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CONCLUSIONS AND SUGGESTIONS FOR FURTHER WORK

10.1 Introduction

In this chapter, the main achievements accomplished in this thesis will be summarised. The conclusions drawn from the present study will be presented in the third section. Finally, suggestions for further work will be outlined and discussed.

10.2 Main achievements

The main achievements can be summarised as follows:

1. A computer-based technique for the design of 2D and 3D steel frame structures to BS 5950 has been developed.
2. Analytical descriptions have been obtained for the charts presented in BS 5950 to determine the effective buckling length factor for columns in sway and non-sway frameworks.
3. A computer code based on the direct method for the stability analysis of 2D frameworks has been developed and verified. This code is then used to compare the

values of the effective buckling length of columns with those determined from the charts presented in BS 5950.

4. The concept of GA methodology has been studied in detail and new modifications and new techniques for the crossover operator are implemented and comprehensively tested. The program has also been developed to deal with discrete design variables, where these variables may have different string lengths.
5. The effects of the GA parameters have been investigated and comprehensively tested. These effects are then graphical represented. In addition, suggestions of the GA parameters are introduced to speed up the algorithm.
6. A technique is introduced and implemented to deal with a situation when the number of catalogue cross sections does not fit a string. The proposed technique allows the catalogue cross sections to have equal probability of selection.
7. The ANSYS optimization methodology has been used to compare the obtained results with those achieved from the developed GA.
8. The maximum ratio between the effective buckling length when using the finite element approach $L^{\text{eff, FE}}_{\text{X}, n_{\text{c}}^{\text{mem}}}$ and that $L^{\text{eff, Code}}_{\text{X}, n_{\text{c}}^{\text{mem}}}$ determined by the BS 5905 approach has been investigated. The influences of the position of the column and the cross sections of framework members at the maximum ratio have also been researched.
9. The modified GA has been linked to a system of structural design rules (BS 5950 and BS 6399), interacting with a finite element package (ANSYS). This shows that the modified GA in combination with structural design rules provides an efficient tool for practising designers of steel frame structures.

10. Three approaches for the determination of the effective buckling length for columns have been successfully applied and the effects of these approaches on the optimum design have been shown.

10.3 Conclusions

The main conclusions can be summarised as follows:

1. Several engineering applications have been tackled and the results show the potential of the modified GA for the treatment of such applications.

2. It is also proven that the modified GA linked to the design rules provides a mathematically less complex structural optimization method, which can be used by practising designers.

3. Suggestions have been made to the use of appropriate GA parameters in order to speed up the algorithm. It has been shown how these parameters can considerably affect the performance of a GA.

4. It has been proven that the modified GA-based search approach is a possible powerful alternative to gradient based algorithms for optimization problems. The developed GA is simple to implement and has a potential in a wide variety of engineering optimization problems. The optimal solutions obtained using the proposed GA-based approach are encouraging when compared with those achieved by the built-up optimization techniques in ANSYS.

5. The analytical descriptions for Figures 23 and 24 of BS 5950 can be easily utilised in either automated design or conventional design.

6. The role of buckling in the design of 2D and 3D steel frame structures is of major importance. The design results obtained using the more accurately evaluated effective buckling lengths shows the need for such a technique in design.

7. The optimization problems should be posed correctly otherwise unrealistic and non-practical solutions may be obtained. Therefore, care should be taken about considering the selection of the design variables and linking of these to the structural members.

8. As anticipated, the use of a greater number of design variables to describe a structure results in a better solution.

9. Although the developed programs based on the modified GA approach have so far only been used for discrete design optimization, the range of applications can be extended to cover discrete-continuous problems.

10. The developed GA provides a designer with more than one solution to choose from, and the difference between them is usually small. This could be an advantage when a designer needs to choose an appropriate solution depending on the availability of the sections.

11. From the solutions achieved in design optimization of 2D and 3D steel frame structures, it can be observed that the same sections are obtained for different members of the structure even though these members are linked to different design variables. This indicates that it can be beneficial to include the grouping of structural members as an additional criterion in the formulation of the design optimization problem.

10.4 Suggestions for further work

The work carried out in this thesis has revealed many promising areas of further research in design optimization field. A few of these areas worthy of further investigations can be briefly summarised as follows:

- The design optimization of complex structures is computationally expensive. The combination of the GA methodology with an appropriate approximation technique is therefore desirable. As one possibility, genetic programming may be used for the creation of approximation functions. More details are given by Toropov and Alvarez (1998) and Sobieszanski-Sobieski and Haftka (1997).
- The developed program for design optimization of 2D and 3D steel framed structures can be easily modified to deal with applications in which size and/or shape design optimization are required.
- In the design of tall buildings, some members may consist of built-up sections or tapered members. In order to carry out design optimization of such buildings, the developed GA program, combined with the appropriate design rules, can be modified to handle such problems.
- Many authors, among them Nethercot (1995), Springfield (1992), mentioned that there is a potential for economy through the use of semi-rigid connections for some types of structures. It is emphasised that the preponderance of steel in the beams focuses attention on the potential savings in these members, requiring development of semi-rigid joints for this specific purpose. It is obvious that the design problem here is complex. The desirability of the use of connections as mechanisms to control bending moments can also be investigated.

- Further improvements in the GA can be achieved when considering more specific and accurate methods for penalising the objective functions (see Adeli and Cheng, 1994). There is also a need to introduce more sophisticated convergence criteria to terminate the optimization process.