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Research Article

Comparison of Elemental Performance for Stress Concentration Factor

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Abstract

Rectangular filleted bar or bracket is used to support horizontal shaft from a pillar where there is no wall in the way of wheels or pulleys on the shaft .It is also used in aerospace and automobile industries for supporting the structures like batteries and sensors in automobile for fixing the body to chassis and for fixing the auxiliaries. After the roofing work is finished, the overhang of sheets is supported by brackets. The railings around walkways and louvers provided for ventilation in a shed system are also supported by brackets. Also Square plate with hole is a frequently used component. Thus their finite element analysis plays important role. In this paper for Rectangular filleted bar, the effect of different types of elements used while meshing on FEA result is studied. Also for Square Plate effect of number of nodes on FEA results is studied.

Keywords: *stress concentration factor(SCF), Plate with hole, Rectangular filleted bar*

1. Introduction

The finite element methods (FEM), sometimes referred to as finite element analysis (FEA), are based on an idea of discretizing a physical domain into small manageable pieces and applying governing equations of the domain to these places which will lead to linear algebraic system of equations.

Types of elements:

1. 1D elements
2. 2D elements(triangular, rectangular)
3. 3D elements(tetrahedral, hexahedral)

Here we have used 2D elements for meshing.

Displacement functions for three-noded triangular element:

$u(x,y) = a_1+a_2x+a_3y$

$v(x,y) = a_4 + a_5x + a_6y$

Shape functions for three-noded triangular element:

$N_i = \frac{1}{2A}(\alpha_i + \beta_i x + \gamma_i y)$

$N_j = \frac{1}{2A}(\alpha_j + \beta_j x + \gamma_j y)$

$N_m = \frac{1}{2A}(\alpha_m + \beta_m x + \gamma_m y)$

Where

$\alpha_i = x_j y_m - y_j x_m$

$\beta_i = y_j - y_m$

$\gamma_i = x_m - x_j$

$\alpha_i = x_j y_m - y_j x_m$

$\beta_i = y_j - y_m$

$\gamma_i = x_m - x_j$

$\alpha_i = x_j y_m - y_j x_m$

$\beta_i = y_j - y_m$

$\gamma_i = x_m - x_j$

Displacement functions for four-noded triangular element:

$u(x,y) = a_1 + a_2x + a_3y + a_4xy$

$v(x,y) = a_5 + a_6x + a_7y + a_8xy$

Shape function for four-noded rectangle element:

$N_1 = \frac{(b-x)(h-y)}{4bh}$

$N_2 = \frac{(b+x)(h-y)}{4bh}$

$N_3 = \frac{(b+x)(h+y)}{4bh}$

$N_4 = \frac{(b-x)(h+y)}{4bh}$

2. Problem statement

The problems we have taken for analysis are 2D rectangular filleted barand plate with hole made of steel (Elasticity modulus (E) = 210 GPa , Modulus of rigidity (G) = 81 GPa, Density (ρ) = 7.9e-9 kg/mm³). Poission's ratio (ν): 0.3

For rectangular filleted bar

Load applied: 1000 N

Cross sectional area (A) = 200 mm²

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Thickness: 5mm

For plate with hole

Load applied: 10000 N
Cross sectional area (A) = 9500 mm^2
Thickness: 10 mm

3. Solution

By Analytical Method

For rectangular filleted bar

Max. stress at fixed end:

σ =5 MPa

Max. displacement:
δ = 0.2380e-02 mm

k_t = 1.6
Stress at fillet:
k_t *σ = 8 MPa

For plate with hole:

Max. stress at fixed end:
σ =1.0526 MPa

k_t= 3

Max. stress near hole:
k_t* σ = 3 * 1.0526 MPa
= 3.1578 MPa

Max. displacement:
δ = 5.01253e-03 mm

4. Finite element modeling

For rectangular filleted bar

1) Mixed Mesh

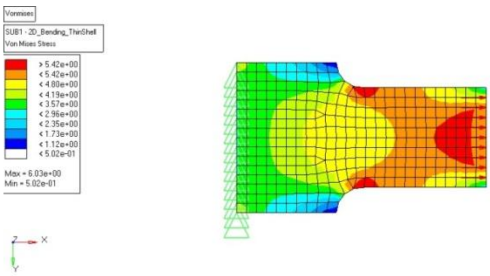


Fig.1 Vonmises Stress

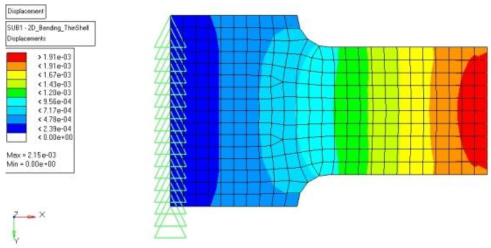


Fig.2 Displacement

Number of quadrilateral elements = 304
Number of trianular elements = 4

2) Triangular Mesh

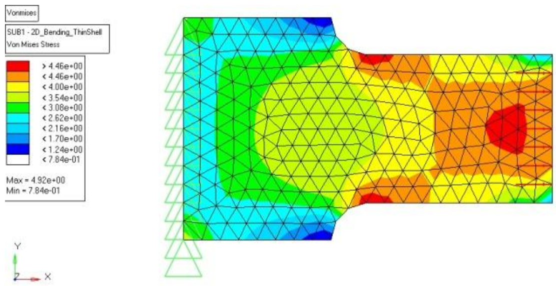


Fig.3 Vonmises Stress

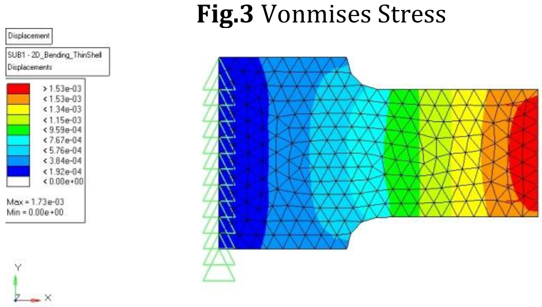


Fig.4 Displacement

Number of triangular elements = 432

3) Mapped Mesh

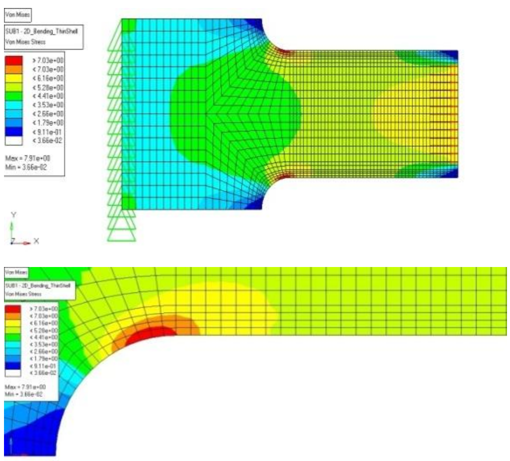


Fig.5 Vonmises Stress

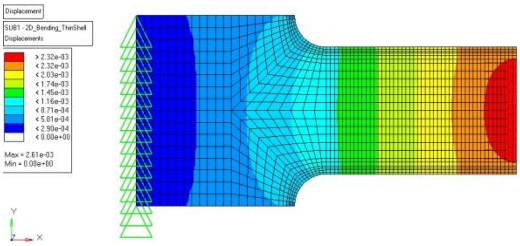


Fig.6 Displacemen

Number of quadrilateral elements = 1728

For plate with hole

1) For 32 nodes

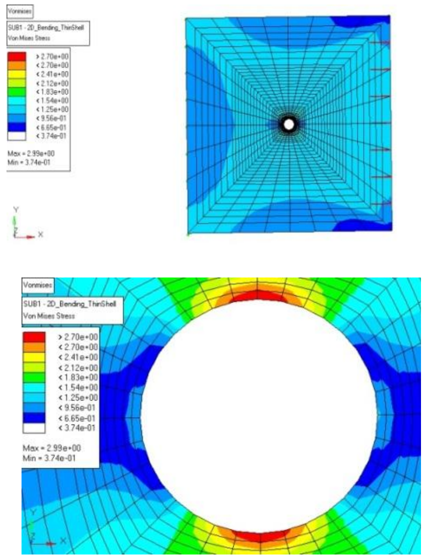


Fig.7 Vonmises Stress

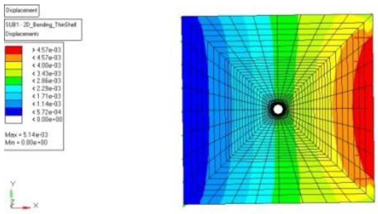
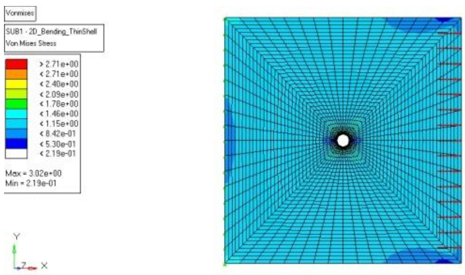


Fig.8 Displacement

Number of elements = 1152

2) For 64 nodes



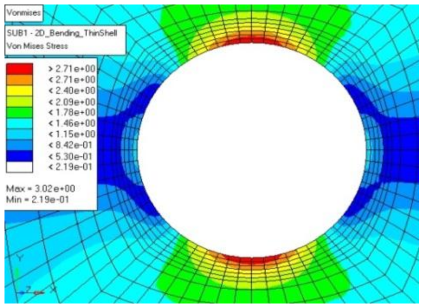


Fig.9 Vonmises Stress

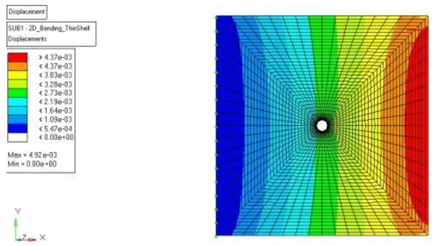


Fig.10 Displacement

Number of elements = 2624

3) For 128 nodes

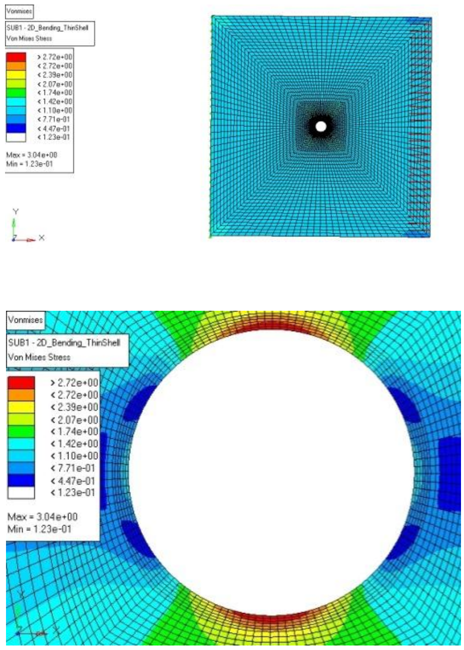


Fig.11 Vonmises Stress

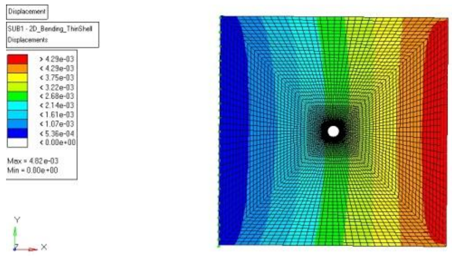


Fig.12 Displacement

Number of elements = 7552

5. FEA Results

For Rectangular filleted bar

Mesh Type	Exact	Mixed	Triangular	Mapped
Max. displacement (mm)	0.2380e-02	0.215126e-02	0.215846e-02	0.261e-02
Max. stress at Fixed End (MPa)	8	6.34500	6.93875	7.91

For Plate with Hole

No. of nodes	**Exact**	**32**	**64**	**128**
Max. displacement (mm)	5.012e-03	5.14e-03	4.92e-03	4.82e-03
Max. stress at Fixed End (MPa)	3.1578	2.99	3.02	3.04

Conclusion

It can be observed from table that for Rectangular filleted bar,Ruled mesh has given closest results to analytical results and mixed mesh has most deviation.

For Square plate with hole, we obtain closer results to Analytical with increase in number of nodes. Thus Elemental Performance is better for quadrilateral nodes and thus are preferred for analysis.

References

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