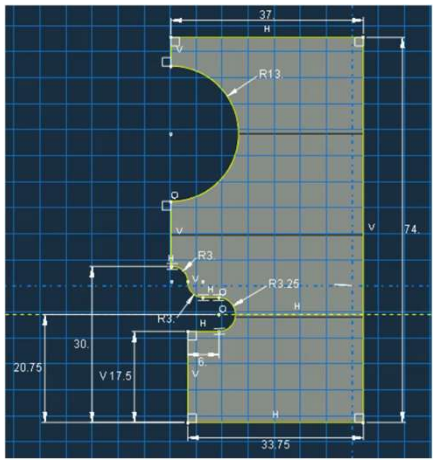
MAE-503 PROJECT-3 FINAL REPORT_1223486849

Improvements/ Corrections Done:

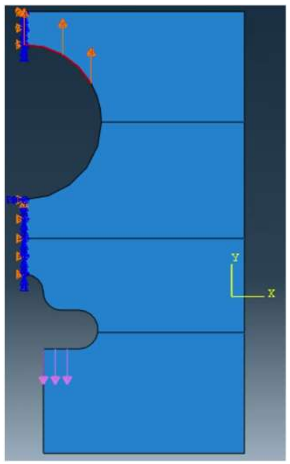
- Considered a lower value for the breaking stress from 50 MPa to 30 MPa.
- Changed the angle of contact of the dowel to the model from 30 deg. to 60 deg (in half symmetry).
- New mesh refinement study for new break load prediction.
- Effect of different angle of contact of dowel studied using previous break load and max stress

FEM Model Description (Base SI Units – N; mm; s; MPa):

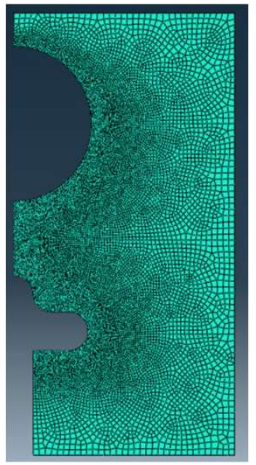
- 2D-Plate (Deformable, shell) modelled with ½ Symmetry along the Y-axis.
- Material Properties – E = 3310 MPa ; nu = 3.75.
- Solid Homogeneous section assigned with plane stress/strain thickness taken 6.35mm. Problem type assumed Plane Stress. Next added a static, general step.
- **Mesh** : (For coarse) Local seeds of size 0.4 taken on the left inner curved edges, single bias seeding along partitions and straight edges and global seeds 3 taken along the exterior edges.
- **Element type** – Plane stress family, Quad element of Quadratic order (QUAD8 elements – with no reduced integration) taken for better accuracy.
- **Element shape control** – Purely Quad elements under free technique selected for element consistency.
- **BC-1** : Y-direction roller support (X-sym) on the vertical edges where body connects to its symmetrical portion.
- **BC-2** : X-direction roller support (Y-sym) on the bottom point of the semi-circle
- **Loading**:
  a) Force(F=650N) applied on both (Dowel and washer) contact surfaces in full body condition.
  b) Values for traction(t1, t2) calculated by dividing the applied force(F) by the total area of contact (A1 for dowel and A2 for washer) in full body condition.
  c) A1 = S*t = 2*r*θ*t, where A1 = dowel contact area (mm2), S = arc length (mm), r = radius of the circle (mm), t = thickness of the plate (mm), θ = angle of contact (rad). Considering r = 13mm, θ = 2π/3 rad, t = 6.35 mm; A1 = 172.8923 mm^2.
  d) A2 = 2*l*t, where A2 = washer contact area (without symmetry), l = washer contact length (mm), t = thickness of the plate (mm). Considering l = 4mm and t = 6.35mm; A2 = 50.8 mm2.
  e) Hence, t1 = 650/ 172.8923 = 3.7596 MPa in the upward direction and t2 = 650/50.8 = 12.7953 MPa in the downward direction, where t1 and t2 are tractions applied on the arc surface and washer contact surface, respectively (refer to pink lines in the 'BC and Loading' image). Therefore, the resultant force in X and Y directions is zero.
  f) Angle of contact (in half symmetry in model) = θ/2 = 60 degree. t1 = applied traction taken on hole surface for this angle in half-symmetry. t2 = applied traction downward on surface of length 4mm.



Geometry



BC & Loading



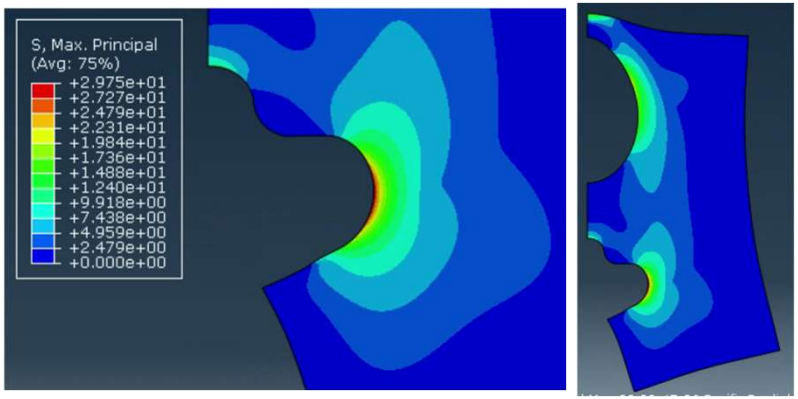
Meshing (Fine)

Mesh	Element size (Local seed – min size , Global seed – max)	No. of elements	Force (N)	Max. Principal Stress (MPa)
Coarse	0.2, 1.6	9094	650	29.83
Medium	0.14, 1.2	17327	650	29.76
Fine	0.08, 1.0	35806	650	29.75

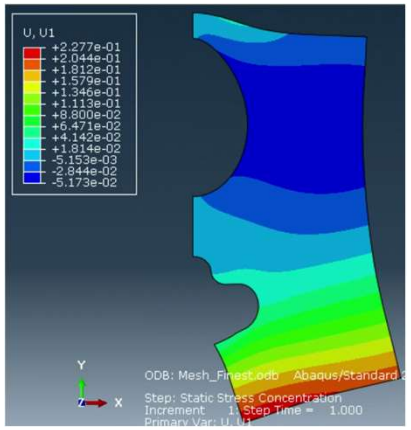
Mesh Size (Min, Max)	Mesh Elements	Load, F	Theta (in degrees)	t1 (N/mm2)	t2 (N/mm2)	Max Stress (MPa)
0.05, 1.5	41421	1200 N	60	6.9407	23.6220	54.95
			120	13.8815	23.6220	54.92
			150	5.5526	23.6220	54.91

Here FEA analysis is done using previously predicted break load (F=1200N) with different angles of contact b/w dowel and surface, to see the effect on max. stress keeping same fine mesh.

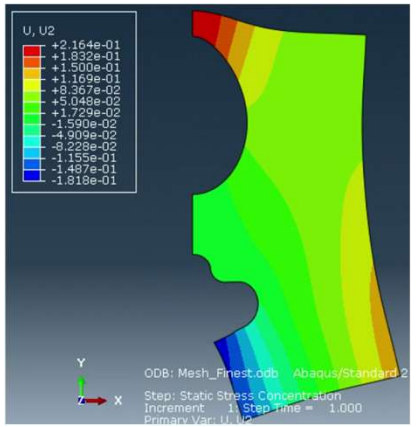
NOTE:- Theta is angle of contact in full body condition .i.e., without symmetry. For half-symmetry we applied traction on at an angle = (theta/2).



Maximum Principal Stress in At Predicted Break Load



Displacement in X-direction



Displacement in Y-direction

Results:

- The maximum principal stress for 650 N load = 29.75 MPa at fine mesh with convergence.
- Hence, considering the breaking stress as 30 MPa, the predicted breaking force is load, F > 650 N.
- The analysis was repeated by applying the predicted breaking load and the mesh was refined on every iteration to achieve convergence.
- Also, with different angle of contact consideration b/w dowel and hole surface, it is observed there is almost negligible effect on max. stress value.

Summary:

The previous break load prediction for a part was 1200N with a maximum stress of 55.22 MPa(>50 MPa), based on Project-2 Experiment Data. However, this was an overprediction, and a new limit of 30 MPa was selected based on the 2-standard deviation below the mean value of the data. Using this limit, the new break load prediction is F>650N, with a maximum stress of 29.75 MPa, which is close to the selected limit. No design changes were made, only the basis of load prediction was different, resulting in a 45% lower prediction than the previous one. Additionally, a different angle of contact study did not affect the max stress or load prediction.