2. General Factors Affecting Economy

2.1 Steel Grades

2.1.1 STRUCTURAL STEEL

Throughout the world the least costly and most commonly used grades of steel for structural purposes are those generally referred to as normal strength structural steel.

In Australia such steel is covered by AS 3678 or AS 3679 (Parts 1 & 2). It has a typical design yield strength of 250/300 MPa (varying above and below this figure depending on thickness), a tensile strength of at least 410/430 MPa, a minimum elongation of 22% and a carbon equivalent of 0.43/0.44 so as to assure good weldability.

AS 3678 and AS 3679 (Parts 1 & 2) are omnibus standards covering a family of structural steel grades including variants of the main grades having superior low temperature toughness.

Plates, rolled sections, welded sections and bars are all produced to these standards, although not every product is available in every grade. This is explained more fully in Table 2.1.

2.1.2 WEATHERING STEEL

AS 3678 and AS 3679 (Parts 1 & 2) also deal with so-called 'weathering steel'. Weathering steel contains alloying elements which cause it to weather to a uniform patina after which no further corrosion takes place. By nature of the chemical composition the steel is high strength (Grade 350) steel. However in Australia it is available in only a limited number of products – see Table 2.1.

2.1.3 HOLLOW SECTIONS

In Australia structural hollow sections are produced to the product standard AS 1163. This standard covers a number of cold-formed (C) grades. Rectangular hollow sections are available in Grade C350 and Grade C450. Circular hollow sections (CHS) are available in Grade C250 and Grade C350.

2.1.4 QUENCHED AND TEMPERED STEEL

Steel plates are produced in Australia in very high strength heat-treated grades known as 'quenched and tempered steel'. These steel plates are useful in special applications where mass reduction is important (e.g. crane booms) or where their high wear resistance is needed (e.g. dump truck bodies).

Australian Standard AS 3597 covers these steel plates for structural steel applications and for use in pressure vessels.

2.1.5 CHOICE OF STEEL GRADE

Table 2.1 lists the availability of various products by steel grade. The indicative relative cost of grades is shown in Table 2.2. For most structures the greatest economy will be achieved by the selection of the least costly and most readily available steel, i.e. Grade 300.

In large structures with longer lead times the use of higher grades will often be worth considering at least for parts of the frame. Heavy plate members such as bridge girders are one instance where higher grades may prove economical. Other applications include:

- Multi-storey structures, particularly with composite steel beams; also in maintaining the same column size down a building by varying steel grades;
- Trusses and lattice girders.

Grade 350 steel costs around 5% more than Grade 300, and generally about 5% more to fabricate. To offset these cost extras, it provides greater yield strength but no increase in stiffness.

In some frames, significant reduction in steel mass may overcome the increase in material cost and fabrication cost by the use of higher grades. Each individual frame must be assessed on its merits, but there are undoubtedly applications where the use of higher grades is economical.

TABLE 2.1: Availability of products by Grade (check currency of information with steel suppliers)

Steel Grade	Plates (or Floor plates)	Rolled Sections	Welded Sections	Structural Hollow Sections
Grade	AS 3678	AS 3679.1	AS 3679.2	AS 1163
200	×	–	–	
250	†	×	–	
250L0	×	×	–	
250L15	‡	×	–	
300	‡	†	†	
300L15	‡	–	+	
350	†	‡	–	
350L0	×	×	–	
350L15	‡	–	–	
400	×	–	†	
400L15	×	–	‡	
WR350/1	‡	–	–	
WR350/1 L0	‡	–	–	
C250				†
C350				†
C450				†
	Quenched & Tempered Structural Steel AS 3597			
80	†			

Notes:

† Regular grade commonly produced, readily available from stockists.

‡ Regular grade not commonly produced, availability subject to time limitations and order size.

× Non-regular grade, availability subject to time limitations and order size.

– Not manufactured.

2. General Factors Affecting Economy

While the information presented in Table 2.1 is indicative of the general situation, it must be remembered that the steel suppliers are always willing to discuss special cases where, for example, the economics of a high strength steel has been considered by the designer and the sections required are not normally manufactured in that grade. For a project requiring large tonnage of specific sections, it may be possible to negotiate a special order with the supplier, provided that an arrangement has been agreed at an early enough phase in the design.

Conversely, on average projects the designer should always be careful to keep within the range of readily available products so as to ensure that no problems of steel procurement occur at the fabrication stage.

TABLE 2.2: Indicative cost ratios for different grades of structural steel (per tonne, supply only)

Grade	Plates	Rolled Sections	Welded Sections
AS 3678, AS 3679.1 & AS 3679.2			
Grade 250	100	100	–
250L0	–	105	–
250L15	110	105	–
300	100	100	100
300L15	105	–	100
350	105	105	–
350L0	–	–	–
350L15	110	–	–
400	115	–	105
400L15	120	–	105
WR350/1	125	–	–
WR350/1 L0	135	–	–
AS 1163			
Grade C250		130	
C350		130	
C450		130	
AS 3597 Quenched & Tempered Steel			
80	200		

2.2 Economy in use of Material

As well as having a knowledge of the factors affecting the choice of steel grade, the designer should also be aware of how design decisions can avoid unnecessary material cost or wastage. This will involve a study of the factors discussed below.

2.2.1 STEEL PRICING

Mill prices are expressed in terms of a base price and various extras. The base price relates to the type of mill product such as plate or sections, while extras relate to specifics of the particular product or section.

The most common extras for structural quality steel include the size or designation, standard or non-standard lengths, quantity extras or discounts related to the total mass of individual order items, and the grade extras which apply to the quality specification for the material chosen.

Quality extras for structural steel relate to the material specifications and reflect the costs of alloying elements, of tighter controls on such elements as carbon, manganese, phosphorus and silicon, and of tighter controls on manufacturing techniques to meet the specified chemical and mechanical properties. The cost of additional tests and greater frequency of testing, necessary for increased stringency of yield strength and notch ductility, are also reflected in increased quality and testing extras.

Designers should recognise that the more exotic the requirements of the steel specification, the greater is the probability that other costs associated with its use, ranging from procurement through all stages of fabrication, will also be increased. Unnecessary demands by specifiers for mill heat certificates for standard sections of known origin to be used on routine projects is another example of unnecessary costs added onto projects.

The foregoing relates to purchases made direct from the steel mill, but in Australia most fabricators obtain their steel through steel distributors. These steel distributors aim to carry comprehensive stocks and are thus able to offer prompter delivery than would be available through the normal steelmaker's rolling programs. Their stock holding tends to concentrate on popular, high turn-over items.

TABLE 2.3: Preferred steel plate thicknesses (in mm)

3	25	70
4	28	80
5	32	90
6	36	100
8	40	110
10	45	120
12	50	140
16	55	150
20	60	

2.2.2 PLATES

In Australia there is a rationalised series of 'preferred' plate thicknesses as listed in Table 2.3.

For practically all structures the designer should operate within this standard range. Non-preferred thicknesses incur cost premiums and extended delivery times, and should only be considered on major projects where the overall saving in using a special thickness is greater than the direct and indirect cost penalties.

2. General Factors Affecting Economy

Similarly there are preferred lengths and widths of plates which should be borne in mind. Major plate elements should be dimensioned as far as possible so that they can be cut from standard plates with a minimum of scrap. Smaller plate details such as brackets and gussets should be considered in the same way, especially when there is a large number of them. The most common sizes for plates up to 25 mm thick are 1.8m × 6m, 2.4m × 6m, 2.4m × 9m, 3m × 9m and 3.2m × 12m.

Note: Small plate components may be substituted by flat bars which are considered as sections.

2.2.3 SECTIONS

Australia produces a range of welded products, universal sections, channels, angles, and hollow sections which provide the designer with a reasonable choice without the proliferation which can lead to problems of availability.

The lowest weight in each nominal size of universal section is the most structurally efficient and they account for over two-thirds of all UB sales. The designer should therefore make every endeavour to keep to the lowest weights in each size range, although this will not always be possible.

Very long lengths of sections become difficult to keep straight and to handle, and the mills impose a price extra for them. It should be especially noted that although universal sections are listed as being available up to 18m long (and up to 22m by enquiry), the usual maximum length found in stock is around 18m. The available lengths of structural hollow sections are usually restricted to 6.5m (circulars) or 12m (rectangulars and squares).

2.2.4 SCRAP AND WASTE

The real cost of material is affected by the quantity of scrap and waste, and designers should be receptive to suggestions for minimising and controlling the generation of waste. This may include greater standardisation of structural sizes, or of plate widths and thicknesses, in order to take advantage of size and quantity discounts. It might also include a more liberal approach to the splicing of beams or other structural sections using standard lengths.

Random splicing, which involves welded splices anywhere within the length of a rolled structural member, can be particularly effective when material is sawn to length and fabricated on a conveyorised production line. When carefully controlled, it can dramatically reduce the accumulation of shorts and thus reduce the total cost.

The only real restriction to random splicing applies to its use for beams subject to severe dynamic loads. Of course the savings in scrap have to be balanced against the welding costs, and the designer should be receptive to this technique where it is appropriate.

2.3 Fabrication

2.3.1 GENERAL

Fabrication costs are a function of complexity and are influenced by:

- Size of the component
- Size and type of sections involved
- Amount of stiffening and reinforcing required
- Amount of repetition
- Shop and field details
- Space requirements in the shop, and
- Facilities available for handling, lifting and moving the structural components.

Fabrication costs are sensitive to simplicity or complexity of detail, and the degree to which production line techniques can be applied. They are controlled by the quality of the shop detail drawings, which must reflect the designer's concept for the structure, but must also permit the optimum utilisation of the fabricator's facilities and equipment. Shop drawing preparation should be guided by the basic principle that they must provide for economy of fabrication and for economy of erection.

Shop operations basically involve cutting material to size, hole-making for mechanical fasteners, and assembling and joining. Other operations include handling, cleaning and corrosion protection. All shop operations require facilities for lifting and for moving or conveying the structural steel.

Cutting operations include shearing, sawing and flame cutting; hole-making operations include punching and drilling; assembly operations include welding and bolting. Increased use of computer numerically controlled (CNC) fabrication processes is changing the economics of steel fabrication. Cutting, drilling and welding operations can now be undertaken by the CNC fabrication process. Information from computer drafted shop drawings can be fed directly into CNC fabrication equipment to further improve operational efficiency. Some fabricators are now bar coding steelwork to facilitate control and monitoring of projects.

Generally welding is the preferred method for shop assembly, with bolting for field assembly. There are, however, some fabricators with sophisticated hole-making equipment, who prefer shop bolting to shop welding for standard connections. Some steel merchants also provide basic cutting and drilling services to the steel fabricators.

Many steel distributors now offer a steel pre-processing service where steel sections and plates are cut and drilled to size. The fabricators then weld the components together in the workshop.

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