Assignment on FEM

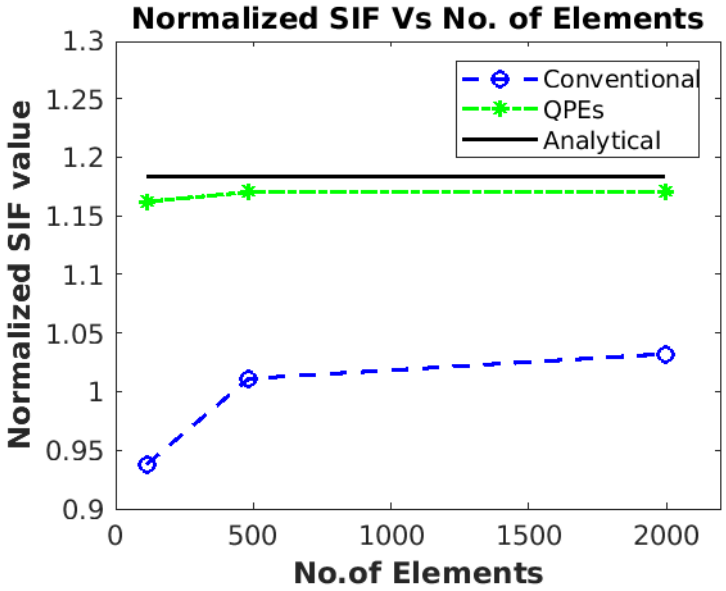
Q1) Given configuration of double edge cracked plate is analyzed for numerical SIF values using Ansys Mechanical APDL. Since the geometry is symmetric both horizontally and vertically about its centre, quarter model is used as domain for finite element modelling. Mesh 1(course), Mesh 2(moderate) and Mesh 3(fine) are generated for the purpose and below table highlights the summary of the analysis.

Mesh	**No. of Elements***	**No. of Nodes***	$K_I/\sigma\sqrt{\pi a}$		
			Computed		**Handbook**
			Conventional Elements	**QPEs**	
Mesh 1	28	105	0.9379	1.1622	1.184#
Mesh 2	121	402	1.0112	1.1704	
Mesh 3	499	1568	1.0322	1.1701	

*Elements & nodes shown are for the FEA domain

#Based on modification of Benthem's formula (Tada 1973), which has an accuracy of 0.5 %.

Graph of normalized SIF values Vs No. of Elements:



Observations:

1) In general, using QPEs at the crack tip yielded much better results than conventional elements.
2) Though the accuracy of conventional elements increases as the mesh gets finer, it is nowhere close to QPEs.
3) On the other hand, QPEs yield very good results even with coarse mesh, which helps in reducing the computational time.
4) As there is no much change in normalized SIF value for moderate and fine meshes of QPEs, moderate mesh with QPEs is the best solution, striking a balance between accuracy and computational time.

Q2) Using Mesh 3(Fine), comparison of normalized SIF values for 'Plane stress' and 'Plane strain' behaviour of plates is presented below:

Plate Behaviour	**No. of Elements***	**No. of Nodes***	$K_I/\sigma\sqrt{\pi a}$		
			Computed		**Handbook**
			Conventional Elements	**QPEs**	
Plane Stress	499	1568	1.0322	1.1701	1.184[#]
Plane Strain	499	1568	1.0568	1.1703	

*Elements & nodes shown are for the FEA domain

#Based on modification of Benthem's formula (Tada 1973), which has an accuracy of 0.5 %.

Observations:

1) Even with plane strain behaviour of plate, using QPEs at the crack tip yield much better results than using conventional elements.
2) As expected, plane stress SIF values are on lower side when compared to plane strain case indicating better Fracture toughness of plane stress state due to large plastic zone size which demands large values of energy(high values of stress) for further crack growth.