LAYOUT OPTIMIZATION IN STRUCTURAL ANALYSIS & DESIGN: RECENT DEVELOPMENTS

***M. Gilbert*[1], *L. He*[1], *C.J. Smith*[2] *and T. Johnson*[3]**
[1]*Dept. Civil & Structural Engineering, University of Sheffield, United Kingdom*
[2]*Dept. Materials Science & Engineering, University of Sheffield, United Kingdom*
[3]*LimitState Ltd, Sheffield, United Kingdom*

1. Introduction

Computational layout optimization procedures, first developed for trusses over half a century ago [1], have been the subject of increasing interest in recent years. For example, methods have now been developed which enable modern computers to solve extremely large-scale truss design optimization problems [2, 3]. This has meant that it is now possible to obtain highly accurate approximations of the optimum volume of a truss structure for a given set of boundary and loading conditions (e.g. [4, 5]). Also, it has been found that layout optimization can be used to solve a range of plasticity problems, in this case using optimization to identify the layout of discontinuities in a loaded body at the point of incipient collapse ('discontinuity layout optimization', DLO). This has recently led to the yield-line method for concrete slabs being systematically automated for the first time [6].

2. Recent developments

2.1. Truss design

The solutions obtained using truss layout optimization can be complex in form, partly due to the nature of the optimal solutions being sought, and partly due to the use of a fixed grid of nodes in the layout optimization procedure. Rapidly developing additive manufacturing (or '3D printing') techniques can fabricate truss designs which are considerably more complex than could be fabricated using conventional techniques, making layout optimization a potentially attractive form finding technique for designers [7]. However, the presence of very thin elements will lead to manufacturability and/or structural instability problems; to address this it has been shown that the solutions obtained using conventional truss layout optimization can be rationalized by using a geometry optimization post-processing step, which involves adjusting the positions of nodes [8]. Furthermore, both techniques can be embedded in an interactive software environment which also permits the design to be edited by the user as necessary and then transformed into a continuum, prior to final validation and/or manufacture; a sample design obtained in this way is shown in Fig. 1.

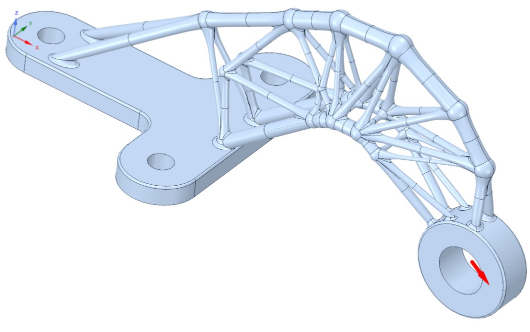

Figure 1. Component design obtained using a new layout optimization-based engineering software application (air brake hinge for the Bloodhound supersonic car)

2.2. Reinforced concrete slab analysis

The same automatic rationalization technique as applied to truss design can be applied to the analysis of reinforced concrete slabs [9]. In this case the main justification is to obtain yield-line patterns which are visually easy to interpret, and also to check by hand.

3. Conclusions

Computational layout optimization is a powerful technique which is proving to be useful in an increasing range of structural analysis and design applications.

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5. References

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