Ramsay Maunder ASSOCIATES *Finite Element Specialists and Engineering Consultants*

Reappraisal of a Simply Supported Landing Slab

Research conducted in 1997 [1] using automated yield-line analysis and geometric optimisation on a simply supported landing slab has be reappraised and using techniques available within EFE a more critical collapse mechanism has been identified with a collapse load some 25% below that originally reported. The research conducted in 1997 highlighted the importance of identifying the critical collapse mechanism in the assessment of a slab and demonstrated the significant reduction in predicted collapse load that could be achieved by geometrically optimising this critical mechanism. At the time of the original research, algorithm and software limitations restricted the work to the consideration of small structured meshes. RMA have recently checked the 1997 results using the advanced features available in EFE and, by using more refined unstructured meshes, have found a more critical collapse mechanism.

The landing slab considered is an 'L' shaped slab with dimensions shown in figure 1. The slab is assumed to have uniform strength equal in both hogging and sagging and is loaded over the entire area with a uniformly distributed load. Three sides of the slab are simply supported and the remaining three sides are free.

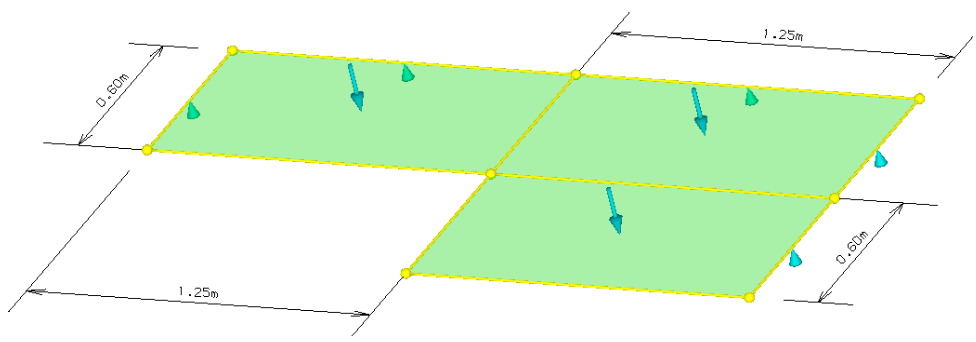
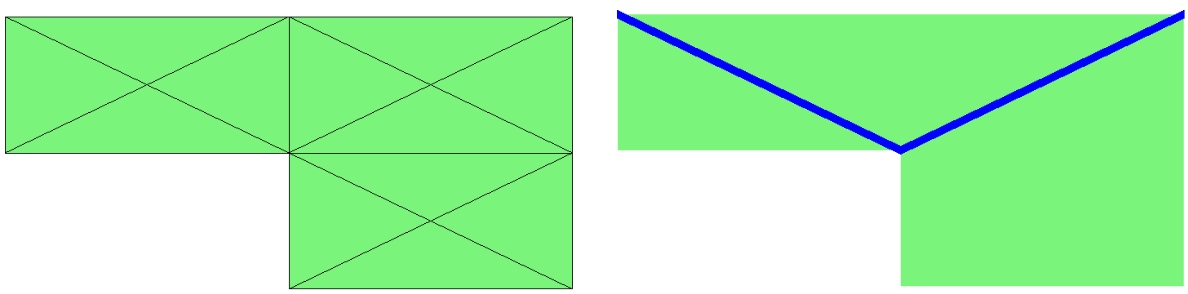


Figure 1: Simply supported landing slab

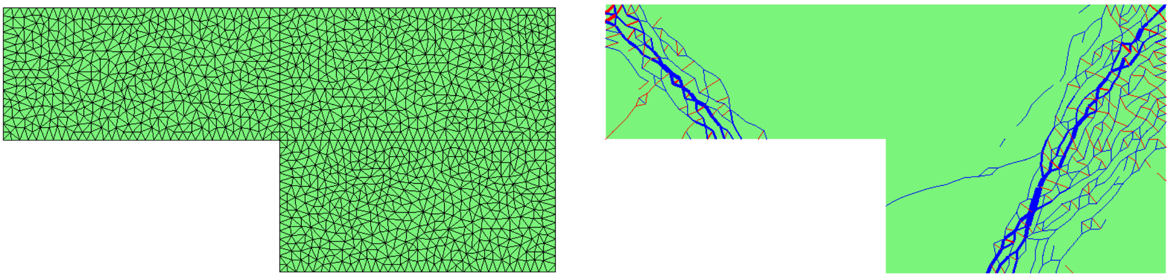
The results reported in 1997 are shown in figure 2.



(a) Mesh (b) Yield Line Pattern

Figure 2: Results from the 1997 research (0.586)

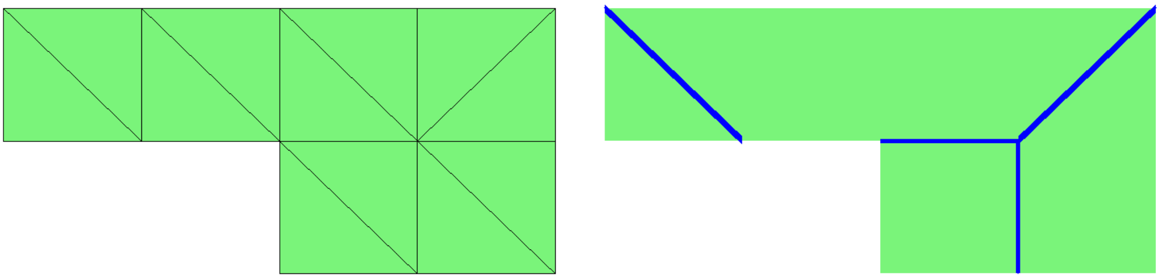
The result presented in figure 3 uses a refined but unstructured mesh and the resulting yield line pattern indicates a different critical collapse mechanism to the one from 1997; whereas the two sagging yield lines met at a slab vertex they now exit the slab midway along different sides of the slab.



(a) Mesh (b) Yield Line Pattern

Figure 3: Results for a refined unstructured mesh from EFE (0.547)

Having identified a more critical collapse mechanism it is now necessary to perform geometric optimisation on this mechanism as this can often bring down the corresponding collapse load significantly. To perform geometric optimisation a mesh that has the potential to capture the critical collapse mechanism is required. The mesh shown in figure 4 is such a mesh and the yield line pattern for the unoptimised mesh is also shown.



(a) Mesh (b) Yield Line Pattern

Figure 4: Results for a coarse unstructured mesh from EFE (0.506)

The process of geometric optimisation is one where the nodes are moved or relocated in order to seek out the lowest load factor (recall that the yield line technique is an upper-bound approach).

Figure 5: Results for a coarse unstructured mesh with geometric optimisation from EFE (0.438)

The yield line pattern shown in figure 5 is the result of geometric optimisation on the coarse unstructured mesh of figure 4(a). The critical load factor reported in 1997 was 0.586 whereas the load factor corresponding to the result in figure 5 is 0.438 and this represents a 25% reduction in the 1997 result.

Closure

Limitations in software for the 1997 research led to identification of a non-critical collapse mechanism which is shown to be about 25% on the unsafe side of the true value. The key feature of EFE that made it possible to uncover this mistake is the ability to use highly refined unstructured meshes; whereas structured meshes tend to force the yield line pattern into a particular and often erroneous configuration, unstructured meshes allow the yield lines to generate in a more realistic manner particularly for refined models. Indeed, it might be noted that the yield line pattern generated by such meshes is more in keeping with the actual failure of the slab which is unlikely to occur precisely along the predicted hinge lines.

It is recommended therefore that the starting point for any yield line analysis should be a mesh refinement study involving possibly structured but certainly unstructured meshes. Once the critical mechanism becomes evident a coarse mesh that contains this mechanism is required for geometric optimisation.

Reference

1) Ramsay, ACA & Johnson, D, 'Analysis of Practical Slab Configurations using Automated Yield-Line Analysis and Geometric Optimization of Fracture Patterns', Engineering Structures, Vol. 20, Issue 8, pp647-654, 1998.