Comparison of EFE with a 2014 Upper Bound Approach for RC Slabs

An upper bound (unsafe) approach for predicting the collapse of RC slabs has been published in a conference paper, [1]. The results from two standard problems with known theoretical solutions are presented in the paper and in this current document the results from EFE are added for purposes of comparison.

Uniformly Loaded Square Slab with Fixed Edges

The results for this problem from [1] are shown in Figure 1 where the theoretical solution, attributed to Fox, is also presented.

$$\lambda = 42.851 \frac{m_p}{l^2}. \qquad (17)$$

For this analysis, there are proposed two mesh types; a structured mesh (see Figure 2b) and a non-structured mesh (see Figure 2c).

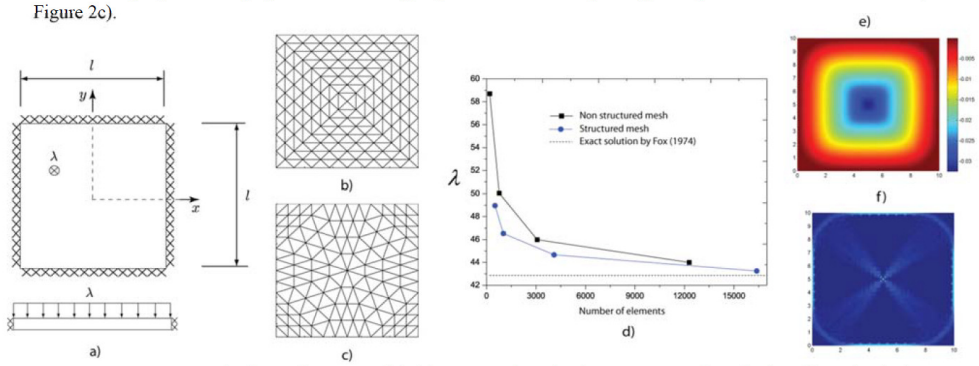
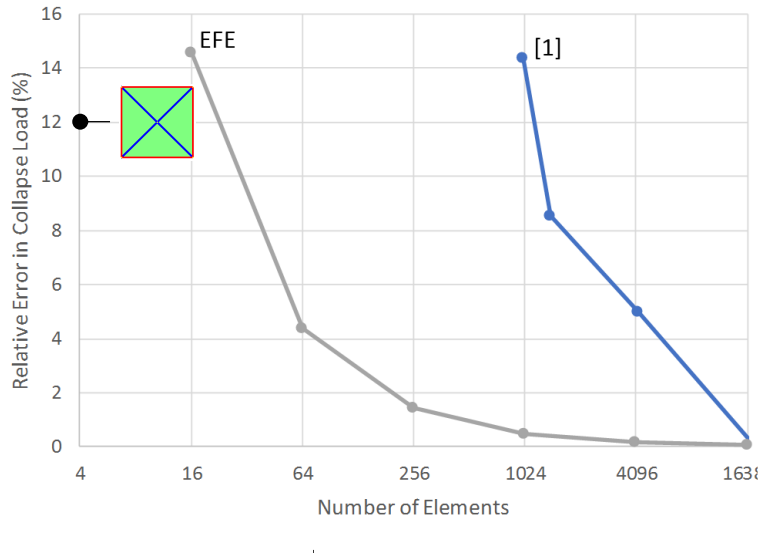


Figure 2. a) Clamped concrete slab. b) Structured mesh. c) Non-structured mesh. d) Collapse load. e) Displacement field. f) Dissipation energy.

Figure 1: Uniformly loaded square slab with fixed edges from [1]

The results generated using EFE are presented in Figure 2 where the results from the non-structured mesh of [1] are included – these have been estimated from the graph of Figure 1.



Number of Elements	Collapse Load	Error (%)
16	36.61	14.56
64	40.97	4.389
256	42.23	1.449
1024	42.64	0.492
4096	42.77	0.189
16384	42.82	0.072

Figure 2: Comparison of results for EFE and Approach of [1]

The results shown in Figure 2 indicate, for this particular slab configuration, that EFE is more efficient in that it is able to recover a more accurate solution than the method of [1] for a given mesh. It is also interesting to note that for the yield line solution for a regular mesh of four triangular elements will produce a collapse load of 48 with an error of just over 12% as shown in Figure 2.

Uniformly Loaded Square Slab with Simply Supported Edges

The results for this problem from [1] are shown in Figure 3 where the theoretical solution is also presented.

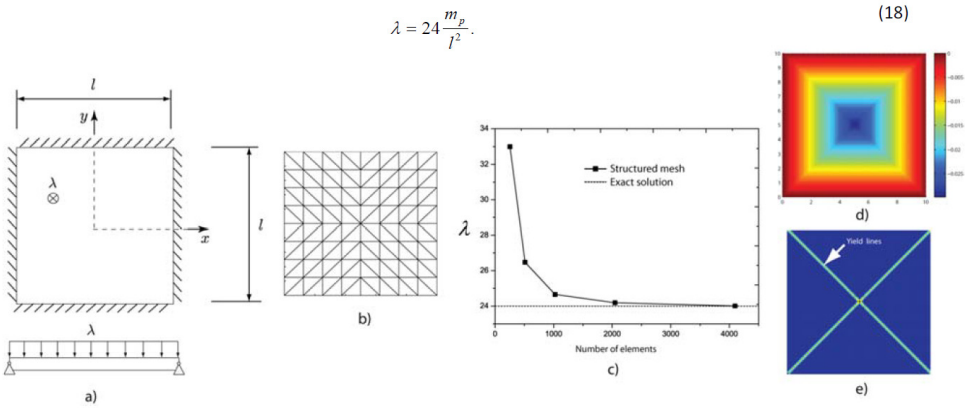


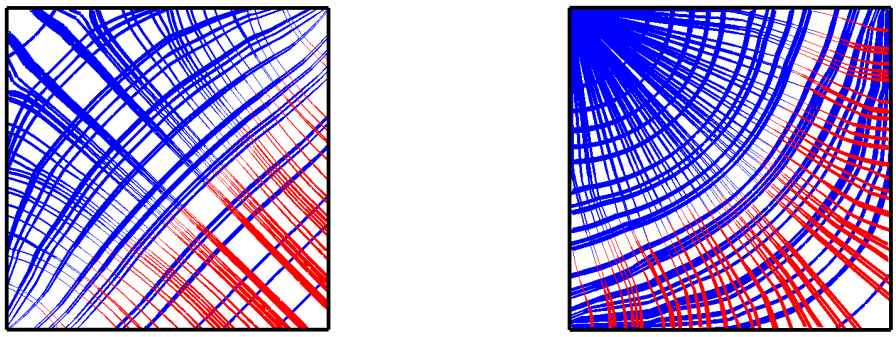
Figure 3. a) Simply supported concrete slab. b) Structured mesh. c) Collapse load. d) Displacement field. e) Dissipation energy.

Figure 3: Uniformly loaded square slab with simply supported edges from [1]

This is a relatively simple problem and the exact solution is recovered with a mesh of four triangular element using the yield line technique or the lower bound technique in EFE.

Principal Moment Trajectories at Collapse

The principal moment trajectories at collapse from EFE are shown for the bottom right-hand quadrant of the slabs in Figure 4 where blue lines represent sagging moments and red lines hogging moments.



(a) Simply supported (b) Fixed

Figure 4: Principal moment trajectories from EFE

References

[1] Hector Nevarro, ***Upper Bound for Determining the Collapse Load of Concrete Slabs with Conic Programming***, 14th Pan-American Congress of Applied Mechanics, March 28-28, 2014, Santiago, Chile.

https://www.researchgate.net/publication/261357604_Upper_Bound_Method_for_Determining_the_Collapse_Load_of_Concrete_Slabs_with_Conic_Programming