PAPER NO. 567

A SIMPLFIED APPROACH FOR THE ANALYSIS AND DESIGN OF TWO WAY JOIST FLOORS

BY

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*Syed Ali Rizwan * , Azhar Ali Bhatti **.*

ABSTRACT

Two way joist floors are extensively used in R.C construction to cover moderate squarish plans spanning up to 40 ft. Their exact analysis is rather complex as they are highly statically indeterminate (1). A method is presented for the purpose which is the extension of the concepts of Z. S. Makowski as applied to reinforced concrete structures.The results of the method have also been compared with those based on SAP90 computer programme . Besides discussing several basic structural considerations, the paper presents a simple analysis tool for two way joist floors.

INTRODUCTION

Two way joist floors can be considered as grids having intersecting beams in two orthogonal directions or at an angle and intersecting at the same level. These grids may be in steel or in reinforced concrete. Makowski [2] states that these grids are very pleasing when viewed from below and possess remarkable acoustic performance. These could be used for public buildings, theaters, cinemas and parking garages etc.These grids are very stiff and avoid excessive deflections commonly occurring in the ordinary construction.

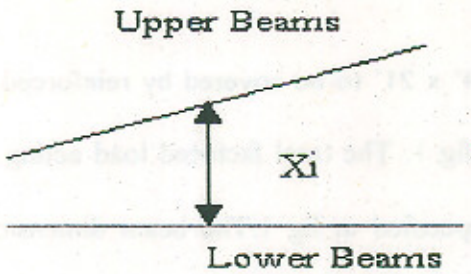
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Owing to the interconnection of the elements forming the grids, the resulting structure is highly structurally indeterminate. However, for symmetrical layouts and symmetrical loading, the analysis maybe simplified by using various methods applicable to grid frameworks. The easiest maybe the comparison of deflections in a torsion free structure having simple supports at the boundaries. For grids with rigidly connected nodes, influence coefficient method or δ_{ix} method can be used. Arguing that deflection at a node should be the same when determined from either of the intersecting beams running in orthogonal directions. The method is perfectly general and is applicable to any layout or loading. The application of the method results in linear simultaneous equations after using influence coefficients and the solution of these equations is not difficult after having setup those equations.

Generally speaking for rigidly connected grids at nodes, the influence of torsion is more for reinforced concrete than for steel, and maybe taken into account for important cases. It is noted that torsional stiffness of beams must always be considered for bridge decks supported on two sides only. Its effect for ordinary grids supported on all four sides is comparatively lesser (2). Therefore by neglecting the torsional stiffness of the intersecting beams, the external forces produces only vertical reactive forces acting in the fictitious link between the intersecting beams running in different directions. These vertical fictitious links can be visualized as having very infinitely small length with pin connections at the top and at the bottom. They serve as connectors to the interconnecting beams at the same level. The axial loads induced in these fictitious links are called "LINK FORCES X_i" as shown below. These forms the redundants in grid analysis. The link force



X_i at node i is positive if it pushes the upper beam (running in shorter direction) upward and pushes the lower beams (running in longer direction) downward.

Therefore a positive link force produces compression in fictitious link when the direction and magnitude of the link forces is known. After the formation of linear simultaneous equations the bending moment, shear forces and deflection of all beams can be determined very easily.Makowski (3) states that for square R.C layouts,diagonal grids are more economical due to stiff corner beams acting as supports for other beams.Detailed behaviour of double layered steel grids may be found elsewhere (4).

ANALYSIS TECHNIQUE

The total of unknown reaction X_i is equal to the total number of internal nodes. The same number of equations results from the compatibility requirements of displacements at any node i .

$$\text{i.e. } \delta_i^{\text{upper beam}} = \delta_i^{\text{lower beam}}$$

EXAMPLE

Consider an area of 14' x 21' to be covered by reinforced concrete grid beam and slab strictures as shown in fig 1. The total factored load acting on the slab is lumped on to the number of nodes specified in fig 1.The beam dimensions have been picked from (5).

CALCULATION OF LOAD [P]

a) *DEAD LOAD*

1) SLAB

3.5" Concrete slab = 150x3.5/12 = 43.73 psf

4" Earth filling = 120x4.0/12 = 40.00 psf

1.5" Tiles = 120x1.5/12 = 15.00 psf

$\sum$ = 98.75 psf

Area of slab contributing load per node = 3.5x2.8 = 9.8 ft^2

Therefore load of slab acting per node = 9.8x98.75

= 967.75 lbs

2) BEAM

Assume beam dimensions as 7" x 15.5"

Self weight of beam = 7x15.5x150/144 = 113 lb/ft

Tributary length of beam per node = 2.8+3.5 = 6.3 ft

Therefore weight of beam acting per node = 113x6.3 = 712 lbs

TOTAL DEAD LOAD = 1679.75 lbs

b) *LIVE LOAD*

Taking live load of 70 psf

Live load acting per node = 70x9.8 = 686 lbs

FACTORED LOAD PER NODE

Factored load per node = 1.4(D.L) + 1.7(L.L)

= 1.4(1679.78) +1.7(686)

= 3520 lbs

= 3.52 kips

Considering some extra allowance of 7% to 10% for the load variation let nodal load P=3.78 Kips.

SETTING UP OF LINEAR SIMULTANEOUS EQUATIONS

Using the Table 1 for simply supported beams under the action of point loads, the numerical values of the deflection coefficients can be obtained directly.

Thus by the principle of superposition the deflection at the joints are calculated as follows;

FOR LOWER BEAM AA

JOINTS 1, 2, 3

$EI\delta_1=(42/3888)21^3X_1+(69/3888)21^3X_2+(39/3888)21^3X_3+(150/3888)21^3P$

$= (21^3/3888)(42X_1+69X_2+39X_3+150P)$

$EI\delta_2 = (21^3/3888)(69X_1+120X_2+69X_3+258P)$

$EI\delta_3 = (21^3/3888)(78X_1+138X_2+81X_3+297P)$

FOR LOWER BEAM BB

JOINTS 4, 5, 6

$EI\delta_4 = (21^3/3888)(42X_4+69X_5+39X_6+150P)$

$EI\delta_5 = (21^3/3888)(69X_4+120X_5+69X_6+258P)$

$EI\delta_6 = (21^3/3888)(78X_4+138X_5+81X_6+297P)$

FOR UPPER BEAMS CC, DD, EE

JOINTS 1, 2, 3, 4, 5, 6

$EI\delta_1 = (14^3/3750)(-55X_1-85X_2+140P)$

$EI\delta_2 = (14^3/3750)(-55X_2-85X_5+140P)$

$EI\delta_3 = (14^3/3750)(-55X_3-85X_6+140P)$

$EI\delta_4 = (14^3/3750)(-85X_1-140X_4+225P)$

$EI\delta_5 = (14^3/3750)(-85X_2-140X_5+225P)$

$EI\delta_6 = (14^3/3750)(-85X_3-140X_6+225P)$

Now comparing the deflections of the longer and shorter beams at the joints 1, 2, 3, 4, 5 and 6,

$$\text{i.e. } \delta_i^{\text{upper beam}} = \delta_i^{\text{lower beam}}$$

The following system of six linear equations is obtained;

$141X_1 + 165X_2 + 93X_3 + 63X_4 + 0 + 0 = -963839$

$165X_1 + 326X_2 + 165X_3 + 0 + 63X_6 + 0 = -1936759$

$186X_1 + 329X_2 + 234X_3 + 0 + 0 + 63X_6 = -2288091$

$63X_1 + 0 + 0 + 203X_4 + 165X_5 + 93X_6 = -728609$

$0 + 63X_2 + 0 + 165X_4 + 389X_5 + 165X_6 = -1701528$

$0 + 0 + 63X_3 + 186X_4 + 329X_5 + 296X_6 = -2052861$

The simultaneous equations can be solved by any standard method. Solving the equations, the values of the reactive forces X are as follows;

$X_1 = -741.362$ or in general terms X1 =-0.245P

$X_2 = -3462.881$ X2 =-0.827P

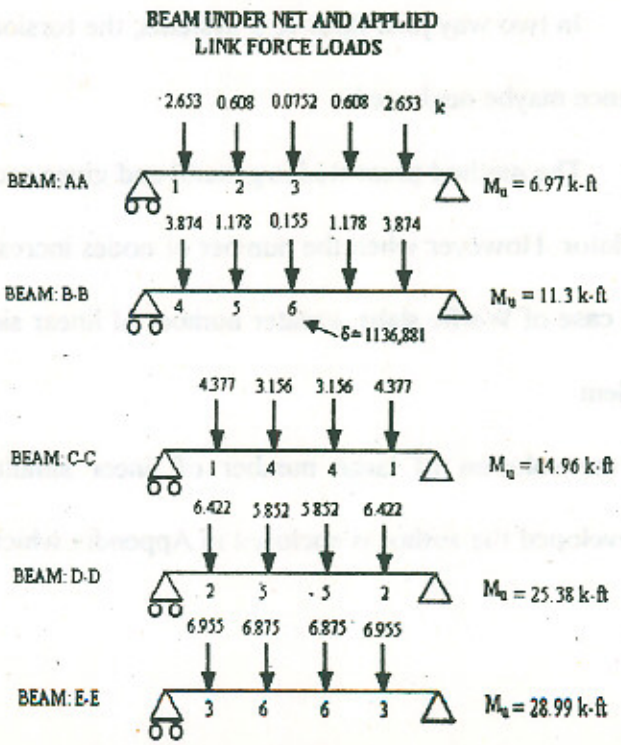
$X_3 = -3280.242$ X3=-0.978P

$X_4 = +271.946$ X4=+0.102P

$X_5 = -2290.346$ X5=-0.665P

$X_6 = -3862.378$ X6=-0.956P

Knowing the reactive forces at all points of interconnections between the longer and shorter beams, the bending moments can be determined. Care must be exercised in plotting the isolated beams under loads for constructing shear force and bending moment diagrams, wherein a nodal applied gravity load equal to P/2 should be considered at nodes in upper and lower beams respectively to satisfy equilibrium



Now consider isolated beams as shown under the action of applied gravity nodal force and link forces in two directions, plot shear force and bending moment diagrams. Pick up maximum moment and maximum shear force for each beam.

This procedure has been checked by SAP90 which also gives the effect of considering torsional stiffness. Structure data file, displaced position of structure and output file F3F is given in appendix alongwith fig1 and table1.

Once $(Mu)_{max}$ for beams are known, $Mu/\varnothing bd^2$ and hence ρ may be picked up from design aids or by solving quadratic equations. The work is in progress to develop such a computer program that may establish the required equations by itself and hence solve them giving the final results.Moreover the table of influence Coefficients for fully fixed ends and other boundary conditions may also be developed for the end users.

CONCLUSIONS:-

1. In two way joist floor R.C systems, the torsional stiffness is of little consequence and hence maybe neglected.

2. The method presented is general and gives accurate results with the help of simple calculator. However when the number of nodes increases, by increasing the number of panels in case of Waffle slabs, greater number of linear simultaneous equations may become a problem.

For the solution of large number of linear simultaneous equations, a FORTRAN code developed the author is enclosed in Appendix which may be used for the purpose.

ACKNOWLEDGMENTS:

The authors are thankful to Prof. Dr. Shaheen Akhtar Vice Chancellor of U.E.T Lahore, for his encouragement of research activities in the university and for his continued patronage and advice.

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5.Lin,T,Y and Stotesbury,S.D."Structural concepts and systems for Architects and Engineers",John Wiley and Sons 1981.pp 183-200

APPENDIX

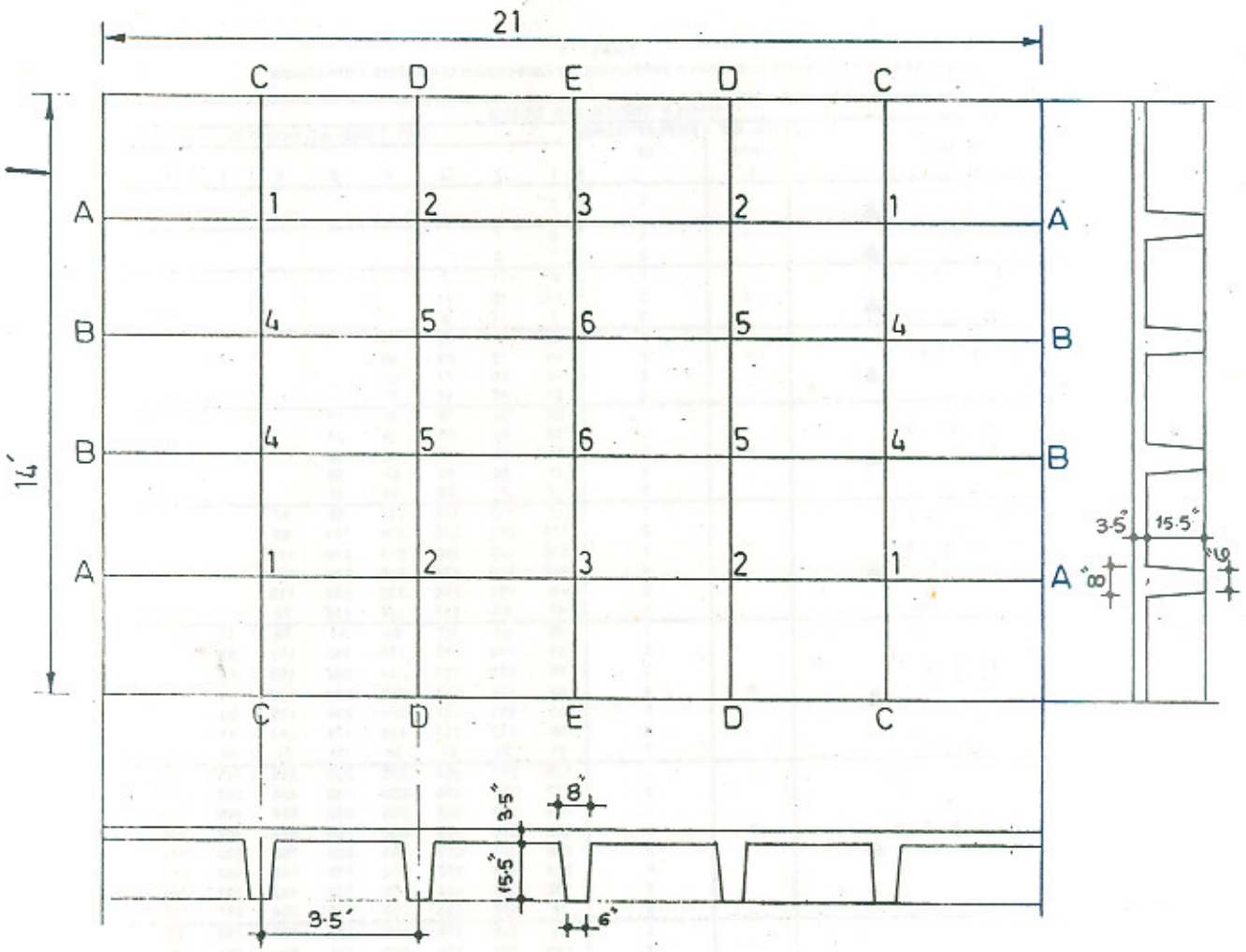
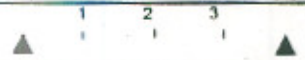
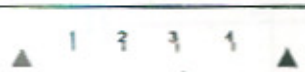


FIG. NO. 1 : LAYOUT OF A TYPICAL TWO WAY JOIST PANEL AND NODE NUMBERING USING SYMMETRY AND THE ORTHOGONAL SECTIONS

TABLE 1

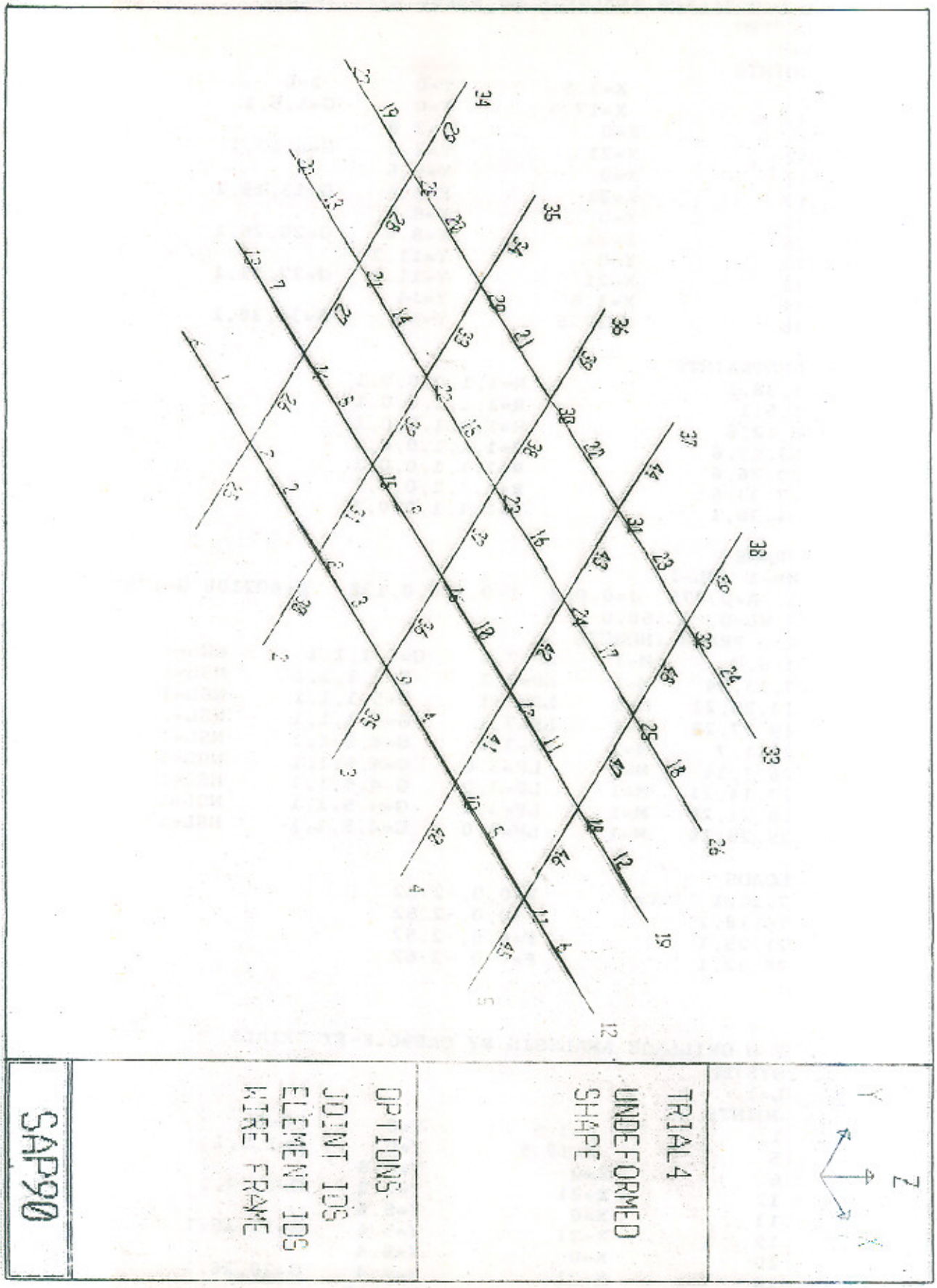
DEFLECTION COEFFICIENTS FOR SIMPLY SUPPORTED BEAMS UNDER CONCENTRATED LOADS

SIMPLY SUPPORTED BEAMS											
KEY DIAGRAM	NO. OF SPANS n	DEFLECTIONS AT	UNIT LOAD AT POINT K									MULTIPLY BY
			1	2	3	4	5	6	7	8	9	
	2	1	1									$L^3/48EI$
	3	1	8	7								$L^3/486EI$
		2	7	8								
	4	1	9	11	7							$L^3/768EI$
		2	11	16	11							
		3	7	11	9							
	5	1	32	45	40	23						$L^3/3750EI$
		2	45	72	68	40						
		3	40	68	72	45						
		4	23	40	45	32						
	6	1	25	38	39	31	17					$L^3/3889EI$
		2	38	64	69	56	31					
		3	39	69	81	69	39					
		4	31	56	69	64	38					
		5	17	31	39	38	25					
	7	1	72	115	128	117	88	47				$L^3/14406EI$
		2	115	200	232	216	164	88				
		3	128	232	288	279	216	117				
		4	117	216	279	288	232	128				
		5	88	164	216	232	200	115				
		6	47	88	117	128	115	72				
	8	1	49	81	95	94	81	59	31			$L^3/12288EI$
		2	81	144	175	176	153	112	59			
		3	95	175	225	234	207	153	81			
		4	94	176	234	256	234	176	94			
		5	81	153	207	234	224	175	95			
		6	59	112	153	176	175	144	81			
		7	31	59	81	94	95	81	49			
	9	1	128	217	254	275	256	213	152	79		$L^3/39366EI$
		2	217	392	492	520	488	408	292	152		
		3	284	492	648	705	672	557	408	213		
		4	275	520	705	800	784	672	488	256		
		5	256	488	672	784	800	705	520	275		
		6	213	408	557	672	705	648	492	284		
		7	152	292	408	488	520	492	392	217		
		8	79	152	213	256	275	254	217	128		
	10	1	81	140	175	189	185	166	135	95	49	$L^3/30000EI$
		2	140	256	329	360	355	320	251	189	95	
		3	175	329	441	495	495	450	389	261	135	
		4	189	360	495	576	590	544	450	320	166	
		5	185	355	495	590	625	590	495	355	185	
		6	166	320	450	544	590	576	495	360	189	
		7	135	261	389	450	495	495	441	329	175	
		8	95	189	251	320	355	360	329	256	140	
		9	49	95	135	166	185	189	175	140	81	

```
C     ************************************************************************
C         PROGRAM BY SYED ALI RIZWAN TO SOLVE SIMULTANOUS EQUATIONS USING GUASS
C         ELIMINATION WITH ROW INTERCHANGES SO THAT LARGEST ELEMENT IS PLACED
C         ON THE DIAGONAL..
C     ************************************************************************


          DIMENSION A(50,50),B(50),X(50)
          READ(5,*) N,((A(I,J),J=1,N),I=1,N)
          READ(5,*) (B(I),I=1,N)
          DO 40 J=1,N
          L=J+1
          DO 30 I=L,N
          IF(ABS(A(J,J)) .GE. (ABS(A(I,J)))) GOTO 30
          S=B(I)
          B(I)=B(J)
          B(J)=S
          DO 20 K=1,N
          S=A(I,K)
          A(I,K)=A(J,K)
          A(J,K)=S
20        CONTINUE
30        CONTINUE
40        CONTINUE
          DO 70 I=2,N
          DO 60 J=1,N
          IF (J .GE. I) GOTO 70
          IF (A(I,J) .EQ. 0.0) GO TO 60
          C=A(I,J)/A(J,J)
          B(I)=B(I)-B(J)*C
          DO 50 K=1,N
          T=C*A(J,K)
          A(I,K)=A(I,K)-T
50        CONTINUE
60        CONTINUE
70        CONTINUE
          DO 100 I=1,N
          SUM=0.0
          DO 80 J=1,N
          L=N+1-J
          K=N+1-I
          IF (K .GE. L) GOTO 90
          IF (A(K,L) .EQ. 0.0) GOTO 80
          SUM=X(L)*A(K,L)+SUM
80        CONTINUE
90        X(K)=(B(K)-SUM)/A(K,K)
100       CONTINUE
          WRITE(1,200) (I,X(I),I=1,N)
200       FORMAT(6X,'X(',I2,') = ',G11.4)
          STOP
          END
```

Y
Z
X
TRIAL4
DEFORMED
SHAPE
LOAD 1
MINIMA
X .00000E+00
Y .00000E+00
Z -.11111E-01
MAXIMA
X .00000E+00
Y .00000E+00
Z .00000E+00
SAP90


Z
Y
X
TRIAL4
UNDEFORMED
SHAPE
OPTIONS:
JOINT IDS
ELEMENT IDS
WIRE FRAME
SAP90

```
2-D GRILLAGE ANALYSIS BY SAP90.K-FT.TRIAL3
SYSTEM
L=1
JOINTS
1              X=3.5          Y=0        Z=0
5              X=17.5         Y=0        G=1,5,1
6              X=0            Y=2.8
12             X=21           Y=2.8      G=6,12,1
13             X=0            Y=5.6
19             X=21           Y=5.6      G=13,19,1
20             X=0            Y=8.4
26             X=21           Y=8.4      G=20,26,1
27             X=0            Y=11.2
33             X=21           Y=11.2     G=27,33,1
34             X=3.5          Y=14
38             X=17.5         Y=14       G=34,38,1
:
RESTRAINTS
1,38,1                  R=1,1,0,0,0,1
1,5,1                   R=1,1,1,0,0,1
6,12,6                  R=1,1,1,0,0,1
13,19,6                 R=1,1,1,0,0,1
20,26,6                 R=1,1,1,0,0,1
27,33,6                 R=1,1,1,0,0,1
34,38,1                 R=1,1,1,0,0,1
:
FRAME
NM=1  NL=1
1  A=0.875  J=0.003  I=0.128,0.128   E=402108 G=175000
1 WL=0,-0.158,0
C   FRAME INDECIS
1,6,7       M=1     LP=7,1     G=5,1,1,1       NSL=1
7,13,14     M=1     LP=7,1      G=5,1,1,1      NSL=1
13,20,21    M=1     LP=7,1      G=5,1,1,1      NSL=1
19,27,28    M=1     LP=7,1      G=5,1,1,1      NSL=1
25,1,7      M=1     LP=3,0      G=4,5,1,1      NSL=1
26,7,14     M=1      LP=3,0     G=4,5,1,1      NSL=1
27,14,21    M=1      LP=3,0     G=4,5,1,1      NSL=1
28,21,28    M=1      LP=3,0     G=4,5,1,1      NSL=1
29,28,34    M=1      LP=3,0     G=4,5,1,1      NSL=1
:
LOADS
7,11,1     L=1        F=0,0,-2.52
14,18,1               F=0,0,-2.52
21,25,1               F=0,0,-2.52
28,32,1               F=0,0,-2.52
:


2-D GRILLAGE ANALYSIS BY SAP90.K-FT.TRIAL3
SYSTEM
L=1
JOINTS
1              X=3.5          Y=0        Z=0
5              X=17.5         Y=0        G=1,5,1
6              X=0            Y=2.8
12             X=21           Y=2.8      G=6,12,1
13             X=0            Y=5.6
19             X=21           Y=5.6      G=13,19,1
20             X=0            Y=8.4
26             X=21           Y=8.4      G=20,26,1
27             X=0            Y=11.2
33             X=21           Y=11.2     G=27,33,1
34             X=3.5          Y=14
```

2-D GRILLAGE ANALYSIS BY SAP90.K-FT.TRIAL3

F R A M E E L E M E N T F O R C E S

ELT ID	LOAD COND	DIST ENDI	1-2 PLANE SHEAR	1-2 PLANE MOMENT	AXIAL FORCE	1-3 PLANE SHEAR	1-3 PLANE MOMENT	AXIA TOR
1								
	1	.000			.000			.00
		.000	1.890	.000				
		3.500	1.337	5.646				
		3.500			.000			.00
2								
	1	.000			.000			-.11
		.000	.561	5.748				
		3.500	.008	6.743				
		3.500			.000			-.11
3								
	1	.000			.000			-.03
		.000	.277	6.798				
		1.756	.000	7.041				
		3.500	-.276	6.801				
		3.500			.000			-.03
4								
	1	.000			.000			.03
		.000	.276	6.801				
		1.744	.000	7.041				
		3.500	-.277	6.798				
		3.500			.000			.03
5								
	1	.000			.000			.11
		.000	-.008	6.743				
		3.500	-.561	5.748				
		3.500			.000			.11
6								
	1	.000			.000			.00
		.000	-1.337	5.646				
		3.500	-1.890	.000				
		3.500			.000			.00
7								
	1	.000			.000			.00
		.000	2.855	.000				
		3.500	2.302	9.024				
		3.500			.000			.00
8								
	1	.000			.000			-.04
		.000	.894	8.921				
		3.500	.341	11.082				
		3.500			.000			-.04

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2-D GRILLAGE ANALYSIS BY SAP90.K-FT.TRIAL3

F R A M E E L E M E N T F O R C E S

ELT ID	LOAD COND	DIST ENDI	1-2 PLANE SHEAR	1-2 PLANE MOMENT	AXIAL FORCE	1-3 PLANE SHEAR	1-3 PLANE MOMENT	AXIA TOR
9								
	1	.000			.000			-.01
		.000	.314	11.028				
		1.989	.000	11.340				
		3.500	-.239	11.160				
		3.500			.000			-.01
10								
	1	.000			.000			.01
		.000	.239	11.160				
		1.511	.000	11.340				
		3.500	-.314	11.028				
		3.500			.000			.01
11								
	1	.000			.000			.04
		.000	-.341	11.082				
		3.500	-.894	8.921				
		3.500			.000			.04
12								
	1	.000			.000			.00
		.000	-2.302	9.024				
		3.500	-2.855	.000				
		3.500			.000			.00
13								
	1	.000			.000			.00
		.000	2.855	.000				
		3.500	2.302	9.024				
		3.500			.000			.00
14								
	1	.000			.000			.04
		.000	.894	8.921				
		3.500	.341	11.082				
		3.500			.000			.04
15								
	1	.000			.000			.01
		.000	.314	11.028				
		1.989	.000	11.340				
		3.500	-.239	11.160				
		3.500			.000			.01
16								
	1	.000			.000			-.01
		.000	.239	11.160				
		1.511	.000	11.340				
		3.500	-.314	11.028				

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2-D GRILLAGE ANALYSIS BY SAP90.K-FT.TRIAL3

F R A M E E L E M E N T F O R C E S

ELT ID	LOAD COND	DIST ENDI	1-2 PLANE SHEAR	1-2 PLANE MOMENT	AXIAL FORCE	1-3 PLANE SHEAR	1-3 PLANE MOMENT	AXIA TOR
		3.500			.000			-.01
17								
	1	.000			.000			-.04
		.000	-.341	11.082				
		3.500	-.894	8.921				
		3.500			.000			-.04
18								
	1	.000			.000			.00
		.000	-2.302	9.024				
		3.500	-2.855	.000				
		3.500			.000			.00
19								
	1	.000			.000			.00
		.000	1.890	.000				
		3.500	1.337	5.646				
		3.500			.000			.00
20								
	1	.000			.000			.11
		.000	.561	5.748				
		3.500	.008	6.743				
		3.500			.000			.11
21								
	1	.000			.000			.03
		.000	.277	6.798				
		1.756	.000	7.041				
		3.500	-.276	6.801				
		3.500			.000			.03
22								
	1	.000			.000			-.03
		.000	.276	6.801				
		1.744	.000	7.041				
		3.500	-.277	6.798				
		3.500			.000			-.03
23								
	1	.000			.000			-.11
		.000	-.008	6.743				
		3.500	-.561	5.748				
		3.500			.000			-.11
24								
	1	.000			.000			.00
		.000	-1.337	5.646				
		3.500	-1.890	.000				
		3.500			.000			.00

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2-D GRILLAGE ANALYSIS BY SAP90.K-FT.TRIAL3

F R A M E E L E M E N T F O R C E S

ELT ID	LOAD COND	DIST ENDI	1-2 PLANE SHEAR	1-2 PLANE MOMENT	AXIAL FORCE	1-3 PLANE SHEAR	1-3 PLANE MOMENT	AXIA TOR
25								
	1	.000			.000			.00
		.000	3.962	.000				
		2.800	3.520	10.475				
		2.800			.000			.00
26								
	1	.000			.000			.10
		.000	1.776	10.587				
		2.800	1.333	14.940				
		2.800			.000			.10
27								
	1	.000			.000			.00
		.000	.221	14.982				
		1.400	.000	15.137				
		2.800	-.221	14.982				
		2.800			.000			.00
28								
	1	.000			.000			-.10
		.000	-1.333	14.940				
		2.800	-1.776	10.587				
		2.800			.000			-.10
29								
	1	.000			.000			.00
		.000	-3.520	10.475				
		2.800	-3.962	.000				
		2.800			.000			.00
30								
	1	.000			.000			.00
		.000	6.389	.000				
		2.800	5.947	17.270				
		2.800			.000			.00
31								
	1	.000			.000			.05
		.000	3.157	17.196				
		2.800	2.715	25.416				
		2.800			.000			.05
32								
	1	.000			.000			.00
		.000	.221	25.389				
		1.400	.000	25.543				
		2.800	-.221	25.389				
		2.800			.000			.00

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2-D GRILLAGE ANALYSIS BY SAP90.K-FT.TRIAL3

F R A M E E L E M E N T F O R C E S

ELT ID	LOAD COND	DIST ENDI	1-2 PLANE SHEAR	1-2 PLANE MOMENT	AXIAL FORCE	1-3 PLANE SHEAR	1-3 PLANE MOMENT	AXIA TOR
33								
	1	.000			.000			-.05
		.000	-2.715	25.416				
		2.800	-3.157	17.196				
		2.800			.000			-.05
34								
	1	.000			.000			.00
		.000	-5.947	17.270				
		2.800	-6.389	.000				
		2.800			.000			.00
35								
	1	.000			.000			.00
		.000	7.175	.000				
		2.800	6.732	19.469				
		2.800			.000			.00
36								
	1	.000			.000			.00
		.000	3.661	19.393				
		2.800	3.219	29.024				
		2.800			.000			.00
37								
	1	.000			.000			.00
		.000	.221	28.995				
		1.400	.000	29.150				
		2.800	-.221	28.995				
		2.800			.000			.00
38								
	1	.000			.000			.00
		.000	-3.219	29.024				
		2.800	-3.661	19.393				
		2.800			.000			.00
39								
	1	.000			.000			.00
		.000	-6.732	19.469				
		2.800	-7.175	.000				
		2.800			.000			.00
40								
	1	.000			.000			.00
		.000	6.389	.000				
		2.800	5.947	17.270				
		2.800			.000			.00

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2-D GRILLAGE ANALYSIS BY SAP90.K-FT.TRIAL3

F R A M E E L E M E N T F O R C E S

ELT ID	LOAD COND	DIST ENDI	1-2 PLANE SHEAR	1-2 PLANE MOMENT	AXIAL FORCE	1-3 PLANE SHEAR	1-3 PLANE MOMENT	AXIA TOR
41								
	1	.000			.000			-.05
		.000	3.157	17.196				
		2.800	2.715	25.416				
		2.800			.000			-.05
42								
	1	.000			.000			.00
		.000	.221	25.389				
		1.400	.000	25.543				
		2.800	-.221	25.389				
		2.800			.000			.00
43								
	1	.000			.000			.05
		.000	-2.715	25.416				
		2.800	-3.157	17.196				
		2.800			.000			.05
44								
	1	.000			.000			.00
		.000	-5.947	17.270				
		2.800	-6.389	.000				
		2.800			.000			.00
45								
	1	.000			.000			.00
		.000	3.962	.000				
		2.800	3.520	10.475				
		2.800			.000			.00
46								
	1	.000			.000			-.10
		.000	1.776	10.587				
		2.800	1.333	14.940				
		2.800			.000			-.10
47								
	1	.000			.000			.00
		.000	.221	14.982				
		1.400	.000	15.137				
		2.800	-.221	14.982				
		2.800			.000			.00
48								
	1	.000			.000			.10
		.000	-1.333	14.940				
		2.800	-1.776	10.587				
		2.800			.000			.10

```
38              X=17.5          Y=14      G=34,38,1
:
RESTRAINTS
1,38,1                  R=1,1,0,0,0,1
1,5,1                   R=1,1,1,0,0,1
6,12,6                  R=1,1,1,0,0,1
13,19,6                 R=1,1,1,0,0,1
20,26,6                 R=1,1,1,0,0,1
27,33,6                 R=1,1,1,0,0,1
34,38,1                 R=1,1,1,0,0,1
:
FRAME
NM=1   NL=1
1   A=0.875   J=0.003   I=0.128,0.128    E=402108 G=175000
1 WL=0,-0.158,0
C    FRAME INDECIS
1,6,7       M=1     LP=7,1     G=5,1,1,1       NSL=1
7,13,14     M=1     LP=7,1      G=5,1,1,1      NSL=1
13,20,21    M=1     LP=7,1      G=5,1,1,1      NSL=1
19,27,28    M=1     LP=7,1      G=5,1,1,1      NSL=1
25,1,7      M=1     LP=3,0      G=4,5,1,1      NSL=1
26,7,14     M=1      LP=3,0     G=4,5,1,1      NSL=1
27,14,21    M=1      LP=3,0     G=4,5,1,1      NSL=1
28,21,28    M=1      LP=3,0     G=4,5,1,1      NSL=1
29,28,34    M=1      LP=3,0     G=4,5 1,1      NSL=1
.
LOADS
7,11,1     L=1        F=0,0,-2.52
14,18,1                F=0,0,-2.52
21,25,1                F=0,0,-2.52
28,32,1                F=0,0,-2.52
.
```