1. Preliminary Considerations

1.1 Introduction

It is generally accepted that the objective of engineering design is the achievement of an acceptable probability that the structure being designed will retain its fitness for purpose during its planned lifetime. It is also of utmost importance that the initial costs plus the maintenance costs of the completed structure be within the limits provided by the Client.

For the design to be successful in the sense just outlined, the designer should search for design alternatives which consider strength and serviceability on the one hand, and economic feasibility on the other. In other words, out of a number of alternative structural solutions which comply with accepted design criteria for strength and serviceability, the designer should select the alternative likely to be the lowest overall cost. To do this successfully, the designer should develop an appreciation of the basic sources of expenditure in building construction and their effect on the overall cost of construction.

In practice, the design problem is an optimisation problem. The solution to any optimisation problem involves having some means of judging the overall merit of alternatives. With regard to a building, the measure of overall merit, usually provided by the Client, will involve one or more of the following criteria:

(a) Functional requirements.

(b) Strength and serviceability.

(c) Aesthetic satisfaction.

(d) Economy in relation to capital and maintenance costs.

This publication deals almost entirely with item (d) above.

In the preliminary and final design, the designer often deals primarily with member design and consequently tends to consider the minimisation of the mass of the structure as a guiding criterion towards achieving minimum cost. That is, the designer substitutes the more straight forward criterion of mass minimisation for the more involved criterion of minimum cost.

In regard to steel structures, a minimum mass solution does not necessarily result in a minimum cost solution. Connection detailing and the resulting cost of fabrication and erection are more often the major influences affecting overall cost. Undue preoccupation with the minimisation of the mass of a steel structure can lead to serious errors of judgement.

This publication is intended to highlight the manner in which a number of factors affect the cost of steel detailing, fabrication and erection. It will also highlight the influence these costs have on the total final cost of a steel structure.

1.2 Factors influencing Framing Cost

Fabricated steel has been traditionally costed on a per tonne basis. Consequently, in discussing the cost of fabricated steel, the question often raised relates to how much is the cost per tonne of fabricated steel. Such a question usually ignores the fact that a large number of factors have a significant influence on the final cost of fabricated steel.

A more rationalised approach to the costing of fabricated steel is based on a cost per metre for sections and cost per square metre for plates depending on the size of the member. Fabrication costs for connections and erection costs, etc can then be added on a component by component basis (Ref 1.1).

For multi-level steel construction a cost per square metre can also be used for fabricated steelwork based on each floor area.

In the design, detailing, fabrication and erection of a steel structure, the following factors influence the cost of the framing:

(a) Selection of the framing system.

(b) Design of the individual members.

(c) Design and detailing of the connections.

(d) Fabrication processes used.

(e) Erection techniques used.

(f) Specification for fabrication and erection.

(g) Other items such as corrosion protection, fire protection, etc.

The selection of the most efficient framing system is fundamental to achieving an economical framing solution and aspects relating to this item are discussed in Sections 3, 4 and 5.

Efficient member design remains an important cost factor tempered by the comments made in Clause 1.1. Detailed consideration of this item does not fall within the scope of this publication. One point that does deserve mention, however, is the avoidance of the individual design of every beam and column in an attempt to achieve least mass. The aim should be to group similar members (e.g. similar main beams in a floor grid) and adopt the one size for all members of the group. An experienced designer will optimise the design by being aware that if too much grouping is done, there will be material wastage. However, if little grouping is done, then there is a great waste of time on the part of the draftsperson and the erector.

Economic fabrication and erection are significantly affected by economical connection details. This publication is very concerned with economic detailing of steelwork and the manner in which detailing influences the cost of fabrication and erection. Sections 6, 7 and 8 deal with a variety of points which need consideration.

The specification (item (f) above) is a major influence on the cost of both the fabrication and erection since it specifies the quality of materials and workmanship required.

Similarly, the costs of both corrosion protection and fire protection (item (g) above) are important influences on the final cost. All these items are discussed in greater detail in Section 2.

1. Preliminary Considerations

1.3 Integrated Design

One of the obstacles to achieving maximum economy is that three of the most important activities in steel frame construction, namely structural design, detailing and fabrication, are usually done in isolation from one another. This is partly due to the specialisation in each of the disciplines and partly because of a lack of an effective dialogue among the people involved.

As a result of this, there often occurs a total preoccupation with the analytical phase of the design, and a complete absence of rational thinking about the detailing phase. Consequently, the problems that arise during the detailing phase are solved by complicating the detail rather than by modifying the design concept. When the job reaches the fabrication shop, there is little alternative but to carry out whatever happens to be shown on the drawings.

A more ideal situation results when the design effort is integrated so that the framework, its members and its connections are considered as a whole. In this way, it becomes possible to modify the structural framing concept to allow the use of simpler and less costly connections in the interest of overall economy.

The cost factors listed in Clause 1.2 should be considered in an integrated manner so that interactions between the framework, its members and its connections are considered during the design process. In this way, one aspect can be altered to enable another to be improved. This enhances the overall cost efficiency of the final structure.

Obviously, such an approach ideally requires an extensive and up-to-date knowledge of the steel fabrication and erection industries. Since such knowledge is not always easily achieved, communication with fabricators is a useful method of establishing the optimum practical solution. An interchange of ideas among fabricators, erectors and designers is an ideal situation for achieving optimisation.

It should be appreciated that what constitutes “design” and “good (i.e. economical) design” will vary depending on whose viewpoint is being considered. To the designer, an economical design is usually the lightest member to carry the load. To the fabricator, a “good design” means high tonnage output with minimum amount of labour. To the erector a ‘good’ design is one where most members are the same size and can be interchanged without any problems.

Clearly such different viewpoints are best resolved by an integrated and interactive approach on the part of the steelwork designer.

The Steel Detailer, using 3D modelling software, can assist in providing a service to designers by modelling the steel structure prior to engineering analysis and exchanging data in a Building Information Modelling (BIM) environment.

The Steel Detailer can also provide a range of outputs for the Steel Distributor and/or Fabricator to utilise, speeding up the production of structural steelwork. Guidelines on Steel Detailing outputs are provided in Ref. 1.5.

Further, the recent emergence of the Steelwork Contractor who integrates design, detailing and fabrication is providing a building solution which minimises overall costs. The Steelwork Contractor can also integrate following trades in order to minimise risk for the main building contractor and provide a “Total Solution”.

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edited by

John Gardner

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