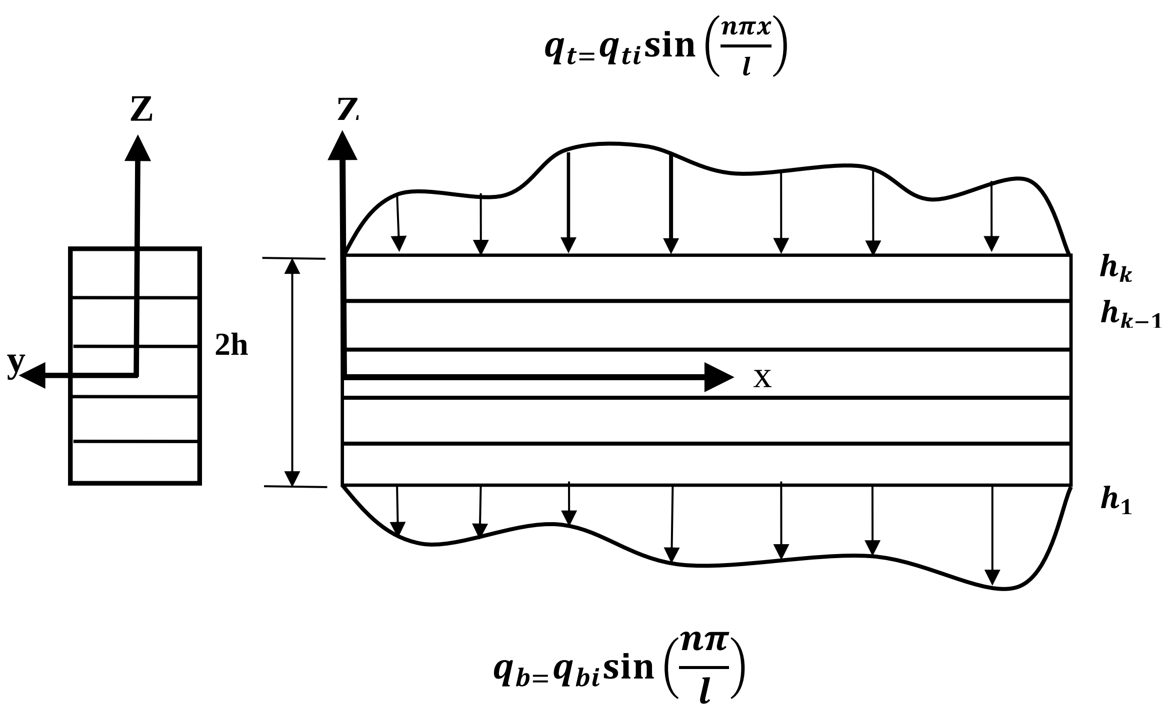
Computation of Three Dimensional Stresses Based on the concept of ESL Theory

A new higher order shear deformation theory has been developed in this research work to accurately estimate three dimensional stresses using constitutive law. The formulation of the theory is based on ESL theory.

There are three ways to accurately calculate transverse normal and shear stresses: The New method developed by me which does not require any additional computational efforts, Constitutive law and integration of equilibrium method. This research work uses these three methods for comparison purposes to examine the predicting capability of the present theory.

The specialty of the new method is that in this formulation, the continuity conditions of transverse stresses are not imposed at the layer interfaces a priori. Further number of unknowns is not increased because of ESL theory. This method gives continuous interlaminar stresses at the interfaces

It has been proved that the transverse normal stress can be calculated from both the new method and the constitutive law in this research work. The numerical results show that the estimation of the transverse normal stress from the constitutive is better than that of the new method. Further the transverse shear stress computed using the new method is very good compared to the elasticity solution.



PT -EQ – Estimation using Present theory from equilibrium equation
PT -NM– Estimation from Present theory from the new method
PT-CL – Present theory from constitutive law.
In this example, there is no load applied at the bottom surface.

Aspect ratio 5; Load=Sinusoidal at the top; Layer [0/90/0]							
z/h	τ_{xz}			σ_{zz}			
	Exact	PT - EQ	PT -NM	Exact	PT-CL	PT-EQ	PT-NM
-0.5	0.0000	0.0000	0	0.0000	0.0766	0.0000	0
-0.4000	-1.1951	-1.1951	-0.7522	-0.0411	-0.0248	-0.0395	-0.1043
-0.3000	-1.8091	-1.8091	-1.3372	-0.1381	-0.1331	-0.1318	-0.2154
-0.2000	-1.9647	-1.9647	-1.7549	-0.2589	-0.2465	-0.2492	-0.3231
-0.1667	-1.9224	-1.9224	-1.8569	-0.2997	-0.2851	-0.2911	-0.3565
-0.1667	-1.9224	-1.9224	-1.8569	-0.2997	-0.3034	-0.2858	-0.3565
-0.1000	-1.9148	-1.9148	-1.9176	-0.3800	-0.3866	-0.3703	-0.4399
0.0000	-1.9063	-1.9063	-1.9535	-0.5001	-0.5128	-0.4967	-0.5630
0.1000	-1.9012	-1.9012	-1.9234	-0.6197	-0.6390	-0.6227	-0.6740
0.1667	-1.8994	-1.8994	-1.8666	-0.6993	-0.7222	-0.7063	-0.7357
0.1667	-1.8994	-1.8994	-1.8666	-0.6993	-0.6788	-0.7050	-0.7357
0.2000	-1.9523	-1.9523	-1.7684	-0.7397	-0.7174	-0.7463	-0.7742
0.3000	-1.8184	-1.8184	-1.3635	-0.8605	-0.8309	-0.8626	-0.8819
0.4000	-1.2101	-1.2101	-0.7934	-0.9583	-0.9391	-0.9542	-0.9701
0.5000	0.0000	0.0000	-0.0583	-1.0000	-1.0405	-0.9934	-1.0285

Aspect ratio 10; Load=Sinusoidal at the top; Layer [0/90/0]							
z/h	τ_{xz}			σ_{zz}			
	Exact	PT - EQ	PT - NM	Exact	PT-CL	PT - EQ	PT-NM
-0.5	0.0000	0.0000	0	0.0000	0.0739	-0.0003	0
-0.4000	-1.9702	-1.9206	-1.6636	-0.0327	-0.0194	-0.0322	-0.09862
-0.3000	-3.3114	-3.2451	-2.9572	-0.1172	-0.1254	-0.1146	-0.20987
-0.2000	-4.0899	-4.1008	-3.8810	-0.2349	-0.2409	-0.2310	-0.31481
-0.1667	-4.2318	-4.2987	-4.1067	-0.2785	-0.2810	-0.2749	-0.34511
-0.1667	-4.2318	-4.2987	-4.1067	-0.2785	-0.2989	-0.2749	-0.34511
-0.1000	-4.2374	-4.3081	-4.2387	-0.3672	-0.3859	-0.3649	-0.43249
0.0000	-4.2382	-4.3109	-4.3139	-0.5004	-0.5188	-0.5003	-0.55983
0.1000	-4.2300	-4.3004	-4.2416	-0.6334	-0.6518	-0.6357	-0.66476
0.1667	-4.2194	-4.2858	-4.1116	-0.7219	-0.7387	-0.7257	-0.71231
0.1667	-4.2194	-4.2858	-4.1116	-0.7219	-0.6943	-0.7257	-0.71231
0.2000	-4.0799	-4.0893	-3.8876	-0.7654	-0.7344	-0.7696	-0.75197
0.3000	-3.3073	-3.2374	-2.9701	-0.8829	-0.8498	-0.8860	-0.85691
0.4000	-1.9697	-1.9167	-1.6840	-0.9673	-0.9558	-0.9684	-0.92604
0.5000	0.0000	0.0000	-0.0293	-1.0000	-1.0492	-1.0003	-0.94042

Aspect ratio 150; Load=Sinusoidal at the top; Layer [0/90/0]							
z/h	τ_{xz}			σ_{zz}			
	Exact	PT-EQ	PT-NM	Exact	PT-CL	PT-EQ	PT-NM
-0.5	0.0000	0.0000	0	0.0000	0.0731	0.0000	0
-0.4000	-26.7472	-26.7432	-25.8676	-0.0290	-0.0172	-0.0290	-0.0965
-0.3000	-47.5369	-47.5317	-45.9868	-0.1079	-0.1223	-0.1079	-0.2078
-0.2000	-62.3736	-62.3745	-60.3576	-0.2240	-0.2385	-0.2240	-0.3117
-0.1667	-65.9968	-66.0019	-63.8705	-0.2689	-0.2791	-0.2688	-0.3408
-0.1667	-65.9968	-66.0019	-63.8705	-0.2689	-0.2970	-0.2688	-0.3408
-0.1000	-66.2075	-66.2128	-65.9144	-0.3612	-0.3854	-0.3612	-0.4297
0.0000	-66.3258	-66.3313	-67.0642	-0.5000	-0.5209	-0.5000	-0.5586
0.1000	-66.2070	-66.2123	-65.9146	-0.6388	-0.6564	-0.6388	-0.6613
0.1667	-65.9960	-66.0010	-63.8708	-0.7311	-0.7448	-0.7312	-0.7034
0.1667	-65.9960	-66.0010	-63.8708	-0.7311	-0.7000	-0.7312	-0.7034
0.2000	-62.3728	-62.3737	-60.3581	-0.7760	-0.7406	-0.7760	-0.7435
0.3000	-47.5364	-47.5312	-45.9877	-0.8921	-0.8568	-0.8921	-0.8474
0.4000	-26.7469	-26.7429	-25.8689	-0.9710	-0.9619	-0.9710	-0.9093
0.5000	0.0000	0.0000	-0.0020	-1.0000	-1.0522	-1.0000	-0.9069

It is proved in this research work that three dimensional stresses can accurately be estimated using two dimensional ESL theory.