PLATE BENDING ANALAYSIS USING FINITE ELEMENT METHOD

A Project Report

Submitted in partial fulfillment for award of degree of

BACHELOR OF TECHNOLOGY

IN

MECHANICAL ENGINEERING

by

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Under the guidance of

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2012

CERTIFICATE

This is to certify that the thesis entitled, “Plate bending analysis using Finite element method” submitted by Mr N.SUDHIR in partial fulfillment of the requirements for the award of Bachelor of Technology Degree in Mechanical Engineering at the National Institute of Technology, Rourkela (Deemed University) is an authentic work carried out by him under my supervision and guidance.

To the best of my knowledge, the matter embodied in the thesis has not been submitted to any other University / Institute for the award of any Degree or Diploma.

Date

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Lastly my sincere thanks to all my friends who has patiently extended all sorts of help for accomplishing this undertaking.

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ABSTRACT

In the modern day to day applications like in industries,ships,pressure vessels,and other structural components plates and shells play a major role so its very important to study their deformations and slopes under loads inorder to understand their behaviour and possible conditions of failure, one of the important factors on which the bending depends is on the load conditions and the support conditions.So in the present study different type of conditions of plate holding such as fixed clamping and simply supported conditions and free boundary conditions are applied on the rectangular plates and their deformations are plotted and verified with that of values obtained with general public licensed software LISA.

INDEX

CHAPTER 1

INTRODUCTION

Finite element method has emerged as a very important mathematical tool in engineering applications because it can reduce a problem with infinite no of degrees to a finite degree problem with the help of discretization which is done according to the problem .For a beam or rod the discretization procedure divides the whole rod or beam in to no of small linear elements thus helping to apply the basic governing equations on each and every element and since all the elements being the part of the complete rod/beam all are related with the help of global stiffness matrices and the boundary conditions are applied inorder to solve the whole matrix of equations and get the values of the unknown values at each node. Similar is the case with the 2 dimensional plates here the plate is discretized into rectangular elements and the boundary conditions are analyzed to get the unknown values at the discretized nodes but the disadvantage with this is it is only a numerical method it can only come close to the analytical value but cannot be equal to it on the other hand the great advantage which comes with FEM is it can easily solve the complex governing equations which are very difficult to solve analytically and takes very long time in getting solved ,thus saving from huge losses to modern industries.All these favourable advantages come at the low cost of little inaccuracy since it's a numerical method.

1.1 AIM OF THE PRESENT WORK

The aim of the present work is to develop a matlab program which can work without the dependence upon the plate materials and the aspect ratio. The input should be the geometric dimensions of the plate such as length ,breadth , thickness. and plate material data such as Poisson's ratio and Young's modulus and plot the graphs of various details such as deflection and slopes of the plate curvature and to verify it with the values that are obtained form the general public licencesed software LISA.

1.2 **LITERATURE REVIEW**

Addidsu Gezahegn Semie[2] had worked on numerical modellling on thin plates and solved the problem of plate bending with the finite element method and Kirchoff's thin plate theory is applied and program is written in fortran and the results were compared with the help of ansys and the fortran program was given as an open source code.The analysis was carried out for simple supported plate with distributed load,concentrated load and clamped/fixed edges plates for both distributed and concentrated load.

L.Belounar and M Guenfoud[1] worked on to develop a rectangular finite element based on the strain approach for plate bending .This new strain based rectangular plate element(SBRP) was then compared with the other plate elements such as DKTM,DSTM ,SBH8 and other type of elements for cantilever platewith edge moment and edge shear and found that SBRP convergence rate is very rapid,and free from shear locking and can be applied to thick and thin plates.

Jian-Gang Han, Wei-Xin Ren,Yih Huang[3] developed a wavelet-based stochastic finite element method is applied for bending bending analysis of thin plates. This wavelet theory was based on the notion that any signal function can be broken down a series of local basis functions called wavelet.Bending of square thin plates by using the developed spine wavelet thin plate element formulation and bending moments and central deflection are analyzed for simply supported and fixed supported.The method can achieve a hign numerical accuracy and is very fast converging in solving the stochastic problem of thin plate bending.

P.R.S Speare,K.O.Kemp[4] worked on making a simplified reissner theory for plate bending. A theory is developed which includes transverse shear and direct stress effects, and solutions to this theories obtained using finite difference method and localized Ritz method and its application to sandwich plates is also done and results are obtained for case of practical shear stiffness to bending stiffness ratios.

CHAPTER 2

METHODOLOGY
ADOPTED IN FINITE ELEMENT METHOD

STEP 1→ adoption of the polynomial for displacement field as

$w(x,y) = \alpha_1 + \alpha_2 x + \alpha_3 y + \alpha_4 x^2 + \alpha_5 xy + \alpha_6 y^2 + \alpha_7 x^3 + \alpha_8 x^2 y + \alpha_9 xy^2 + \alpha_{10} y^3 + \alpha_{11} x^3 y + \alpha_{12} xy^3$

here x,y are local coordinates and the axes for the local element is shown in fig 1

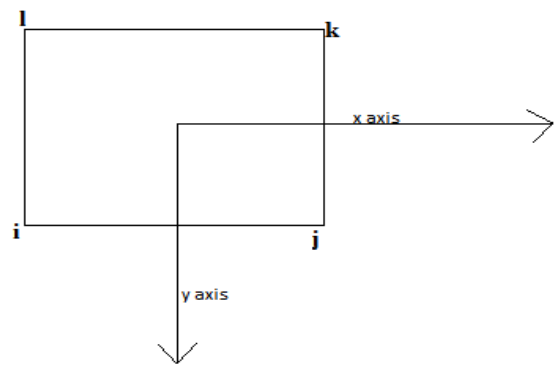

fig 1

because of this

$\frac{\partial w}{\partial y}$ =slope of plate in y direction when x is constant therefore it is equal to β_x

$\beta_x = \alpha_3 + \alpha_5 x + 2\alpha_6 y + \alpha_8 x^2 + 2\alpha_9 xy + 3\alpha_{10} y^2 + \alpha_{11} x^3 + 3\alpha_{12} xy^2$

$-\frac{\partial w}{\partial x}$=slope of plate in x direction when y is constant therefore it is equal to β_y

$\beta_y = -(\alpha_2 + 2\alpha_4 x + \alpha_5 y + 3\alpha_7 x^2 + 2\alpha_8 xy + \alpha_9 y^2 + 3\alpha_{11} x^2 y + \alpha_{12} y^3)$

STEP2→ Let us define displacement matrix as $\{d_i\}=[w_i,(\beta_x)_i ,(\beta_y)_i]^T$

coefficient matrix $[\alpha] = [\alpha_1 , \alpha_2 , \alpha_3 , \alpha_4 , \alpha_5 , \alpha_6 , \alpha_7 , \alpha_8 , \alpha_9 , \alpha_{10} , \alpha_{11} , \alpha_{12}]^T$

$$\{d_i\}= \begin{bmatrix} 1 & x_i & y_i & x_i^2 & x_i y_i & y_i^2 & x_i^3 & x_i^2 y_i & x_i y_i^2 & y_i^3 & x_i^3 y_i & x_i y_i^3 \\ 0 & 0 & 1 & 0 & x_i & 2y_i & 0 & x_i^2 & 2x_i y_i & 3y_i^2 & x_i^3 & 3x_i y_i^2 \\ 0 & -1 & 0 & -2x_i & -y_i & 0 & -3x_i^2 & -2x_i y_i & -y_i^2 & 0 & -3x_i^2 y_i & -y_i^3 \end{bmatrix} \quad x$$

$[\alpha]$

STEP3→ similarly $\{d_i, d_j, d_k, d_l\}^T = [A]^e \times [\alpha]$

now strain matrix $\{\varepsilon\}^e = \{-\frac{\partial^2 w}{\partial x^2}, -\frac{\partial^2 w}{\partial y^2}, -2\frac{\partial^2 w}{\partial x \partial y}\}$

this gives

$$[A]=\begin{bmatrix} 1 & x_i & y_i & x_i^2 & x_iy_i & y_i^2 & x_i^3 & x_i^2y_i & x_iy_i^2 & y_i^3 & x_i^3y_i & x_iy_i^3 \\ 0 & 0 & 1 & 0 & x_i & 2y_i & 0 & x_i^2 & 2x_iy_i & 3y_i^2 & x_i^3 & 3x_iy_i^2 \\ 0 & -1 & 0 & -2x_i & -y_i & 0 & -3x_i^2 & -2x_iy_i & -y_i^2 & 0 & -3x_i^2y_i & -y_i^3 \\ 1 & x_j & y_j & x_j^2 & x_jy_j & y_j^2 & x_j^3 & x_j^2y_j & x_jy_j^2 & y_j^3 & x_j^3y_j & x_jy_j^3 \\ 0 & 0 & 1 & 0 & x_j & 2y_j & 0 & x_j^2 & 2x_jy_j & 3y_j^2 & x_j^3 & 3x_jy_j^2 \\ 0 & -1 & 0 & -2x_j & -y_j & 0 & -3x_j^2 & -2x_jy_j & -y_j^2 & 0 & -3x_j^2y_j & -y_j^3 \\ 1 & x_k & y_k & x_k^2 & x_ky_k & y_k^2 & x_k^3 & x_k^2y_k & x_ky_k^2 & y_k^3 & x_k^3y_k & x_ky_k^3 \\ 0 & 0 & 1 & 0 & x_k & 2y_k & 0 & x_k^2 & 2x_ky_k & 3y_k^2 & x_k^3 & 3x_ky_k^2 \\ 0 & -1 & 0 & -2x_k & -y_k & 0 & -3x_k^2 & -2x_ky_k & -y_k^2 & 0 & -3x_k^2y_k & -y_k^3 \\ 1 & x_l & y_l & x_l^2 & x_ly_l & y_l^2 & x_l^3 & x_l^2y_l & x_ly_l^2 & y_l^3 & x_l^3y_l & x_ly_l^3 \\ 0 & 0 & 1 & 0 & x_l & 2y_l & 0 & x_l^2 & 2x_ly_l & 3y_l^2 & x_l^3 & 3x_ly_l^2 \\ 0 & -1 & 0 & -2x_l & -y_l & 0 & -3x_l^2 & -2x_ly_l & -y_l^2 & 0 & -3x_l^2y_l & -y_l^3 \end{bmatrix}$$

now strain matrix is similarly

$$[\varepsilon]^e = \begin{bmatrix} 0 & 0 & 0 & -2 & 0 & 0 & -6x & -2y & 0 & 0 & -6xy & 0 \\ 0 & 0 & 0 & 0 & 0 & -2 & 0 & 0 & -2x & -6y & 0 & -6xy \\ 0 & 0 & 0 & 0 & -2 & 0 & 0 & -4x & -4y & 0 & -6x^2 & -6y^2 \end{bmatrix} \times [\alpha]$$

$[\varepsilon]^e = [H] \times [\alpha]$

STEP4→ now calculation of strain displacement matrix is done which is represented as [B]

this will be equal to for each element

$[B] = [H] \times [A]^{-1}$

now element stiffness matrix is calculated which is represented as $[K]^e$

$[K]^e = \iint_A [B]^T [D][B] dxdy$

here [D] represents rigidity matrix which is equal to

$$\frac{Eh^3}{12(1-\nu^2)}\begin{bmatrix}1 & \nu & 0\\ \nu & 1 & 0\\ 0 & 0 & \frac{1-\nu}{2}\end{bmatrix}$$

and ν represents poission's ratio here

h is thickness of the plate

and E is the youngs modulus of the plate material.

A represents the area of the element here

now interpolation matrix '[N]' is to be found out for each element

$[N]^e = [C] \times [A]^{-1}$

here $[C] = [\,1, x, y, x^2, xy, y^2, x^3, x^2y, xy^2, y^3, x^3y, xy^3\,]$

<u>STEP5→</u> now let us take the force matrix for the uniform load conditions is

$\{F\}^e = \iint_A [N]^T p(x,y)dxdy$

now summing up all the elemental stiffness matrices to get global matrix with the the help of direct stiffness method to get [K] and similarly summing up all the elemental force matrices we get {F} the global force vector.

and finally we can write as

$[K][d] = \{F\}$

on multiplying with $[K]^{-1}$ on both sides of above equation we get

$[d] = [K]^{-1}[F]$

here $[d] = \{\, d_1, d_2, d_3, d_4 \ldots\ldots\ldots\ldots d_{(n+1)^2}\}^T$

since if we do 'n' no of equal divisions on plate we will get $(n+1)^2$ nodes on the plate .

now as the $\{d_i\}$ is obtained for each and every node we can get displacement and slopes of each and every node and graphs are plotted accordingly.

DICRETIZATION

The discretization is done according to the following figure and if the no of divisions gets increased it is done in the same manner. This dicretization is done for 64 elements.The node and element number is shown accordingly.

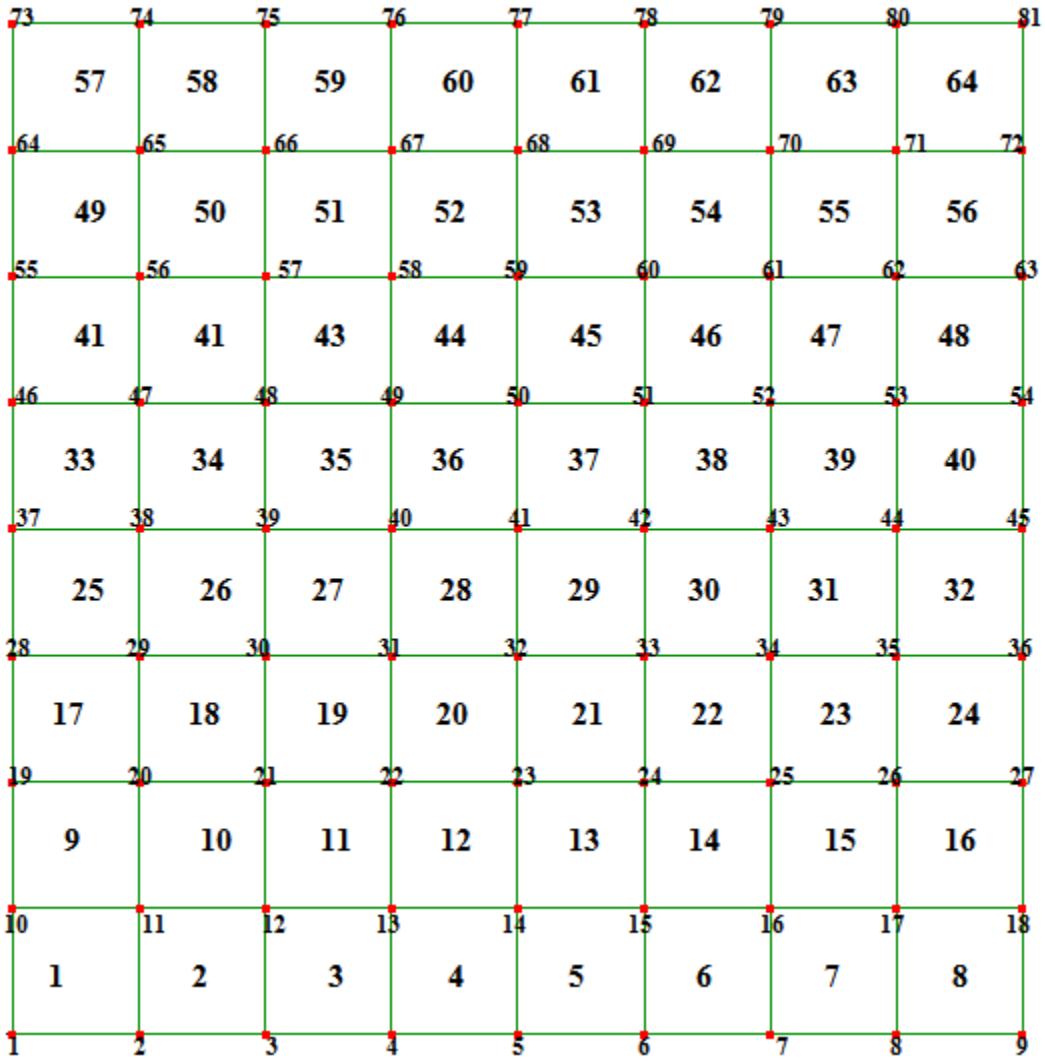

fig 2

now the figures showing the node numbers according to which the graphs are plot in the x and y direction using the matlab program if plotted for a 64 elements division

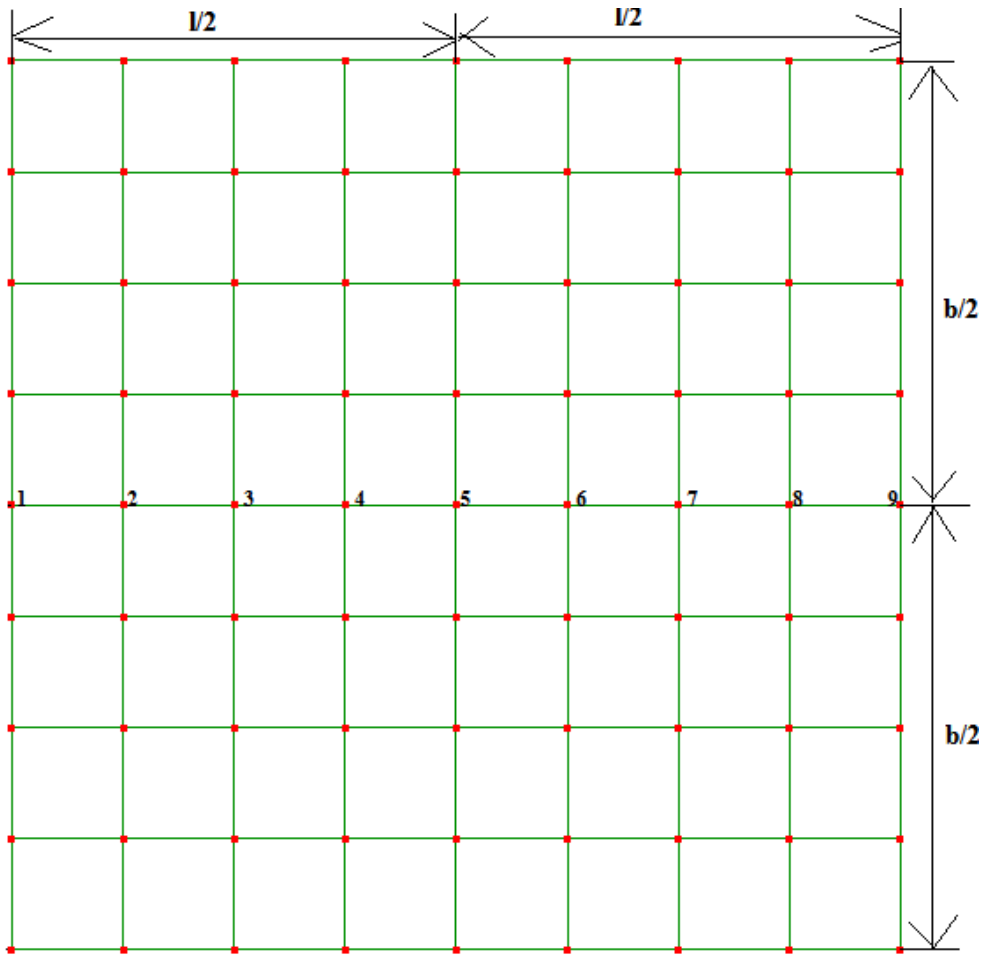

fig 3 showing the node numbering which is done in matlab program for x axis for 64 elements

same procedure for numbering of nodes when the number of nodes increase the numbering will start from the centre line of plate along x axis from left to right.

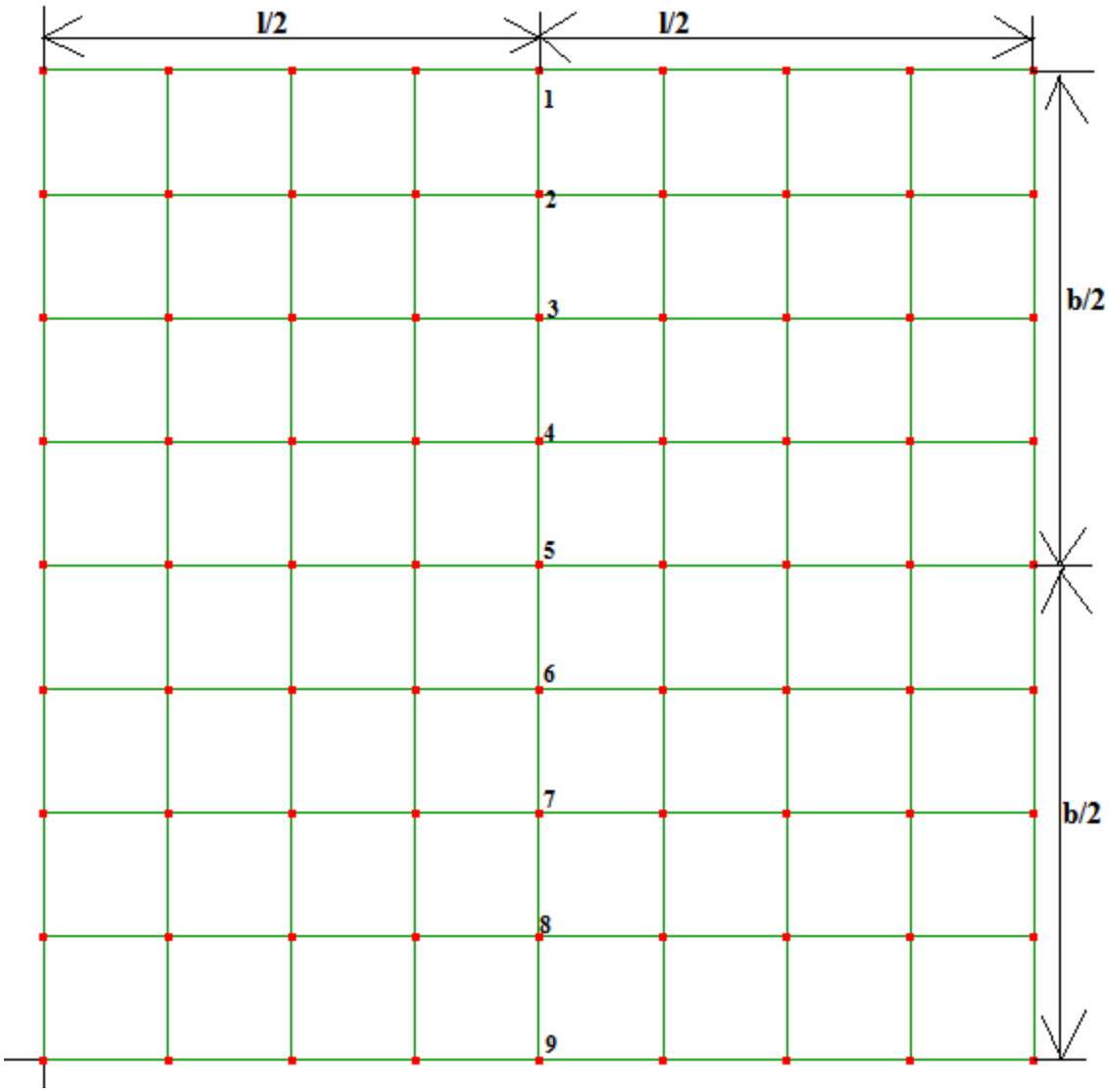

fig 4 showing the node numbering which is done in matlab program for y axis for 64 elements

same procedure will follow in the no of elements increase node numbering will be done along the centre line of the plate from the top to bottom

CHAPTER 3

Steps to solve for the deflections using the software lisa

1. Create 4 nodes using the single node creation option with the proper location using the appropriate coordinates may be Cartesian or rectangular coordinates .
2. Select the add single option under the elements menu and select the element as ‘quad4’ type and select the four nodes that are created in the step 1
3. In step 3 refine the element of quad4 type as many no of times as required to get a smooth meshing this will divide the original quad4 element in 4,16,64,256 …. sub elements
4. In step 4 select the boundary nodes and implement the boundary conditions such as displacement in the z direction as zero along with other conditions of slopes ie rotation about x and y
5. Select the type of analysis as 2d analysis in the model menu and select plate under static option
6. Under the menu model material properties are to be inserted with the help of ‘add’ button and add geometric properties and its mechanical properties as required
7. Next step is to assign the material to all the elements by selecting them and then assigning the material using properties under elements menu
8. Next step is to assign the load type either faceload or pressure load or anyother type of loading
9. Then using the solver and then analyzing the post processor we can get the results for displacement field of the plate and rotation of plate about x and y axis or slopes of the curvature of the plate and can be analyzed.

the axis assumed in the lisa are given in the fig 5

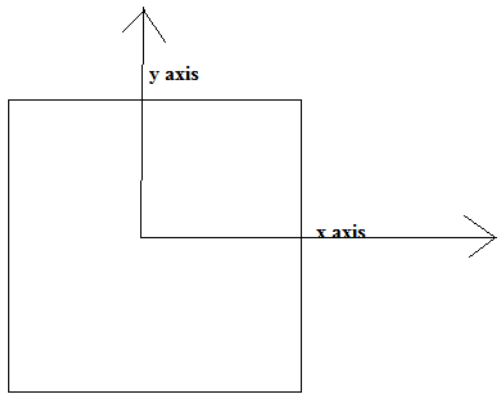

fig 5

the axes in lisa and matlab program y axis are just opposite to each other so the rotation about x axis will be exactly opposite.

CHAPTER 4

RESULTS

CASE 1 - Rectangular plate clamped from all sides

dimension of the plate is 3 x 2 m, plate material is steel so Young's modulus is 21 x 10^{10} Pa and Poission's ratio of 0.3 , face load/pressure load is taken as 14x 10^{4} Pa. and plate thickness is 0.025 m, No of plate elements is taken as 400.

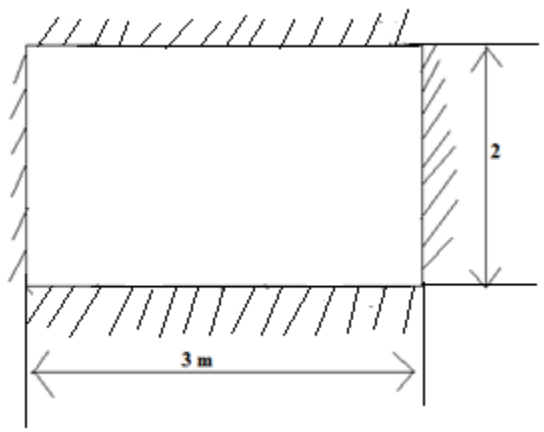

fig 6

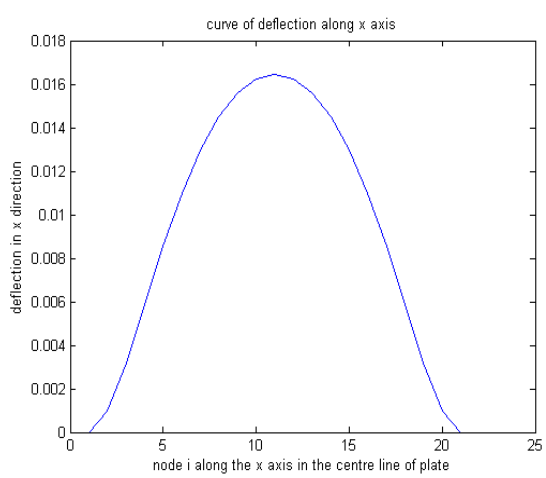

fig 7

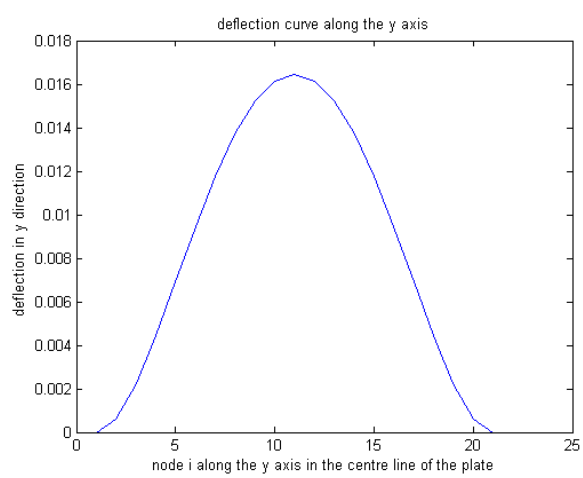

fig 8

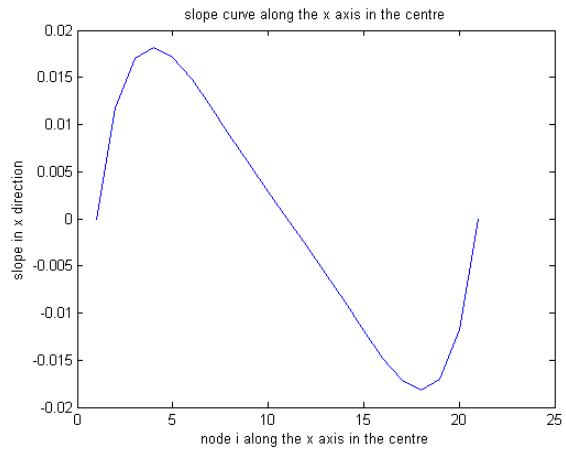

fig 9

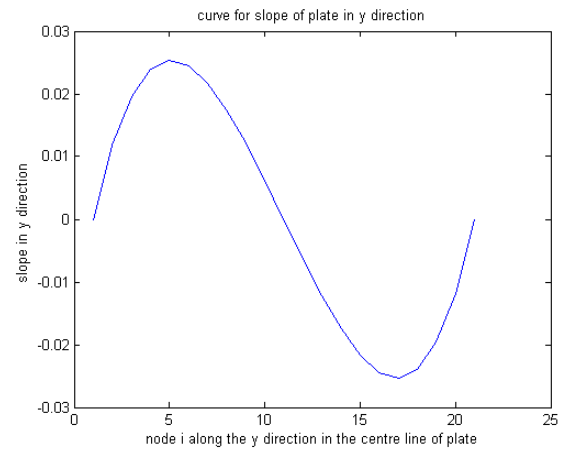

fig 10

<u>CASE 2</u> simply supported plate from all sides

dimension of the plate is 3 x 2 m, plate material is steel so Young's modulus is 21 x 10^{10} Pa and Poission's ratio of 0.3 , face load/pressure load is taken as 14x 10^{4} Pa. and plate thickness is 0.025 m, No of plate elements is taken as 400.

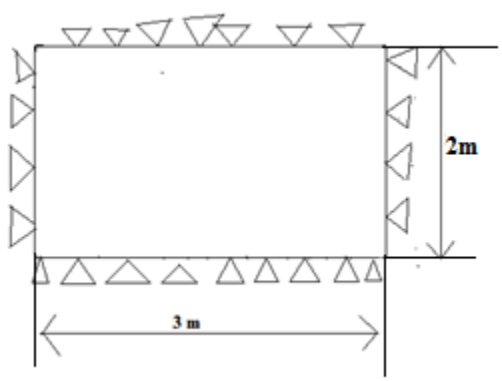

fig 11

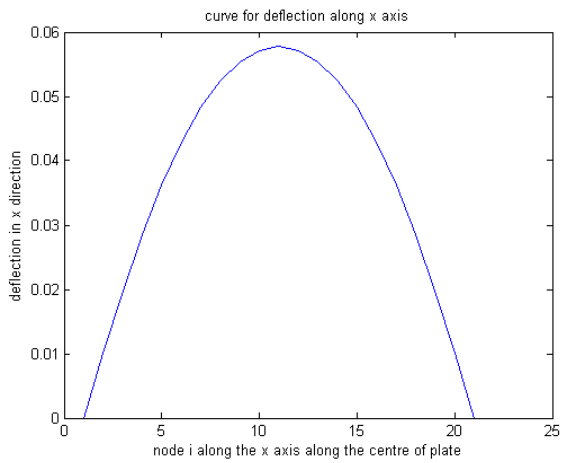

fig 12

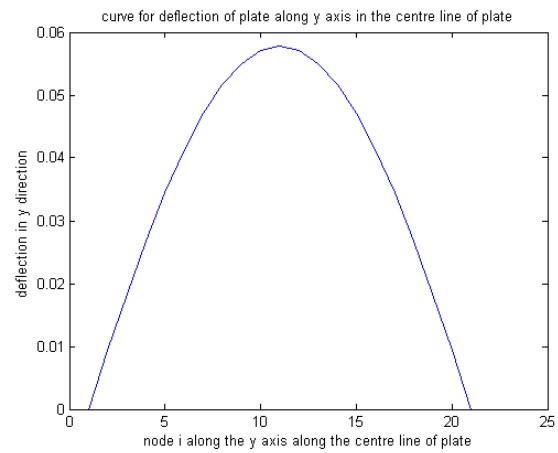

fig 13

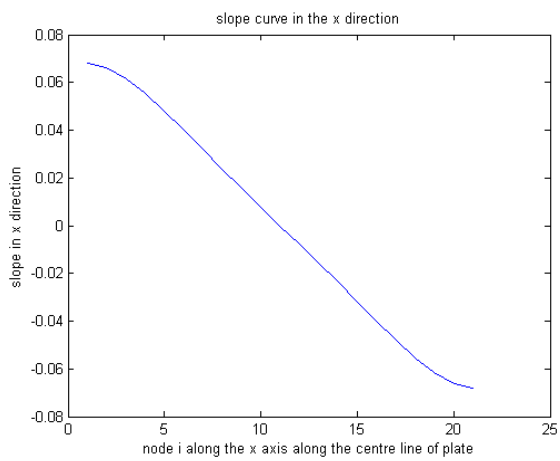

fig 14

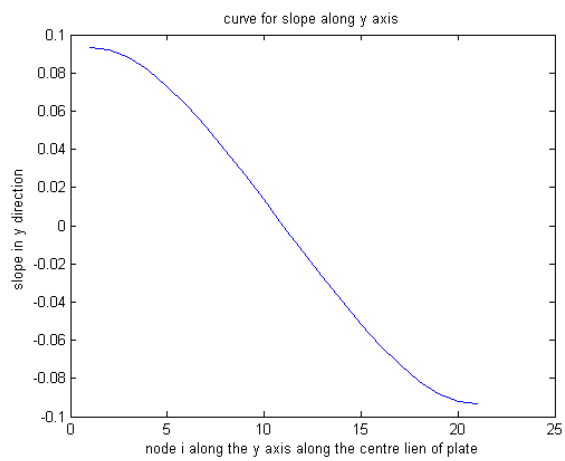

fig 15

<u>CASE 3</u> rectangular plate which is simply supported on y axis and clamped along the x axis dimension of the plate is 3 x 2 m, plate material is steel so Young's modulus is 21 x 10^{10} Pa and Poission's ratio of 0.3 , face load/pressure load is taken as 14x 10^{4} Pa. and plate thickness is 0.025 m, No of plate elements is taken as 400

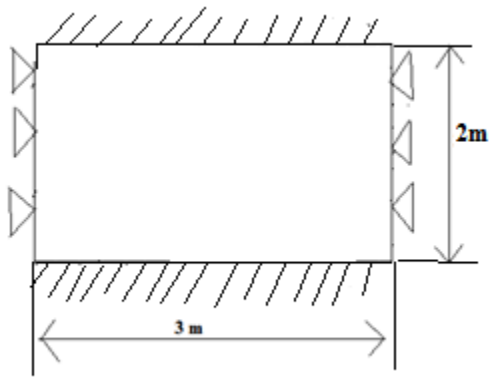

fig 16

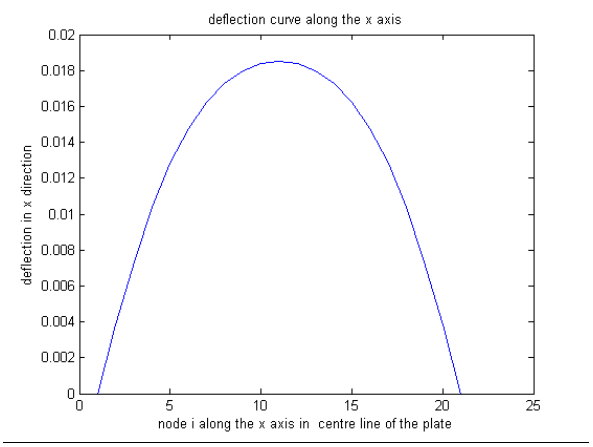

fig 17

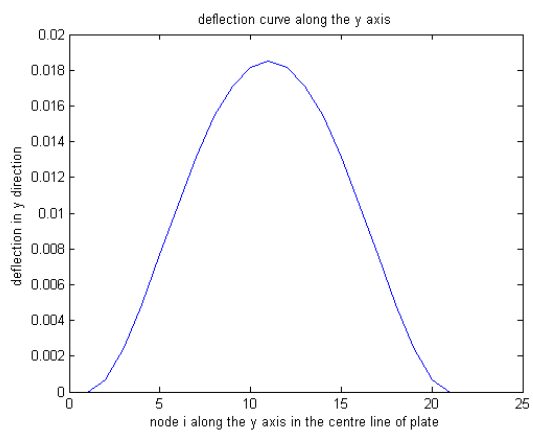

fig 18

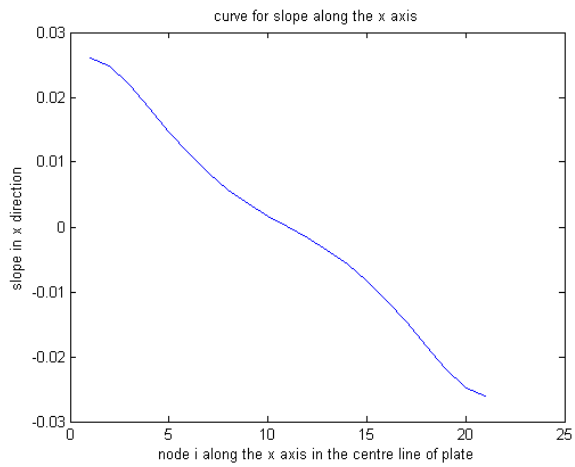

fig 19

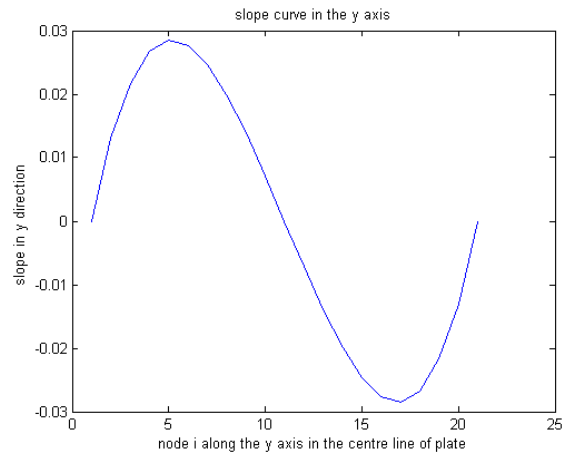

fig 20

<u>CASE 4</u> Rectangular plate which is clamped from two edges and free from the other two edges . clamped along the x axis and free along the y axis.

dimension of the plate is 3 x 2 m, plate material is steel so Young's modulus is 21 x 10^{10} Pa and Poission's ratio of 0.3 , face load/pressure load is taken as 14x 10^{4} Pa. and plate thickness is 0.025 m, No of plate elements is taken as 400

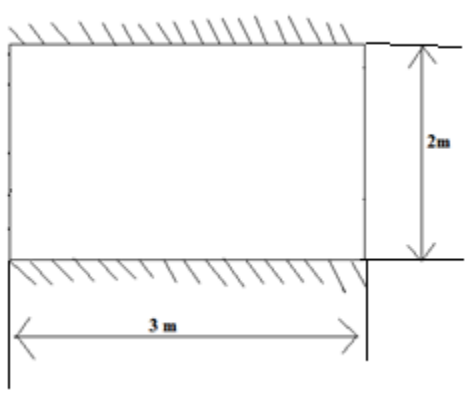

fig 21

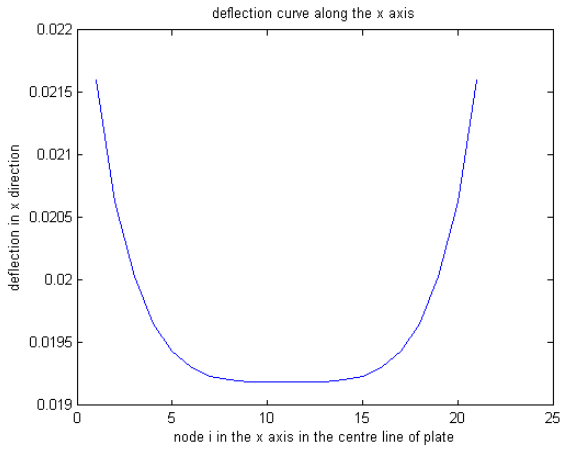

fig 22

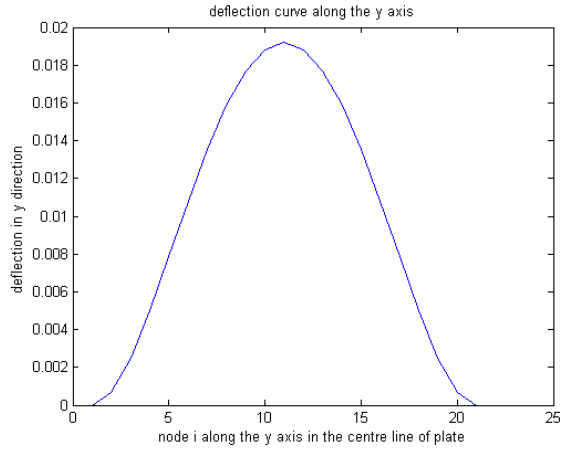

fig 23

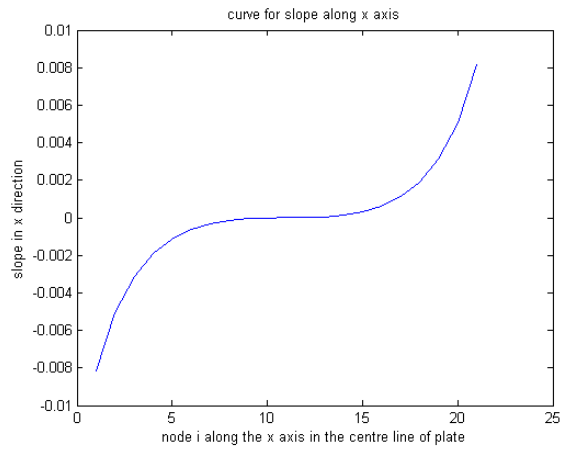

fig 24

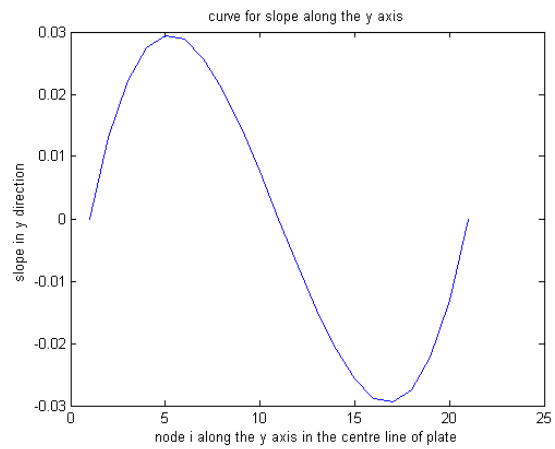

fig 25

RESULTS USING THE LISA

CASE 1

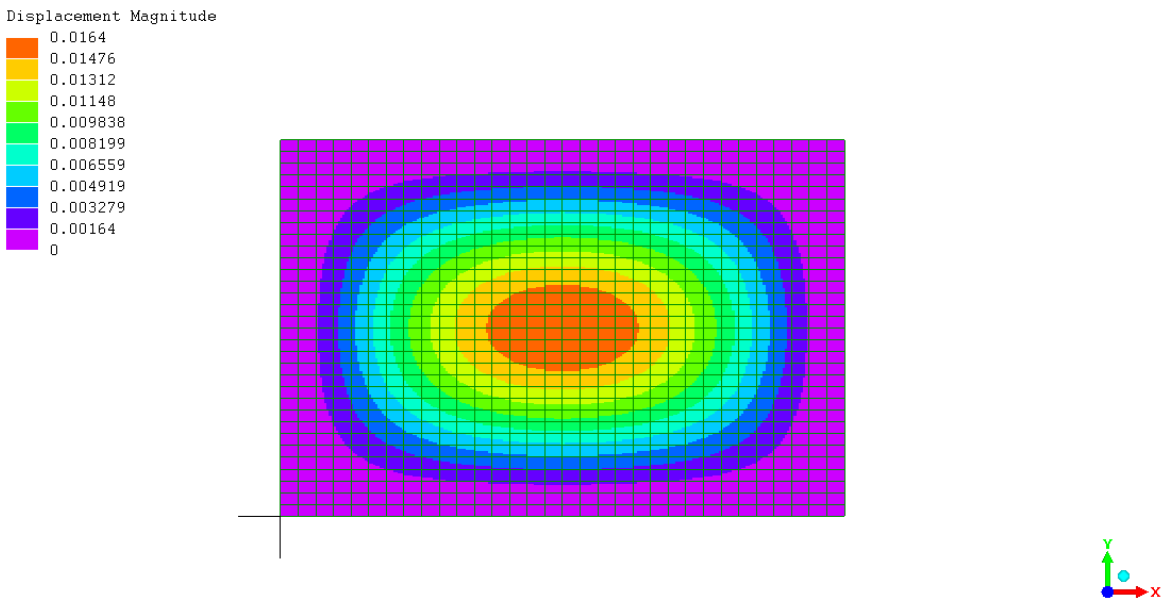

fig 26 displacement field

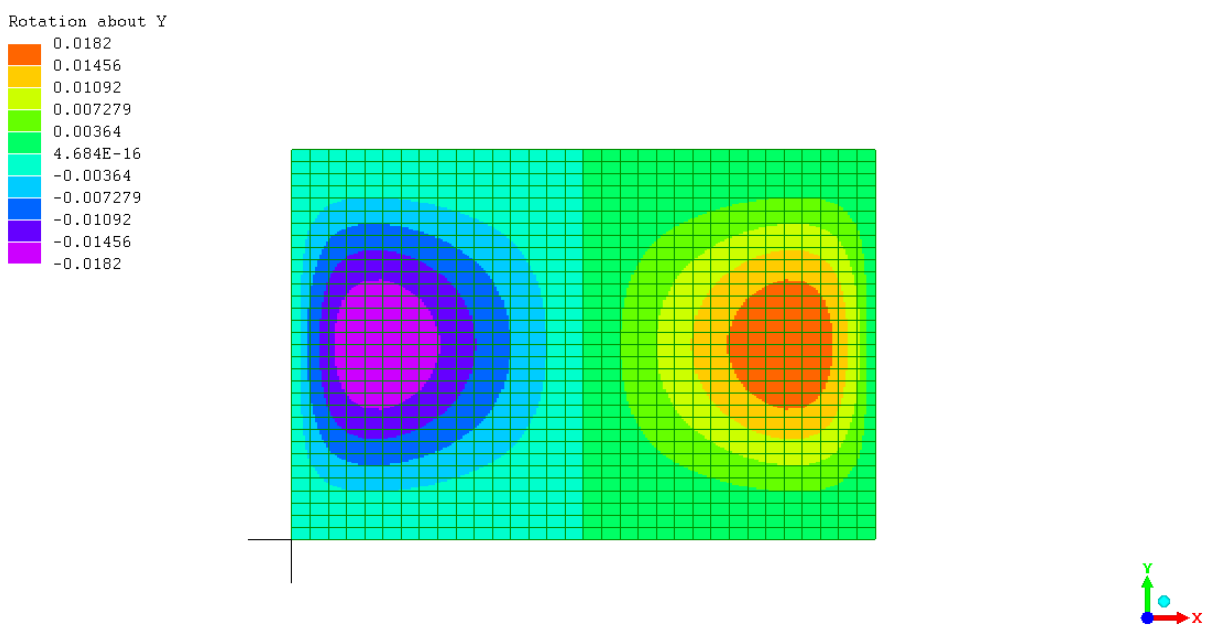

fig 27 slope along the x axis

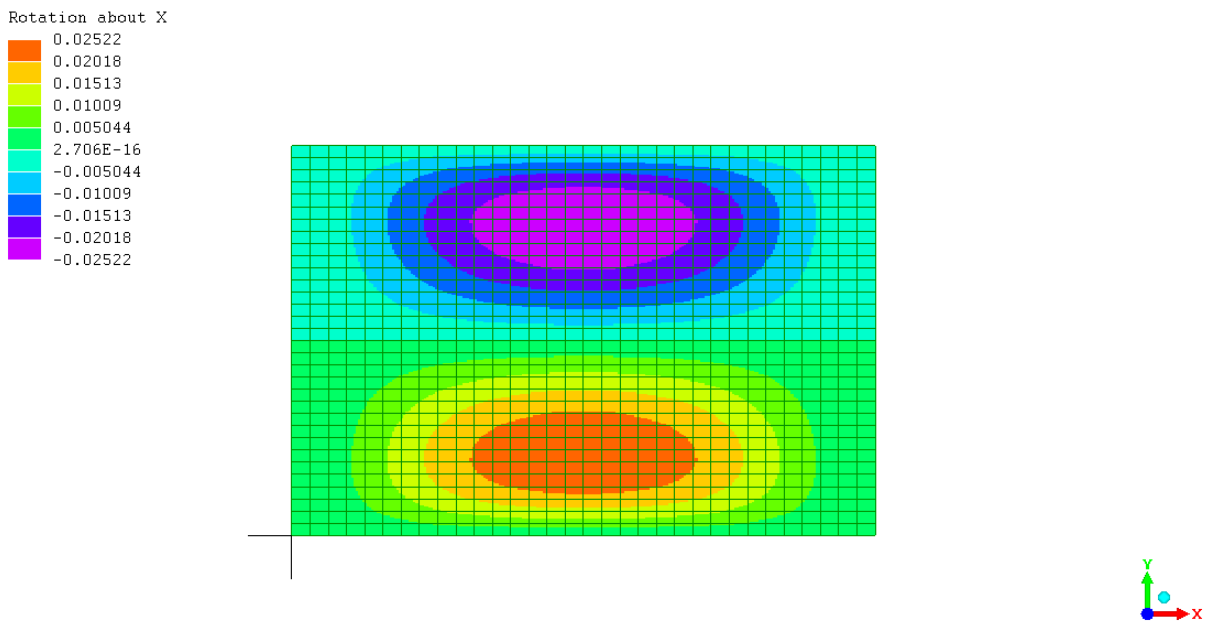

fig 28 slope along the y axis

CASE 2

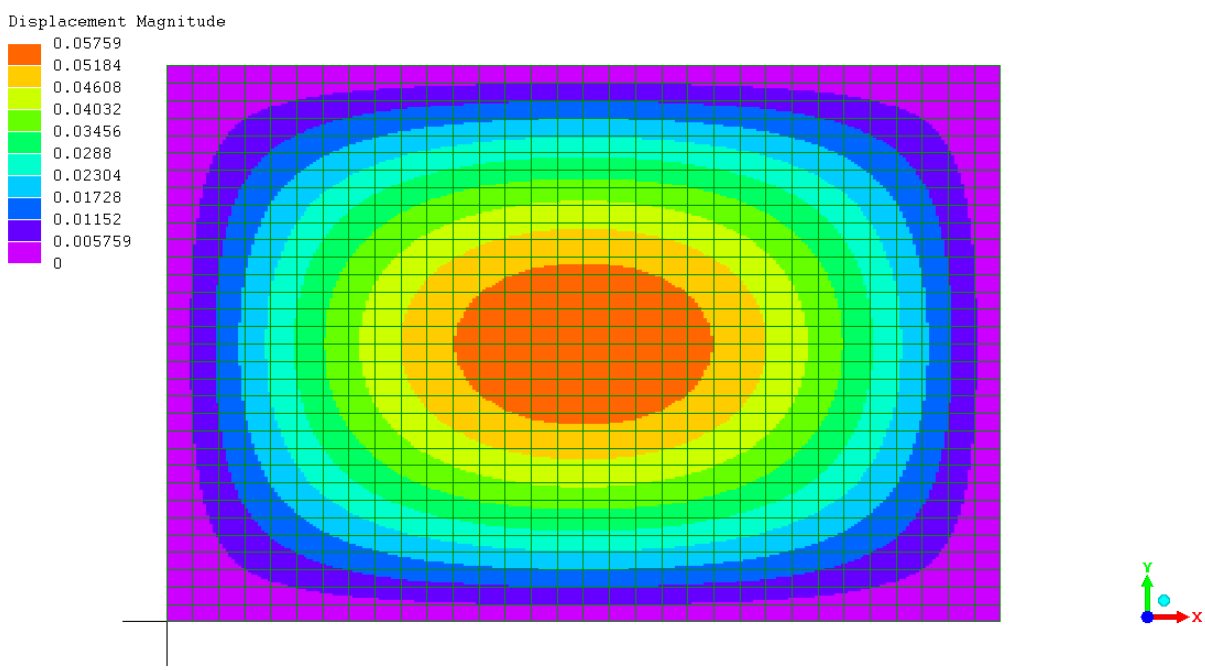

fig 29 displacement field

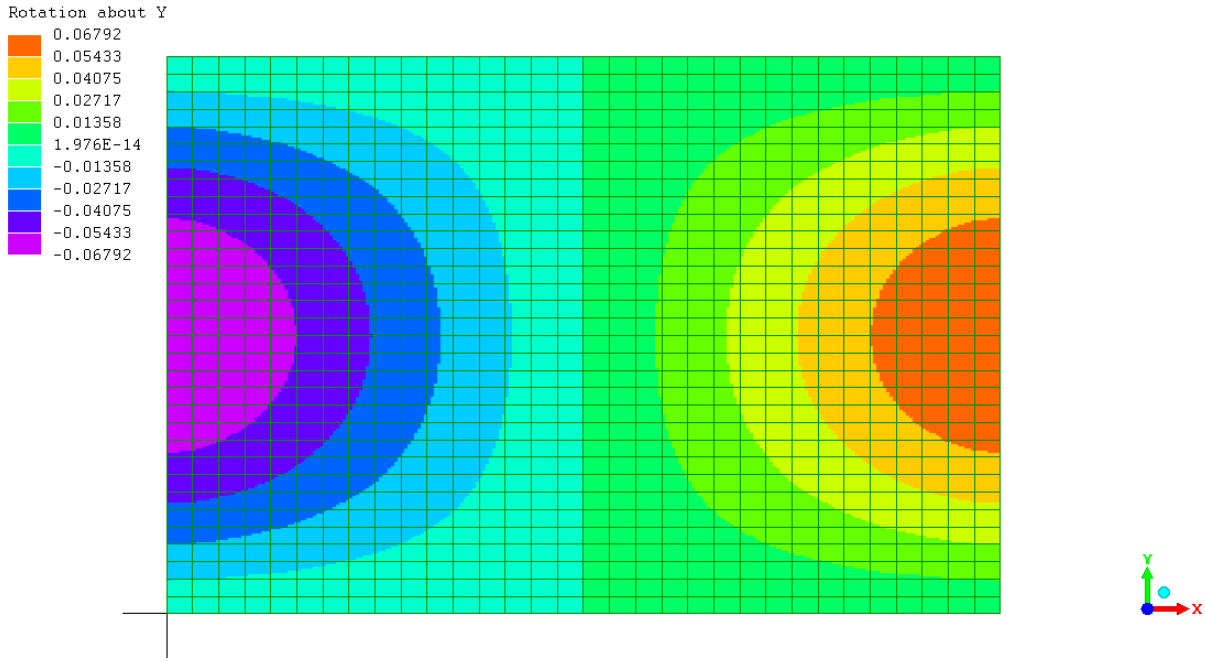

fig 30 slope in the x direction

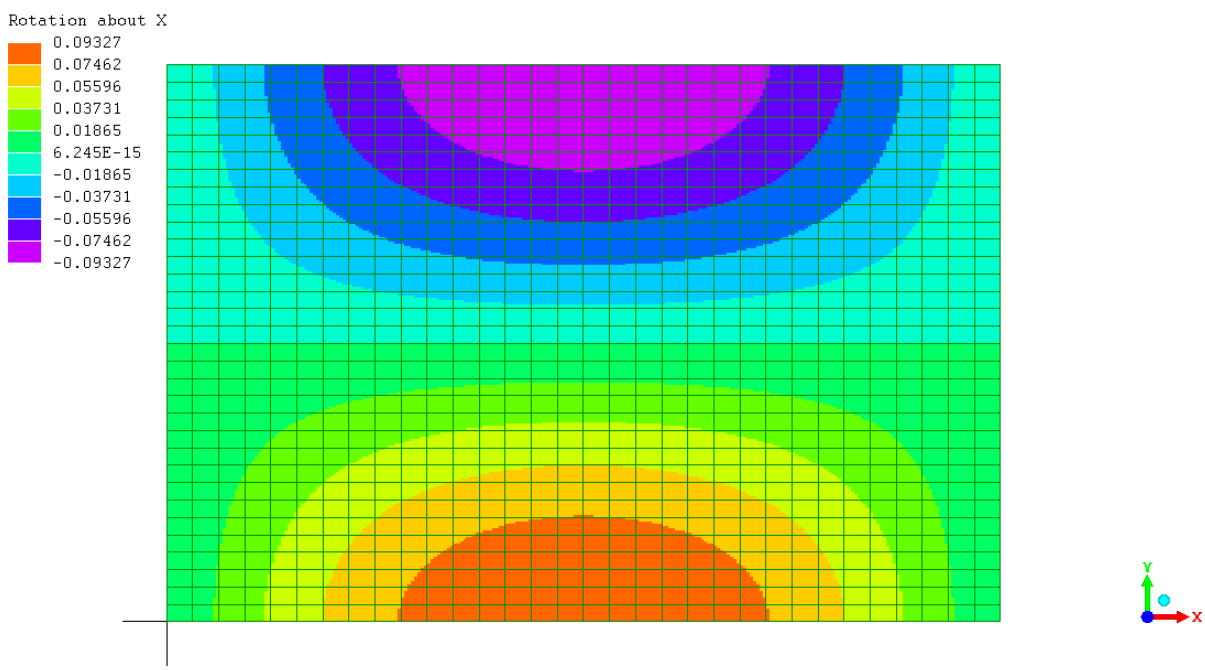

fig 31 slope in the y direction

CASE 3

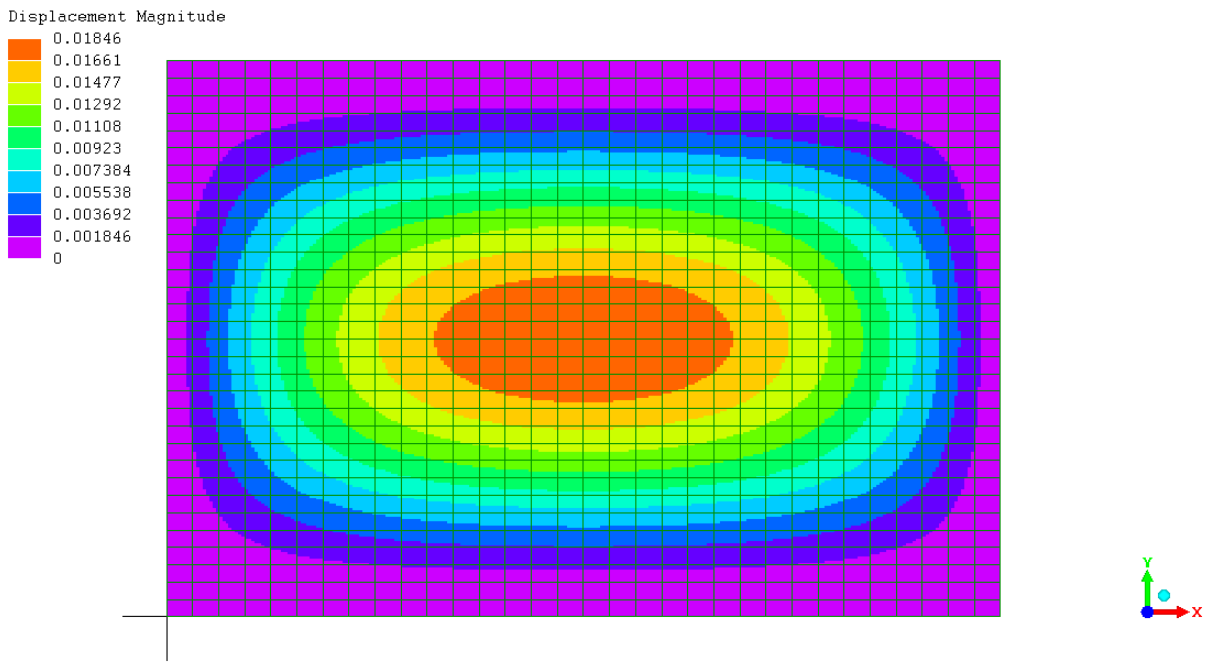

fig 32 displacement field

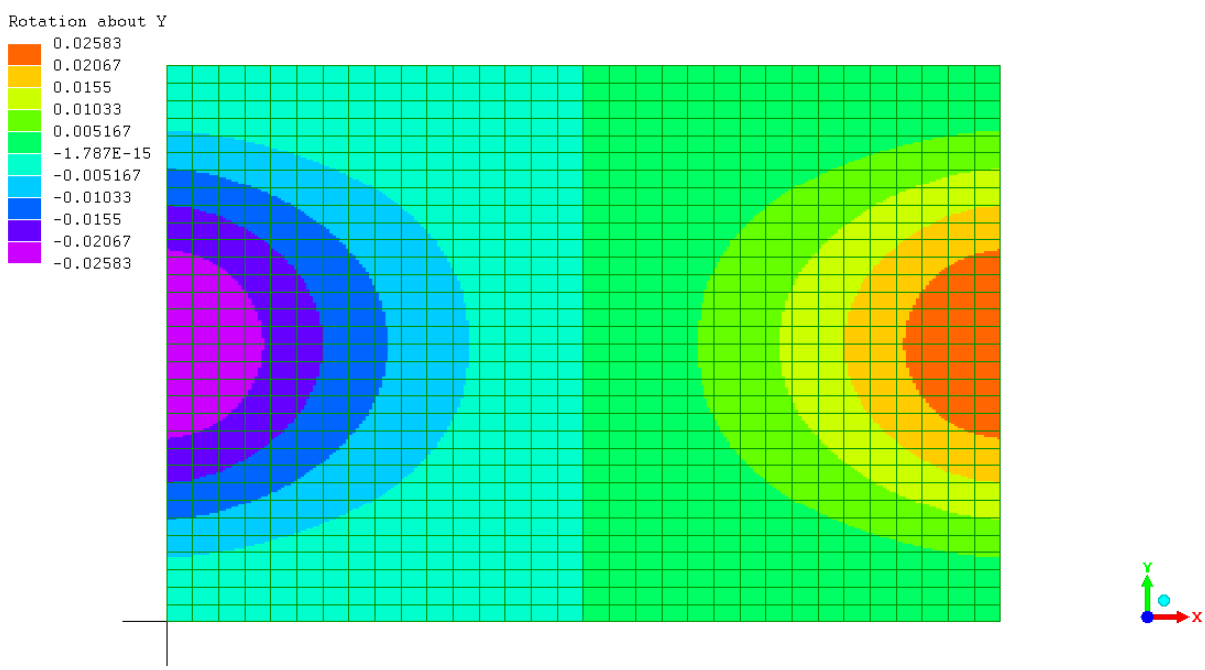

fig 33 slope in the x direction

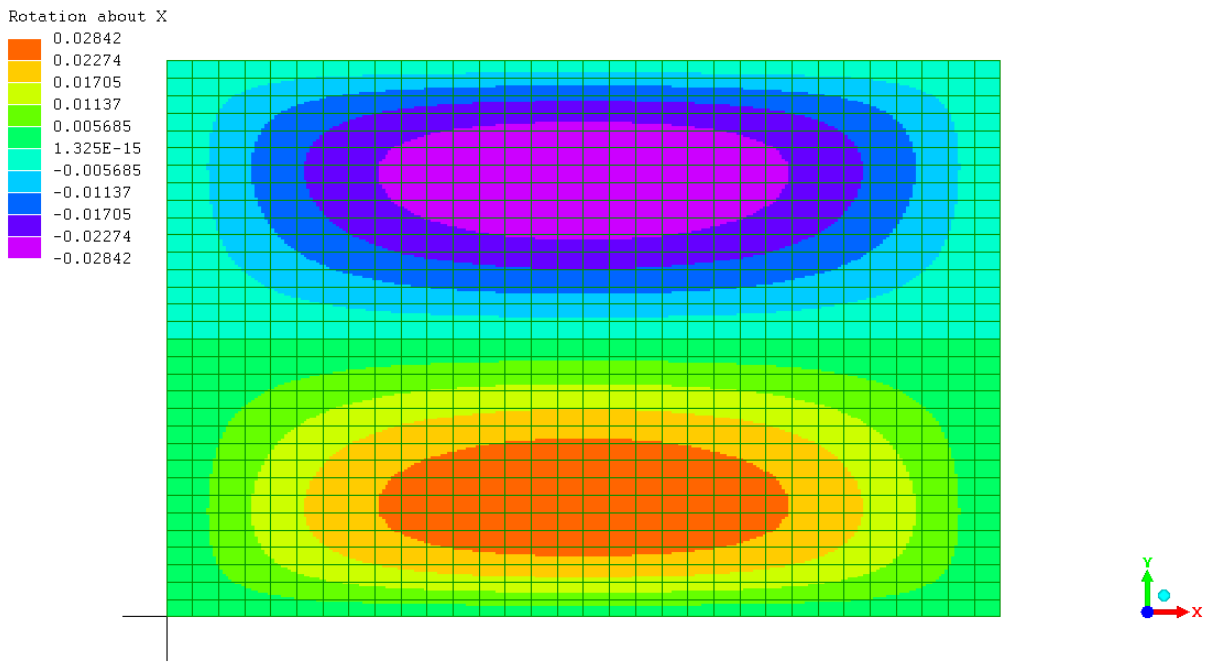

fig 34 slope in y direction

CASE 4

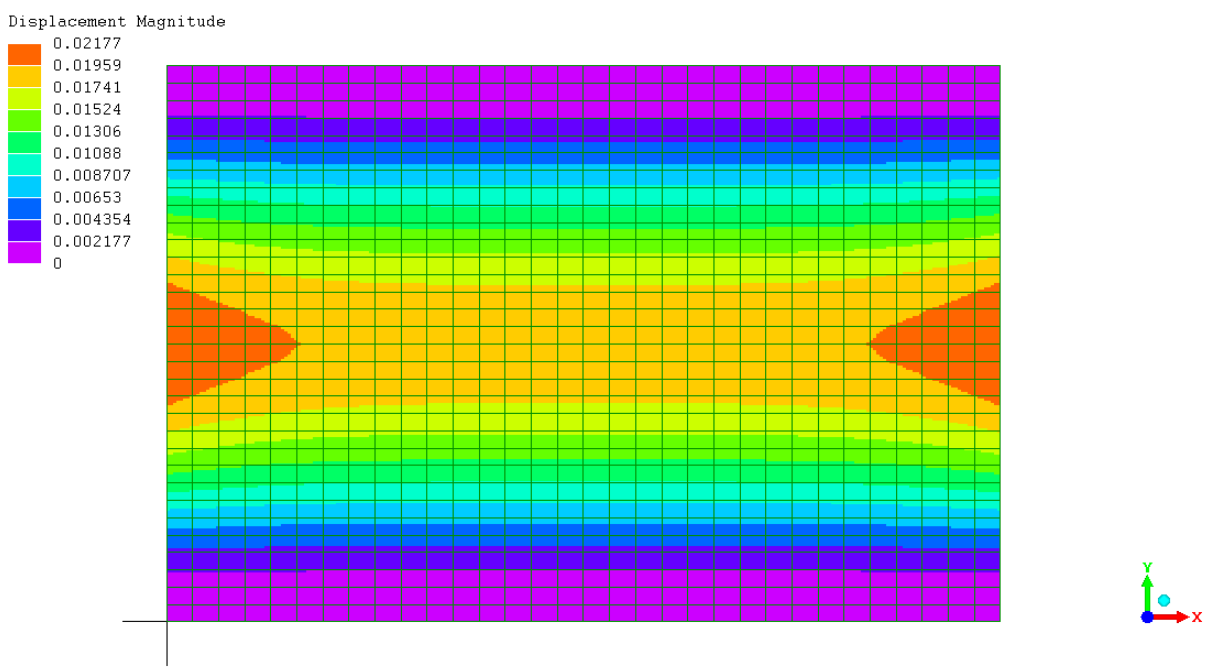

fig 35 displacement field

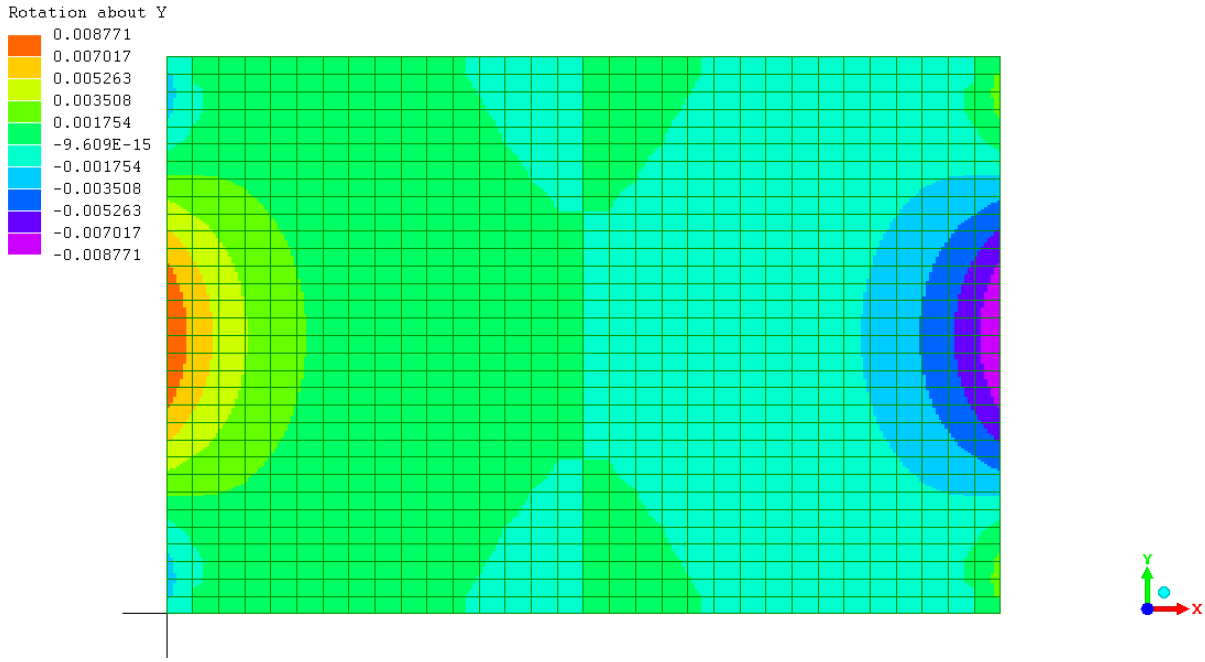

fig 36 slope in x direction

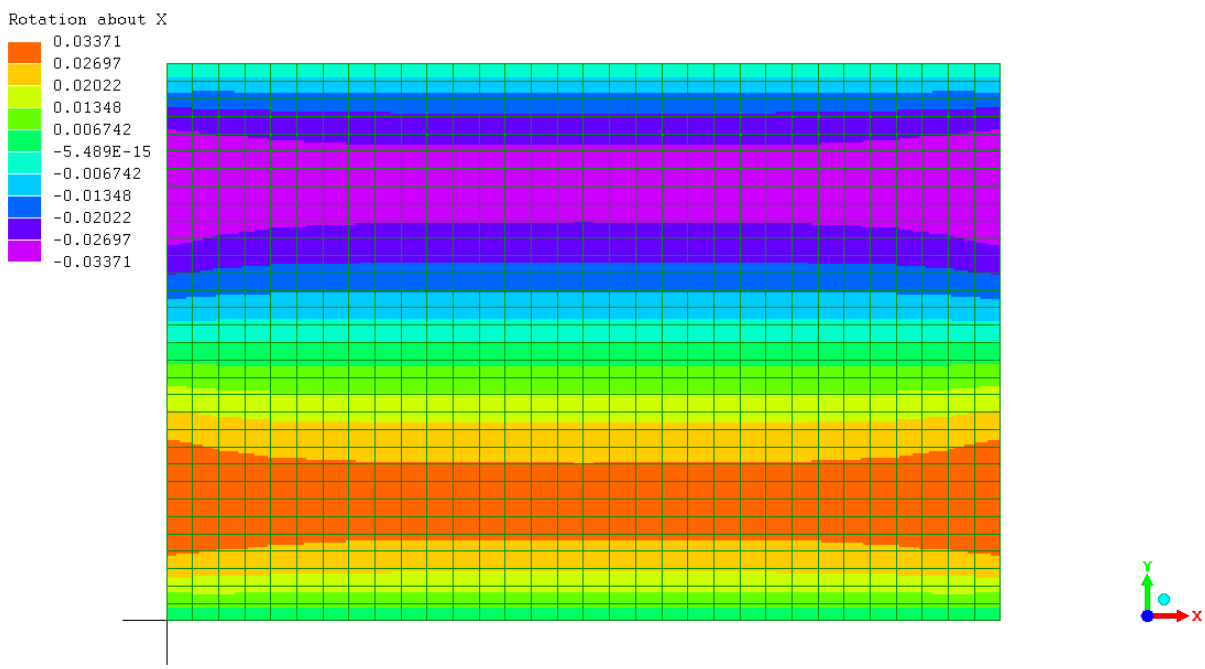

fig 37 slope in y direction

Table 1 for the central point deflection with the different cases

No of elements	Case 1 deflection	Case 2 deflection	Case 3 deflection	Case 4 Deflection
4	1.965 cm	7.3345cm	2.6692cm	2.4664cm
16	1.811cm	6.1633cm	2.0181cm	1.9727cm
36	1.7202cm	5.9381cm	1.9194cm	1.9367cm
64	1.685cm	5.8593cm	1.8866cm	1.9272cm
100	1.668cm	5.8228cm	1.8717cm	1.9233cm
LISA	1.6397cm	5.7595cm	1.8459cm	1.9132cm

CHAPTER 5

CONCLUSION AND DISCUSSIONS

These problems that are encountered here are very common in nature we can easily find structures having plates on which constant pressures (may be even for a small time interval but constant)are applied such as the top plate of table,piston head,leaf valve,thin tin plate against fast moving wind etc. We can see that due to symmetry we can easily predict that in a rectangular plate that may be clamped from all edges,simply supported from all edges ,clamped and simply supported etc. Maximum deflection is found to be at the centre of the plate in all cases and the value of the deflection which are obtained from the finite element method using the Matlab program is getting more and more accurate .Among the different conditions of clamping the maximum deflection is obatined with the help of simply supported plates hence these type of clampings are done to the plate in which deflection is acceptable and accordingly the fixed plates are used where no deflection is needed. and rest other type of clampings are done in intermediate requirements.And LISA colour coded deflection and slope fields can be easily visualized and can give us the more details like bending moment about X and Y etc.and if presented code is extended then again LISA can serve the purpose of comparing and crosschecking of the results.

Similarly bending moment and shear stresses are directly proportional to the rate of change of slopes of slopes of the curvature of the deformed plate hence the steepness of the slope graphs in X and Y direction indicates a stress value qualitatively

Since the present matlab code can be appended with the new and extra code without disturbing the original code there is a scope to find out stresses, strains,analysis of plate with patch loading conditions ,Bending moment ,shear forces,and analysis of skew plates,circular plates ,triangular plates etc.

CHAPTER 6

APPENDIX

```
clear
syms x y
poly=[1,x,y,x^2,x*y,y^2,x^3,x^2*y,x*y^2,y^3,x^3*y,x*y^3];
node=sym(ones(3,12));
element=sym(ones(12,12));
format shortEng
for i=1:1:12
    node(1,i)=poly(1,i);
    clc
end
diff(poly,y);
for i=1:1:12
    node(2,i)=ans(1,i);
    clc
end
-diff(poly,x);
   for i=1:1:12
    node(3,i)=ans(1,i);
    clc
   end
 poly;
 pause
 clc
 node;
 pause
length=input('  enter the length of the plate  ');
breadth=input(' enter the breadth of the plate   ');
div=input(' enter the no of divisions on the length and breadth  ');
p=length/(div*2);
q=breadth/(div*2);
ans =subs(node,{x,y},{-p,q});
pause on
pause
for i=1:1:3     %for node 1
    for j=1:1:12
element(i,j)=ans(i,j);
    end
end
ans=subs(node,{x,y},{p,q});
for i=4:1:6   %for node 2
    for j=1:1:12
```

```
element(i,j)=ans(i-3,j);
    end
end
ans =subs(node,{x,y},{p,-q});
for i=7:1:9        %for node 3
    for j=1:1:12
element(i,j)=ans(i-6,j);
    end
end
ans =subs(node,{x,y},{-p,-q}) ;
for i=10:1:12        %for node 4
    for j=1:1:12
element(i,j)=ans(i-9,j);
    end
end
element;
pause
hmat=sym(ones(3,12));
-diff(diff(poly));
for i=1:1:12
    hmat(1,i)=ans(1,i);
end
-diff(diff(poly,y),y);
for i=1:1:12
    hmat(2,i)=ans(1,i);
end
-2*diff(diff(poly,x),y);
for i=1:1:12
    hmat(3,i)=ans(1,i);
end
clc
hmat;
pause
clc
bmat=hmat*inv(element);
poirat=input('  enter poison ratio of the plate ');
thickness=input(' enter the thickness of the plate  ');
youngmod= input(' enter the youngs modulus of the plate  ');
xxx=input('enter the load function  ');
disp(' enter 1 to analyse for fixed plate from all sides ')
disp(' enter 2 to analyse for simply supported plate from all sides ')
disp(' enter 3 to analyse for simply supported from 2 sides and fixed from
other two sides ')
disp('enter 4 to analyse for plate which is clamped at opposite edges ')
choice=input('enter your choice ');
d=youngmod*thickness^3/(12*(1-poirat^2));
dmat=[1,poirat,0;poirat,1,0;0,0,(1-poirat)/2];
dmat=d*dmat;
pause
```

```
clc
bmat'*dmat*bmat;
kmat=int((int (ans,x,-p,p)),y,-q,q);
kmat;
for i=1:1:12
    for j=7:1:9
        swap=kmat(i,j);
        kmat(i,j)=kmat(i,j+3);
        kmat(i,j+3)=swap;
    end
end
for i=7:1:9
    for j=1:1:12
        swap=kmat(i,j);
        kmat(i,j)=kmat(i+3,j);
        kmat(i+3,j)=swap;
    end
end
kmat;
pause
clc
globalmat=zeros((div+1)^2*3,(div+1)^2*3);
for i=1:1:div^2
    for j=1:1:12
        for k=1:1:12
            quo=((i-1)-rem(i-1,div))/div;
            if j<7
                if k<7
                    globalmat(j+(i-1+quo)*3,k+(i-1+quo)*3)=globalmat(j+(i-
1+quo)*3,k+(i-1+quo)*3)+kmat(j,k);
                else
                    globalmat(j+(i-1+quo)*3,k+(i-1+quo)*3+(div-
1)*3)=globalmat(j+(i-1+quo)*3,k+(i-1+quo)*3+(div-1)*3)+kmat(j,k);
                end
            else
                if k<7
                    globalmat(j+(i-1+quo)*3+(div-1)*3,k+(i-
1+quo)*3)=globalmat(j+(i-1+quo)*3+(div-1)*3,k+(i-1+quo)*3)+kmat(j,k);
                else
                    globalmat(j+(i-1+quo)*3+(div-1)*3,k+(i-1+quo)*3+(div-
1)*3)=globalmat(j+(i-1+quo)*3+(div-1)*3,k+(i-1+quo)*3+(div-1)*3)+kmat(j,k);
                end
            end
        end
    end
end
globalmat;
pause
clc
```

```
nmat=poly*inv(element);
qmat =int((int(nmat'*xxx,x,-p,p)),y,-q,q);
for i=7:1:9
    swap=qmat(i,1);
    qmat(i,1)=qmat(i+3,1);
    qmat(i+3,1)=swap;
end
qmat
qmattotal=zeros((div+1)^2*3,1);
clc
quo=0;
for i=1:1:div^2
    quo=((i-1)-rem(i-1,div))/div;
    for j=1:1:12
        if j<7
            qmattotal(j+quo*3+(i-1)*3,1)=qmattotal(j+quo*3+(i-
1)*3,1)+qmat(j,1);
        else
            qmattotal(j+quo*3+(i-1)*3+(div-1)*3,1)=qmattotal(j+quo*3+(i-
1)*3+(div-1)*3,1)+qmat(j,1);
        end
    end
end
qmattotal;
b=10e20;
switch choice
    case 1
        for i=1:1:div+1  %modification of qmatrix
         for j=1:1:3
            qmattotal((i-1)*3+j,1)=0;
        end
        end
    for i=(div+1)*div+1:1:(div+1)^2
        for j=1:1:3
            qmattotal((i-1)*3+j,1)=0;
        end
    end
    for i=1:(div+1):1+div*(div+1)
        for j=1:1:3
            qmattotal((i-1)*3+j,1)=0;
        end
    end
    for i=div+1:div+1:(div+1)^2
        for j=1:1:3
             qmattotal((i-1)*3+j,1)=0;
        end
    end
    for i=1:1:div+1    %modification of stiffness matrix
        for j=1:1:3
```

```
            globalmat((i-1)*3+j,(i-1)*3+j)=globalmat((i-1)*3+j,(i-1)*3+j)*b;
        end
    end
    for i=(div+1)*div+1:1:(div+1)^2
        for j=1:1:3
            globalmat((i-1)*3+j,(i-1)*3+j)=globalmat((i-1)*3+j,(i-1)*3+j)*b;
        end
    end
    for i=1+div+1:(div+1):1+(div-1)*(div+1)
        for j=1:1:3
            globalmat((i-1)*3+j,(i-1)*3+j)=globalmat((i-1)*3+j,(i-1)*3+j)*b;
        end
    end
    for i=(div+1)*2:div+1:(div+1)*div
        for j=1:1:3
             globalmat((i-1)*3+j,(i-1)*3+j)=globalmat((i-1)*3+j,(i-1)*3+j)*b;
        end
    end
    amat=zeros((div+1)^2*3,1);
    amat=inv(globalmat)*qmattotal;
            for i=1:1:3
           disp(amat(((div+1)*(div/2)+(div/2))*3+i,1))
        end
     displacemat=zeros((div+1)^2,1);
    slopey=zeros((div+1)^2,1);
    slopex=zeros((div+1)^2,1);
    for i=1:1:(div+1)^2
          displacemat(i,1)=amat((i-1)*3+1);
          slopey(i,1)=amat((i-1)*3+2);
          slopex(i,1)=-amat((i-1)*3+3);
    end
x=(div+1)*(div/2)+1:1:(div+1)*((div/2)+1);
y=displacemat(x,1);
plot(x-(div+1)*(div/2),y)
ylabel('deflection in x direction');
pause
x=(div+1)*(div/2)+1:1:(div+1)*((div/2)+1);
y=slopex(x,1);
plot(x-(div+1)*(div/2),y)
ylabel('slope in x direction');
pause
x=((div+1)*div)+(div/2)+1:-(div+1):(div/2)+1;
y=displacemat(x,1);
x=1:1:div+1;
plot(x,y)
ylabel('deflection in y direction ');
pause
x=((div+1)*div)+(div/2)+1:-(div+1):(div/2)+1;
y=slopey(x,1);
```

```
x=1:1:div+1;
plot(x,y)
ylabel('slope in y direction ');
    case 2
        for i=1:1:div+1  %modification of qmatrix
              for j=1:2:3
                  qmattotal((i-1)*3+j,1)=0;
              end
        end
        for i=(div+1)*div+1:1:(div+1)^2
        for j=1:2:3
            qmattotal((i-1)*3+j,1)=0;
        end
        end
        for i=1:(div+1):1+div*(div+1)
        for j=1:1:2
            qmattotal((i-1)*3+j,1)=0;
        end
        end
    for i=div+1:div+1:(div+1)^2
        for j=1:1:2
             qmattotal((i-1)*3+j,1)=0;
        end
    end
    for i=1:1:div+1    %modification of stiffness matrix
        for j=1:2:3
            globalmat((i-1)*3+j,(i-1)*3+j)=globalmat((i-1)*3+j,(i-1)*3+j)*b;
        end
    end
    for i=(div+1)*div+1:1:(div+1)^2
        for j=1:2:3
            globalmat((i-1)*3+j,(i-1)*3+j)=globalmat((i-1)*3+j,(i-1)*3+j)*b;
        end
    end
    for i=1+div+1:(div+1):1+(div-1)*(div+1)
        for j=1:1:2
            globalmat((i-1)*3+j,(i-1)*3+j)=globalmat((i-1)*3+j,(i-1)*3+j)*b;
        end
    end
    for i=(div+1)*2:div+1:(div+1)*div
        for j=1:1:2
             globalmat((i-1)*3+j,(i-1)*3+j)=globalmat((i-1)*3+j,(i-1)*3+j)*b;
        end
    end
    amat=zeros((div+1)^2*3,1);
    amat=inv(globalmat)*qmattotal;
            for i=1:1:3
           disp(amat(((div+1)*(div/2)+(div/2))*3+i,1))
        end
```

```
    displacemat=zeros((div+1)^2,1);
    slopey=zeros((div+1)^2,1);
    slopex=zeros((div+1)^2,1);
    for i=1:1:(div+1)^2
          displacemat(i,1)=amat((i-1)*3+1);
          slopey(i,1)=amat((i-1)*3+2);
          slopex(i,1)=-amat((i-1)*3+3);
    end
x=(div+1)*(div/2)+1:1:(div+1)*((div/2)+1);
y=displacemat(x,1);
plot(x-(div+1)*(div/2),y)
ylabel('deflection in x direction');
pause
x=(div+1)*(div/2)+1:1:(div+1)*((div/2)+1);
y=slopex(x,1);
plot(x-(div+1)*(div/2),y)
ylabel('slope in x direction');
pause
x=((div+1)*div)+(div/2)+1:-(div+1):(div/2)+1;
y=displacemat(x,1);
x=1:1:div+1;
plot(x,y)
ylabel('deflection in y direction ');
pause
x=((div+1)*div)+(div/2)+1:-(div+1):(div/2)+1;
y=slopey(x,1);
x=1:1:div+1;
plot(x,y)
ylabel('slope in y direction ');
    case 3
        disp('along the x axis plate is fixed and along y axis the plate is
simply supported')
        for i=1:1:div+1  %modification of qmatrix
         for j=1:1:3
            qmattotal((i-1)*3+j,1)=0;
        end
        end
    for i=(div+1)*div+1:1:(div+1)^2
        for j=1:1:3
            qmattotal((i-1)*3+j,1)=0;
        end
    end
    for i=1:(div+1):1+div*(div+1)
        for j=1:1:2
            qmattotal((i-1)*3+j,1)=0;
        end
    end
    for i=div+1:div+1:(div+1)^2
        for j=1:1:2
```

```
            qmattotal((i-1)*3+j,1)=0;
        end
    end
    for i=1:1:div+1    %modification of stiffness matrix
        for j=1:1:3
            globalmat((i-1)*3+j,(i-1)*3+j)=globalmat((i-1)*3+j,(i-1)*3+j)*b;
        end
    end
    for i=(div+1)*div+1:1:(div+1)^2
        for j=1:1:3
            globalmat((i-1)*3+j,(i-1)*3+j)=globalmat((i-1)*3+j,(i-1)*3+j)*b;
        end
    end
    for i=1+div+1:(div+1):1+(div-1)*(div+1)
        for j=1:1:2
            globalmat((i-1)*3+j,(i-1)*3+j)=globalmat((i-1)*3+j,(i-1)*3+j)*b;
        end
    end
    for i=(div+1)*2:div+1:(div+1)*div
        for j=1:1:2
             globalmat((i-1)*3+j,(i-1)*3+j)=globalmat((i-1)*3+j,(i-1)*3+j)*b;
        end
    end
    amat=zeros((div+1)^2*3,1);
    amat=inv(globalmat)*qmattotal;
            for i=1:1:3
           disp(amat(((div+1)*(div/2)+(div/2))*3+i,1))
        end
     displacemat=zeros((div+1)^2,1);
    slopey=zeros((div+1)^2,1);
    slopex=zeros((div+1)^2,1);
    for i=1:1:(div+1)^2
          displacemat(i,1)=amat((i-1)*3+1);
          slopey(i,1)=amat((i-1)*3+2);
          slopex(i,1)=-amat((i-1)*3+3);
    end
x=(div+1)*(div/2)+1:1:(div+1)*((div/2)+1);
y=displacemat(x,1);
plot(x-(div+1)*(div/2),y)
ylabel('deflection in x direction');
pause
x=(div+1)*(div/2)+1:1:(div+1)*((div/2)+1);
y=slopex(x,1);
plot(x-(div+1)*(div/2),y)
ylabel('slope in x direction');
pause
x=((div+1)*div)+(div/2)+1:-(div+1):(div/2)+1;
y=displacemat(x,1);
x=1:1:div+1;
```

```
plot(x,y)
ylabel('deflection in y direction ');
pause
x=((div+1)*div)+(div/2)+1:-(div+1):(div/2)+1;
y=slopey(x,1);
x=1:1:div+1;
plot(x,y)
ylabel('slope in y direction ');
    case 4
        disp('the plate is clamped in both the x direction edges')
        pause
        for i=1:1:div+1  %modification of qmatrix
         for j=1:1:3
            qmattotal((i-1)*3+j,1)=0;
        end
        end
        for i=(div+1)*div+1:1:(div+1)^2
        for j=1:1:3
            qmattotal((i-1)*3+j,1)=0;
        end
        end
        for i=1:1:div+1    %modification of stiffness matrix
        for j=1:1:3
            globalmat((i-1)*3+j,(i-1)*3+j)=globalmat((i-1)*3+j,(i-1)*3+j)*b;
        end
        end
        for i=(div+1)*div+1:1:(div+1)^2
        for j=1:1:3
            globalmat((i-1)*3+j,(i-1)*3+j)=globalmat((i-1)*3+j,(i-1)*3+j)*b;
        end
        end
        amat=zeros((div+1)^2*3,1);
    amat=inv(globalmat)*qmattotal;
            for i=1:1:3
           disp(amat(((div+1)*(div/2)+(div/2))*3+i,1))
        end
     displacemat=zeros((div+1)^2,1);
    slopey=zeros((div+1)^2,1);
    slopex=zeros((div+1)^2,1);
    for i=1:1:(div+1)^2
          displacemat(i,1)=amat((i-1)*3+1);
          slopey(i,1)=amat((i-1)*3+2);
          slopex(i,1)=-amat((i-1)*3+3);
    end
x=(div+1)*(div/2)+1:1:(div+1)*((div/2)+1);
y=displacemat(x,1);
plot(x-(div+1)*(div/2),y)
ylabel('deflection in x direction');
pause
```

```
x=(div+1)*(div/2)+1:1:(div+1)*((div/2)+1);
y=slopex(x,1);
plot(x-(div+1)*(div/2),y)
ylabel('slope in x direction');
pause
x=((div+1)*div)+(div/2)+1:-(div+1):(div/2)+1;
y=displacemat(x,1);
x=1:1:div+1;
plot(x,y)
ylabel('deflection in y direction ');
pause
x=((div+1)*div)+(div/2)+1:-(div+1):(div/2)+1;
y=slopey(x,1);
x=1:1:div+1;
plot(x,y)
ylabel('slope in y direction ')
end
```

CHAPTER 7
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