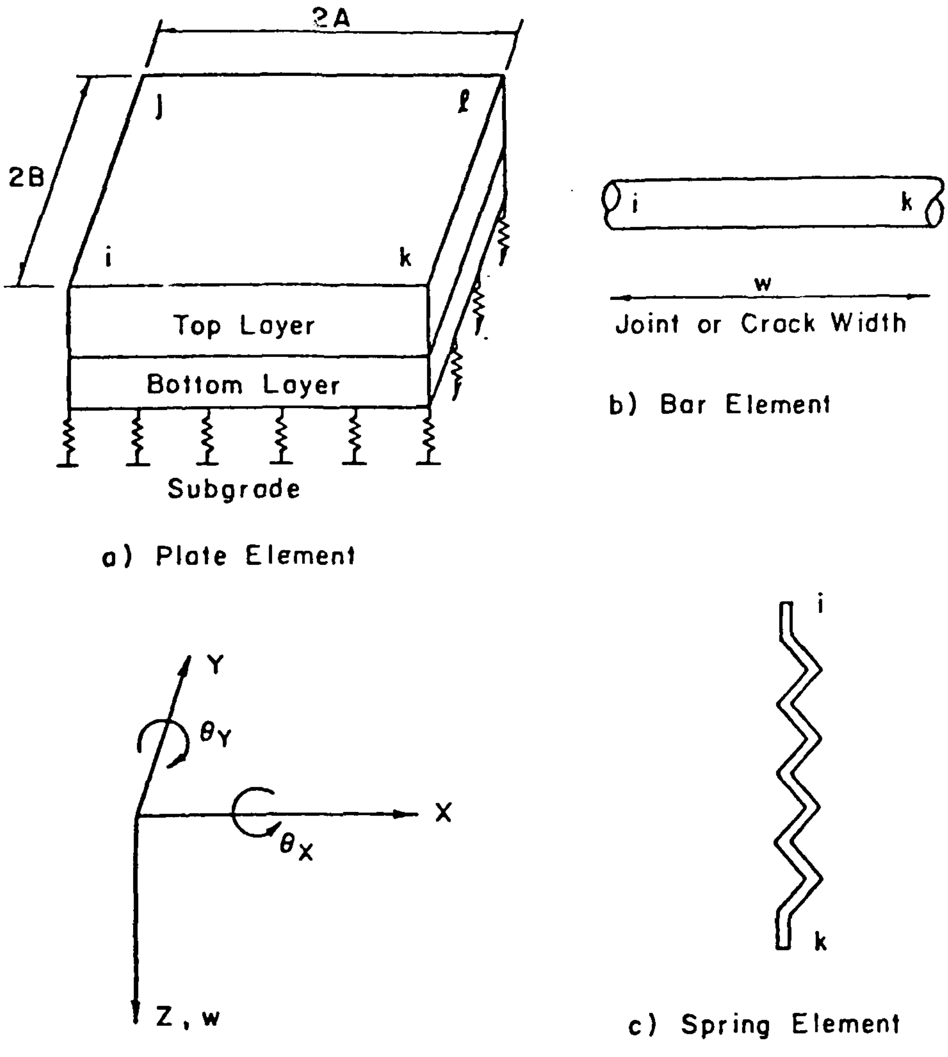

Figure 1. FINITE-ELEMENT MODEL OF PAVEMENT SYSTEM

the neutral axis, β is the distance from the middle surface of the top layer to the neutral axis, and h_t, h_b, E_t, and E_b are respectively, thickness of the top layer, thickness of the bottom layer, modulus of elasticity of the top layer and modulus of elasticity of the bottom layer.

The bar element as shown in Figure 1-b with two degrees of freedom per node is used to model dowel bars at joints. Two displacement components at each node are: a vertical displacement (W) in the Z-direction, and a rotation (θ_Y) about the Y-axis. Corresponding to these two displacement components are two forces: a vertical force (P_W) and a couple about the Y-axis (P_{θ_Y}). The force-displacement relation (including shear deformation) for each bar element can be written as:

$$\{P\}_b = [K_{dowel}]_b \{D\}_b \tag{4}$$

where $[K_{dowel}]_b$ is the stiffness matrix of the dowel bars, $\{P\}_b$ is the force vector, and $\{D\}_b$ is the displacement vector of the bar element.

The relative deformation of the dowel bar and surrounding concrete is represented as the stiffness of a vertical spring element (Figure 1-c) between dowel bar and surrounding concrete at the joint face. The force-displacement relation for this spring element can be written as:

$$F = K_{DCI} \Delta \tag{5}$$

where K_{DCI} is the stiffness of the spring element representing the dowel-concrete interaction, F is the shear force on the dowel bar, and Δ is the relative deformation of the dowel bar with respect to the surrounding concrete at the joint face.

Neglecting the moment transfer (if any) across a joint or crack wnere load transfer is achieved only by means of aggregate interlock or keyway, the spring element shown in Figure 1-c with one degree of freedom per node is employed. The displacement component at each node is a vertical displacement (W) in the Z-direction, and the corresponding force component is a vertical force (P_W). The force-displacement relation for a spring element can be written as:

$$\{P\}_s = [K_{Agg}]_s \{D\}_s \tag{6}$$

where $[K_{Agg}]_s$ is the stiffness matrix of the spring element, and $\{P\}_s$ is the force vector, and $\{D\}_s$ is the displacement vector for the spring element.

The overall structural stiffness matrix [K] is formulated by superimposing the effect of individual element stiffnesses using the topological or the element connecting properties of the pavement system. The overall stiffness matrix is used to solve the set of simultaneous equations having the form:

$$\{P\} = [K] \{D\} \tag{7}$$

where {P} is equivalent nodal forces for a uniformly distributed load over a rectangular section of the concrete slab, and {D} is the resultant nodal displacements for the whole system. The generalized stresses are then calculated.

INPUT GUIDE FOR "ILLI-SLAB" FINITE-ELEMENT PROGRAM

The "ILLI-SLAB" finite-element program provides solution for the deflections and stresses due to loading of concrete pavements with joints and/or cracks. Longitudinal and transverse joints may have any or a combination of load transfer system such as dowel bars, aggregate interlock, and keyways. ILLI-SLAB program is also capable of handling a stabilized base or an overlay, by assuming either a perfect bond or no bond between two layers. Thickness of the slab, concrete modulus of elasticity and modulus of subgrade reaction can be varied from node to node.

The wheel loads may be applied to any slabs, and the stresses and deflections at all of the nodes in the slab, stresses in the stabilized base or overlay, vertical stresses on the subgrade, and transferred load by dowel bars are computed.

The concrete pavement can consist of 1, 2, 3, 4, or 6 slabs separated by one longitudinal and two transverse joints. The slabs are numbered from 1 to 6, beginning from left to right in the direction of X-axis, and from bottom to top in the direction of Y-axis. Each slab is divided into rectangular elements of various sizes. The elements and nodes are numbered consecutively from bottom to top along the Y-axis, and from left to right along the X-axis. Joints are treated as rectangular elements having zero width.

The program can accept only fixed form type of format which is detailed below.

Card #1

N1X	N2X	N3X	N1Y	N2Y	NFOR	
I5	I5	I5	I5	I5	I5	

N1X = number of nodes in X-direction in slabs 1 and 4.

N2X = number of nodes in X-direction in slabs 2 and 5.

N3X = number of nodes in X-direction in slabs 3 and 6.

N1Y = number of nodes in Y-direction in slabs 1, 2, and 3.

N2Y = number of nodes in Y-direction in slabs 4, 5, and 6.

NFOR = number of loaded elements.

Card #2 (Use as many as needed)

XC(I), I = 1, N1X+N2X+N3X
8F 10.3

XC(I) = X - Coordinate of node I.

Card #3 (Use as many as needed)

YC(I), I = 1, N1Y+N2Y
8F 10.3

YC(I) = Y - Coordinate of node I.

Card #4

NSLAB	NLAYER	COMP	CK	
I5	I5	I5	F10.3	

NSLAB = number of slabs, 1, 2, 3, 4, or 6.

NLAYER = number of layers, 1, or 2.

COMP = composite action factor, set COMP to 0 if no bond exists between the slab and stabilized base or overlay, and set COMP to 1 if complete bond.

CK = set CK to the value of subgrade modulus if subgrade modulus at all points are equal, and set CK to 0.0 if not.

Card #5

CT1	CE1	V(1)	
F10.3	E10.3	F10.3	

CT1 = set CT1 to the value of the top layer thickness if thickness of the top layer at all nodes are equal, and set CT1 to 0.0 if not.

CE1 = set CE1 to the value of the modulus of elasticity of the top layer if it is equal at all nodes, and set CE1 to 0.0 if not.

V(1) = Poisson's Ratio of the top layer.

Card #6 (Read only if CT1 = 0.0, use as many as needed)

T1(I), I = 1, ((N1X+N2X+N3X)* (N1Y+N2Y))
8F10.3

T1(I) = thickness of the top layer at node I.

Card #7 (Read only if CE1 = 0.0, use as many as needed)

E1(I), I = 1, ((N1X+N2X+N3X)* (N1Y+N2Y))
8E10.3

E1(I) = modulus of elasticity of the top layer at node I.

Card #8 (Read only if NLAYER = 2)

CT2	CE2	V(2)	
F10.3	E10.3	F10.3	

CT2 = set CT2 to the value of the bottom layer thickness if thickness of the bottom layer at all nodes are equal, and set to 0.0 if not.

CE2 = set CE2 to the value of the modulus of elasticity of the bottom layer if it is equal at all nodes, and set CE2 to 0.0 if not.

V(2) = Poisson's Ratio of the bottom layer.

Card #9 (Read only if CT2 = 0.0, use as many as needed)

T2(I), I = 1, ((N1X + N2X + N3X)* (N1Y+N2Y))
8F10.3

T2(I) = thickness of the bottom layer at node I.

Card #10 (Read only if CE2 = 0.0, use as many as needed)

E2(I), I = 1, ((N1X + N2X + N3X)* (N1Y+N2Y))
8E10.3

E2(I) = modulus of elasticity of the bottom layer at node I.

Card #11 (Read only if CK = 0.0, use as many as needed)

SUB(I), I = 1, ((N1X+N2X+N3X)* (N1Y+N2Y))
8F10.3

SUB (I) = modulus of the subgrade reaction at node I.

Card #12 (Read only if N2X or N3X not equal to 0)

LTDX	
I5	

LTDX = type of load transfer in X-direction, set

LTDX = 0, if aggregate interlock or keyway

LTDX = 1, if dowel bars

LTDX = 2, if a combination of dowel bars and aggregate interlock or dowel bars and keyway.

Card #13 (Read only if LTDX = 1 or 2)

DIN	DOUT	DE	DS	DL	DJW	DPR	DCI
F10.3	F10.3	E10.3	F10.3	F10.3	F10.3	F10.3	E10.3

DIN = inside diameter of the dowel bars, set DIN to 0.0 for round bars.

DOUT = outside diameter of the dowel bars

DE = modulus of elasticity of the dowel bars

DS = spacing of the dowel bars

DL = length of the dowel bars

DJW = joint width opening

DPR = Poisson's ratio of the dowel bars

DCI = dowel-concrete interaction

DCI for a round steel dowel bar may be determined from either Friberg's dowel analysis or from the relation developed based upon a three-dimensional dowel analysis:

a) Friberg's Analysis

$$DCI = \frac{K^{0.75}\ D^{2.5}}{0.041\ D^{0.75} + 0.0004\ K^{0.25}\ W}$$

b) Three-Dimensional Analysis

$$DCI = \frac{E^{0.75}}{(0.057 - 0.010\ D)(0.810 + 0.013\ h)(1 + 0.414\ W)}$$

where

E = concrete modulus of elasticity, psi

D = dowel diameter, in.

h = slab thickness, in.

W = joint width opening, in.

K = modulus of dowel support, pci

Card #14 (Read only if LTDX = 0 or 2)

Agg,X	
E10.3	

Agg,X = aggregate interlock factor. Use a large value, i.e., Agg,X = 10^8 for keyways.

Card #15 (Read only if N2Y not equal to 0)

LTDY	
I5	

LTDY = type of load transfer system in Y-direction, set

LTDY = 0, if aggregate interlock or keyway

LTDY = 1, if dowel bars

LTDY = 2, if a combination of dowel bars and aggregate interlock or dowel bars and keyway

Card #16 (Read only if LTDY = 1 or 2)

DIN	DOUT	DE	DS	DL	DJW	DPR	DCI
F10.3	F10.3	E10.3	F10.3	F10.3	F10.3	F10.3	E10.3

See Card #13 for notations.

Card #17 (Read only if LTDY = 0 or 2)

Agg,Y	
E10.3	

Agg,Y = aggregate interlock factor. Use a large value, i.e., Agg,Y = 10^8 for keyway.

Card #18 (Read NFOR times)

NEL	PRS	X1	X2	Y1	Y2	
I5	F10.3	F10.3	F10.3	F10.3	F10.3	

NEL = element number of the loaded element

PRS = tire pressure

X1, X2 = lower and upper limits of the loaded area in X-direction, in element coordinate system (local coordinates).

Y1, Y2 = lower and upper limits of the loaded area in Y-direction, in element coordinate system (local coordinates).

TYPICAL EXAMPLES

Five example problems are presented here to illustrate various applications of the "ILLI-SLAB" finite-element program, for determining the response of the concrete pavement system due to loading. Following each example problem the finite-element mesh used for each problem, computer inputs and outputs and a summary of maximum stresses and deflections of the slabs, as well as load transferring systems are given.

Example 1, Jointed Concrete Pavement with Dowel Bars

Slabs = Two 25 ft. square panels.

Thickness = 12 in.

Modulus of elasticity = 5×10^6 psi

Poisson's ratio = 0.15

Load Transferring System = Round steel dowel bars

Inside diameter = 0.0

Outside diameter = 1 1/4 in.

Spacing = 15 in.

Length = 24 in.

Modulus of elasticity = 29×10^6 psi

Poisson's ratio = 0.29

Dowel-concrete interaction = 2.4×10^6

Joint Width = 0.10 in.

Modulus of Subgrade Reaction = 200 psi

Load = 50,000 # at the center of joint in Slab 1

Contact pressure = 222 psi

Contact area = 15 ft. square

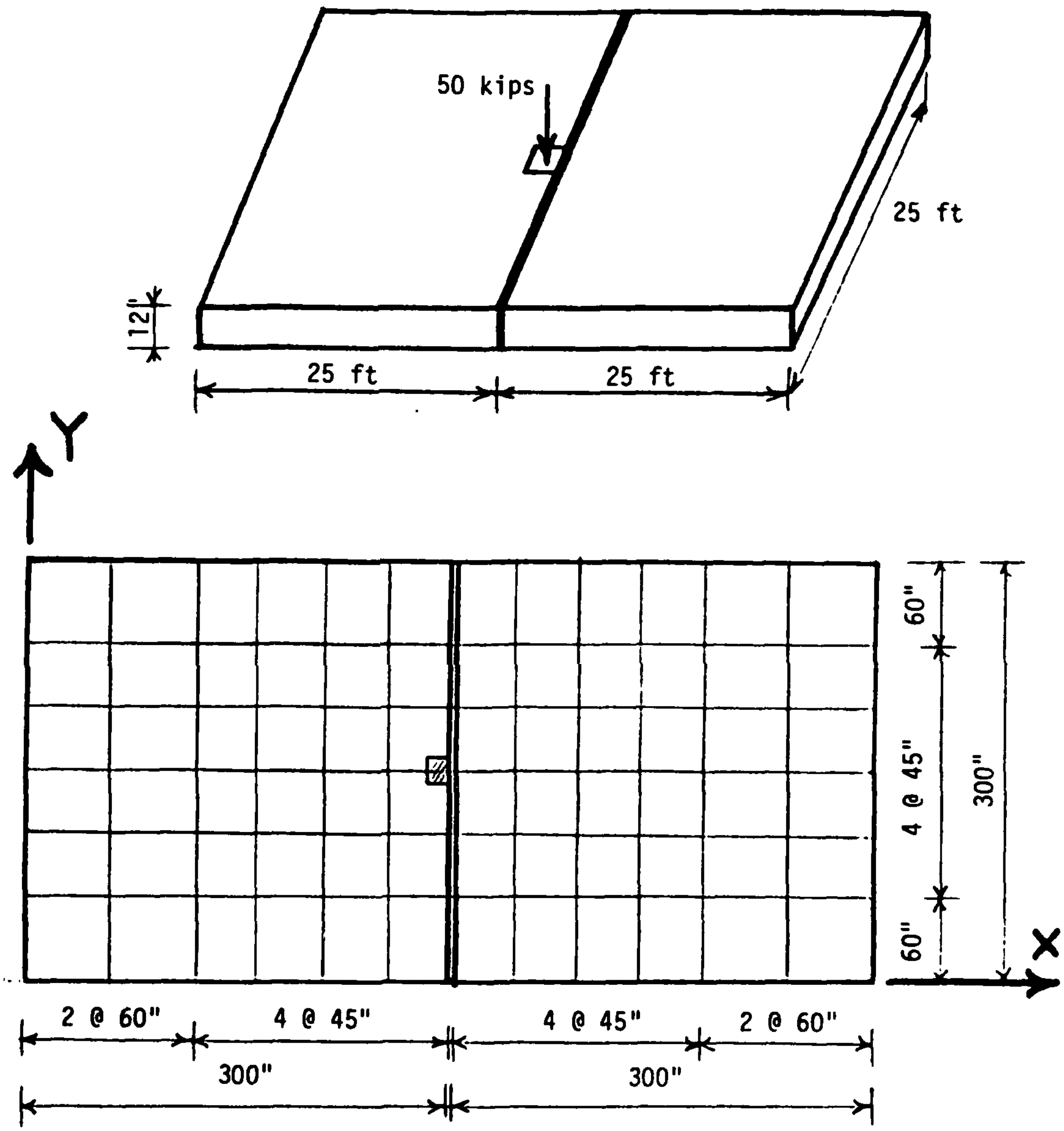

Figure 2. FINITE-ELEMENT MESH CONFIGURATION USED FOR EXAMPLE PROBLEMS 1, 2, and 3

IBM

FORTRAN Coding Form

GX28-7327-6 U/M 050**
Printed in U.S.A.

PROGRAM: DOWELED CONC. PAV. JOINT

PROGRAMMER: AMIR

PAGE 1 OF 1

```
    7    7    0    7    0    2
     0.000    60.000   120.000   165.000   210.000   255.000   300.000   300.000
   345.000   390.000   435.000   480.000   540.000   600.000
     0.000    60.000   105.000   150.000   195.000   240.000   300.000
    2    1    0   200.000
    12.000 0.500E+07     0.150
    1
     0.000     1.250 0.290E+08    15.000    24.000     0.100     0.290 0.240E+07
   33   222.222    30.000    45.000    37.500    45.000
   34   222.222    30.000    45.000     0.000     7.500
```

```
**********************************************
*   JOINT PROGRAM                            *
*   FINITE ELEMENT ANALYSIS OF CONC. PAV.    *
*   AMIR M. TABATABAIE                       *
*   UNIVERSITY OF ILLINOIS          1977     *
**********************************************

NO. OF NODES IN X-DIRECTION SLABS   1,4=     7
NO. OF NODES IN X DIRECTION SLABS   2,5=     7
NO. OF NODES IN X_DIRECTION SLABS   3,6=     0
NO. OF NODES IN Y DIRECTION SLABS 1,2,3=     7
NO. OF NODES IN Y_DIRECTION SLABS 4,5,6=     0

 X-COORDINATES ARE:
   0.0         60.000       120.000       165.000       210.000       255.000
 300.000      300.000       345.000       390.000       435.000       480.000
 540.000      600.000

 Y-COORDINATES ARE:
   0.0         60.000       105.000       150.000       195.000       240.000
 300.000
 NO. OF SLABS=     2
 NO. OF LAYERS=     1
 COMP. ACTION=     0

 PROPERTIES OF THE TOP LAYER IS:
 POISSON RATIO OF TOP LAYER=       0.150
 THICKNESS OF TOP LAYER=     12.000
 MODULUS OF TOP LAYER= 0.500E 07
 SUBGRADE MODULUS=    200.000

 TYPE OF LOAD TRANSFER IS STEEL BARS
```

PROPERTIES OF THE DOWEL BARS ARE:
INSIDE DIA.= 0.0
OUTSIDE DIA.= 1.250
MODULUS OF ELASTICITY= 0.290E 08
SPACING= 15.000
LENGTH= 24.000
POISSON RATIO= 0.290
DOWEL-CONCRETE INTERACTION= 0.240E 07

JOINT WIDTH= 0.100

ELEMENT	PRESS	X1-COOR.	X2-COOR.	Y1-COOR.	Y2-COOR.
33	222.222	30.000	45.000	37.500	45.000
34	222.222	30.000	45.000	0.0	7.500

NODE	DEFLECTION	X_ROTATION	Y_ROTATION	SUBGRADE STRESS
1	0.506670E-04	-0.204144E-05	-0.766415E-05	0.010
2	0.146796E-03	-0.768243E-06	-0.585778E-05	0.029
3	0.154682E-03	0.184832E-06	-0.534611E-05	0.031
4	0.147641E-03	0.144951E-10	-0.517142E-05	0.030
5	0.154681E-03	-0.184796E-06	-0.534611E-05	0.031
6	0.146794E-03	0.768302E-06	-0.585777E-05	0.029
7	0.506594E-04	0.204155E-05	-0.766415E-05	0.010
8	-0.460076E-03	-0.529241E-05	-0.104911E-04	0.0
9	-0.207644E-03	-0.246708E-05	-0.592270E-05	0.0
10	-0.149798E-03	-0.426322E-06	-0.459208E-05	0.0
11	-0.144437E-03	-0.671463E-12	-0.424027E-05	0.0
12	-0.149799E-03	0.426341E-06	-0.459206E-05	0.0
13	-0.207646E-03	0.246712E-05	-0.592267E-05	0.0
14	-0.460083E-03	0.529253E-05	-0.104911E-04	0.0
15	-0.126482E-02	-0.152675E-04	-0.159511E-04	0.0
16	-0.503472E-03	-0.878758E-05	-0.241191E-05	0.0
17	-0.244555E-03	-0.345771E-05	0.451911E-05	0.0
18	-0.171978E-03	-0.540012E-10	0.703404E-05	0.0
19	-0.244551E-03	0.345762E-05	0.451927E-05	0.0
20	-0.593467E-03	0.678757E-05	-0.241172E-05	0.0
21	-0.126482E-02	0.152676E-04	-0.159508E-04	0.0
22	-0.199362E-02	-0.312151E-04	-0.147725E-04	0.0
23	-0.332170E-03	-0.231390E-04	0.125735E-04	0.0
24	0.500580E-03	-0.133471E-04	0.334899E-04	0.100
25	0.804575E-03	-0.259296E-09	0.425179E-04	0.161
26	0.500595E-03	0.133468E-04	0.334902E-04	0.100
27	-0.332153E-03	0.231389E-04	0.125738E-04	0.0
28	-0.199361E-02	0.312151E-04	-0.147722E-04	0.0
29	-0.243681E-02	-0.561885E-04	-0.221844E-05	0.0
30	0.864201E-03	-0.558648E-04	0.419993E-04	0.173
31	0.327487E-02	-0.459297E-04	0.943621E-04	0.655
32	0.439625E-02	-0.433829E-09	0.128003E-03	0.877
33	0.327490E-02	0.459295E-04	0.943626E-04	0.655
34	0.864237E-03	0.558651E-04	0.419996E-04	0.173
35	-0.243679E-02	0.561885E-04	-0.221836E-05	0.0
36	-0.203799E-02	-0.642592E-04	0.221975E-04	0.0
37	0.344903E-02	-0.108638E-03	0.703081E-04	0.690
38	0.909111E-02	-0.133515E-03	0.150937E-03	1.818
39	0.130330E-01	-0.115233E-08	0.267375E-03	2.607

40	0.914119E-02	0.133515E-03	0.150639E-03	1.416
41	0.344910E-02	0.109639E-03	0.703091E-04	0.690
42	-0.203795E-02	0.842596E-04	0.221979E-04	0.0
43	-0.642112E-03	-0.112953E-03	0.354722E-04	0.0
44	0.683522E-02	-0.163560E-03	0.703789E-04	1.367
45	0.158750E-01	-0.248672E-03	0.150231E-03	3.175
46	0.243583E-01	-0.422006E-09	0.139242E-03	4.872
47	0.158752E-01	0.248672E-03	0.150232E-03	3.175
48	0.683545E-02	0.160562E-03	0.703809E-04	1.367
49	-0.642045E-03	0.112954E-03	0.354729E-04	0.0
50	-0.577466E-03	-0.108939E-03	-0.304179E-04	0.0
51	0.684158E-02	-0.159382E-03	-0.913573E-04	1.368
52	0.153281E-01	-0.195165E-03	-0.209281E-03	3.066
53	0.215035E-01	-0.633008E-09	-0.345735E-03	4.301
54	0.153282E-01	0.195166E-03	-0.209282E-03	3.066
55	0.684172E-02	0.159384E-03	-0.913586E-04	1.368
56	-0.577404E-03	0.108941E-03	-0.304197E-04	0.0
57	-0.186089E-02	-0.739237E-04	-0.205194E-04	0.0
58	0.276396E-02	-0.845629E-04	-0.785887E-04	0.553
59	0.658054E-02	-0.781806E-04	-0.157536E-03	1.316
60	0.852798E-02	-0.263753E-10	-0.215919E-03	1.706
61	0.658060E-02	0.781805E-04	-0.157537E-03	1.316
62	0.276402E-02	0.845640E-04	-0.785900E-04	0.553
63	-0.186087E-02	0.739246E-04	-0.205196E-04	0.0
64	-0.221174E-02	-0.439867E-04	0.343286E-05	0.0
65	0.196207E-03	-0.357789E-04	-0.348171E-04	0.039
66	0.155387E-02	-0.228388E-04	-0.683213E-04	0.311
67	0.208970E-02	-0.470095E-10	-0.843973E-04	0.418
68	0.155389E-02	0.228385E-04	-0.683215E-04	0.311
69	0.196229E-03	0.357790E-04	-0.348174E-04	0.039
70	-0.221172E-02	0.439870E-04	0.343272E-05	0.0
71	-0.172771E-02	-0.225238E-04	0.154721E-04	0.0
72	-0.609486E-03	-0.135906E-04	-0.455749E-05	0.0
73	-0.178571E-03	-0.611029E-05	-0.158316E-04	0.0
74	-0.469624E-04	-0.445759E-10	-0.202264E-04	0.0
75	-0.178566E-03	0.611022E-05	-0.158319E-04	0.0
76	-0.609480E-03	0.135905E-04	-0.455783E-05	0.0
77	-0.172770E-02	0.225237E-04	0.154719E-04	0.0
78	-0.100640E-02	-0.102691E-04	0.151030E-04	0.0
79	-0.520788E-03	-0.500040E-05	0.590399E-05	0.0
80	-0.383807E-03	-0.136744E-05	0.243499E-05	0.0
81	-0.363935E-03	-0.523670E-10	0.137928E-05	0.0
82	-0.388808E-03	0.136737E-05	0.243493E-05	0.0
83	-0.520790E-03	0.500031E-05	0.590390E-05	0.0
84	-0.100639E-02	0.102690E-04	0.151030E-04	0.0
85	-0.290840E-03	-0.314611E-05	0.879668E-05	0.0
86	-0.136969E-03	-0.147149E-05	0.583436E-05	0.0
87	-0.106274E-03	-0.135667E-06	0.523863E-05	0.0
88	-0.106447E-03	0.139373E-10	0.514521E-05	0.0
89	-0.106276E-03	0.135688E-06	0.523863E-05	0.0
90	-0.136971E-03	0.147146E-05	0.583437E-05	0.0
91	-0.290842E-03	0.314607E-05	0.879668E-05	0.0
92	0.128965E-03	-0.125193E-05	0.628750E-05	0.026
93	0.187495E-03	-0.508104E-06	0.520750E-05	0.037
94	0.193231E-03	0.110161E-06	0.496362E-05	0.039
95	0.188953E-03	0.155502E-10	0.488520E-05	0.038
96	0.193229E-03	-0.110151E-06	0.496363E-05	0.039
97	0.187495E-03	0.508082E-06	0.520753E-05	0.037
98	0.128966E-03	0.125190E-05	0.628754E-05	0.026

NODE	DEPTH	X_STRESS	Y_STRESS	XY_STRESS
1	0.0	0.0	0.0	0.0
	12.000	0.0	0.0	0.0
	12.000	0.0	0.0	0.0
	12.000	0.0	0.0	0.0
2	0.0	0.0	0.120458E 01	0.471958E 00
	12.000	0.0	-0.120458E 01	-0.471958E 00
	12.000	0.0	0.0	0.0
	12.000	0.0	0.0	0.0
3	0.0	0.0	0.145414E 00	0.163396E 00
	12.000	0.0	-0.145414E 00	-0.163396E 00
	12.000	0.0	0.0	0.0
	12.000	0.0	0.0	0.0
4	0.0	0.0	-0.384911E 00	0.408890E-05
	12.000	0.0	0.384911E 00	-0.408890E-05
	12.000	0.0	0.0	0.0
	12.000	0.0	0.0	0.0
5	0.0	0.0	0.145432E 00	-0.163392E 00
	12.000	0.0	-0.145432E 00	0.163392E 00
	12.000	0.0	0.0	0.0
	12.000	0.0	0.0	0.0
6	0.0	0.0	0.120461E 01	-0.471947E 00
	12.000	0.0	-0.120461E 01	0.471947E 00
	12.000	0.0	0.0	0.0
	12.000	0.0	0.0	0.0
7	0.0	0.0	0.0	0.0
	12.000	0.0	0.0	0.0
	12.000	0.0	0.0	0.0
	12.000	0.0	0.0	0.0
8	0.0	0.334647E 01	0.0	0.246941E 01
	12.000	-0.334647E 01	0.0	-0.246941E 01
	12.000	0.0	0.0	0.0
	12.000	0.0	0.0	0.0
9	0.0	0.729064E 00	0.230961E 01	0.130768E 01
	12.000	-0.729064E 00	-0.230961E 01	-0.130768E 01
	12.000	0.0	0.0	0.0
	12.000	0.0	0.0	0.0
10	0.0	-0.212050E 00	0.656130E 00	0.468770E 00
	12.000	0.212050E 00	-0.656130E 00	-0.468770E 00
	12.000	0.0	0.0	0.0
	12.000	0.0	0.0	0.0
11	0.0	-0.536565E 00	-0.172358E 00	0.103736E-04
	12.000	0.536565E 00	0.172358E 00	-0.103736E-04
	12.000	0.0	0.0	0.0
	12.000	0.0	0.0	0.0

12	0.0	-0.212074E 00	0.656126E 00	-0.468752E 00
	12.000	0.212074E 00	-0.656126E 00	0.468752E 00
	12.000	0.0	0.0	0.0
	12.000	0.0	0.0	0.0
13	0.0	0.729012E 00	0.230966E 01	-0.130767E 01
	12.000	-0.729012E 00	-0.230966E 01	0.130767E 01
	12.000	0.0	0.0	0.0
	12.000	0.0	0.0	0.0
14	0.0	0.334639E 01	0.0	-0.246940E 01
	12.000	-0.334639E 01	0.0	0.246940E 01
	12.000	0.0	0.0	0.0
	12.000	0.0	0.0	0.0
15	0.0	0.263814E 01	0.0	0.647930E 01
	12.000	-0.263814E 01	0.0	-0.647930E 01
	12.000	0.0	0.0	0.0
	12.000	0.0	0.0	0.0
16	0.0	-0.419400E 01	0.415052E 01	0.505723E 01
	12.000	0.419400E 01	-0.415052E 01	-0.505723E 01
	12.000	0.0	0.0	0.0
	12.000	0.0	0.0	0.0
17	0.0	-0.916644E 01	0.127065E 01	0.302602E 01
	12.000	0.916644E 01	-0.127065E 01	-0.302602E 01
	12.000	0.0	0.0	0.0
	12.000	0.0	0.0	0.0
18	0.0	-0.112579E 02	0.152218E 00	0.719083E-04
	12.000	0.112579E 02	-0.152218E 00	-0.719083E-04
	12.000	0.0	0.0	0.0
	12.000	0.0	0.0	0.0
19	0.0	-0.916650E 01	0.127073E 01	-0.302595E 01
	12.000	0.916650E 01	-0.127073E 01	0.302595E 01
	12.000	0.0	0.0	0.0
	12.000	0.0	0.0	0.0
20	0.0	-0.419410E 01	0.415063E 01	-0.505719E 01
	12.000	0.419410E 01	-0.415063E 01	0.505719E 01
	12.000	0.0	0.0	0.0
	12.000	0.0	0.0	0.0
21	0.0	0.263791E 01	0.0	-0.647923E 01
	12.000	-0.263791E 01	0.0	0.647923E 01
	12.000	0.0	0.0	0.0
	12.000	0.0	0.0	0.0
22	0.0	-0.323738E 01	0.0	0.114576E 02
	12.000	0.323738E 01	0.0	-0.114576E 02
	12.000	0.0	0.0	0.0
	12.000	0.0	0.0	0.0

23	0.0	-0.152426E 02	0.324229E 01	0.125926E 02
	12.000	0.152426E 02	-0.324229E 01	-0.125926E 02
	12.000	0.0	0.0	0.0
	12.000	0.0	0.0	0.0
24	0.0	-0.297474E 02	0.361228E 01	0.107308E 02
	12.000	0.297474E 02	-0.361228E 01	-0.107308E 02
	12.000	0.0	0.0	0.0
	12.000	0.0	0.0	0.0
25	0.0	-0.345305E 02	0.404556E 01	0.114704E-03
	12.000	0.345305E 02	-0.404556E 01	-0.114704E-03
	12.000	0.0	0.0	0.0
	12.000	0.0	0.0	0.0
26	0.0	-0.297476E 02	0.361257E 01	-0.107308E 02
	12.000	0.297476E 02	-0.361257E 01	0.107308E 02
	12.000	0.0	0.0	0.0
	12.000	0.0	0.0	0.0
27	0.0	-0.152427E 02	0.324233E 01	-0.125927E 02
	12.000	0.152427E 02	-0.324233E 01	0.125927E 02
	12.000	0.0	0.0	0.0
	12.000	0.0	0.0	0.0
28	0.0	-0.323736E 01	0.0	-0.114576E 02
	12.000	0.323736E 01	0.0	0.114576E 02
	12.000	0.0	0.0	0.0
	12.000	0.0	0.0	0.0
29	0.0	0.125799E 02	0.0	0.161192E 02
	12.000	0.125799E 02	0.0	-0.161192E 02
	12.000	0.0	0.0	0.0
	12.000	0.0	0.0	0.0
30	0.0	-0.242864E 02	-0.711137E 01	0.248430E 02
	12.000	0.242864E 02	0.711137E 01	-0.248430E 02
	12.000	0.0	0.0	0.0
	12.000	0.0	0.0	0.0
31	0.0	-0.550630E 02	0.122435E 02	0.325547E 02
	12.000	0.550630E 02	-0.122435E 02	-0.325547E 02
	12.000	0.0	0.0	0.0
	12.000	0.0	0.0	0.0
32	0.0	-0.711767E 02	0.268718E 02	0.179253E-03
	12.000	0.711767E 02	-0.268718E 02	-0.179253E-03
	12.000	0.0	0.0	0.0
	12.000	0.0	0.0	0.0
33	0.0	-0.550632E 02	0.122442E 02	-0.325547E 02
	12.000	0.550632E 02	-0.122442E 02	0.325547E 02
	12.000	0.0	0.0	0.0
	12.000	0.0	0.0	0.0

34	0.0	-0.242863E 02	-0.711099E 01	-0.248432E 02
	12.000	0.242863E 02	0.711099E 01	0.248432E 02
	12.000	0.0	0.0	0.0
	12.000	0.0	0.0	0.0
35	0.0	-0.125801E 02	0.0	-0.161193E 02
	12.000	0.125801E 02	0.0	0.161193E 02
	12.000	0.0	0.0	0.0
	12.000	0.0	0.0	0.0
36	0.0	-0.191975E 02	0.0	0.171952E 02
	12.000	0.191975E 02	0.0	-0.171952E 02
	12.000	0.0	0.0	0.0
	12.000	0.0	0.0	0.0
37	0.0	-0.217637E 02	-0.337549E 02	0.327386E 02
	12.000	0.217637E 02	0.337549E 02	-0.327386E 02
	12.000	0.0	0.0	0.0
	12.000	0.0	0.0	0.0
38	0.0	-0.541418E 01	0.232768E 01	0.707952E 02
	12.000	0.541418E 01	-0.232768E 01	-0.707952E 02
	12.000	0.0	0.0	0.0
	12.000	0.0	0.0	0.0
39	0.0	-0.876756E 02	0.159211E 03	0.167477E-03
	12.000	0.876756E 02	-0.159211E 03	-0.167477E-03
	12.000	0.0	0.0	0.0
	12.000	0.0	0.0	0.0
40	0.0	-0.541368E 01	0.233172E 01	-0.707954E 02
	12.000	0.541368E 01	-0.233172E 01	0.707954E 02
	12.000	0.0	0.0	0.0
	12.000	0.0	0.0	0.0
41	0.0	-0.217643E 02	-0.337552E 02	-0.327390E 02
	12.000	0.217643E 02	0.337552E 02	0.327390E 02
	12.000	0.0	0.0	0.0
	12.000	0.0	0.0	0.0
42	0.0	-0.191981E 02	0.0	-0.171954E 02
	12.000	0.191981E 02	0.0	0.171954E 02
	12.000	0.0	0.0	0.0
	12.000	0.0	0.0	0.0
43	0.0	0.0	0.0	0.0
	12.000	0.0	0.0	0.0
	12.000	0.0	0.0	0.0
	12.000	0.0	0.0	0.0
44	0.0	0.0	-0.501973E 02	0.293333E 02
	12.000	0.0	0.501973E 02	-0.293333E 02
	12.000	0.0	0.0	0.0
	12.000	0.0	0.0	0.0

45	0.0	0.0	-0.840269E 02	0.355808E 02
	12.000	0.0	0.840269E 02	-0.355808E 02
	12.000	0.0	0.0	0.0
	12.000	0.0	0.0	0.0
46	0.0	0.0	0.475015E 03	-0.502431E-03
	12.000	0.0	-0.475015E 03	0.502431E-03
	12.000	0.0	0.0	0.0
	12.000	0.0	0.0	0.0
47	0.0	0.0	-0.840205E 02	-0.355812E 02
	12.000	0.0	0.840205E 02	0.355812E 02
	12.000	0.0	0.0	0.0
	12.000	0.0	0.0	0.0
48	0.0	0.0	-0.501953E 02	-0.293333E 02
	12.000	0.0	0.501953E 02	0.293333E 02
	12.000	0.0	0.0	0.0
	12.000	0.0	0.0	0.0
49	0.0	0.0	0.0	0.0
	12.000	0.0	0.0	0.0
	12.000	0.0	0.0	0.0
	12.000	0.0	0.0	0.0
50	0.0	0.0	0.0	0.0
	12.000	0.0	0.0	0.0
	12.000	0.0	0.0	0.0
	12.000	0.0	0.0	0.0
51	0.0	0.0	-0.622276E 02	-0.472234E 02
	12.000	0.0	0.622276E 02	0.472234E 02
	12.000	0.0	0.0	0.0
	12.000	0.0	0.0	0.0
52	0.0	0.0	-0.217354E 01	-0.842361E 02
	12.000	0.0	0.217354E 01	0.842361E 02
	12.000	0.0	0.0	0.0
	12.000	0.0	0.0	0.0
53	0.0	0.0	0.286678E 03	-0.365484E-03
	12.000	0.0	-0.286678E 03	0.365484E-03
	12.000	0.0	0.0	0.0
	12.000	0.0	0.0	0.0
54	0.0	0.0	-0.217074E 01	0.842369E 02
	12.000	0.0	0.217074E 01	-0.842369E 02
	12.000	0.0	0.0	0.0
	12.000	0.0	0.0	0.0
55	0.0	0.0	-0.622232E 02	0.472233E 02
	12.000	0.0	0.622232E 02	-0.472233E 02
	12.000	0.0	0.0	0.0
	12.000	0.0	0.0	0.0

56	0.0	0.0	0.0	0.0
	12.000	0.0	0.0	0.0
	12.000	0.0	0.0	0.0
	12.000	0.0	0.0	0.0
57	0.0	-0.191358E 02	0.0	-0.198660E 02
	12.000	0.191358E 02	0.0	0.198660E 02
	12.000	0.0	0.0	0.0
	12.000	0.0	0.0	0.0
58	0.0	-0.317242E 02	-0.154169E 02	-0.362705E 02
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	12.000	0.0	0.0	0.0
59	0.0	-0.689461E 02	0.163552E 02	-0.486333E 02
	12.000	0.689461E 02	-0.163552E 02	0.486333E 02
	12.000	0.0	0.0	0.0
	12.000	0.0	0.0	0.0
60	0.0	-0.108429E 03	0.525973E 02	-0.237695E-03
	12.000	0.108429E 03	-0.525973E 02	0.237695E-03
	12.000	0.0	0.0	0.0
	12.000	0.0	0.0	0.0
61	0.0	-0.689456E 02	0.163574E 02	0.486337E 02
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	12.000	0.0	0.0	0.0
	12.000	0.0	0.0	0.0
62	0.0	-0.317250E 02	-0.154159E 02	0.362710E 02
	12.000	0.317250E 02	0.154159E 02	-0.362710E 02
	12.000	0.0	0.0	0.0
	12.000	0.0	0.0	0.0
63	0.0	-0.191367E 02	0.0	0.198666E 02
	12.000	0.191367E 02	0.0	-0.198666E 02
	12.000	0.0	0.0	0.0
	12.000	0.0	0.0	0.0
64	0.0	-0.128979E 02	0.0	-0.145887E 02
	12.000	0.128979E 02	0.0	0.145887E 02
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	12.000	0.0	0.0	0.0
65	0.0	0.288563E 02	0.688186E 00	-0.192242E 02
	12.000	0.288563E 02	-0.688186E 00	0.192242E 02
	12.000	0.0	0.0	0.0
	12.000	0.0	0.0	0.0
66	0.0	-0.511912E 02	0.499480E 01	-0.185093E 02
	12.000	0.511912E 02	-0.499480E 01	0.185093E 02
	12.000	0.0	0.0	0.0
	12.000	0.0	0.0	0.0

67	0.0	-0.594873E 02	0.825375E 01	0.105109E-03
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	12.000	0.0	0.0	0.0
68	0.0	-0.511923E 02	0.499483E 01	0.185094E 02
	12.000	0.511923E 02	-0.499483E 01	-0.185094E 02
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	12.000	0.0	0.0	0.0
69	0.0	-0.288568E 02	0.688543E 00	0.192244E 02
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	12.000	0.0	0.0	0.0
70	0.0	-0.128978E 02	0.0	0.145888E 02
	12.000	0.128978E 02	0.0	-0.145888E 02
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	12.000	0.0	0.0	0.0
71	0.0	-0.241105E 01	0.0	-0.919507E 01
	12.000	0.241105E 01	0.0	0.919507E 01
	12.000	0.0	0.0	0.0
	12.000	0.0	0.0	0.0
72	0.0	-0.119503E 02	0.435309E 01	-0.795264E 01
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	12.000	0.0	0.0	0.0
73	0.0	-0.203039E 02	0.119208E 01	-0.517223E 01
	12.000	0.203039E 02	-0.119208E 01	0.517223E 01
	12.000	0.0	0.0	0.0
	12.000	0.0	0.0	0.0
74	0.0	-0.236805E 02	0.814112E-02	-0.139564E-04
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	12.000	0.0	0.0	0.0
75	0.0	-0.203039E 02	0.119224E 01	0.517216E 01
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76	0.0	-0.119505E 02	0.435313E 01	0.795269E 01
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	12.000	0.0	0.0	0.0
77	0.0	-0.241113E 01	0.0	0.919520E 01
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	12.000	0.0	0.0	0.0

78	0.0	0.348595E 01	0.0	-0.484205E 01
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79	0.0	-0.113360E 01	0.354819E 01	-0.292593E 01
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	12.000	0.0	0.0	0.0
80	0.0	-0.391922E 01	0.838932E 00	-0.134212E 01
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	12.000	0.0	0.0	0.0
81	0.0	-0.498698E 01	-0.360323E 00	-0.771419E-05
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	12.000	0.0	0.0	0.0
82	0.0	-0.391926E 01	0.838934E 00	0.134210E 01
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	12.000	0.0	0.0	0.0
83	0.0	-0.113368E 01	0.354808E 01	0.292591E 01
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84	0.0	0.348587E 01	0.0	0.484207E 01
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85	0.0	0.306549E 01	0.0	-0.170084E 01
	12.000	-0.306549E 01	0.0	0.170084E 01
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86	0.0	0.139047E 01	0.169901E 01	-0.714609E 00
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	12.000	0.0	0.0	0.0
87	0.0	0.919137E 00	0.527423E 00	-0.145617E 00
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	12.000	0.0	0.0	0.0
88	0.0	0.795545E 00	-0.741504E-01	-0.123482E-04
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	12.000	0.0	0.0	0.0
	12.000	0.0	0.0	0.0

89	0.0	0.919119E 00	0.527403E 00	0.145603E 00
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	12.000	0.0	0.0	0.0
	12.000	0.0	0.0	0.0
90	0.0	0.139047E 01	0.169899E 01	0.714596E 00
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	12.000	0.0	0.0	0.0
	12.000	0.0	0.0	0.0
91	0.0	0.306539E 01	0.0	0.170082E 01
	12.000	-0.306539E 01	0.0	-0.170082E 01
	12.000	0.0	0.0	0.0
	12.000	0.0	0.0	0.0
92	0.0	0.0	0.0	0.0
	12.000	0.0	0.0	0.0
	12.000	0.0	0.0	0.0
	12.000	0.0	0.0	0.0
93	0.0	0.0	0.689923E 00	-0.258320E 00
	12.000	0.0	-0.689923E 00	0.258320E 00
	12.000	0.0	0.0	0.0
	12.000	0.0	0.0	0.0
94	0.0	0.0	0.794421E-01	-0.597485E-01
	12.000	0.0	-0.794421E-01	0.597485E-01
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	12.000	0.0	0.0	0.0
95	0.0	0.0	-0.261248E 00	-0.224948E-05
	12.000	0.0	0.261248E 00	0.224948E-05
	12.000	0.0	0.0	0.0
	12.000	0.0	0.0	0.0
96	0.0	0.0	0.794156E-01	0.597552E-01
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	12.000	0.0	0.0	0.0
	12.000	0.0	0.0	0.0
97	0.0	0.0	0.689901E 00	0.258318E 00
	12.000	0.0	-0.689901E 00	-0.258318E 00
	12.000	0.0	0.0	0.0
	12.000	0.0	0.0	0.0
98	0.0	0.0	0.0	0.0
	12.000	0.0	0.0	0.0
	12.000	0.0	0.0	0.0
	12.000	0.0	0.0	0.0

NODE	TRANSFERRED LOAD	NODE	TRANSFERRED LOAD
43	-120.917	50	120.917
44	-144.576	51	144.576
45	922.204	52	-922.204
46	5443.156	53	-5443.156
47	922.271	54	-922.271
48	-144.599	55	144.599
49	-120.913	56	120.913

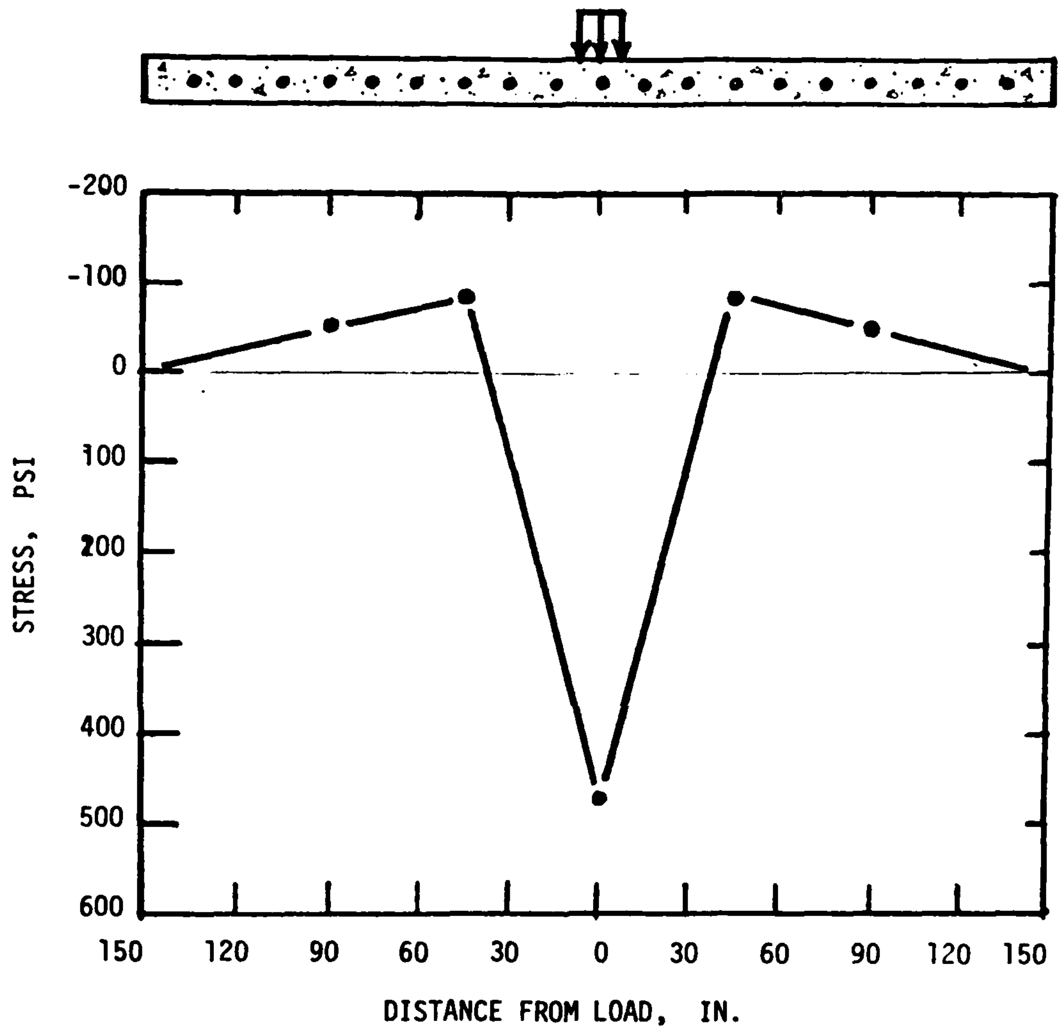

Figure 3. DISTRIBUTION OF STRESSES ALONG THE DOWELED JOINT

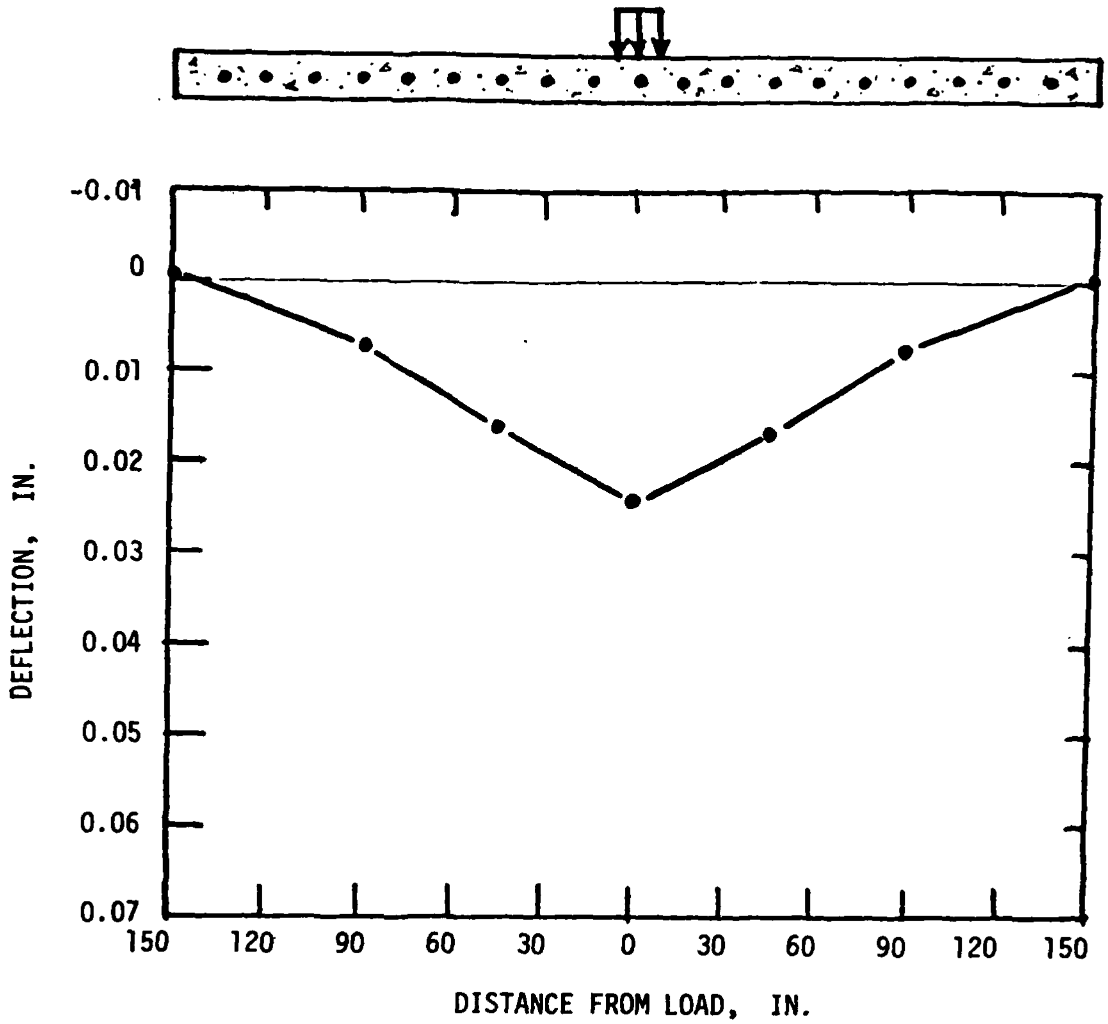

Figure 4. DISTRIBUTION OF DEFLECTIONS ALONG THE DOWELED JOINT

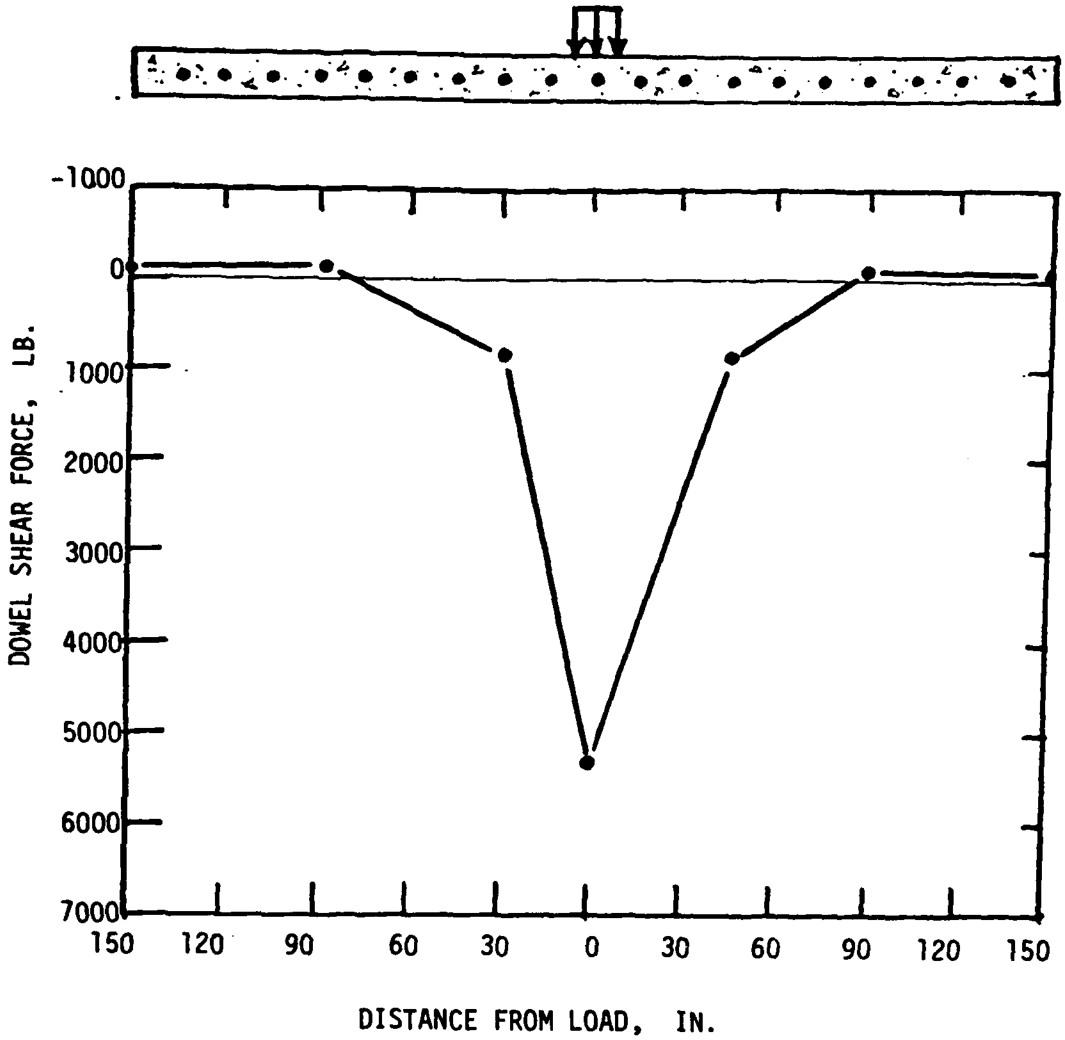

Figure 5. DISTRIBUTION OF DOWEL SHEAR FORCE ALONG THE JOINT

Example 2, Jointed Concrete Pavement with Aggregate-Interlock

Slab = Two 25 ft. square panels.

Thickness = 12 in.

Modulus of elasticity = 5×10^6 psi

Poisson's Ratio = 0.15

Load Transferring System = aggregate-interlock

Aggregate Interlock Factor (Agg) = 5×10^4 psi

Modulus of Subgrade Reaction = 200 pci

Load = 50,000 # at the center of joint in Slab 1

Contact pressure = 222 psi

Contact area = 15 in. square

IBM FORTRAN Coding Form

GX28-7327-6 U/M 050**
Printed in U.S.A.

PROGRAM: CONC. PAV. JOINT WITH AGG. INTERLOCK

PROGRAMMER: AMIR

PAGE 1 OF 1

```
    7    7    0    7    0    2
     0.000    60.000   120.000   165.000   210.000   255.000   300.000   300.000
   345.000   390.000   435.000   480.000   540.000   600.000
     0.000    60.000   105.000   150.000   195.000   240.000   300.000
    2    1    0   200.000
    12.000 0.500E+07     0.150
    0
 0.500E+05
   33   222.222    30.000    45.000    37.500    45.000
   34   222.222    30.000    45.000     0.000     7.500
```

*A standard card form, IBM electro 888157, is available for punching statements from this form

**Number of forms per pad may vary slightly

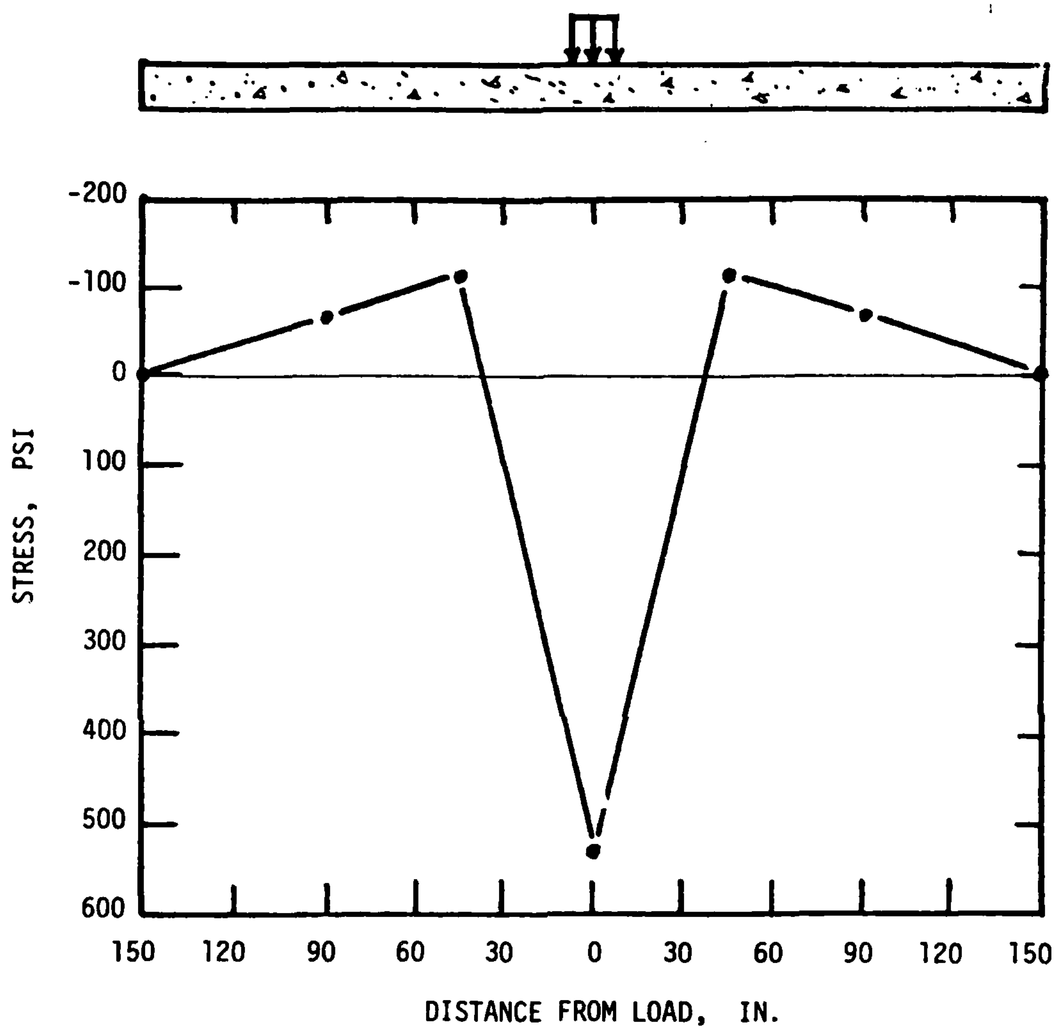

Figure 6. DISTRIBUTION OF STRESSES ALONG THE JOINT WITH AGG. INTERLOCK

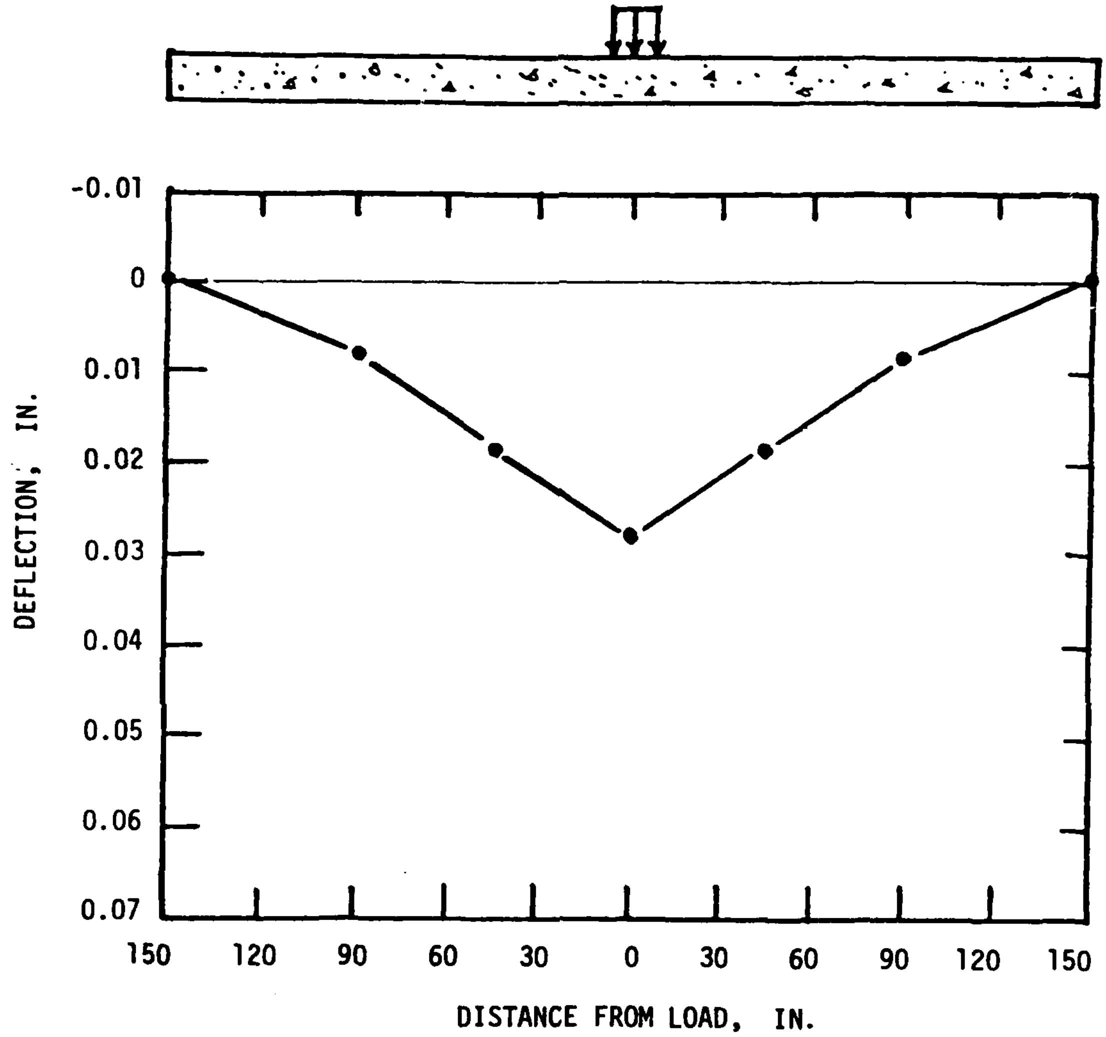

Figure 7. DISTRIBUTION OF DEFLECTIONS ALONG THE JOINT WITH AGG. INRWELOCK

Example 3, Jointed Concrete Pavement with Keyway

Slabs = Two 25 ft. square panels

Thickness = 12 in.

Modulus of elasticity = 5×10^6 psi

Poisson's Ratio = 0.15

Load Transferring System = keyway

Modulus of Subgrade Reaction = 200 pci

Load = 50,000 # at the center of joint in Slab 1

Contact pressure = 222 psi

Contact area = 15 in. square

IBM FORTRAN Coding Form

GX28-7327-6 U/M 050**
Printed in U.S.A.

PROGRAM: KEYED CONC. PAV. JOINT

PROGRAMMER: AMIR

PAGE 1 OF 1

FORTRAN STATEMENT

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    7    7    0    7    0    2
     0.000    60.000   120.000   165.000   210.000   255.000   300.000   300.000
   345.000   390.000   435.000   480.000   540.000   600.000
     0.000    60.000   105.000   150.000   195.000   240.000   300.000
    2    1    0   200.000
    12.000 0.500E+07     0.150
    0
 0.100E+08
   33   222.222    30.000    45.000    37.500    45.000
   34   222.222    30.000    45.000     0.000     7.500
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*A standard card form, IBM electro 888157, is available for punching statements from this form

**Number of forms per pad may vary slightly

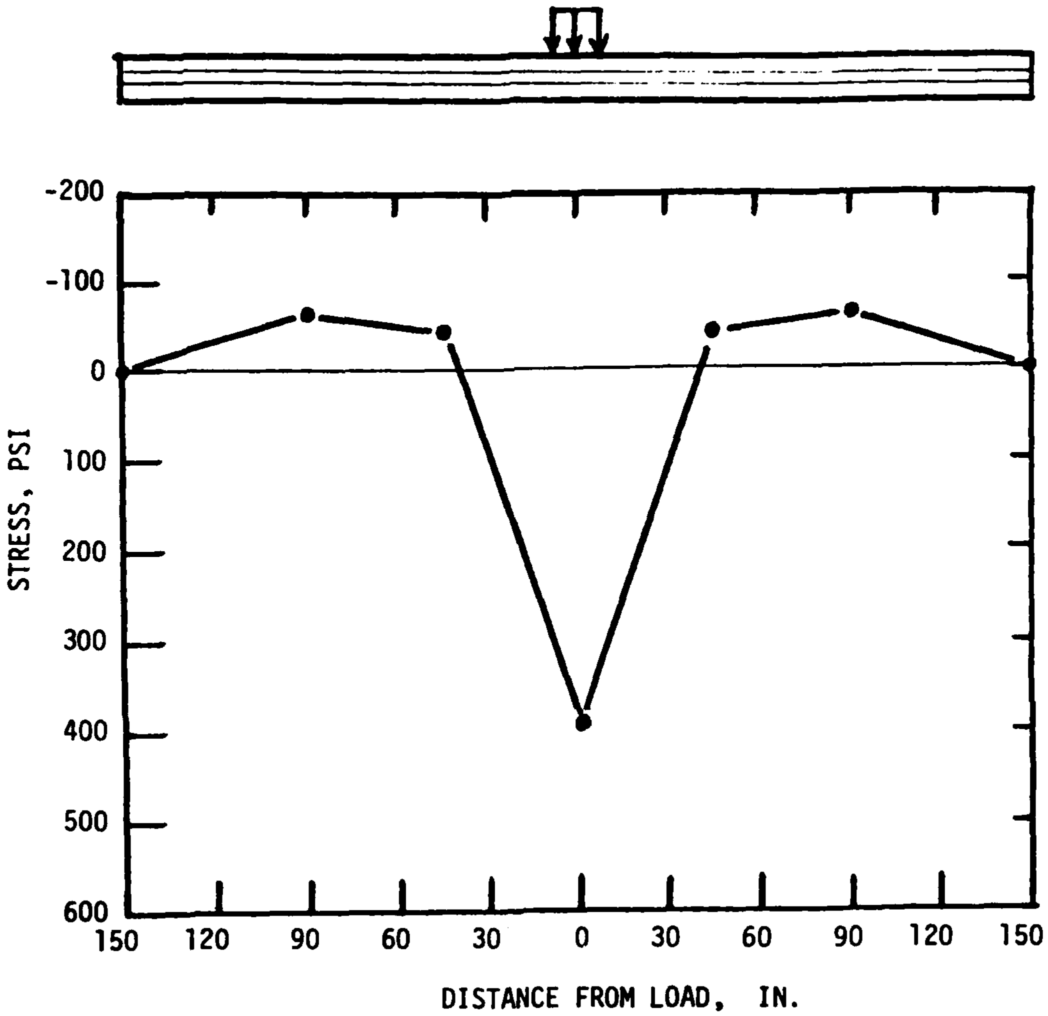

Figure 8. DISTRIBUTION OF STRESSES ALONG THE KEYED JOINT

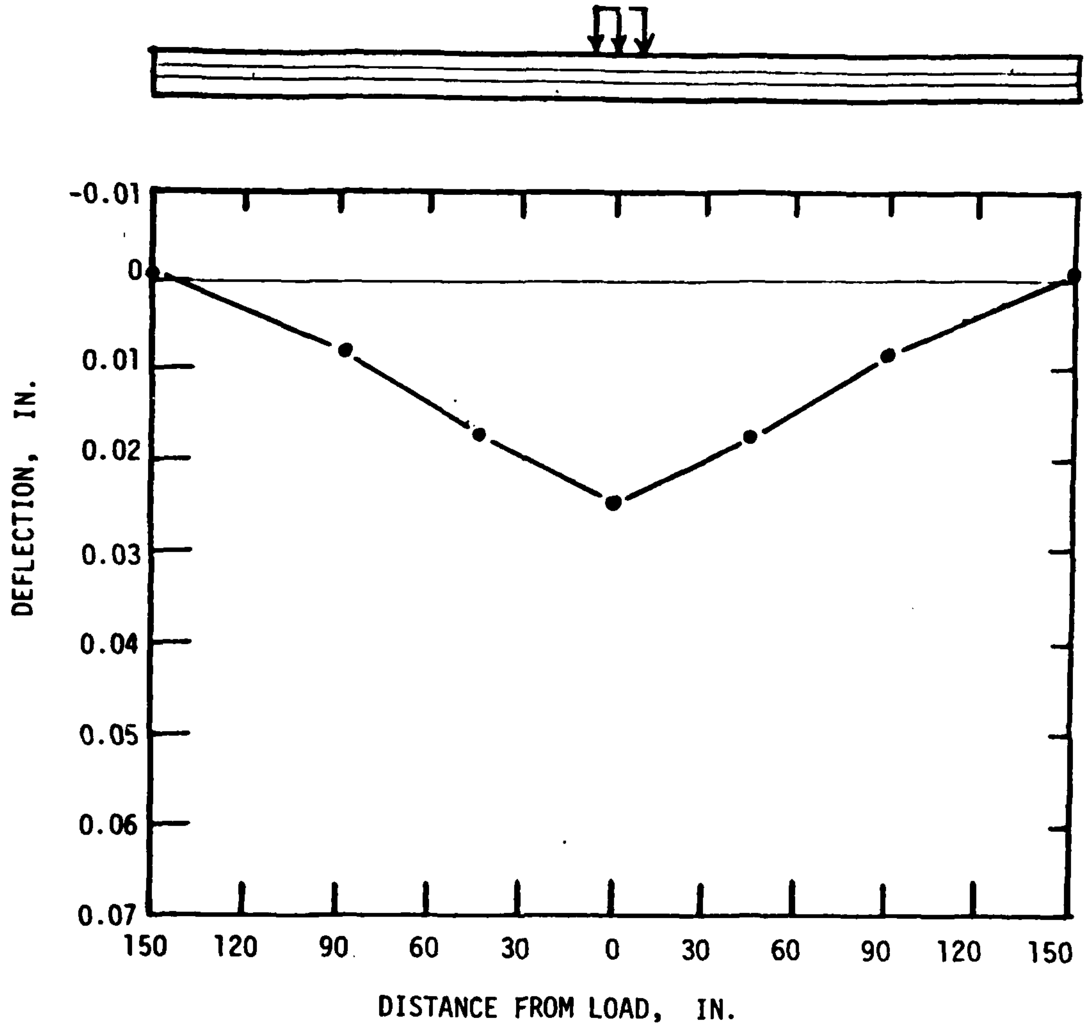

Figure 9. DISTRIBUTION OF DEFLECTIONS ALONG THE KEYED JOINT

Example 4, Keel-Section for Runway

Slab = 25 ft. square panel

Thickness of the center = 12 in.

Thickness of edge = 18 in.

Modulus of elasticity = 5×10^6 psi

Poisson's ratio = 0.15

Modulus of Subgrade Reaction = 200 pci

Load = 50,000 # at the center of thickened edge

Contact pressure = 222 psi

Contact area = 15 in. square

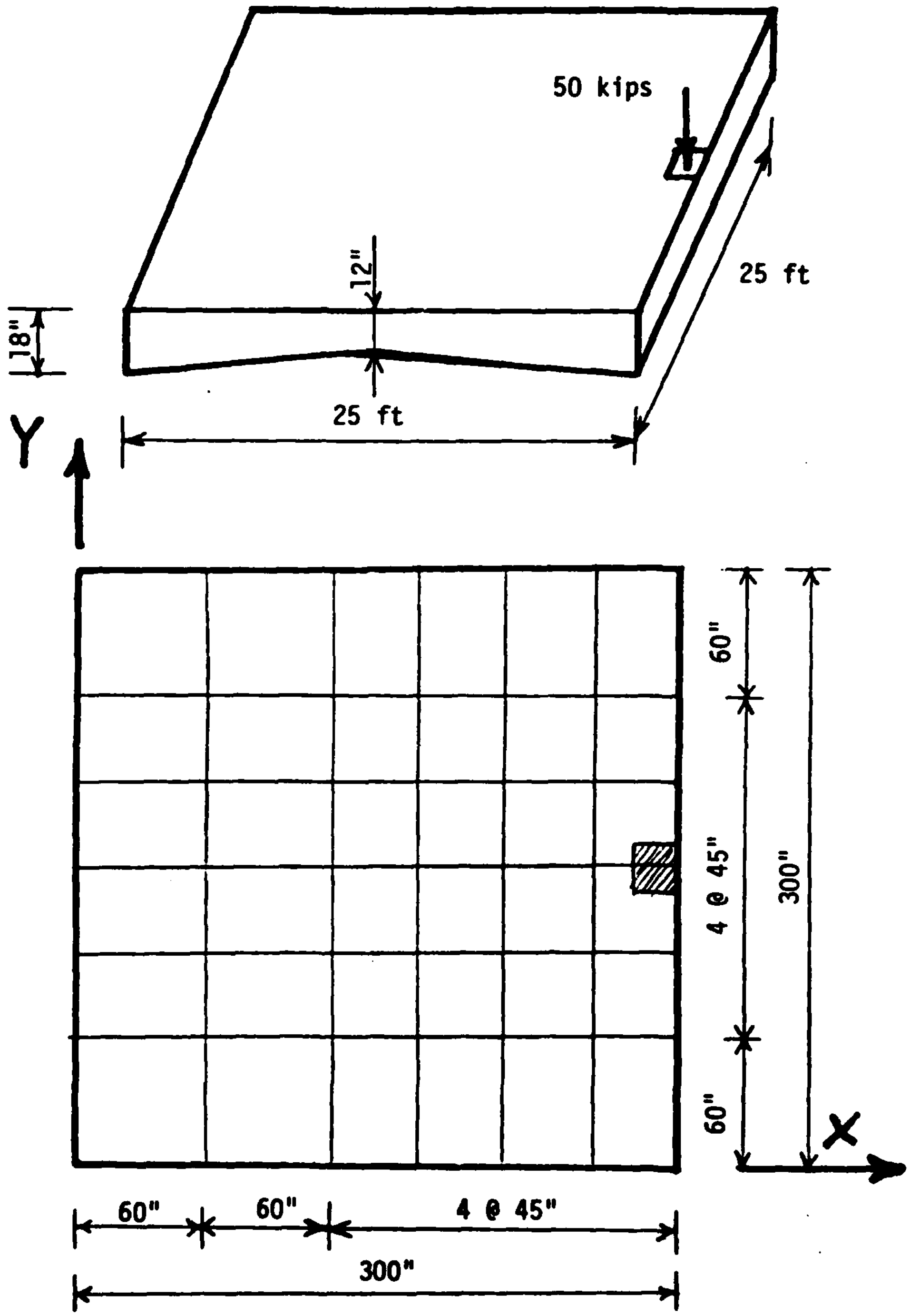

Figure 10. FINITE-ELEMENT MESH CONFIGURATION USED FOR EXAMPLE PROBLEM 4.

IBM FORTRAN Coding Form

GX28-7327-6 U/M 050**
Printed in U.S.A.

PROGRAM: THICKENED EDGE SLAB
PROGRAMMER: AMIR
PAGE 1 OF 1

FORTRAN STATEMENT

```
    7    0    0    7    0    2
     0.000    60.000   120.000   165.000   210.000   255.000   300.000
     0.000    60.000   105.000   150.000   195.000   240.000   300.000
    1    1    0   200.000
     0.000 0.500E+07     0.150
    18.000    18.000    18.000    18.000    18.000    18.000    18.000    15.600
    15.600    15.600    15.600    15.600    15.600    15.600    13.200    13.200
    13.200    13.200    13.200    13.200    13.200    12.600    12.600    12.600
    12.600    12.600    12.600    12.600    14.400    14.400    14.400    14.400
    14.400    14.400    14.400    16.200    16.200    16.200    16.200    16.200
    16.200    16.200    18.000    18.000    18.000    18.000    18.000    18.000
    18.000
   33   222.222    30.000    45.000    37.500    45.000
   34   222.222    30.000    45.000     0.000     7.500
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*A standard card form, IBM electro 888157, is available for punching statements from this form

**Number of forms per pad may vary slightly

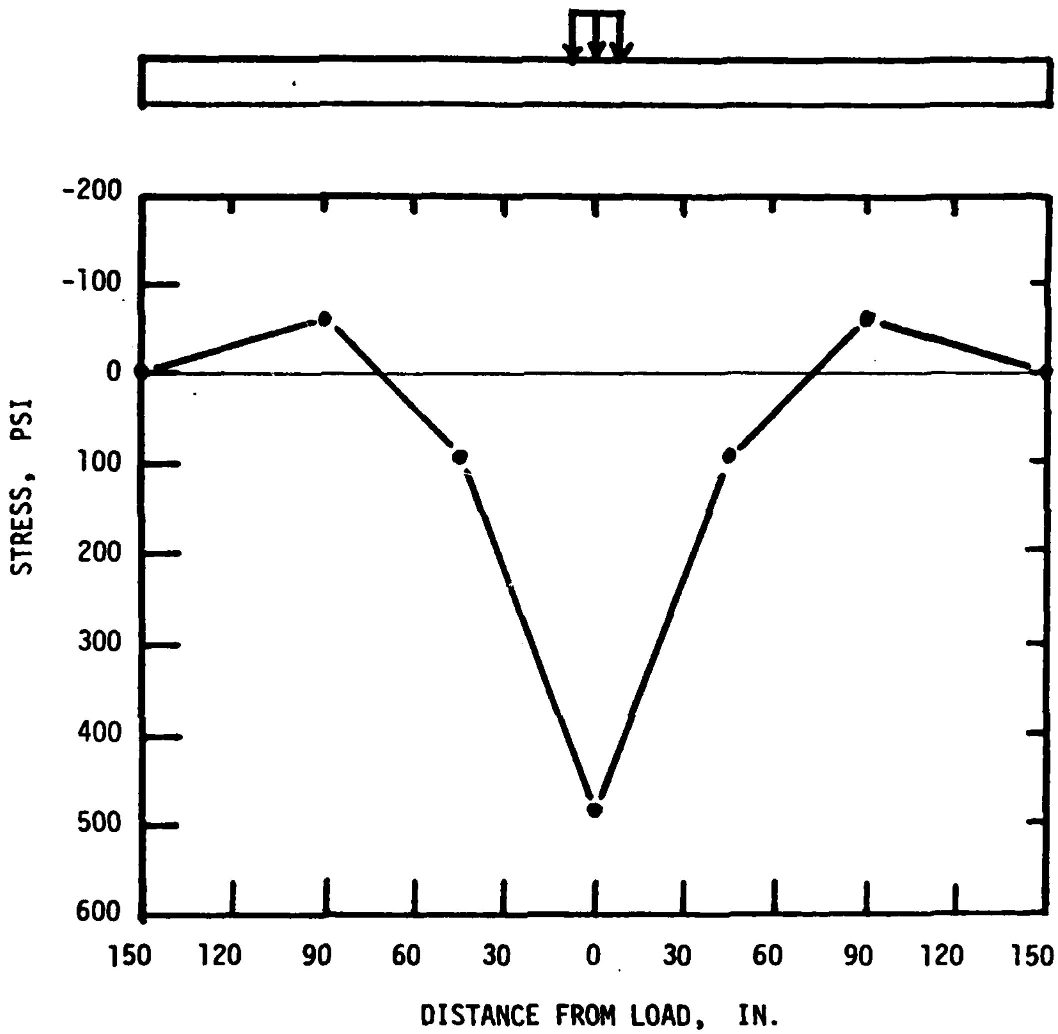

Figure 11. DISTRIBUTION OF STRESSES ALONG THE THICKENED EDGE SLAB

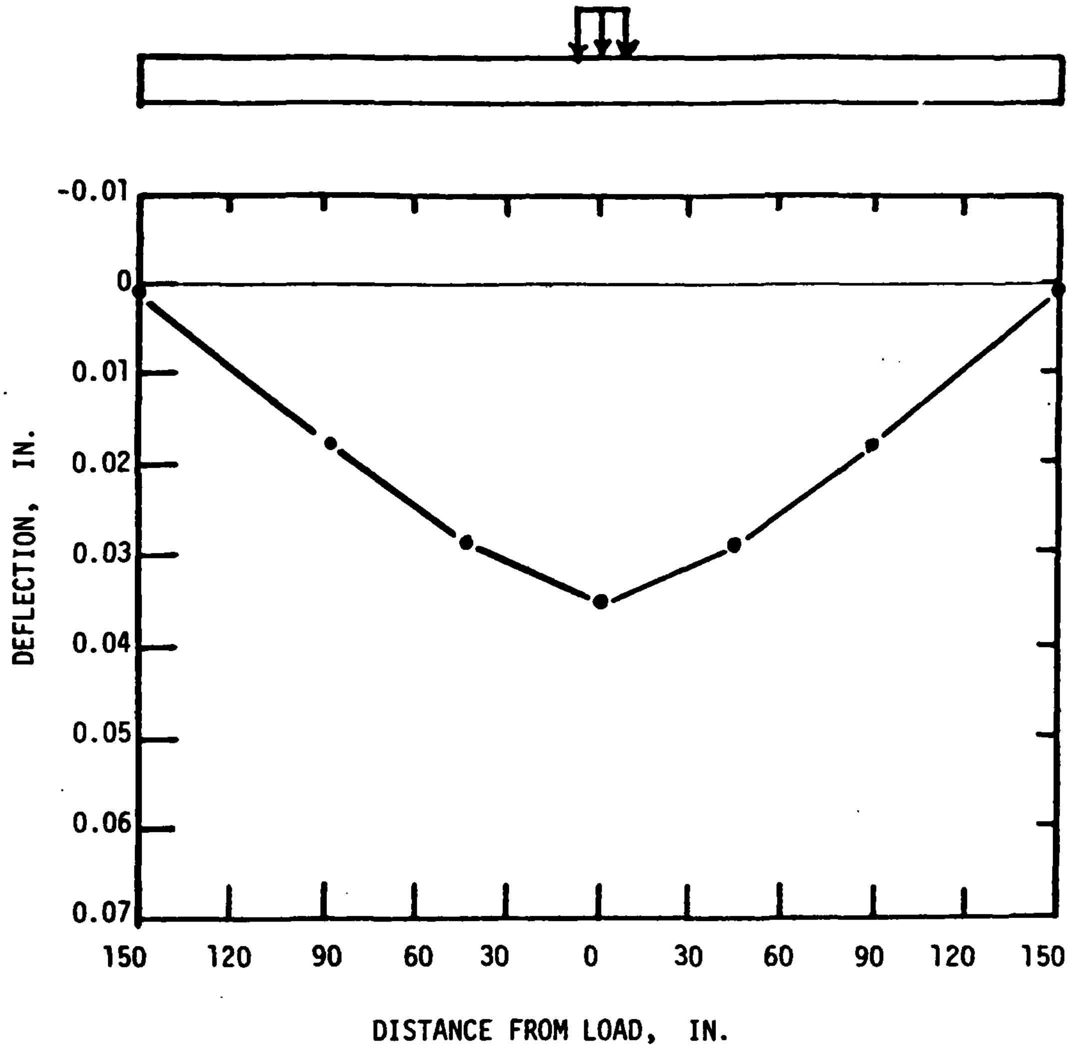

Figure 12. DISTRIBUTION OF DEFLECTIONS ALONG THE THICKENED EDGE SLAB

Example 5, Stabilized Base

Slab = 25 ft. square panel

Thickness = 12 in.

Modulus of elasticity = 5×10^6 psi

Poisson's ratio = 0.15

Base = Cement stabilized

Thickness = 6 in.

Modulus of elasticity = 1×10^6 psi

Poisson's ratio = 0.25

Composite Action Factor (COMP) = 1

Modulus of Subgrade Reaction = 200 pci

Load = 50,000 # at center of edge

Contact pressure = 222 psi

Contact area = 15 in. square

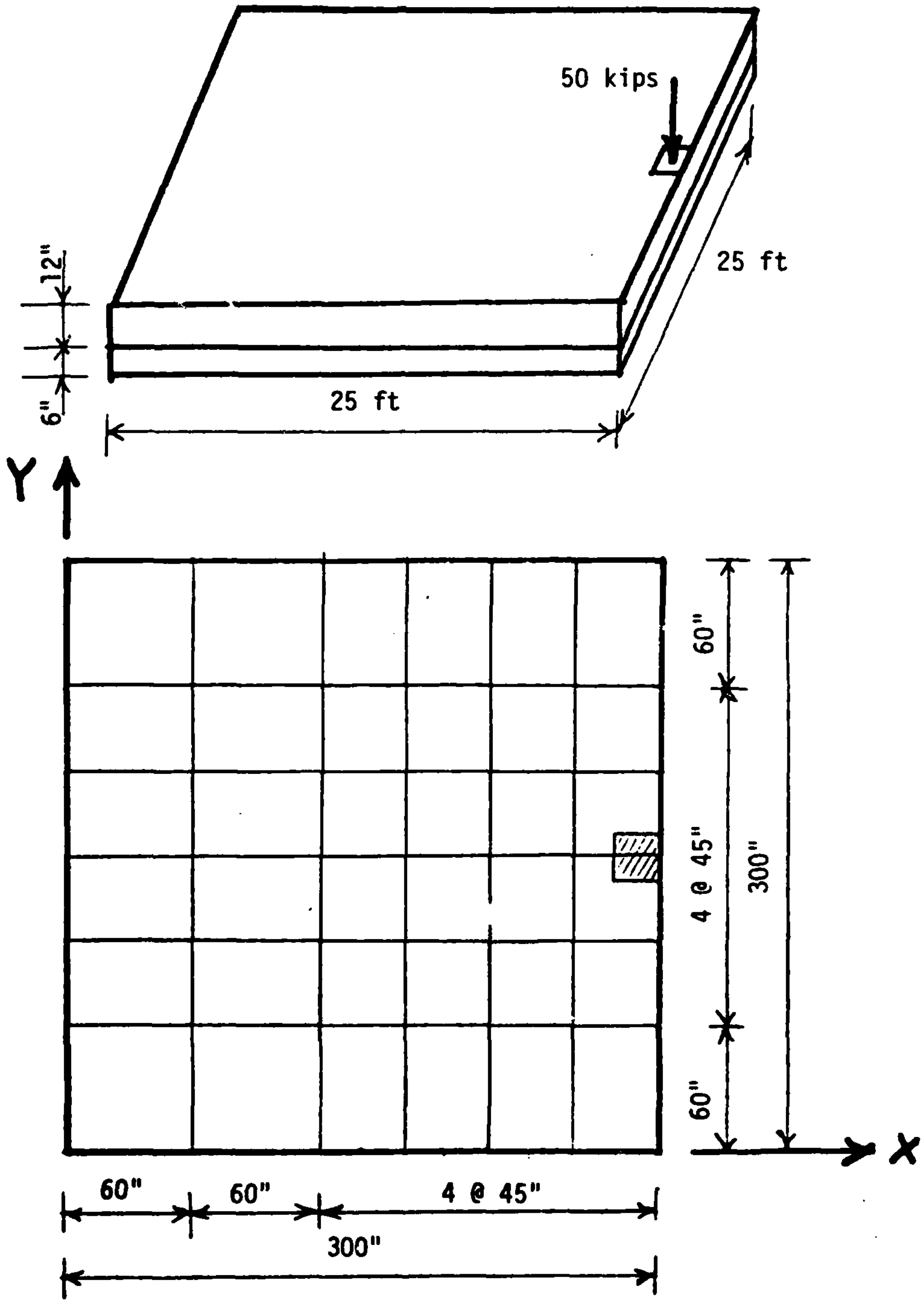

Figure 13. FINITE-ELEMENT MESH CONFIGURATION USED FOR EXAMPLE PROBLEM 5

IBM FORTRAN Coding Form GX28-7327-6 U/M 050** Printed in U.S.A.

PROGRAM: CONC. SLAB ON STAB. BASE

PROGRAMMER: AMIR

PAGE 1 OF 1

FORTRAN STATEMENT

```
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     0.000    60.000   105.000   150.000   195.000   240.000   300.000
    1    2    1   200.000
    12.000 0.500E+07     0.150
     6.000 0.100E+07     0.250
   33   222.222    30.000    45.000    37.500    45.000
   34   222.222    30.000    45.000     0.000     7.500
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*A standard card form, IBM electro 888157, is available for punching statements from this form

**Number of forms per pad may vary slightly

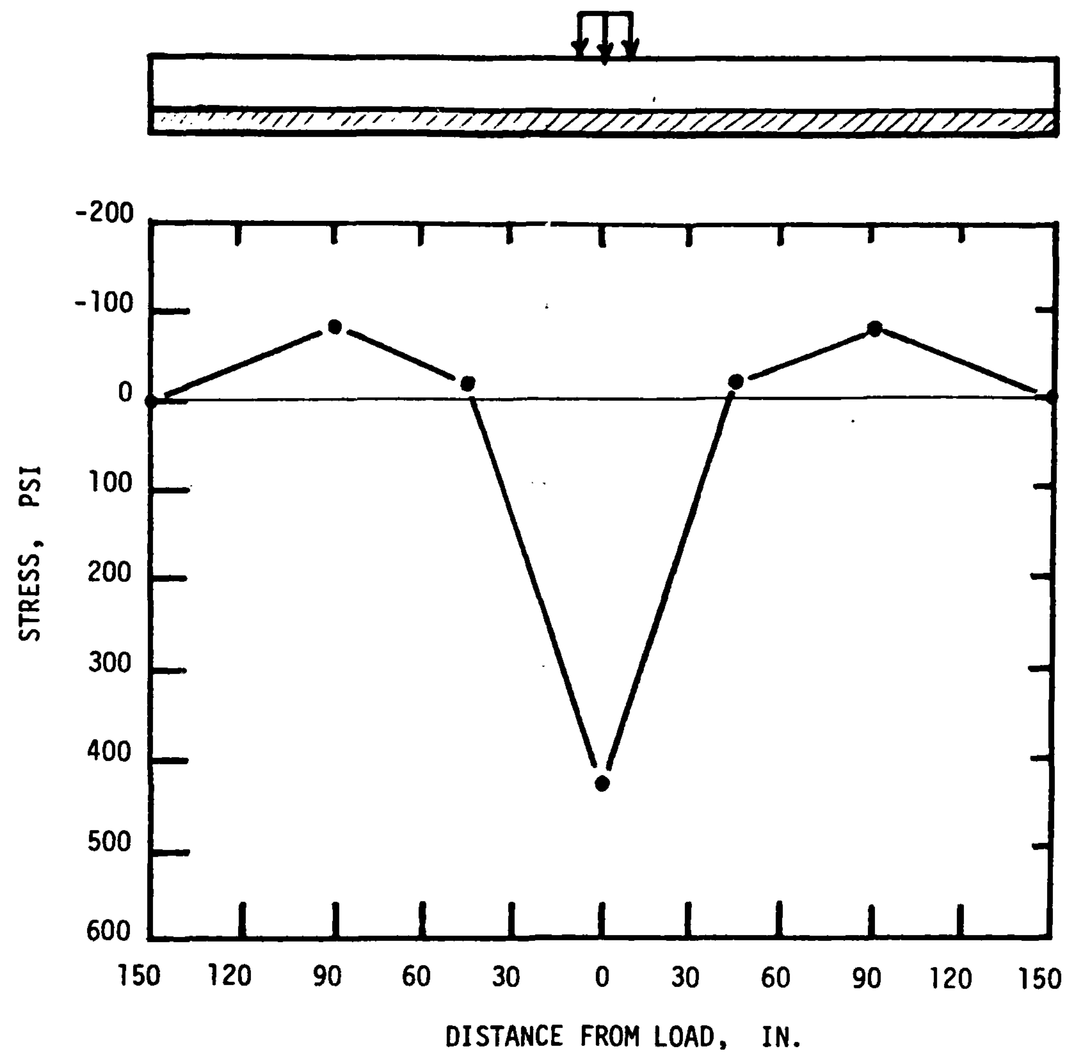

Figure 14. DISTRIBUTION OF STRESSES ALONG THE SLAB EDGE

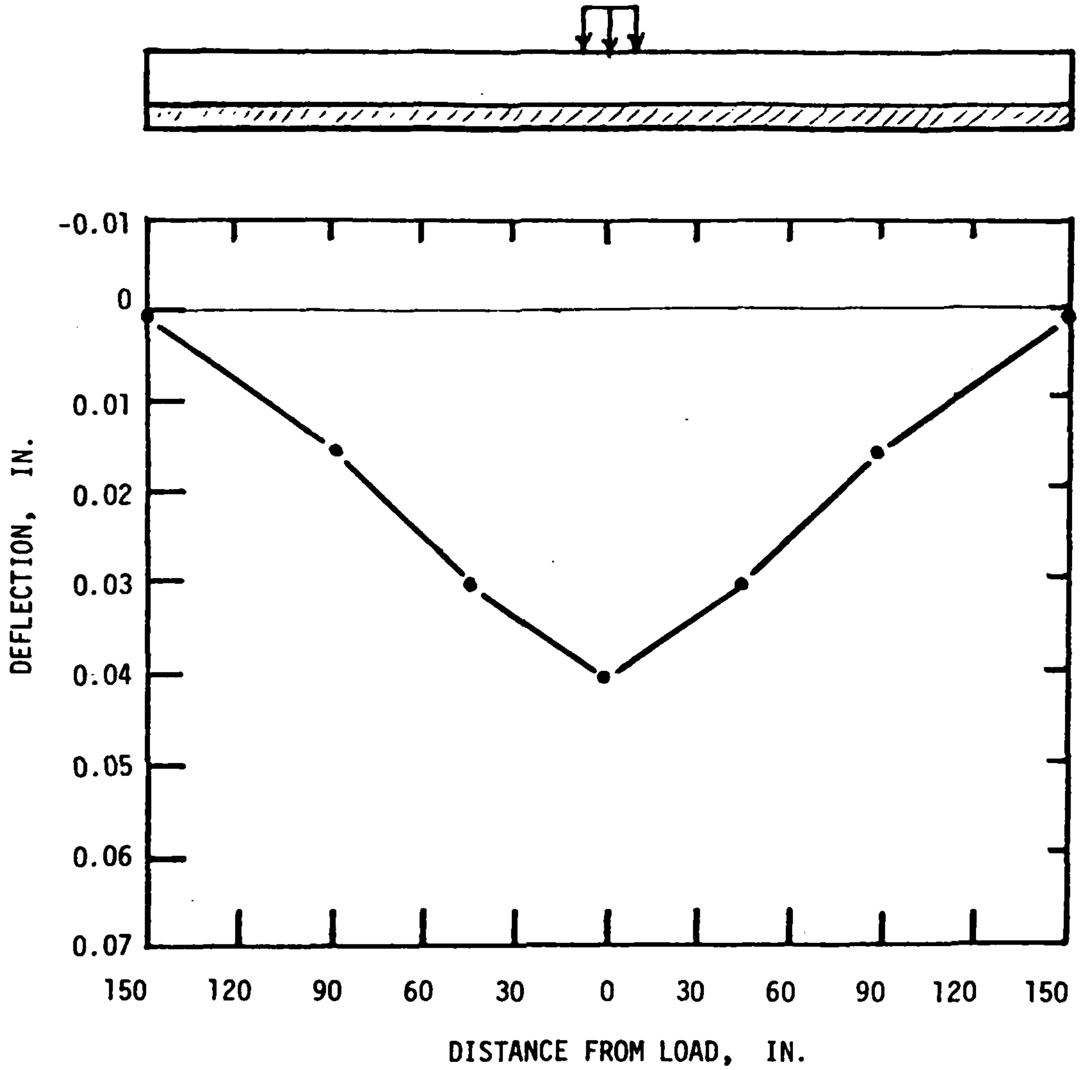

Figure 15. DISTRIBUTION OF DEFLECTIONS ALONG THE SLAB EDGE

PROGRAM LISTING

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      WRITE (6,97)
   97 FORMAT (//,20X,'*********************************************',
     1        //,20X,'*    JOINT PROGRAM                                *',
     2        //,20X,'*    FINITE ELEMENT ANALYSIS OF CONC. PAV.        *',
     3        //,20X,'*    AMIR M. TABATABAIE                           *',
     4        //,20X,'*    UNIVERSITY OF ILLINOIS            1977       *',
     5        //,20X,'*********************************************')
      READ (5,500) N1X,N2X,N3X,N1Y,N2Y,NFOR
  500 FORMAT (6I5)
      NX=N1X+N2X+N3X
      NY=N1Y+N2Y
      IDM9=NX*NY
      IDM8=IDM9*3
      IDM7=(NY+2)*3
      IDM6=IDM8*IDM7
      IDM5=(NX-1)*(NY-1)
      IDM4=NFOR
      CALL CCREZ (PROGRM,IDM9,IDM9,2,IDM9,IDM9,IDM9,IDM9,IDM9,
     1            2,2,4,90,90*2,IDM6,IDM6,IDM4,IDM4,IDM4,IDM4,IDM4,
     1            IDM4,IDM9,
     2            IDM8,IDM9*3,IDM9*3,IDM9*5,IDM9*5,IDM9*5,IDM9*5,
     3            IDM9,IDM9,IDM9,NX,NY,0,N1X,0,N2X,0,N3X,0,N1Y,0,N2Y,0,NY,
     4     0,NFOR,0,NX,0,IDM9,0,IDM8,0,IDM7,0,IDM6,0,IDM5,0,IDM4)
      STOP
      END
```

```
      SUBROUTINE PROGRM (X,Y,V,T1,T2,E1,E2,SUB,U,R,N,SF,S,ST,SU,NEL,PRS,
     1      X1,Y1,X2,Y2,FC,P,STR1,STR2,STRT1,STRB1,STRT2,STRB2,TT,XF,YF,
     2              XC,YC,N1X,N2X,N3X,N1Y,N2Y,NY,NFOR,NX,IDM9,IDM8,IDM7,
     3      IDM6,IDM5,IDM4)
      INTEGER COMP
      DIMENSION X(IDM9),Y(IDM9),V(2),T1(IDM9),T2(IDM9),E1(IDM9),
     1              E2(IDM9),SUB(IDM9),U(2),R(2),N(4),SF(90),S(90,2),
     2              ST(IDM6),SU(IDM6),NEL(IDM4),PRS(IDM4),X1(IDM4),
     3              Y1(IDM4),FC(IDM9),P(IDM8),STR1(IDM9,3),STR2(IDM9,3),
     4              STRT1(IDM9,5),STRB1(IDM9,5),STRT2(IDM9,5),STRB2(IDM9,5),
     5           TT(IDM9),XF(IDM9),YF(IDM9) ,XC(NX),YC(NY),X2(IDM4),
     6              Y2(IDM4)
    2 FORMAT  (8F10.3)
    3 FORMAT  (//,10X,'NO. OF NODES IN X-DIRECTION SLABS   1,4=',I5,//,
     *        10X,'NO. OF NODES IN X_DIRECTION SLABS   2,5=',I5,//,
     *        10X,'NO. OF NODES IN X_DIRECTION SLABS   3,6=',I5,//,
     *        10X,'NO. OF NODES IN Y_DIRECTION SLABS 1,2,3=',I5,//,
     *        10X,'NO. OF NODES IN Y_DIRECTION SLABS 4,5,6=',I5)
    4 FORMAT  (//,10X,'X-COORDINATES ARE:',//,10(3X,F10.3))
    5 FORMAT  (//,10X,'Y-COORDINATES ARE:',//,10(3X,F10.3))
    8 FORMAT  (3I5,F10.3)
    9 FORMAT  (//,10X,'NO. OF SLABS=',I5,//,10X,'NO. OF LAYERS=',I5,
     *     //,10X,'COMP. ACTION=',I5)
   11 FORMAT  (//,10X,'PROPERTIES OF THE TOP LAYER IS:')
   12 FORMAT  (F10.3,F10.3,F10.3)
   13 FORMAT  (/,10X,'POISSON RATIO OF TOP LAYER=',F10.3)
   16 FORMAT  (/,10X,'THICKNESS OF TOP LAYER=',F10.3)
   18 FORMAT  (8F10.3)
   19 FORMAT  (/,10X,'THICKNESS OF TOP LAYER AT THE NODES IS:',/,
     *     8(I5,F10.3))
   22 FORMAT  (/,10X,'MODULUS OF TOP LAYER=',E10.3)
   24 FORMAT  (8E10.3)
   25 FORMAT  (/,10X,'MODULUS OF TOP LAYER AT THE NODES IS:',/,
     *     8(I5,F10.3))
   27 FORMAT  (//,10X,'PROPERTIES OF THE BOTTOM LAYER IS:')
   29 FORMAT  (/,10X,'POISSON RATIO OF BOTTOM LAYER IS:',F10.3)
   31 FORMAT  (/,10X,'THICKNESS OF BOTTOM LAYER=',F10.3)
   33 FORMAT  (/,10X,'THICKNESS OF BOTTOM LAYER AT THE NODES IS:',/,
     *     8(I5,F10.3))
   36 FORMAT  (/,10X,'MODULUS OF BOTTOM LAYER=',E10.3)
   38 FORMAT  (/,10X,'MODULUS OF BOTTOM LAYER AT THE NODES IS:',/,
     *     8(I5,E10.3))
   42 FORMAT  (/,10X,'SUBGRADE MODULUS=',F10.3)
   44 FORMAT  (8F10.3)
   45 FORMAT  (//,10X,'SUBGRADE MODULUS AT THE NODES IS:',/,
     *     8(I5,F10.3))
    6 FORMAT  (2F10.3,E10.3,4F10.3,E10.3)
    7 FORMAT  (//,10X,'PROPERTIES OF THE DOWEL BARS ARE:',/,10X,
     *    'INSIDE DIA.=',F10.3,/,10X,'OUTSIDE DIA.=',F10.3,/,10X,
     *    'MODULUS OF ELASTICITY=',E10.3,/,10X,'SPACING=',F10.3,/,10X,
     *    'LENGTH=',F10.3,/,10X,'POISSON RATIO=',F10.3,
     *    /,10X,'DOWEL CONCRETE INTERACTION=',E10.3,
     *    //,10X,'JOINT WIDTH=',F10.3)
   61 FORMAT  (I5,5F10.3)
   62 FORMAT  (//,13X,'ELEMENT',5X,'PRESS',2X,'X1-COOR.',2X,'X2-COOR.',
     *          2X,'Y1-COOR.',2X,'Y2-COOR.')
   64 FORMAT  (/,10X,I5,5X,5F10.3)
   70 FORMAT  (//,11X,'NODE',5X,'DEFLECTION',5X,'X_ROTATION',
     *    5X,'Y_ROTATION',15X,'SUBGRADE STRESS',/)
```

```
71 FORMAT (10X,I5,3(2X,F13.6),20X,F10.3)
79 FORMAT (//,11X,'NODE',10X,'DEPTH',6X,'X_STRESS',8X,'Y_STRESS',
  *    8X,'XY_STRESS',7X,'MAX_STRESS',6X,'MIN_STRESS',/)
81 FORMAT (/,10X,I5,5X,F10.3,5(3X,F13.6))
82 FORMAT (20X,F10.3,5(3X,E13.6))
83 FORMAT (//,11X,'NODE',9X,'TRANSFERRED LOAD',21X,'NODE',9X,
  * 'TRANSFERRED LOAD',/)
85 FORMAT (10X,I5,10X,F10.3,20X,I5,10X,F10.3)
190 FORMAT (//,10X,'*********** JOINTS IN X_DIRECTION **********')
191 FORMAT (//,10X,'*********** JOINT  IN Y_DIRECTION **********')
200 FORMAT (I5)
211 FORMAT (//,10X,'TYPE OF LOAD TRANSFER IS AGGREGATE INTERLOCK')
212 FORMAT (//,10X,'TYPE OF LOAD TRANSFER IS STEEL BARS')
213 FORMAT (//,10X,'TYPE OF LOAD TRANSFER IS COMB. OF AGG. INTERLOCK A
  *ND STEEL BARS')
202 FORMAT (F10.3)
203 FORMAT (//,10X,'AGGREGATE INTERLOCK FACTOR=',F10.3)
    DO 1 I=1,IDM9
    X(I)=0.
    Y(I)=0.
    T1(I)=0.
    T2(I)=0.
    E1(I)=0.
    E2(I)=0.
  1 SUB(I)=0.
    READ (5,2) (XC(I),I=1,NX)
    READ (5,2) (YC(I),I=1,NY)
    WRITE (6,3) N1X,N2X,N3X,N1Y,N2Y
    WRITE (6,4) (XC(I),I=1,NX)
    WRITE (6,5) (YC(I),I=1,NY)
    DO 10 I=1,IDM9
    J=(I-1)/NY
    X(I)=XC(J+1)
 10 Y(I)=YC(I-J*NY)
    READ (5,8) NSLAB,NLAYER,COMP,CK
    WRITE (6,9) NSLAB,NLAYER,COMP
    WRITE (6,11)
    READ (5,12) CT1,CE1,V(1)
    WRITE (6,13) V(1)
    IF (CT1.EQ.0.) GO TO 14
    DO 15 I=1,IDM9
 15 T1(I)=CT1
    WRITE (6,16) CT1
    GO TO 17
 14 READ (5,18) (T1(I),I=1,IDM9)
    WRITE (6,19) (I,T1(I),I=1,IDM9)
 17 IF (CE1.EQ.0.) GO TO 20
    DO 21 I=1,IDM9
 21 E1(I)=CE1
    WRITE (6,22) CE1
    GO TO 23
 20 READ (5,24) (E1(I),I=1,IDM9)
    WRITE (6,25) (I,E1(I),I=1,IDM9)
 23 IF (NLAYER.EQ.1) GO TO 26
    WRITE (6,27)
    READ (5,12) CT2,CE2,V(2)
    WRITE (6,28) V(2)
    IF (CT2.EQ.0.) GO TO 29
    DO 30 I=1,IDM9
```

```
   30 T2(I)=CT2
      WRITE (6,31) CT2
      GO TO 32
   29 READ (5,18) (T2(I),I=1,IDM9)
      WRITE (6,33) (I,T2(I),I=1,IDM9)
   32 IF (CE2.EQ.0.) GO TO 34
      DO 35 I=1,IDM9
   35 E2(I)=CE2
      WRITE (6,36) CE2
      GO TO 37
   34 READ (5,24) (E2(I),I=1,IDM9)
      WRITE (6,38) (I,E2(I),I=1,IDM9)
      GO TO 37
   26 DO 39 I=1,IDM9
   39 T2(I)=0.
   37 IF (CK.EQ.0.) GO TO 40
      DO 41 I=1,IDM9
   41 SUB(I)=CK
      WRITE (6,42) CK
      GO TO 43
   40 READ (5,44) (SUB(I),I=1,IDM9)
      WRITE (6,45) (I,SUB(I),I=1,IDM9)
   43 CONTINUE
       IF (NSLAB.EQ.1) GO TO 49
      IF (N2X.EQ.0) GO TO 999
      READ (5,200) LTDX
      WRITE (6,190)
      IF (LTDX.EQ.1) WRITE (6,212)
      IF (LTDX.EQ.0) WRITE (6,211)
      IF (LTDX.EQ.2) WRITE (6,213)
      IF (LTDX.EQ.0) GO TO 201
      READ (5,6) DINX,DOUTX,DEX,DSX,DLX,DJWX,DPRX,DCIX
      WRITE (6,7) DINX,DOUTX,DEX,DSX,DLX,DPRX,DCIX,DJWX
      DIX=0.049087*(DOUTX**4-DINX**4)
      IF (DINX.EQ. .) GO TO 149
      SHAX=0.350617*(DOUTX-DINX)*((DOUTX**2+DINX**2)**2)/((DOUTX+
     1      DINX)**3)
      GO TO 150
  149 SHAX=0.706858*(DOUTX**2)
  150 FYX=24.*DIX*(1.+DPRX)/(SHAX*DJWX**2)
      IF (LTDX.EQ.1) GO TO 999
  201 READ (5,202) AGGX
      WRITE (6,203) AGGX
  999 IF (N2Y.EQ.0) GO TO 49
      READ (5,200) LTDY
      WRITE (6,191)
      IF (LTDY.EQ.1) WRITE (6,212)
      IF (LTDY.EQ.0) WRITE (6,211)
      IF (LTDY.EQ.2) WRITE (6,213)
      IF (LTDY.EQ.0) GO TO 301
      READ (5,6) DINY,DOUTY,DEY,DSY,DLY,DJWY,DPRY,DCIY
      WRITE (6,7) DINY,DOUTY,DEY,DSY,DLY,DPRY,DCIY,DJWY
      DIY=0.049087*(DOUTY**4-DINY**4)
      IF (DINY.EQ.0.) GO TO 349
      SHAY=0.350617*(DOUTY-DINY)*((DOUTY**2+DINY**2)**2)/((DOUT+
     *      DINY)**3)
      GO TO 350
  349 SHAY=0.706858*(DOUTY**2)
  350 FYY=24.*DIY*(1.+DPRY)/(SHAY*DJWY**2)
```

```
      IF (LTDY.EQ.1) GO TO 49
  301 READ (5,202) AGGY
      WRITE (6,203) AGGY
   49 U(1)=0.5*(1.-V(1))
      U(2)=0.5*(1.-V(2))
      DO 50 I=1,2
   50 R(I)=0.
      DO 51 I=1,90
      SF(I)=0.
      S(I,1)=0.
   51 S(I,2)=0.
      DO 52 I=1,4
   52 N(I)=0
      DO 53 I=1,IDM6
      ST(I)=0.
   53 SU(I)=0.
      DO 54 I=1,IDM9
      FC(I)=0.
      XF(I)=0.
   54 YF(I)=0.
      DO 55 I=1,IDM8
   55 P(I)=0.
      CALL STIFP (IDM5,NX,N1Y,N2Y,NY,
     *                        X,Y,IDM9,NSLAB,N1X,N2X,N3X,SF,SUB,T1,E1,V,
     1            T2,E2,U,R,S,N,IDM7,ST,IDM6,COMP,NLAYER,
     2      DINX,DOLTX,DEX,DSX,DLX,DJWX,DIX,DPRX,FYX,LTDX,AGGX,
     3      DINY,DOLTY,DEY,DSY,DLY,DJWY,DIY,DPRY,FYY,LTDY,AGGY,DCIX,DCIY)
      CALL UPTRI (IDM7,IDM8,SU,ST,IDM6)
      DO 60 I=1,IDM4
   60 READ (5,61) NEL(I),PRS(I),X1(I),X2(I),Y1(I),Y2(I)
      WRITE (6,62)
      DO 63 I=1,IDM4
   63 WRITE (6,64) NEL(I),PRS(I),X1(I),X2(I),Y1(I),Y2(I)
      CALL LOAD (IDM4,NEL,PRS,X1,Y1,NY,X,Y,IDM9,    P,IDM8,X2,Y2)
      CALL DISP (IDM7,IDM8,P,SU,ST,IDM6)
      WRITE (6,70)
      DO 98 I=1,IDM9
      FC(I)=P((I-1)*3+1)*SUB(I)
      IF (FC(I).LE.0.) FC(I)=0.
   98 WRITE (6,71) I,P((I-1)*3+1),P((I-1)*3+2),P((I-1)*3+3),FC(I)
      CALL STRESS (IDM9,N1X,N2X,N3X,NX,N1Y,N2Y,NY,
     *                              STR1,STR2,STRT1,STRB1,STRT2,
     1            STRB2,P,IDM8,X,Y,V,U,NLAYER,E1,E2,T1,T2,COMP,TT,
     2      NSLAB,X  ,YF,DEX,DSX,DIX,DJWX,DPRX,FYX,LTDX,AGGX,
     3      DEY,DSY,DIY,DJWY,DPRY,FYY,LTDY,AGGY,DCIX,DCIY)
      TS=0.
      WRITE (6,79)
      DO 80 I=1,IDM9
      WRITE (6,81) I,TS,(STRT1(I,J),J=1,5)
      WRITE (6,82) T1(I),(STRB1(I,J),J=1,5)
      WRITE (6,82) T1(I),(STRT2(I,J),J=1,5)
   80 WRITE (6,82) TT(I),(STRB2(I,J),J=1,5)
      IF (NSLAB.EQ.1) GO TO 90
      IF (N2X.EQ.0) GO TO 890
      IF (LTDX.EQ.0) GO TO 890
      WRITE (6,190)
      WRITE (6,83)
      J11=(N1X-1)*NY+1
      J33=N1X*NY
```

```
      DO 84 K=J11,J33
      J1=K
      J2=K+NY
   84 WRITE (6,85) J1,XF(J1),J2,XF(J2)
      IF (N3X.EQ.0) GO TO 890
      L11=(N1X+N2X-1)*NY+1
      L33=(N1X+N2X)*NY
      DO 86 K=L11,L33
      L1=K
      L2=K+NY
   86 WRITE (6,85) L1,XF(L1),L2,XF(L2)
  890 IF (ITEY.EQ.0) GO TO 90
      IF (N2Y.EQ.0) GO TO 90
      IF (ITEY.EQ.0) GO TO 90
      WRITE (6,191)
      WRITE (6,63)
      NX=N1X+N2X+N3X
      JJ11=(NX-1)* Y+N1Y
      DO 886 K=N1Y,JJ11,NY
      LL1=K
      LL2=K+1
  886 WRITE (6,85) LL1,YF(LL1),LL2,YF(LL2)
   90 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE STIFF (IDM5,NX,N1Y,N2Y,NY,
                        X,Y,IDM9,NSLAB,N1X,N2X,N3X,SF,SUR,
     1      T1,E1,V,T2,E2,U,R,S,N,IDM7,ST,IDM6,COMP,NLAYER,
     2      DINX,DOUTX,DIX,DSX,DIX,DJWX,DIX,DPRX,FYX,LTDX,AGGX,
     3      DINY,DOUTY,DEY,DSY,DIY,DJWY,DIY,DPRY,FYY,LTDY,AGGY,DCIX,DCIY)
      INTEGER COMP
      DIMENSION X(IDM9),Y(IDM9),SF(90),SUB(IDM9),T1(IDM9),E1(IDM9),
     1      V(2),T2(IDM9),E2(IDM9),U(2),R(2),S(90,2),N(4),ST(IDM6)
      DO 101 I=1,IDM5
      NE1=I+(I-1)/(NY-1)
      NE2=NE1+1
      NE3=NE1+NY
      NE4=NE1+NY+1
      A=(X(NE3)-X(NE1))/2.
      B=(Y(NE2)-Y(NE1))/2.
      DO 1911 JK=1,90
      SF(JK)=0.
      IF (NSLAB.EQ.1) GO TO 102
      IF (A.EQ.0..AND.B.EQ.0.) GO TO 101
      IF (A.EQ.0.) GO TO 600
      IF (B.EQ.0.). GO TO 601
      GO TO 102
      IF (LTDX.EQ.0) GO TO 510
      DIX=DIX*DIX*E/DSX
      IF (DJWX.LT.0.01) DJWX=0.01
      DCX=DCIX*B/D X
      D5X=12.*DDX/(DJWX**3*(1.+FYX))
      D2X=6.*DIX/(DJWX**2*(1.+FYX))
      D3X=(4.+FYX)*DIX/(DJWX*(1.+FYX))
      D4X=(2.-FYX)*DIX/(DJWX*(1.+FYX))
      D1X=(1./((1./DCX)+(1./D5X)))
      SF(1)=D1X
      SF(3)=D2X
      SF(9)=D3X
      SF(19)=-D1X
      SF(21)=D2X
      SF(25)=-D2X
      SF(27)=D4X
      SF(37)=D1X
      SF(39)=D2X
      SF(45)=D3X
      SF(55)=-D1X
      SF(57)=D2X
      SF(61)=-D2X
      SF(63)=D4X
      SF(64)=D1X
      SF(66)=-D2X
      SF(72)=D3X
      SF(82)=D1X
      SF(84)=-D2X
      SF(90)=D3X
      IF (LTDX.EQ.1) GO TO 303
      AGX=AGGX*B
      SF(1)=SF(1)+AGX
      SF(19)=SF(19)-AGX
      SF(37)=SF(37)+AGX
      SF(55)=SF(55)-AGX
      SF(64)=SF(64)+AGX
      SF(82)=SF(82)+AGX
```

```
      GO TO 303
  601 IF (LTDY.EQ.0) GO TO 610
      DDY=DLY*DLY*A/DSY
      IF (DJWY.LE.0.01) DJWY=0.01
      DCY=DCLY*A/DSY
      D5Y=12.*DDY/(DJWY**3*(1.+FYY))
      D2Y=6.*DDY/(DJWY**2*(1.+FYY))
      D3Y=(4.+FYY)*DDY/(DJWY*(1.+FYY))
      D4Y=(2.-FYY)*DDY/(DJWY*(1.+FYY))
      D1Y=(1./((1./DCY)+(1./D5Y)))
      SF(1)=D1Y
      SF(2)=-D2Y
      SF(10)=-D1Y
      SF(11)=-D2Y
      SF(5)=D3Y
      SF(13)=D2Y
      SF(14)=D4Y
      SF(37)=D1Y
      SF(39)=D2Y
      SF(41)=D3Y
      SF(64)=D1Y
      SF(65)=-D2Y
      SF(73)=-D1Y
      SF(74)=-D2Y
      SF(68)=D3Y
      SF(76)=D2Y
      SF(77)=D4Y
      SF(82)=D1Y
      SF(83)=D2Y
      SF(86)=D3Y
      IF (LTDY.EQ.1) GO TO 303
  610 AGY=AGGY*A
      SF(1)=SF(1)+AGY
      SF(10)=SF(10)-AGY
      SF(37)=SF(37)+AGY
      SF(64)=SF(64)+AGY
      SF(73)=SF(73)-AGY
      SF(82)=SF(82)+AGY
      GO TO 303
  102 AVSUB=(SUB(NE1)+SUB(NE2)+SUB(NE3)+SUB(NE4))/4.
      IF (NLAYER.EQ.2.AND.COMP.EQ.1) GO TO 8005
      AVT1=(T1(NE1)+T1(NE2)+T1(NE3)+T1(NE4))/4.
      AVE1=(E1(NE1)+E1(NE2)+E1(NE3)+E1(NE4))/4.
      R1=AVE1*AVT1**3/(12.*(1.-V(1)**2))
      IF (NLAYER.EQ.2) GO TO 8003
      R2=0.
      V(2)=0.
      GO TO 8004
 8003 AVT2=(T2(NE1)+T2(NE2)+T2(NE3)+T2(NE4))/4.
      AVE2=(E2(NE1)+E2(NE2)+E2(NE3)+E2(NE4))/4.
      R2=AVE2*AVT2**3/(12.*(1.-V(2)**2))
      GO TO 8004
 8005 AVT1=(T1(NE1)+T1(NE2)+T1(NE3)+T1(NE4))/4.
      AVT2=(T2(NE1)+T2(NE2)+T2(NE3)+T2(NE4))/4.
      AVE1=(E1(NE1)+E1(NE2)+E1(NE3)+E1(NE4))/4.
      AVE2=(E2(NE1)+E2(NE2)+E2(NE3)+E2(NE4))/4.
      ENA2=0.5*AVT1*(AVT1+AVT2)/(AVT1+AVT2*AVE2/AVE1)
      ENA1=0.5*(AVT1+AVT2)-ENA2
      AVT13=0.5*((AVT1+2.*ENA1)**3+(AVT1-2.*ENA1)**3)
```

```
      AVT23=0.5*((AVT2+2.*ENA2)**3+(AVT2-2.*EKA2)**3)
      B1=AVT1*AVT1 /(12.*(1.-V(1)**2))
      B2=AVT2*AVT23/(12.*(1.-V(2)**2))
 8004 B2=2.*B
      A2=2.*A
      BS4=4.*B**2
      AS4=4.*A**2
      AB4=4.*A*B
      AB=A*B
      BS=(B/A)**2
      AS=(A/B)**2
      R(1)=B1/(60.*AB)
      R(2)=B2/(60.*AB)
      DO 336 J=1,2
      S(1,J)=R(J)*(60.*BS+60.*AS+30.*V(J)+84.*U(J))
      S(2,J)=R(J)*(-30.*AS-15.*V(J)-6.*U(J))*B2
      S(3,J)=R(J)*(30.*BS+15.*V(J)+6.*U(J))*A2
      S(4,J)=0.
      S(5,J)=R(J)*(20.*AS+8.*U(J))*BS4
      S(6,J)=R(J)*(-15.*V(J))*AB4
      S(7,J)=0.
      S(8,J)=0.
      S(9,J)=R(J)*(20.*BS+8.*U(J))*AS4
      S(10,J)=R(J)*(30.*BS-60.*AS-30.*V(J)-84.*U(J))
      S(11,J)=R(J)*(-30.*AS-6.*U(J))*B2
      S(12,J)=R(J)*(15.*BS-15.*V(J)-6.*U(J))*A2
      S(13,J)=-S(11,J)
      S(14,J)=R(J)*(10.*AS-2.*U(J))*BS4
      S(15,J)=0.
      S(16,J)=S(12,J)
      S(17,J)=0.
      S(18,J)=R(J)*(10.*BS-8.*U(J))*AS4
      S(19,J)=R(J)*(-60.*BS+30.*AS-30.*V(J)-84.*U(J))
      S(20,J)=R(J)*(-15.*AS+15.*V(J)+6.*U(J))*B2
      S(21,J)=R(J)*(30.*BS+6.*U(J))*A2
      S(22,J)=S(20,J)
      S(23,J)=R(J)*(10.*AS-8.*U(J))*BS4
      S(24,J)=0.
      S(25,J)=-S(21,J)
      S(26,J)=0.
      S(27,J)=R(J)*(10.*BS-2.*U(J))*AS4
      S(28,J)=R(J)*(-30.*BS-30.*AS+30.*V(J)+84.*U(J))
      S(29,J)=R(J)*(-15.*AS+6.*U(J))*B2
      S(30,J)=R(J)*(15.*BS-6.*U(J))*A2
      S(31,J)=-S(2 ,J)
      S(32,J)=R(J)*(5.*AS+2.*U(J))*BS4
      S(33,J)=0.
      S(34,J)=-S(30,J)
      S(35,J)=0.
      S(36,J)=R(J)*(5.*BS+2.*U(J))*AS4
      S(37,J)=S(1,J)
      S(38,J)=-S(2 J)
      S(39,J)=S(3,J)
      S(40,J)=0.
      S(41,J)=S(5,J)
      S(42,J)=-S(6,J)
      S(43,J)=0.
      S(44,J)=0.
      S(45,J)=S(9,J)
```

```
      S(46,J)=S(28,J)
      S(47,J)=-S(29,J)
      S(48,J)=S(30,J)
      S(49,J)=-S(31,J)
      S(50,J)=S(32,J)
      S(51,J)=0.
      S(52,J)=S(34,J)
      S(53,J)=0.
      S(54,J)=S(36,J)
      S(55,J)=S(19,J)
      S(56,J)=-S(20,J)
      S(57,J)=S(21,J)
      S(58,J)=-S(22,J)
      S(59,J)=S(23,J)
      S(60,J)=0.
      S(61,J)=S(25,J)
      S(62,J)=0.
      S(63,J)=S(27,J)
      S(64,J)=S(1,J)
      S(65,J)=S(2,J)
      S(66,J)=-S(3,J)
      S(67,J)=0.
      S(68,J)=S(5,J)
      S(69,J)=-S(6,J)
      S(70,J)=0.
      S(71,J)=0.
      S(72,J)=S(9,J)
      S(73,J)=S(10,J)
      S(74,J)=S(11,J)
      S(75,J)=-S(12,J)
      S(76,J)=S(13,J)
      S(77,J)=S(14,J)
      S(78,J)=0.
      S(79,J)=-S(16,J)
      S(80,J)=0.
      S(81,J)=S(18,J)
      S(82,J)=S(1,J)
      S(83,J)=-S(2,J)
      S(84,J)=-S(3,J)
      S(85,J)=0.
      S(86,J)=S(5,J)
      S(87,J)=S(6,J)
      S(88,J)=0.
      S(89,J)=0.
  300 S(90,J)=S(9,J)
      DO 301 K=1,90
  301 SF(K)=S(K,1)+S(K,2)
      Q=(AB*AVSUB)/44100.
      Q1=A*Q
      Q2=B*Q
      Q3=A*A*Q
      Q4=B*B*Q
      Q5=A*B*Q
      SF(1)=SF(1)+24178.*Q
      SF(2)=SF(2)-6454.*Q2
      SF(3)=SF(3)+6454.*Q1
      SF(5)=SF(5)+2240.*Q4
      SF(6)=SF(6)-1764.*Q5
      SF(9)=SF(9)+2240.*Q3
```

```
SF(10)=SF(10)+8582.*Q
SF(11)=SF(11)+3836.*Q2
SF(12)=SF(12)+2786.*Q1
SF(13)=SF(13)-3836.*Q2
SF(14)=SF(14)-1680.*Q4
SF(15)=SF(15)-1176.*Q5
SF(16)=SF(16)+2786.*Q1
SF(17)=SF(17)+1176.*Q5
SF(18)=SF(18)+1120.*Q3
SF(19)=SF(19)+8592.*Q
SF(20)=SF(20)-2786.*Q2
SF(21)=SF(21)-3836.*Q1
SF(22)=SF(22)-2786.*Q2
SF(23)=SF(23)+1120.*Q4
SF(24)=SF(24)+1176.*Q5
SF(25)=SF(25)+3836.*Q1
SF(26)=SF(26)-1176.*Q5
SF(27)=SF(27)-1680.*Q3
SF(28)=SF(28)+2758.*Q
SF(29)=SF(29)+1624.*Q2
SF(30)=SF(30)-1624.*Q1
SF(31)=SF(31)-1624.*Q2
SF(32)=SF(32)-840.*Q4
SF(33)=SF(33)+784.*Q5
SF(34)=SF(34)+1624.*Q1
SF(35)=SF(35)+784.*Q5
SF(36)=SF(36)-840.*Q3
SF(37)=SF(37)+24178.*Q
SF(38)=SF(38)+6454.*Q2
SF(39)=SF(39)+6454.*Q1
SF(41)=SF(41)+2240.*Q4
SF(42)=SF(42)+1764.*Q5
SF(45)=SF(45)+2240.*Q3
SF(46)=SF(46)+2758.*Q
SF(47)=SF(47)-1624.*Q2
SF(48)=SF(48)-1624.*Q1
SF(49)=SF(49)+1624.*Q2
SF(50)=SF(50)-840.*Q4
SF(51)=SF(51)-794.*Q5
SF(52)=SF(52)+1624.*Q1
SF(53)=SF(53)-784.*Q5
SF(54)=SF(54)-840.*Q3
SF(55)=SF(55)+8582.*Q
SF(56)=SF(56)+2786.*Q2
SF(57)=SF(57)-3836.*Q1
SF(58)=SF(58)+2786.*Q2
SF(59)=SF(59)+1120.*Q4
SF(60)=SF(60)-1176.*Q5
SF(61)=SF(61)+3836.*Q1
SF(62)=SF(62)+1176.*Q5
SF(63)=SF(63)-1680.*Q3
SF(64)=SF(64)+24178.*Q
SF(65)=SF(65)-6454.*Q2
SF(66)=SF(66)-6454.*Q1
SF(68)=SF(68)+2240.*Q4
SF(69)=SF(69)+1764.*Q5
SF(72)=SF(72)+2240.*Q3
SF(73)=SF(73)+8582.*Q
SF(74)=SF(74)-3836.*Q2
```

```
      SF (75)=SF (75)-2786.*Q1
      SF (76)=SF (76)+3930.*Q2
      SF (77)=SF (77)-1680.*Q4
      SF (78)=SF (78)-1176.*Q5
      SF (79)=SF (79)-2786.*Q1
      SF (80)=SF (80)+1176.*Q5
      SF (81)=SF (81)+1120.*Q3
      SF (82)=SF (82)+24178.*Q
      SF (83)=SF (83)+6454.*Q2
      SF (84)=SF (84)-6454.*Q1
      SF (86)=SF (86)+2240.*Q4
      SF (87)=SF (87)-1764.*Q5
      SF (90)=SF (90)+2240.*Q3
 303  N (1)=NE1
      N (2)=NE2
      N (3)=NE3
      N (4)=NE4
      II=0
      DO 302 I1=1,4
      DO 302 I2=I1,4
      II=II+1
      DO 302 I3=1,3
      DO 302 I4=1,3
      JJ=I4+(I3-1)*3+(II-1)*9
      IF (I1.EQ.I2.AND.I4.LT.I3) GO TO 302
      KK=(N(I1)-1)*IDM7*3+I4-I3+1+(I3-1)* IDM7+(N(I2)-N(I1))*3
      ST (KK)=ST (KK)+SF(JJ)
 302  CONTINUE
 101  CONTINUE
      RETURN
      END
```

```
      SUBROUTINE UITEI (IDM7,IDM8,SU,ST,IDM6)
      DIMENSION SU(IDM6),ST(IDM6)
      I1=IDM7-1
      I2=IDM8-IDM7+1
      DO 1000 I=1,I2
      J=(I-1)*IDM7+1
      SU(J)=ST(J)
      DO 1001 K=1,I1
      SU(J+K)=ST(J+K)
 1001 ST(J+K)=ST(J+K)/SU(J)
      I3=I1
      DO 1000 L=1,I1
      M=J+L*IDM7-1
      DO 1002 K=1,I3
 1002 ST(M+K)=ST(M+K)-ST(J+K+I1-I3)*SU(J+L)
 1000 I3=I3-1
      I2=I2+1
      I4=I1-1
      DO 1003 I=I2,IDM8
      J=(I-1)*IDM7+1
      SU(J)=ST(J)
      IF (1-I4) 1004,1004,1005
 1004 DO 1006 K=1,I4
 1006 SU(J+K)=ST(J+K)
 1005 DO 1007 K=1,I1
 1007 ST(J+K)=ST(J+K)/SU(J)
      I3=I1-1
      IF (I-IDM8) 1008,1003,1008
 1008 DO 1010 L=1,I4
      M=J+L*IDM7-1
      DO 1011 K=1,I3
 1011 ST(M+K)=ST(M K)-ST(J+K+I1-I3-1)*SU(J+L)
      I3=I3-1
      IF (1-I3) 1010,1010,1012
 1010 CONTINUE
 1012 I4=I4-1
 1003 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE LOAD (IDM4,NEL,PRS,X1,Y1,NY,X,Y,IDM9,P,IDM8,X2,Y2)
      DIMENSION NEL(IDM4),PRS(IDM4),X1(IDM4),Y1(IDM4),X(IDM9),Y(IDM9),
     1          P(IDM8),X2(IDM4),Y2(IDM4)
      DO 2006 I=1,IDM4
      NE1=NEL(I)+(NEL(I)-1)/(NY-1)
      NE2=NE1+1
      NE3=NE1+NY
      NE4=NE1+NY+1
      A=(X(NE3)-X(NE1))/2.
      B=(Y(NE2)-Y(NE1))/2.
      F1=PRS(I)*(X2(I)-X1(I))*(Y2(I)-Y1(I))
      F2=PRS(I)*(X2(I)**2-X1(I)**2)*(Y2(I)-Y1(I))/2.
      F3=PRS(I)*(X2(I)-X1(I))*(Y2(I)**2-Y1(I)**2)/2.
      F4=PRS(I)*(X2(I)**3-X1(I)**3)*(Y2(I)-Y1(I))/3.
      F5=PRS(I)*(X2(I)**2-X1(I)**2)*(Y2(I)**2-Y1(I)**2)/4.
      F6=PRS(I)*(X2(I)-X1(I))*(Y2(I)**3-Y1(I)**3)/3.
      F7=PRS(I)*(X2(I)**4-X1(I)**4)*(Y2(I)-Y1(I))/4.
      F8=PRS(I)*(X2(I)**3-X1(I)**3)*(Y2(I)**2-Y1(I)**2)/6.
      F9=PRS(I)*(X2(I)**2-X1(I)**2)*(Y2(I)**3-Y1(I)**3)/6.
      F10=PRS(I)*(X2(I)-X1(I))*(Y2(I)**4-Y1(I)**4)/4.
      F11=PRS(I)*(X2(I)**4-X1(I)**4)*(Y2(I)**2-Y1(I)**2)/8.
      F12=PRS(I)*(X2(I)**2-X1(I)**2)*(Y2(I)**4-Y1(I)**4)/8.
      J1=(NE1-1)*3+1
      L1=(NE2-1)*3+1
      K1=(NE3-1)*3+1
      M1=(NE4-1)*3+1
      A2=A**2
      B2=B**2
      AB=A*B
      A3=A**3
      B3=B**3
      AB2=A*B**2
      A2B=A**2*B
      AB3=A*B**3
      A3B=A**3*B
      P(J1)=P(J1)+(F1-0.75*F4/A2-0.25*F5/AB-0.75*F6/B2+0.25*F7/A3+
     *    0.375*F8/A2B+0.375*F9/AB2+0.25*F10/B3-0.125*F11/A3B-0.125*
     *    F12/AB3)
      P(J1+1)=P(J1+1)+(-F3+0.5*F5/A+F6/B-0.5*F9/AB-0.25*F10/B2+
     *    0.125*F12/AB2)
      P(J1+2)=P(J1+2)+(F2-F4/A-0.5*F5/B+0.25*F7/A2+0.5*F8/AB-
     *    0.125*F11/A2B)
      P(L1)=P(L1)+(0.25*F5/AB+0.75*F6/B2-0.375*F8/A2B-0.375*F9/AB2-
     *    0.25*F10/B3+0.125*F11/A3B+0.125*F12/AB3)
      P(L1+1)=P(L1+1)+(0.5*F6/B-0.25*F9/AB-0.25*F10/B2+0.125*F12/AB2)
      P(L1+2)=P(L1+2)+(0.5*F5/B-0.5*F9/AB+0.125*F11/A2B)
      P(K1)=P(K1)+(0.75*F4/A2+0.25*F5/AB-0.25*F7/A3-0.375*F8/A2B-
     *    0.375*F9/AB2+0.125*F11/A3B+0.125*F12/AB3)
      P(K1+1)=P(K1+1)+(-0.5*F5/A+0.5*F9/AB-0.125*F12/AB2)
      P(K1+2)=P(K1+2)+(-0.5*F4/A+0.25*F7/A2+0.25*F8/AB-0.125*F11/A2B)
      P(M1)=P(M1)+(-0.25*F5/AB+0.375*F8/A2B+0.375*F9/AB2-0.125*
     *    F11/A3B-0.125*F12/AB3)
      P(M1+1)=P(M1+1)+(0.25*F9/AB-0.125*F12/AB2)
      P(M1+2)=P(M1+2)+(-0.25*F8/AB+0.125*F11/A2B)
 2006 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE DISP (IDM7,IDM8,P,SU,ST,IDM6)
      DIMENSION P(IDM8),ST(IDM6),SU(IDM6)
      I1=IDM7-1
      I2=IDM8-IDM7+1
      DO 3000 I=1,I2
      J=(I-1)*IDM7+1
      P(I)=P(I)/SU(J)
      DO 3000 L=1,I1
 3000 P(I+L)=P(I+L)-P(I)*SU(J+L)
      I2=I2+1
      I4=I1-1
      DO 3001 I=I2,IDM8
      J=(I-1)*IDM7+1
      P(I)=P(I)/SU(J)
      I3=I1-1
      IF (I-IDM8) 3003,3002,3003
 3003 DO 3004 L=1,I4
      P(I+L)=P(I+L)-P(I)*SU(J+L)
      I3=I3-1
      IF (I-I3) 3004,3004,3005
 3004 CONTINUE
 3005 I4=I4-1
 3001 CONTINUE
 3002 DO 3006 M=1,IDM8
      I=IDM8-M+1
      J=(I-1)*IDM7+2
      DO 3006 K=1,I1
      IF (I+K.GT.IDM8) GO TO 3006
      P(I)=P(I)-P(I+K)*ST(J+K-1)
 3006 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE STRESS (IDM9,N1X,N2X,N3X,NX,N1Y,N2Y,NY,
     *                                    STR1,STR2,STRT1,STRB1,STRT2,
     1             STRB2,P,IDM8,X,Y,V,U,NLAYER,E1,E2,T1,T2,COMP,TT,
     2       NSLAB,XF,YF,DLX,DSX,EIX,DJWX,DPRX,FYX,LTDX,AGGX,
     3       EIY,DSY,EIY,DJWY,DPRY,FYY,LTDY,AGGY,DCIX,DCIY)
      INTEGER COMP
      DIMENSION STR1(IDM9,3),STR2(IDM9,3),STRT1(IDM9,5),STRB1(IDM9,5),
     2             STRT2(IDM9,5),STRB2(IDM9,5),P(IDM8),X(IDM9),Y(IDM9),
     3             V(2),U(2),E1(IDM9),E2(IDM9),T1(IDM9),T2(IDM9),
     4             TT(IDM9),XF(IDM9),YF(IDM9)
      N1XY=N1X*NY
      N2XY=N2X*NY+N1XY
      DO 4000 I=1,IDM9
      IF (I.LE.N1XY) GO TO 4001
      IF (I.LE.N2XY) GO TO 4002
      I1=NY
      I2=N3X
      I3=N2XY
      I4=NY-N2Y
      GO TO 4003
 4002 I1=NY
      I2=N2X
      I3=N1XY
      I4=NY-N2Y
      GO TO 4003
 4001 I1=NY
      I2=N1X
      I3=0
      I4=NY-N2Y
 4003 DO 4004 J=1,3
      STR1(I,J)=0.
 4004 STR2(I,J)=0.
      DO 4005 J=1,5
      STRT1(I,J)=0.
      STRB1(I,J)=0.
      STRT2(I,J)=0.
 4005 STRB2(I,J)=0.
      IF (I.EQ.I3+1.OR.I.EQ.I1+I3.OR.I.EQ.I1*(I2-1)+1+I3.OR.I.EQ.I1*I2+
     1             I3) GO TO 4006
      IF (I.EQ.I3+I4.OR.I.EQ.I3+I4+1.OR.I.EQ.I1*(I2-1)+N1Y+I3.
     *          OR.I.EQ.I1*(I2-1)+N1Y+I3+1) GO TO 4006
      IF (I.EQ.(I-I3-1)/I1*I1+I1+I3) GO TO 4007
      IF (I.EQ.(I-I3-1)/I1*I1+I1+I3-N2Y) GO TO 4007
      IF (I.GT.I1*(I2-1)+1+I3) GO TO 4008
      A=(X(I+I1)-X(I))/2.
      B=(Y(I+1)-Y( ))/2.
      A1=A/B
      B1=B/A
      AB4=4*A*B
      J=I*3
      L=I1*3
      STR1(I,1)=(6*(B1+V(1)*A1)*P(J-2)-8*A*V(1)*P(J-1)+8*B*P(J)-6*A1*
     1    V(1)*P(J+1)-4*A*V(1)*P(J+2)-6*B1*P(J+L-2)+4*B*P(J+L))/AB4
      STR1(I,2)=(6*(A1+V(1)*B1)*P(J-2)-8*A*P(J-1)+8*B*V(1)*P(J)-6*A1*
     1    P(J+1)-4*A*P(J+2)-6*B1*V(1)*P(J+L-2)+4*B*V(1)*P(J+L))/AB4
      STR1(I,3)=U(1)*(-2*P(J-2)+4*B*P(J-1)-4*A*P(J)+2*P(J+1)+4*A*
     1    P(J+3)+2*P(J+L-2)-4*B*P(J+L-1)-2*P(J+L+1))/AB4
      IF (NLAYER.EQ.1) GO TO 4009
      STR2(I,1)=(6*(B1+V(2)*A1)*P(J-2)-8*A*V(2)*P(J-1)+8*B*P(J)-6*A1*
```

```
     1   V(2)*P(J+1)-4*A*V(2)*P(J+2)-6*B1*P(J+L-2)+4*B*P(J+L))/AB4
      STR2(I,2)=(6*(A1+V(2)*E1)*P(J-2)-8*A*P(J-1)+8*B*V(2)*P(J)-6*A1*
     1   P(J+1)-4*A*P(J+2)-6*B1*V(2)*P(J+L-2)+4*B*V(2)*P(J+L))/AB4
      STR2(I,3)=U(2)*(-2*P(J-2)+4*B*P(J-1)-4*A*P(J)+2*P(J+1)+4*A*
     1   P(J+3)+2*P(J+L-2)-4*B*P(J+L-1)-2*P(J+L+1))/AB4
 4009 IF (I.EQ.(I-I3-1)/I1*I1+1+I3) GO TO 4008
      IF (I.EQ.(I-I3-1)/I1*I1+1+I3+NY-N2Y) GO TO 4008
 4007 A=(X(I+I1)-X(I))/2.
      B=(Y(I)-Y(I-1))/2.
      A1=A/B
      B1=B/A
      AB4=4*A*B
      J=I*3
      L=I1*3
      STR1(I,1)=STR1(I,1)+(-6*A1*V(1)*P(J-5)+4*A*V(1)*P(J-4)+6*(B1+V(1)*
     1   A1)*P(J-2)+8*A*V(1)*P(J-1)+8*B*P(J)-6*B1*P(J+L-2)+4*B*
     2   P(J+L))/AB4
      STR1(I,2)=STR1(I,2)+(-6*A1*P(J-5)+4*A*P(J-4)+6*(A1+V(1)*B1)*
     1   P(J-2)+8*A*P(J-1)+8*B*V(1)*P(J)-6*B1*V(1)*P(J+L-2)+4*B*V(1)*
     2   P(J+L))/AB4
      STR1(I,3)=STR1(I,3)+U(1)*(-2*P(J-5)-4*A*P(J-3)+2*P(J-2)+4*B*
     1   P(J-1)+4*A*P(J)+2*P(J+L-5)-2*P(J+L-2)-4*B*P(J+L-1))/AB4
      IF (NLAYER.EQ.1) GO TO 4010
      STR2(I,1)=STR2(I,1)+(-6*A1*V(2)*P(J-5)+4*A*V(2)*P(J-4)+6*(B1+V(2)*
     1   A1)*P(J-2)+8*A*V(2)*P(J-1)+8*B*P(J)-6*B1*P(J+L-2)+4*B*
     2   P(J+L))/AB4
      STR2(I,2)=STR2(I,2)+(-6*A1*P(J-5)+4*A*P(J-4)+6*(A1+V(2)*B1)*
     1   P(J-2)+8*A*P(J-1)+8*B*V(2)*P(J)-6*B1*V(2)*P(J+L-2)+4*B*V(2)*
     2   P(J+L))/AB4
      STR2(I,3)=STR2(I,3)+U(2)*(-2*P(J-5)-4*A*P(J-3)+2*P(J-2)+4*B*
     1   P(J-1)+4*A*P(J)+2*P(J+L-5)-2*P(J+L-2)-4*B*P(J+L-1))/AB4
 4010 IF (I.EQ.(I-I3-1)/I1*I1+I1+I3) GO TO 4011
      IF (I.EQ.(I-I3-1)/I1*I1+I1+I3-N2Y) GO TO 4011
      IF (I.LE.I1+I3) GO TO 4012
 4008 A=(X(I)-X(I-I1))/2.
      B=(Y(I+1)-Y(I))/2.
      A1=A/B
      B1=B/A
      AB4=4*A*B
      J=I*3
      L=I1*3
      STR1(I,1)=STR1(I,1)+(-6*B1*P(J-L-2)-4*B*P(J-L)+6*(B1+V(1)*A1)*
     1 P(J-2)-8*A*V(1)*P(J-1)-8*B*P(J)-6*A1*V(1)*P(J+1)-4*A*V(1)*
     2   P(J+2))/AB4
      STR1(I,2)=STR1(I,2)+(-6*B1*V(1)*P(J-L-2)-4*B*V(1)*P(J-L)+6*
     1   (A1+V(1)*B1)*P(J-2)-8*A*P(J-1)-8*B*V(1)*P(J)-6*A1*P(J+1)-4*A*
     2   P(J+2))/AB4
      STR1(I,3)=STR1(I,3)+U(1)*(-2*P(J-L-2)+4*B*P(J-L-1)+2*P(J-L+1)+2*
     1   P(J-2)-4*B*P(J-1)-4*A*P(J)-2*P(J+1)+4*A*P(J+3))/AB4
      IF (NLAYER.EQ.1) GO TO 4013
      STR2(I,1)=STR2(I,1)+(-6*B1*P(J-L-2)-4*B*P(J-L)+6*(B1+V(2)*A1)*
     1 P(J-2)-8*A*V(2)*P(J-1)-8*B*P(J)-6*A1*V(2)*P(J+1)-4*A*V(2)*
     2   P(J+2))/AB4
      STR2(I,2)=STR2(I,2)+(-6*B1*V(2)*P(J-L-2)-4*B*V(2)*P(J-L)+6*
     1   (A1+V(2)*B1)*P(J-2)-8*A*P(J-1)-8*B*V(2)*P(J)-6*A1*P(J+1)-4*A*
     2   P(J+2))/AB4
      STR2(I,3)=STR2(I,3)+U(2)*(-2*P(J-L-2)+4*B*P(J-L-1)+2*P(J-L+1)+2*
     1   P(J-2)-4*B*P(J-1)-4*A*P(J)-2*P(J+1)+4*A*P(J+3))/AB4
 4013 IF (I.EQ.(I-I3-1)/I1*I1+1+I3) GO TO 4012
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      IF (I.EQ.(I-I3-1)/I1*I1+1+I3+NY-N2Y) GO TO 4012
      GO TO 4011
 4012 C=2.
      GO TO 4014
 4011 A=(X(I)-X(I-I1))/2.
      B=(Y(I)-Y(I-1))/2.
      A1=A/B
      B1=B/A
      AB4=4*A*B
      J=I*3
      L=I1*3
      STR1(I,1)=STR1(I,1)+(-6*B1*P(J-L-2)-4*B*P(J-L)-6*A1*V(1)*P(J-5)+
     1    4*A*V(1)*P(J-4)+6*(B1+V(1)*A1)*P(J-2)+8*A*V(1)*P(J-1)-
     2    8*B*P(J))/AB4
      STR1(I,2)=STR1(I,2)+(-6*B1*V(1)*P(J-L-2)-4*B*V(1)*P(J-L)-6*A1*
     1    P(J-5)+4*A*P(J-4)+6*(A1+V(1)*B1)*P(J-2)+8*A*P(J-1)-8*B*V(1)*
     2    P(J))/AB4
      STR1(I,3)=STR1(I,3)+U(1)*(-2*P(J-L-5)+2*P(J-L-2)+4*B*P(J-L-1)+2*
     1    P(J-5)-4*A*P(J-3)-2*P(J-2)-4*B*P(J-1)+4*A*P(J))/AB4
      IF (NLAYER.EQ.1) GO TO 4015
      STR2(I,1)=STR2(I,1)+(-6*B1*P(J-L-2)-4*B*P(J-L)-6*A1*V(2)*P(J-5)+
     1    4*A*V(2)*P(J-4)+6*(B1+V(2)*A1)*P(J-2)+8*A*V(2)*P(J-1)-
     2    8*B*P(J))/AB4
      STR2(I,2)=STR2(I,2)+(-6*B1*V(2)*P(J-L-2)-4*B*V(2)*P(J-L)-6*A1*
     1    P(J-5)+4*A*P(J-4)+6*(A1+V(2)*B1)*P(J-2)+8*A*P(J-1)-8*B*V(2)*
     2    P(J))/AB4
      STR2(I,3)=STR2(I,3)+U(2)*(-2*P(J-L-5)+2*P(J-L-2)+4*B*P(J-L-1)+2*
     1    P(J-5)-4*A*P(J-3)-2*P(J-2)-4*B*P(J-1)+4*A*P(J))/AB4
 4015 IF (I.EQ.(I-I3-1)/I1*I1+I1+I3.OR.I.GE.I1*(I2-1)+1+I3) GO TO 4012
      IF (I.EQ.(I-I3-1)/I1*I1+I1+I3-N2Y) GO TO 4012
      C=4.
 4014 IF (NLAYER.EQ.2) GO TO 4016
      H1=E1(I)*T1(I)**3/(12.*(1.-V(1)**2))
      DO 4017 J=1,3
      STRT1(I,J)=H1*6.*STR1(I,J)/(C*T1(I)**2)
      STRB1(I,J)=-STRT1(I,J)
      STRT2(I,J)=0.
 4017 STRB2(I,J)=0.
      GO TO 4018
 401' IF (COMP.EQ.1) GO TO 4019
      H1=E1(I)*T1(I)**3/(12.*(1.-V(1)**2))
      H2=E2(I)*T2(I)**3/(12.*(1.-V(2)**2))
      DO 4020 J=1,3
      STRT1(I,J)=H1*6.*STR1(I,J)/(C*T1(I)**2)
      STRB1(I,J)=-STRT1(I,J)
      STRT2(I,J)=H2*6.*STR2(I,J)/(C*T2(I)**2)
 4020 STRB2(I,J)=-STRT2(I,J)
      GO TO 4018
 4019 ENA2=0.5*T1(I)*(T1(I)+T2(I))/(T1(I)+T2(I)*E2(I)/E1(I))
      ENA1=0.5*(T1(I)+T2(I))-ENA2
      H1=E1(I)/(12.*(1.-V(1)**2))
      H2=E2(I)/(12.*(1.-V(2)**2))
      DO 4021 J=1,3
      STRT1(I,J)=H1*6.*STR1(I,J)*(T1(I)+2.*ENA1)/C
      STRB1(I,J)=H1*6.*STR1(I,J)*(-T1(I)+2.*ENA1)/C
      STRT2(I,J)=H2*6.*STR2(I,J)*(T2(I)-2.*ENA2)/C
 4021 STRB2(I,J)=H2*6.*STR2(I,J)*(-T2(I)-2.*ENA2)/C
 4018 IF (I.EQ.(I-I3-1)/I1*I1+1+I3.OR.I.EQ.(I-I3-1)/I1*I1+I1+I3) GO TO
     1    4022
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      IF (I.EQ.(I-I3-1)/I1*I1+1+I3+NY-N2Y.OR.I.EQ.(I-I3-1)/I1*I1+I1+
     *   I3-I2Y) GO TO 4022
      GO TO 4023
 4022 STRT1(I,2)=0.
      STRB1(I,2)=0.
      STRT2(I,2)=0.
      STRB2(I,2)=0.
 4023 IF (I.LE.I1+I3.OR.I.GT.I1*(I2-1)+I3) GO TO 4024
      GO TO 4025
 4024 STRT1(I,1)=0.
      STRB1(I,1)=0.
      STRT2(I,1)=0.
      STRB2(I,1)=0.
 4025 IF (STRT1(I,1).EQ.0..OR.STRT1(I,2).EQ.0.) GO TO 4026
      GO TO 4006
 4026 STRT1(I,3)=0.
      STRB1(I,3)=0.
      STRT2(I,3)=0.
      STRB2(I,3)=0.
 4006 CONTINUE
      STRT1(I,4)=(STRT1(I,1)+STRT1(I,2))/2.+
     *      SQRT(0.25*(STRT1(I,1)-STRT1(I,2))**2+STRT1(I,3)**2)
      STRB1(I,4)=(STRB1(I,1)+STRB1(I,2))/2.+
     *      SQRT(0.25*(STRB1(I,1)-STRB1(I,2))**2+STRB1(I,3)**2)
      STRT2(I,4)=(STRT2(I,1)+STRT2(I,2))/2.+
     *      SQRT(0.25*(STRT2(I,1)-STRT2(I,2))**2+STRT2(I,3)**2)
      STRB2(I,4)=(STRB2(I,1)+STRB2(I,2))/2.+
     *      SQRT(0.25*(STRB2(I,1)-STRB2(I,2))**2+STRB2(I,3)**2)
      STRT1(I,5)=(STRT1(I,1)+STRT1(I,2))/2.-
     *      SQRT(0.25*(STRT1(I,1)-STRT1(I,2))**2+STRT1(I,3)**2)
      STRB1(I,5)=(STRB1(I,1)+STRB1(I,2))/2.-
     *      SQRT(0.25*(STRB1(I,1)-STRB1(I,2))**2+STRB1(I,3)**2)
      STRT2(I,5)=(STRT2(I,1)+STRT2(I,2))/2.-
     *      SQRT(0.25*(STRT2(I,1)-STRT2(I,2))**2+STRT2(I,3)**2)
      STRB2(I,5)=(STRB2(I,1)+STRB2(I,2))/2.-
     *      SQRT(0.25*(STRB2(I,1)-STRB2(I,2))**2+STRB2(I,3)**2)
      TT(I)=T1(I)+T2(I)
 4000 CONTINUE
      IF (NSLAB.EQ.1) GO TO 4100
      IF (LTDX.EQ.0.OR.N2X.EQ.0) GO TO 5100
      J11=(N1X-1)*NY+1
      J33=N1X*NY
      DDX=DIX*DIX
      IF (DJWX.LT.0.01) DJWX=0.01
      DCX=DCIX
      D5X=12.*DDX/(DJWX**3*(1.+FYX))
      D2X=6.*DDX/(DJWX**2*(1.+FYX))
      D1X=(1./((1./DCX)+(1./D5X)))
      DO 4101 K=J11,J33
      J1=K
      J2=K+NY
      XF(J1)=D1X*P(J1*3-2)+D2X*P(J1*3)-D1X*P(J2*3-2)+D2X*P(J2*3)
 4101 XF(J2)=-XF(J1)
      IF (N3X.EQ.0) GO TO 5100
      L11=(N1X+N2X-1)*NY+1
      L33=(N1X+N2X)*NY
      DO 4111 K=L11,L33
      L1=K
      L2=K+NY
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4101  YF(L1)=D1X*P(L1*3-2)+D2X*P(L1*3)-D1X*P(L2*3-2)+D2X*P(L2*3)
5100  IF (N2DY.EQ.0.OR.N2Y.EQ.0) GO TO 4100
      NX=N1X+N2X+N3X
      JJ11=(NY-1)*NY+N1Y
      DEY=FEY*DIY
      IF (DJWY.LT.0.01) DJWY=0.01
      DCY=DC1Y
      D5Y=12.*EEY/(DJWY**3*(1.+FYY))
      D2Y=6.*EEY/(DJWY**2*(1.+FYY))
      D1Y=(1./((1./DCY)+(1./D5Y)))
      DO 5101 K=N1Y,JJ11,NY
      LL1=K
      LL2=K+1
      YF(LL1)=D1Y*P(LL1*3-2)-D2Y*P(LL1*3-1)-D1Y*P(LL2*3-2)-D2Y
     *        *P(LL2*3-1)
5101  YF(LL2)=-YF(LL1)
4100  CONTINUE
      RETURN
      END
```