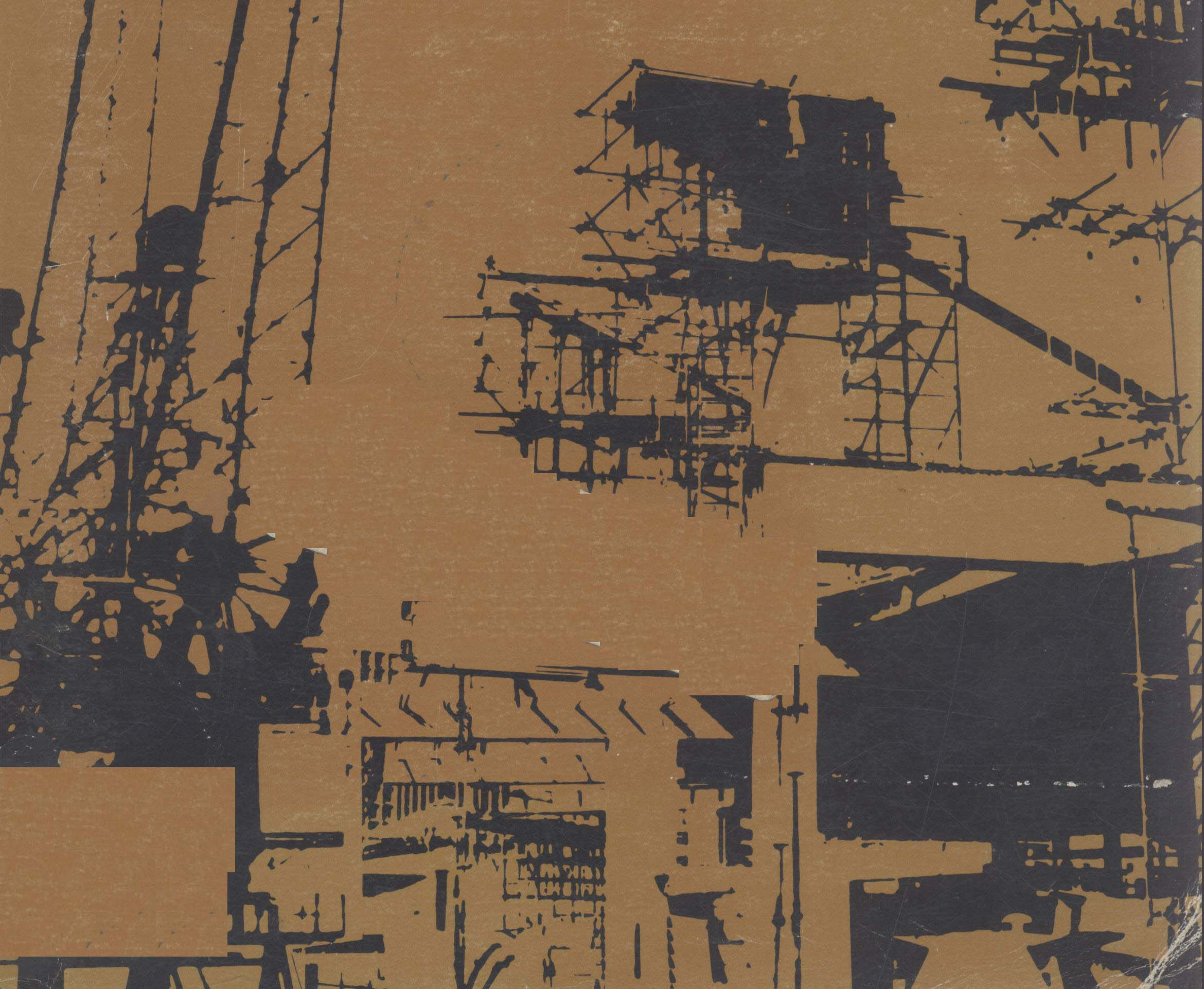
Australian Engineering Drawing Handbook

Part 2

Structural Drawing

The Institution of Engineers, Australia

Revised 1982 Edition



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PREFACE

All chapters of this 1982 revised edition comply with the relevant parts of AS 1100, Australian Standard for Drawing Practice. The Institution appreciates its close liaison over many years with the Standards Association of Australia, and the need for complementary publications, such as this handbook, as an aid in the preparation of structural drawings.

Fourteen typical drawings have been reproduced on fold-out pages to facilitate reference to them and minimise loss of detail. Where details of drawing practice are required reference should be made to the Australian Engineering Drawing Handbook, Part 1, Basic Principles and Techniques.

The Council of The Institution wishes to thank all those who have assisted with the preparation of the handbook in past years, and particularly the members of the Structural Drawing Sub-Committee of the former Engineering Drawing Practice Committee.

E. D. STORR
Secretary of the Institution

May, 1982

CONTENTS

Chapter 1

PERSONNEL AND ORGANISATIONS

1.1 PROJECT DEVELOPMENT GROUP

The principal members of the group who normally participate in the development of a project from idea to reality, and their functions, are described hereunder and shown in Fig. 1.1.

The client, commonly known in construction contracts as the Principal, may be a company, an individual or a public authority. The client's objective is to erect a building, to develop an area of land, or to provide a public facility. The client usually retains a professional architect or engineer as the prime consultant to plan and control the project.

An architect is concerned with the functional planning and appearance of a building. He produces drawings of the project ranging from sketch plans and elevations to the final working drawings. He usually employs specialist consultants to advise him on engineering design, construction methods and costs.

Consulting engineers, public authorities and others in the field of structural engineering would document their work in accordance with the examples set out in the sections of this book dealing with steelwork, reinforced concrete and timber. Similarly those in the building services field – i.e. electrical, air conditioning, hydraulics and fire protection – would document their work in accordance with the relevant standards.

The main contractor who may be a company or an individual, controls the building operations carried out on the site. It is the builder's responsibility to co-ordinate the work of all trades and sub-contractors commencing with the excavation work through to the final finishes. He compiles the costs of the project, programmes time schedules, checks the work in conformity with the contract documents and in most cases works within the direction of the owner's consultants.

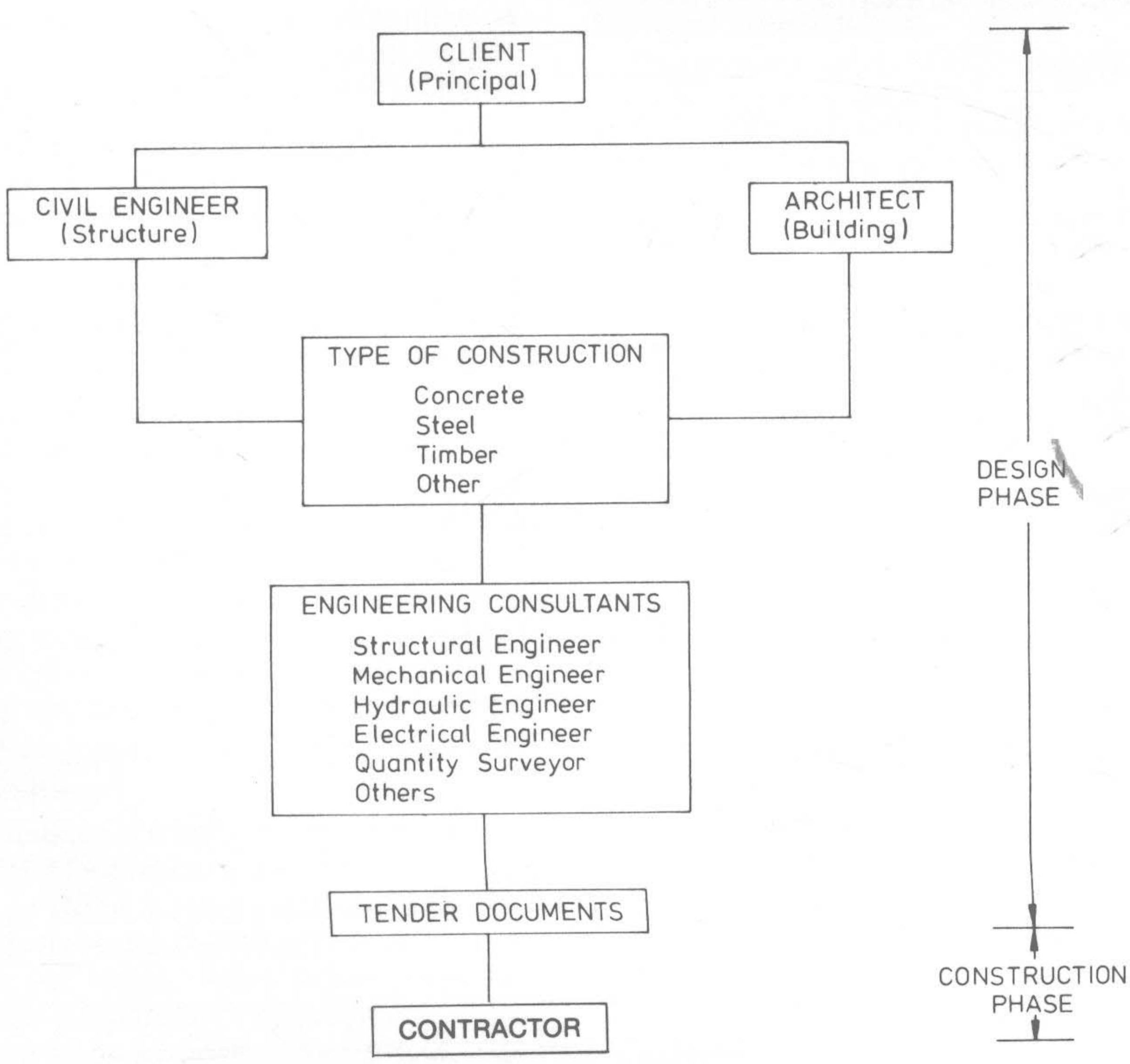


Fig. 1.1 – Relationship between the principal members of a project development group.

1.2 KEY PERSONNEL

1.2.1 Design phase

The engineer is academically trained in civil or structural engineering. His responsibility is to devise the most suitable engineering systems for the project within given economic and environmental constraints.

The design engineer analyses the proposed structure to determine the size and strength requirements of each individual part. From his calculations and sketches and the architectural drawings, the detail draftsman prepares the working drawings (or design drawings). These drawings must convey all of the design engineer's intentions as they will form, in conjunction with the specification, the basis on which tenderers will prepare their quotations to build the structure.

The quantity surveyor, using all the documents prepared for a project, will measure the quantities of items of materials and labour. He then lists all these items in a bill of quantities, which facilitates the preparation of a tender and also the control of variations.

1.2.2 Construction phase

1.2.2.1 General

The construction of a project involves the process of transmitting information from the designer by scale drawings and other documents to the persons who physically build the project. The process involves a large number of people. Each of these persons, in performing his own specialist role, is essential to the successful completion of the project. The contribution of each of these specialists is described in relation to the basic materials used in the structure of the project.

1.2.2.2 Reinforced concrete

The activities of the personnel listed in Fig. 1.2 are described in more detail below.

Considering only the structural component of a reinforced concrete structure the major trades would be:

- formworker
- reinforcement or prestressing fabricator
- concreter
- precast supplier/fabricator

It should be noted that the main contractor may elect to perform these specialist tasks either by using his own personnel or by sub-contract.

The basic activities of the major trades can be summarised briefly as follows:–

The formwork contractor is responsible for the design and construction of the falsework or moulds which will be used to contain and shape the plastic concrete, and the framework required to support it and hold it in position. This falsework must not only support and shape the concrete, but should also be so designed and constructed as to allow the maximum number of re-uses, and be easily removed without damaging the green concrete. So important is this phase of the secondary design and planning that it can be a prime factor in achieving the successful execution of a project.

The reinforcement fabricator supplies the steel reinforcement required for the project. Before the steel reinforcement shown on the design drawings can be placed into the forms, a schedule must be prepared which details the size and shape of each and every bar. This schedule is sometimes prepared by the company which supplies and fabricates the reinforcement.

Working from this schedule only, the fabricator cuts to length, bends, bundles and tags the bars, and delivers them to the site.

On the site, the bundles of reinforcing bars or fabric are sorted, opened, the individual bars or sheets placed in position in the forms and securely tied in place, by a reinforcement fixer, commonly referred to as the "steel fixer." He generally works from both the reinforcement schedule and the design drawings to ensure that each structural component has reinforcement of the size and quantity specified correctly placed in it.

The concrete contractor is responsible for the ordering of the correct grade of concrete in the quantities required to complete the placing programme for a particular day. He must ensure that it is placed into the forms economically and in accordance with the construction schedule, and also that the concrete in the completed structure will satisfy all of the designer's requirements. This means that he must ensure that the strength, compaction, surface finishing and curing of the concrete is in accordance with the specification.

If the design calls for certain elements to be precast, and erected into position in the structure as a completed unit, the main contractor may elect either to have them cast in a factory and delivered to the site, or to set up a casting yard on the site. In either case it will be necessary to carefully design and detail the individual elements in such a way that they can be produced and handled in a production-line type operation. The economic success of a pre-casting operation is primarily dependent on the number of times an individual mould can be re-used. Consequently the design and construction of the moulds is of great importance.

It is normal practice to prepare a mould drawing of each type of element to be cast. These are similar in concept to the "shop drawings" used in structural steel fabrication, and must therefore contain all of the information necessary to build the particular element. This includes reinforcement, type and spacing, type and location of inserts and surface finishes, in addition to all dimensions.

The use of prestressed concrete is established and it is common for some or all of the elements forming the struc-

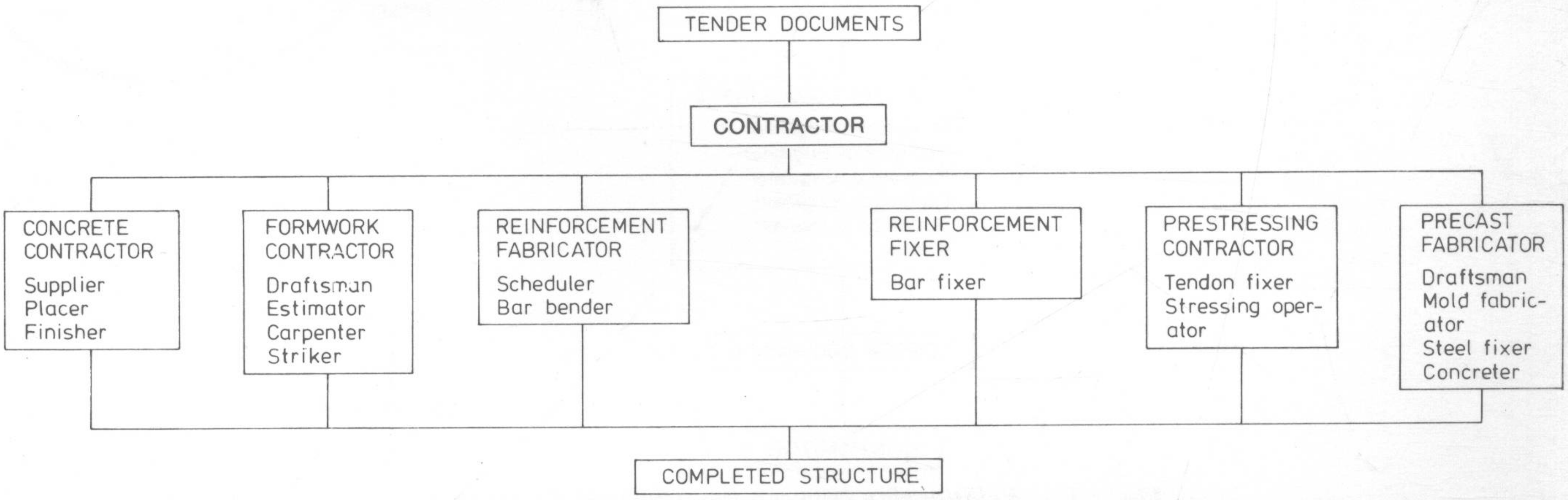


Fig. 1.2 — Reinforced concrete construction activities.

ture to be prestressed. If the structure contains precast "standard" elements such as piles or floor planks, it is likely that they will be constructed on long-line pretensioning beds. In this technique the fabricator stretches high tensile prestressing wires along the moulds and tensions them before casting the concrete around them. When the concrete has gained sufficient strength the tension is released and the wires cut between the individual elements.

Where in-situ concrete or large precast elements are to be prestressed, the post-tensioning technique is normally adopted. Here the tendons are placed in ducts and cast into the concrete untensioned. When the concrete has gained sufficient strength, a tension is applied to the tendons with hydraulic jacks, and the tendons locked in the stretched (tensioned) condition with anchorages, which have been cast into the member.

Both techniques require the services of a highly skilled specialist operator, and may in addition require the preparation of specialist engineering design calculations and detailing over and above that prepared by the structural engineer.

1.2.2.3 Structural steel

The activities of the personnel listed in Fig. 1.3 are described in more detail below.

The structural steel fabricator manufactures the steel frame work used to support the building fabric and floors. The principal personnel he employs to carry out this work are estimators, detail draftsmen and boilermakers.

Estimators are basically concerned with the cost of the structural component of the project and secondly with production methods and times. The cost is usually calculated by measuring the engineer's design plans to obtain the value of materials, labour, purchase items and site costs. An estimator has usually had prior experience as an engineer, draftsman or a boilermaker.

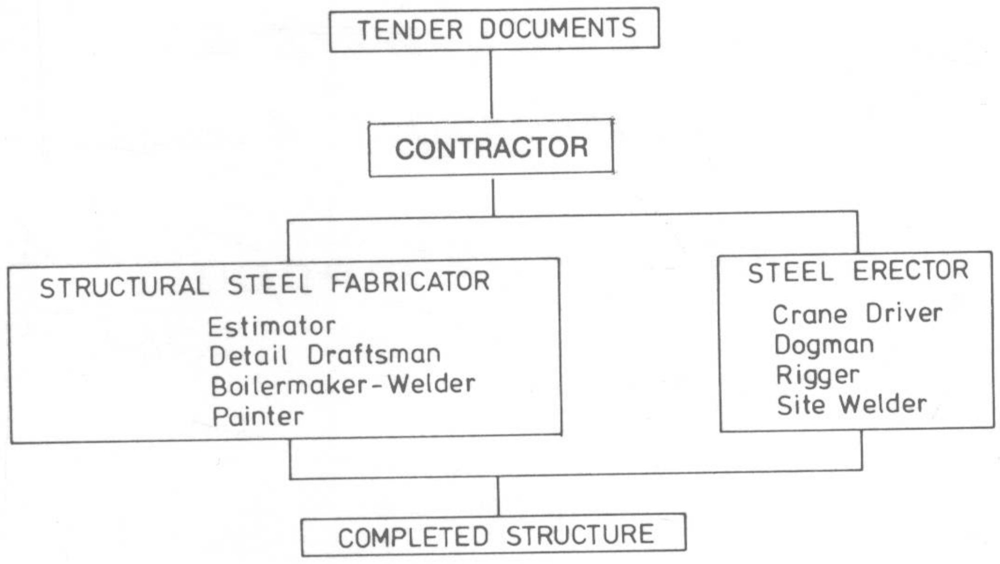


Fig. 1.3 — Structural steel construction activities.

Detail draftsmen prepare workshop detail drawings from the engineer's design plans from which boilermakers in the factory can manufacture the steelwork. The workshop drawings comprise marking plans, and individual part details and are usually fully dimensioned showing the size of members and connections, to enable the individual part of the structure to fit and be joined together within the tolerances specified. The detail draftsman may have gained his experience as an apprentice or have been promoted from a boilermaker or other trade.

The boilermaker is a tradesman who is proficient in reading drawings, marking out of members into the shape required, cutting, assembly of parts, welding and drilling. The boilermaker has gained his training and experience by serving his apprenticeship in the trade. After fabrication, the steelwork is given a surface preparation appropriate to the specified protective coating to be applied. The type of coating applied by the painter is determined by the environment of the completed structure.

The steelwork erection is usually performed by a specialist crew consisting of crane driver, dogmen, riggers and welders employing the type of cranes and equipment appropriate to the structure to be erected.

1.2.2.4 Structural timber

There are relatively few applications where the inherent properties of timber dictate its exclusive use. In most cases the decision to construct in timber is taken after consideration of such factors as availability, appearance, nature of the on-site workforce, comparative costs and so on. The accompanying organisation chart (Fig. 1.4) shows the fabrication and erection trades involved in the construction of a timber project.

The principal uses of timber in modern engineering construction are:

Trusses
- (i) exposed trusses to achieve a desired aesthetic effect
- (ii) factory manufactured lightweight trusses

Columns
- (i) solid
  - (a) sawn
  - (b) poles
- (ii) built-up

Beams
- (i) solid
- (ii) built-up
- (iii) laminated

Composite construction
- (i) trusses (steel and timber)
- (ii) piles (concrete and timber)

Bridge and wharf construction
- (i) round or squared timber

It will be seen from Fig. 1.4 that irrespective of the type of construction one set of drawings only is required — due to the comparative simplicity of timber fabrication. It will be seen also that basically only one trade is involved, i.e. carpenters.

Timber trusses normally incorporate gusset plates, bolts, connectors, rods or other shaped tension members of steel which are fabricated off site by boilermakers. The detailing and manufacturing process for such sections is as described for steel construction.

Carpenters and bridge carpenters obtain their trade qualification by apprenticeship.

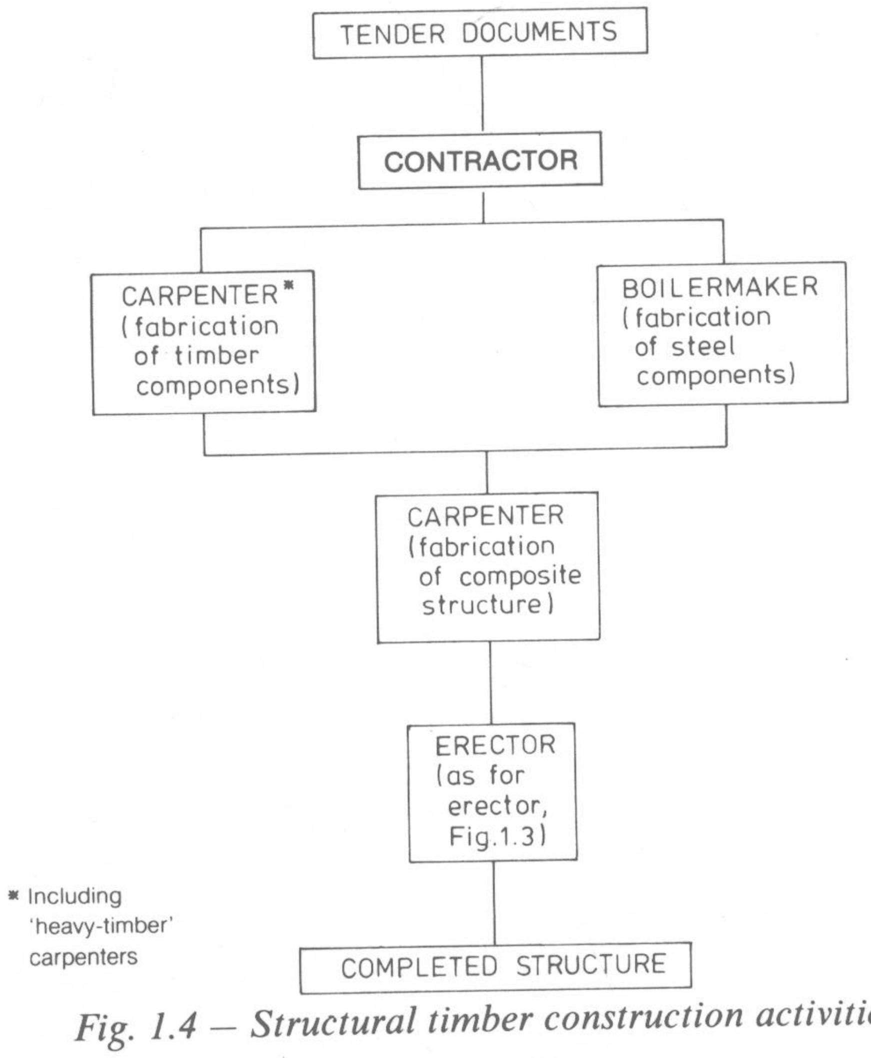


Fig. 1.4 — Structural timber construction activities.

Chapter 2

DRAWING PRACTICE

2.1 GENERAL

This chapter outlines in general terms the information required to produce structural drawings. Should specific details of drawing practice be required the reader is referred to Part 1 of this handbook, namely; *Australian Engineering Drawing Handbook Part 1 — Basic Principles and Techniques.*

2.2 LETTERING

2.2.1 Characters

Vertical characters (Fig. 2.1(a)) are preferred to sloping characters (Fig. 2.1(b)). Only one style of character should be adopted for general use throughout a drawing. Vertical characters are recommended for titles, drawing numbers and reference numbers, irrespective of the style used in the body of the drawing.

For reproduction purposes, upper case letters are preferred because they have fewer small enclosed areas than have lower case.

Lower case letters must be used for conventional signs and symbols normally using such characters e.g. mm, kg, kPa, kW.h, *p*H.

The height *h* of the characters is related to the size of drawing sheet used and should not be less than the height stated in Table 2.1. Regardless of the minimum height in Table 2.1, the character height *h* should be selected such that it is not less than 1.7 mm in the smallest print likely to be produced from the drawing or microfilm of the drawing.

2.2.2 Spacing

Characters forming a word or a number should be so spaced that the shortest distance between the characters (dimension *s* in Fig. 2.2) is twice the thickness of the line forming such characters or 1 mm whichever is the greater.

The space between words should not be less than that needed for the letter "N".

When characters fall vertically, one below the other (as in notes or tables or vulgar fractions) the minimum space between the lines of characters should be 0,6h where h is the height of character.

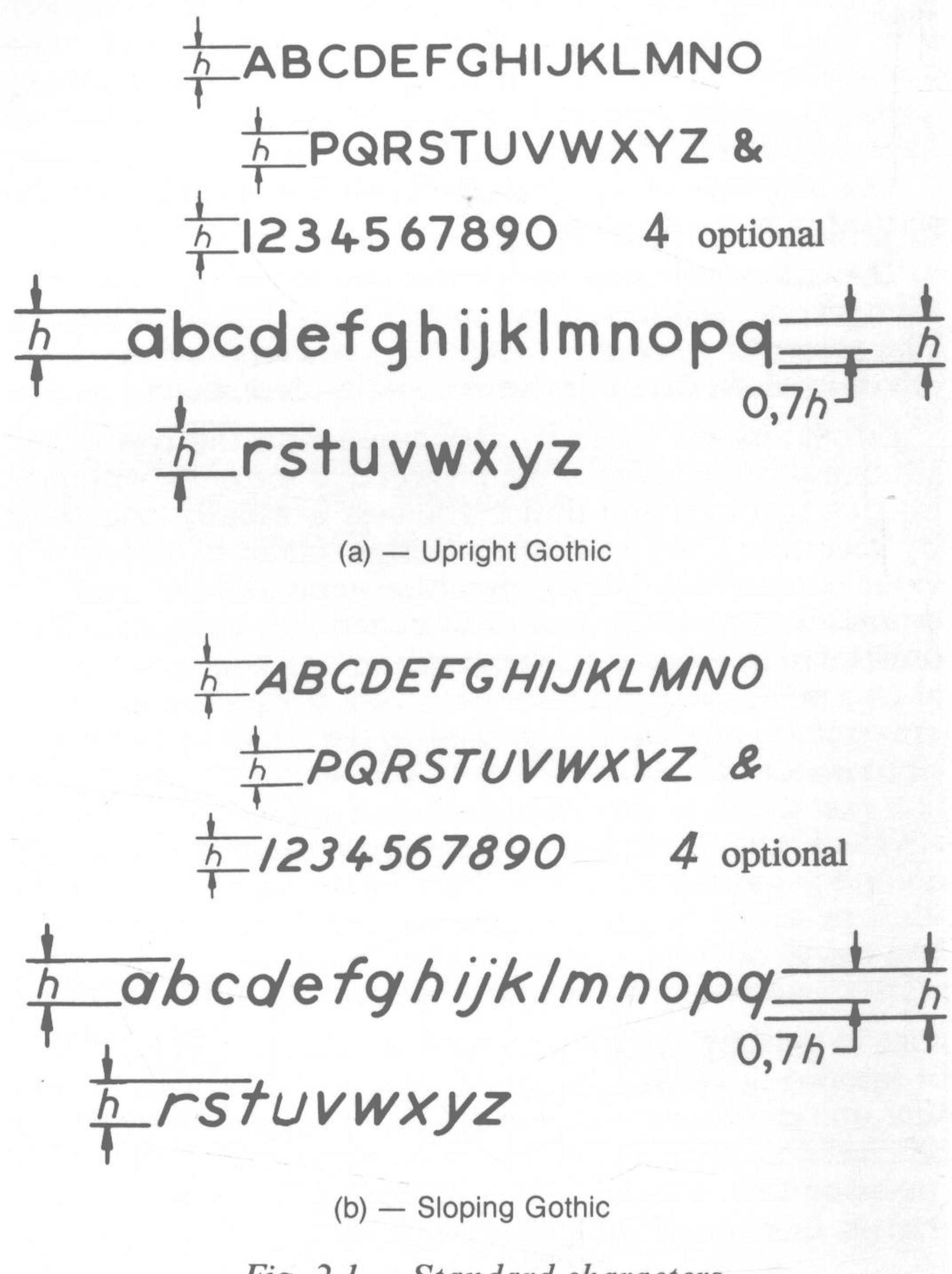


Fig. 2.1 — Standard characters.

TABLE 2.1
Minimum height of characters on drawings

Character use	Character height *h*, mm		
	Freehand and stencil characters		Mechanically produced characters
	Sheet size		
	A0, B1	A1, A2, A3, A4	A2, A3, A4
Titles and drawing numbers	7	5	3.5
Sub-titles, headings, view and section designations, etc.	5	3.5	2.5
General notes, material lists, dimensions, etc.	3.5	2.5	1.8

NOTES:

1. Table 2.1 specifies minimum character heights for upper case lettering only. For upper and lower case combinations, the minimum character height should be one size larger than that specified in the table.
2. The minimum values stated in the table are suitable for copies produced according to current copying practice, i.e. A0, B1, and A1 sizes reduced to A2 size, and A2, A3 and A4 sizes not reduced in size.

2.3 LINES

2.3.1 Types and dimensions of lines

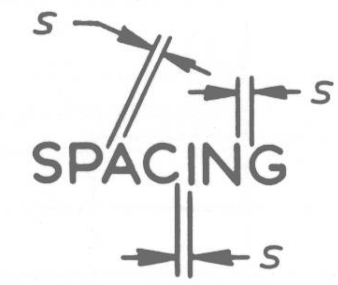
Table 2.2 shows the types of lines used in technical drawing. It also shows the minimum thickness to be used with each size of sheet and the recommended proportions of dashes and spaces in lines which are not continuous.

The minimum values given in Table 2.2 are suitable for drawings to be printed at a reduced size of not less than one-half original size. If greater reduction is required then the line thickness should be selected such that the thickness as printed will not be less than 0.17 mm.

The length and spacing of dashes should be consistent, but may vary in length depending on the complete length of the line and size of the drawing. Recommended dimensions are shown in Table 2.2, column 3.

On any one drawing, only line thickness from one of the groups shown in Table 2.3 should be used.

If other types of lines are used on a drawing it is necessary to explain their meaning in a note on the drawing.



$s = 2t$ where t = Line Thickness

Fig. 2.2 — Spacing of characters.

2.3.2 Application of lines

The application of lines for structural drawings in Concrete, Steel and Timber is covered repectively in Sections 3.3.1, 4.3.1 and 5.3.1.

2.3.3 Line groups

If all lines on a drawing are identical the drawing is confusing and difficult to interpret (Fig. 2.3(a)).

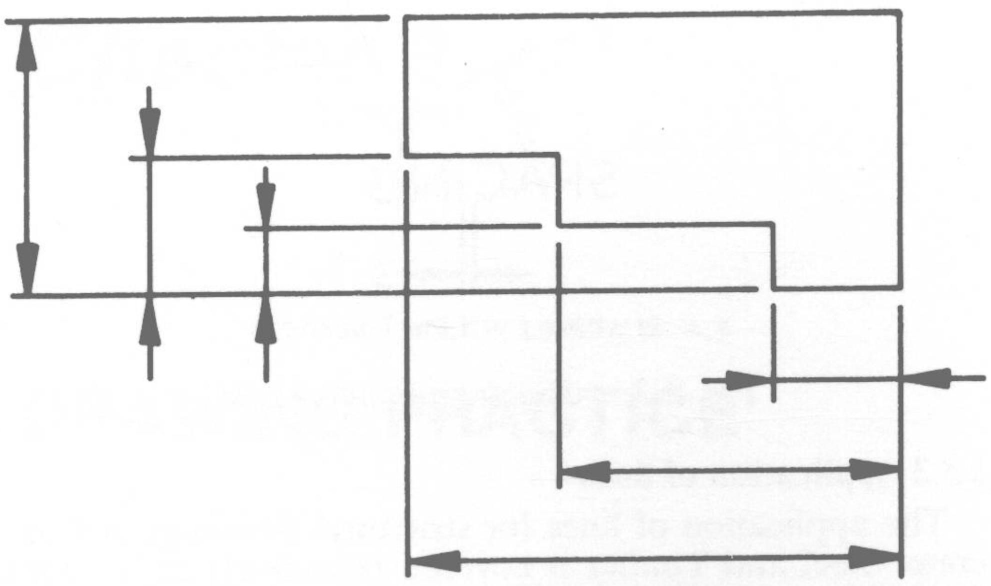
If however the outline of the part is in thick lines and the projection and dimension lines thin, the outline of the part

TABLE 2.2

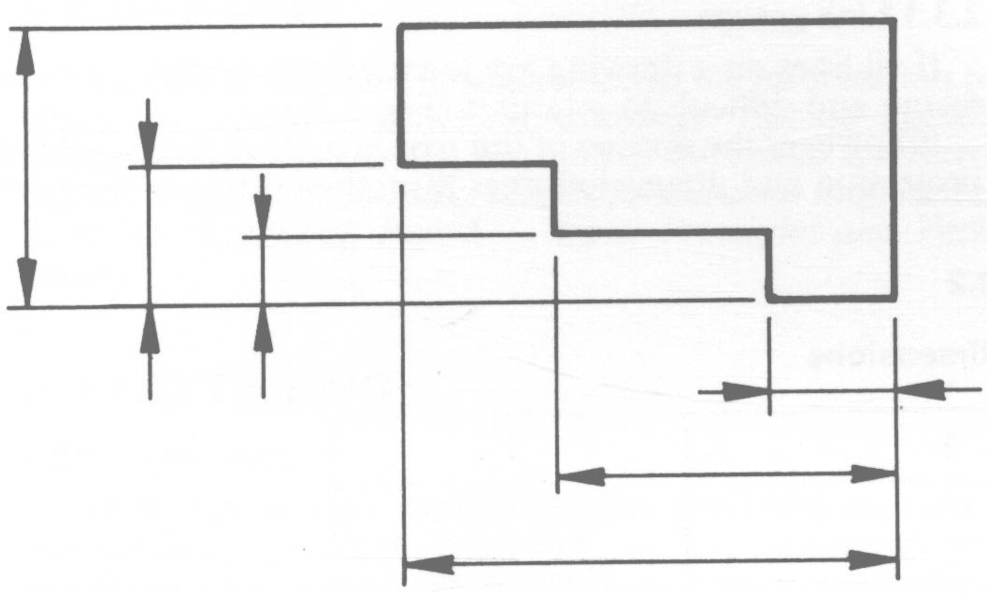
Lines — Types, Dimensions

1	2	3	4		
Desig-nating letter	Type of Line	Example of Line	Minimum thickness according to Sheet Size, mm		
			A0	A1	A2,A3 A4
A	Continuous—thick		0.7	0.5	0.35
B	Continuous—thin		0.35	0.25	0.18
C	Continuous—thin, freehand or ruled with zig-zag		0.35	0.25	0.18
D	Dashed—medium	s = 1 mm minimum $q = 2s$ to $4s$	0.5	0.35	0.25
E	Chain—thin	s = 1 mm minimum $q = 2s$ to $3s$ $p = 3q$ to $10q$	0.35	0.25	0.18
F	Chain—thick at ends and at change of direction	(See Note)	0.7	0.5	0.35
	—thin elsewhere		0.35	0.25	0.18
G	Chain—thick	(See Note)	0.7	0.5	0.35

NOTE: Proportions of lines and spaces are as specified for Line E.



(a) All lines of equal thickness



(b) Lines of different thicknesses to aid interpretation.

Fig. 2.3 — Effect on the interpretation of a drawing due to the thickness of construction lines.

becomes the salient feature and the drawing is more readily interpreted (Fig. 2.3(b)).

By varying the thickness and construction of lines it is possible to express meaning in the drawing which is otherwise difficult to convey. To ensure uniformity in interpretation the use of each type and thickness of line is defined in the international and national drafting standards.

Line groups which will produce drawings in conformity with these standards are given in Table 2.3.

TABLE 2.3

Line Groups

Type of Line	Thickness of Line (mm)			
	Group 1.0	Group 0.7	Group 0.5	Group 0.35
A	1.0	0.7	0.5	0.35
B	0.5	0.35	0.25	0.18
C	0.5	0.35	0.25	0.18
D	0.7	0.5	0.35	0.25
E	0.5	0.35	0.25	0.18
F	0.5	0.35	0.25	0.18
	1.0	0.7	0.5	0.35
G	1.0	0.7	0.5	0.35

2.4 DIMENSIONING

2.4.1 Linear dimensions

Linear dimensions consist of two elements, the unit of measurement and the numerical value.

The preferred unit for linear dimensions on drawings is the millimetre.

Units should be clearly indicated by one of the following methods:

(*a*) Where only one unit is used — by the display of a prominent note

DIMENSIONS ARE IN MILLIMETRES

(*b*) Where two or more units are used but one unit occurs more frequently than the other unit(s) —

(i) most frequently used unit — by the display of a prominent note

UNLESS OTHERWISE STATED
DIMENSIONS IN mm

(ii) other unit(s) — by placing the appropriate unit symbol after the numerical value and separated therefrom by a small space

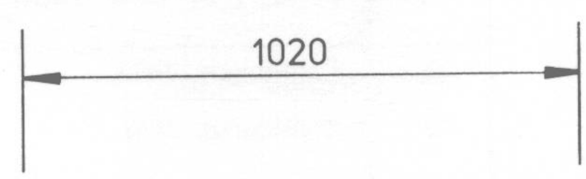
14 m

(*c*) Where neither (a) nor (b) applies — by placing the appropriate unit symbol after the numerical value and separated therefrom by a small space.

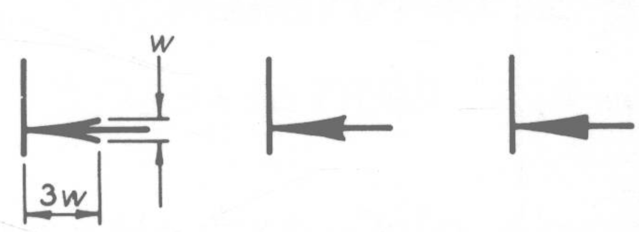
Numerical values shall be clearly indicated adjacent to a dimension line or a leader or in a note as illustrated elsewhere in this standard.

2.4.2 Dimension lines and arrowheads

Unbroken dimension lines are preferable with the dimension placed above the line and approximately in the middle of the line



Arrowheads should be well defined and may be partly or completely filled in. Acceptable formations and proportions are



For normal use the length should be from 3 mm to 5 mm and the point should touch the extension line or outline.

2.5 PROJECTIONS, SECTIONS AND INCLINATION

2.5.1 Projections

Structural drawings should be prepared using Third Angle Projection.

This projection is illustrated in Fig. 2.4 showing

(i) the elevation or side view of the member.
(ii) the plan or top view above the elevation.
(iii) the views at each end looking directly on the end and adjacent to it.
(iv) the bottom or plan view on the bottom side is drawn as a view looking up from the under side.

2.5.2 Sections

As an alternative to the identification system given in Section 7.8.4.3 of Australian Engineering Drawing Handbook, Part 1, the following method is used on some structural drawings to identify cutting or viewing planes and the corresponding section or view.

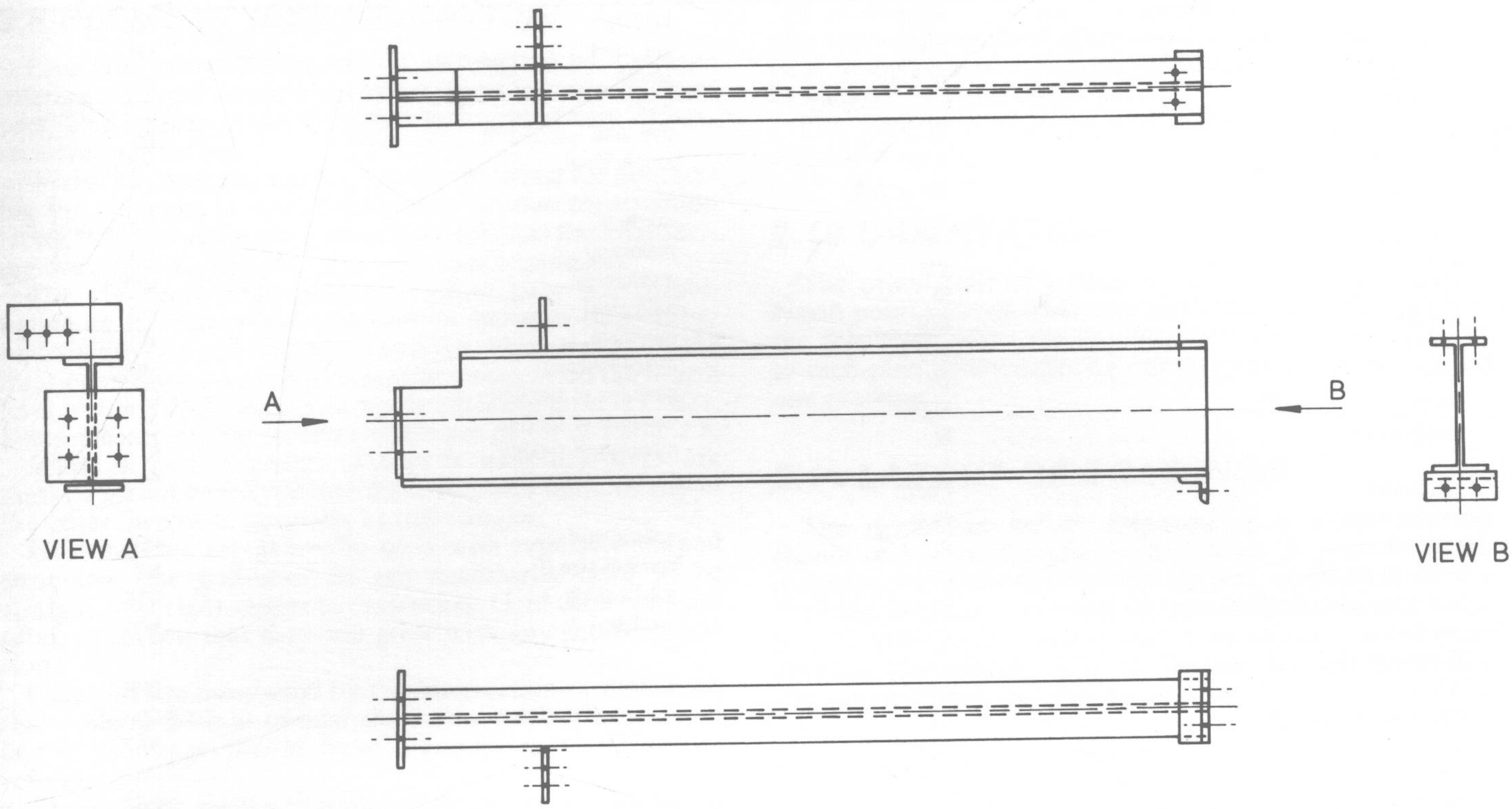
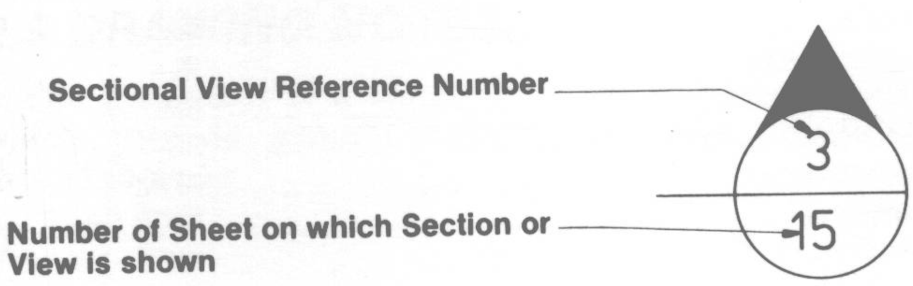
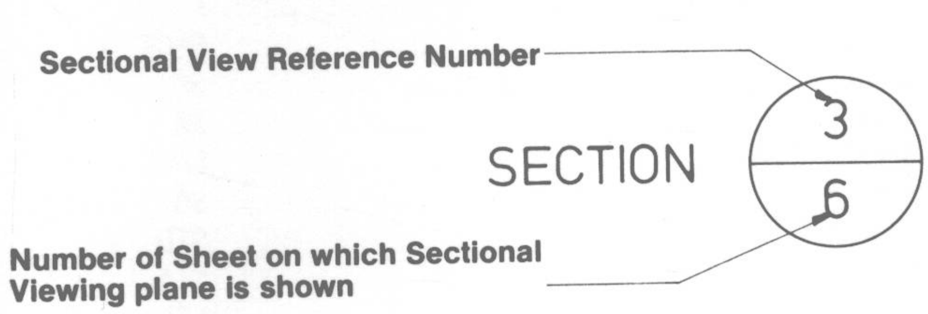


Fig. 2.4 — Example of third angle projection.

Each section or view is numbered consecutively throughout the project; the cutting or viewing plane is identified on the plan or elevation as follows

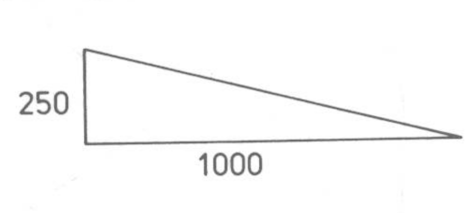


and the view or section is identified in its title as follows



2.5.3 Inclination

The inclination of one member to another or the slope of a member in relation to a given plane is shown by means of a small triangle adjacent to the member,



2.6 SCALES

The scale used to show details should be selected to suit the amount of detail to be shown. Table 2.4 shows the scales recommended for use on engineering drawings and the method of indicating them on such drawings.

2.7 ABBREVIATIONS

Abbreviations and symbols are the same in the plural as in the singular.

Symbols must be inscribed strictly in accordance with appropriate standards. Upper case and lower case letters must not be altered in any way as there may then be a significant difference in their meaning.

Abbreviations other than symbols are generally shown with upper case letters. Lower case letters however may be used in conjunction with textual matter.

Abbreviations should only be used when their meanings are unquestionably clear to the intended reader — WHEN IN DOUBT, SPELL IT OUT.

An abbreviation or a word combination should not be separated for use singly. Abbreviations for single words however may be combined when necessary if there is no other abbreviation listed for the combination. For example, HD and WD may be combined so that HDWD means hardwood.

Abbreviations used in structural engineering drawings are given in Table 2.5. For further abbreviations see *Australian Engineering Drawing Handbook, Part 1, Basic Principles and Techniques.*

TABLE 2.4

Scales

Drawing Type	Preferred Scales
Locality Plans	1:2000
Site Plans	1:500; 1:1000
Working Drawings	1:100; 1:50 1:200
Assembly Drawings	1:20 ; 1:10 1:50
Detail Drawings	1:5 ; 1:10
	1:1

TABLE 2.5
Abbreviations

aggregate	AGGR
amendment	AMDT
approximate	APPROX
arrangement	ARR or ARRGT
asbestos cement	AC
assembly	ASSY
average	AV or AVG
bearing	BRG
bench mark	BM
bending moment	M
bottom	BOT
bracket	BRKT
brick	BK
building	BLDG
building line	BL
calculated	CALC
cement lined	CL
centre-line	CL or ℄
centre of gravity	CG
centre-to-centre, centres	C/C or C TO C
chamfer	CHAM
circumference	CIRC
column	COL
compressive strength	CS
concrete	CONC
construction	CONSTR
construction joint	CJ
corrugated	CORR
countersink	CSK
dead load	DL
detail	DET
diagonal	DIAG
diameter	DIA
inside	ID(I/D)
outside	OD(O/D)
dimension	DIM
drawing	DWG or DRG
dressed all round	DAR
each	EA
elevation	ELEV
expansion	EXP
external	EXT
finished floor level	FFL
figure	FIG
flange	FLG
flat	FL
galvanize	GALV
general arrangement	GA
grid	GD
ground level	GL
head	HD
cup	CUP HD
hexagon	HEX HD
mushroom	MUSH HD
round	RD HD
square	SQ HD
height	HT or HGT
holding down	HD
hollow section	
circular	CHS
rectangular	RHS
square	SHS
horizontal	HORIZ
include	INCL
internal diameter	ID(I/D)
International System of Units (Système International d'Unités)	SI
invert level	IL
landing	LDG
left hand	LH
length	LG
level	LEV
live load	LL
longitudinal	LONG
machine	MACH or M/C
maximum	MAX
mechanical	MECH
mild steel	MS
minimum	MIN
miscellaneous	MISC
modulus of elasticity	E
modulus of section	Z
modulus of rigidity	G
moment of inertia	I
natural surface	NS
nominal size	NS
not to scale	NTS
number	NO
opposite	OPP
outside diameter	OD(O/D)
overall	OA
parallel	PAR
permanent mark	PM
pitch circle diameter	PCD
plate	PL
polyvinylchloride	PVC
quantity	QTY
radius	RAD
reduced level	RL
reference mark	RM
reinforced concrete	RC
reinforcement	REINF
required	REQD
right hand	RH
round	RD
schedule	SCHED
screwed	SCR
second moment of area	I
section	SECT
sheet	SH
sketch	SK
specification	SPEC
square	SQ
standard	STD
station	STA
steel	STL
straight	STR
street	ST
structural floor level	SFL
symmetry	SYM
temporary bench mark	TBM
tensile strength	TS
thick	THK
tolerance	TOL
tongue and grooved	T & G
transverse	TRANSV
typical	TYP
ultimate	ULT
vertical	VERT
weatherboard	WB
wind load	WL
wood	WD

2.8 ELEMENT IDENTIFICATION

Each structural element should be labelled by a unique reference using a suitable combination of letters and numbers. This reference may be either by a grid system or consecutive numbering.

Where a system has already been established for numbering the elements or for showing the various construction levels, an identical system should be used on the engineering drawings. To do otherwise will cause confusion.

The consecutive numbering method uses the combination of location prefix followed by the type-of-member alphabetic code followed by a number which describes the location of the element. For example, beam 21 on the fourth level is called 4B21; beam 21 on the fifteenth level is 15B21. Some recommended member codes are given in Table 2.6.

When a grid reference system is used grid-lines are marked alphabetically in one direction, and numerically in the other direction, normally at right angles.

Grid systems are generally used with regularly shaped structures but grid-lines do not necessarily have to be straight or at right angles to each other. Grid directions are often so chosen that they will grow with any future extension.

Columns are numbered by the intersection of grid-lines, thus column B4 is at or near the intersection of line B and line 4. Footings should have identical numbers to the columns above.

Beams, slabs, walls and similar elements generally should not be numbered by a grid reference system.

The grid reference system mentioned above should not be confused with grid marks sometimes shown on drawings to assist in readily locating a particular dimension or feature.

2.9 DRAWING NOTES

The first sheet of a set of drawings should carry notes which provide general information. This information should include:

(i) references to standards and codes,
(ii) cross-references to other contract documents,
(iii) quality requirements for materials and workmanship,
(iv) design criteria, and so on.

For examples of such notes see sample drawings in Appendix C.

2.10 ORIENTATION

The orientation of a plan is indicated by the use of a North point symbol. This may be located either adjacent to the title block when the application is general or adjacent to each plan where differing orientations are shown on the one drawing.

2.11 LAYOUT OF DRAWINGS

The draftsman before commencing a detail drawing should give some thought to the layout. A prior freehand roughing-out drawing showing to scale the object of the drawing, sectional views and the necessary details may assist him in presenting a neater and more clearly set-out final drawing (for details refer to Section 6.5 of *Australian Engineering Drawing Handbook, Part 1*).

TABLE 2.6

Member Code

F	Stair (flight)	RW	Retaining wall
L	Stair (landing)	RF	Raft footing
J	Joist	SF	Strip footing
R	Rib	P	Pier or Pedestal
S	Slab	PC	Pile cap
B	Beam	PF	Portal frame
L	Lintel	F	Pad footing
C	Column	T	Truss
W	Wall		

Chapter 3

REINFORCED CONCRETE

3.1 TYPES OF STRUCTURES

3.1.1 General

Reinforced concrete, in-situ, precast or prestressed is used in the construction of a vast range of structures. For convenience these can be classified into two main groups:

(*a*) Building structures.
(*b*) Civil engineering structures.

Although used in each of the above groups, prestressed concrete has developed as a highly specialised form of concrete construction which merits separate treatment.

3.1.2 Building structures

These range from multi-storey buildings, power stations, factories, small blocks of flats, to a simple garage floor. Basically they comprise foundations; vertical elements such as columns, walls and stair wells; and horizontal elements such as beams and slabs.

The drawings required to detail these elements follow fundamentally the same practice, irrespective of the type of building involved. This is because the basic design information which must be transmitted to the builder is the same. The major difference between the details for a simple structure and a major building, apart from the number of drawings required, is the element numbering system. Whereas in a simple structure beam marks such as B1 to B10, and slabs S1 to S5 may suffice, in a multi-storey building a much more complex system would be required.

Element identification systems are discussed in Section 2.8.

3.1.3 Civil engineering structures

The range of structures in this category is even greater, and more diverse, than that of the building group.

Some typical examples of civil engineering structures are listed below:

- Bridges.
- Tunnels.
- Hydraulic structures.
- Marine structures.
- Roads and airport pavements.
- Retaining walls.

Notwithstanding such a diversity of structures, in all cases the same basic information must be communicated, namely the concrete outlines and the type, size, quantity and location of the reinforcement. In civil engineering works, probably more than other types of structures, element numbering systems are of paramount importance. For instance, in some large projects each individual element will be given a unique reference number. This reference may even be extended further by allocating individual bar marks to the reinforcing. The basic aim is to ensure that the reinforcement associated with a particular component can be readily identified.

3.1.4 Prestressed concrete structures

The applications of prestressed concrete construction are diverse but the methods of detailing vary little from those used for reinforced concrete except in the delineation of main stressing tendons.

In post-tensioned prestressed concrete work the tendons and ducts may be required to conform to predetermined curves, usually parabolic or a combination of parabolas. Detail drawings should provide sufficient information to enable the tendons to be accurately placed.

Various types of stressing tendons are in use, each type having its special form of end anchorage.

Particular care is required in detailing the end anchorages and anchorage blocks.

Pre-tensioned prestressed concrete units are usually constructed using a number of straight wires tensioned on a special prestressing bed.

No special detailing is required for this form of construction, but correct reinforcement, spacing and special details should be shown or noted in the drawing.

In addition to the notes on concrete strengths, type of normal reinforcing steel (if any) and type of prestressing tendons and methods of tensioning, further notes should give details of the points to be used for lifting, handling and stacking the units. Information to be given in notes on the drawing should include concrete strength at load transfer and final strength.

3.2 TYPES OF DRAWINGS

3.2.1 Design drawings

The design drawings should communicate all the designer's intentions, with the possible exception of such items as quality, tolerances, testing requirements etc., which can be adequately covered in the specification. The drawings should show clearly the dimensions and shape of all concrete sections and the type, size, shape, extent and location of all reinforcement. Depending on the complexity of the structure, the design drawings may show both the concrete outlines and reinforcement on the same view (combined

Table 3.1

MATERIAL TYPE
C = Grade 410C to AS 1302.
S = Grade 230S to AS 1302.
R = Grade 230R to AS 1302.
F = Fabric to AS 1304.
W = Wire to AS 1303.

PROCESS CODE "P"
C = Cut only.
B = Bent bar.
F = Bent fitment.

REINFORCEMENT SCHEDULE
for use with First and Second Preference
Bar Bending Shapes given in Table 3.2.

Scheduled by ..../....../......
Checked by ..../....../......

BUILDER ....
JOB ....
PART of Job ....

DIMENSIONS are in mm.
TOLERANCES are AS 1480 "NORMAL" values unless stated otherwise.

	Drawing No.	Schedule No.	Revision
Schedule Ref. No.			

Item	E	MEMBER or LOCATION	MARK	Col.	No.	Type-size	TOTAL	LENGTH	P	Shape	h/c	A	B	C	D	E	h/c	Tonnes
1																		
2																		
3																		
4																		
5																		
6																		
7																		
8																		
9																		
10																		
11																		
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16																		
17																		
18																		
19																		
20																		

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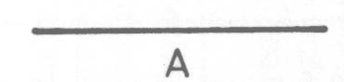
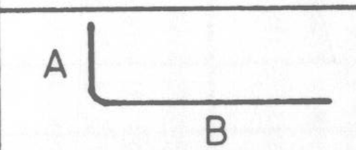
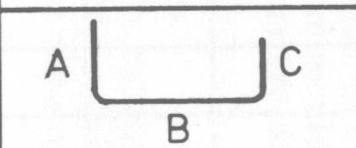
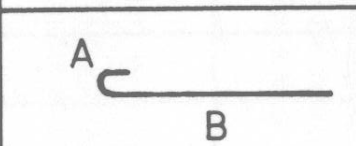
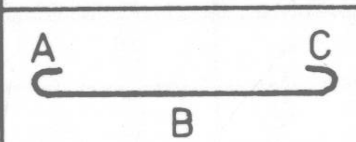
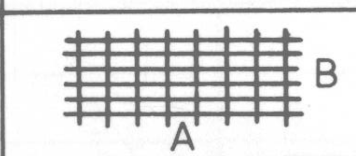
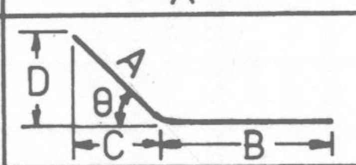
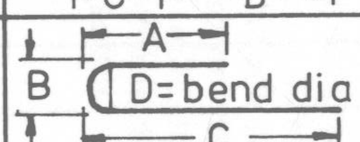
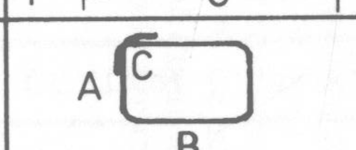
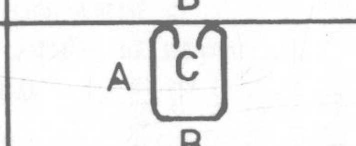
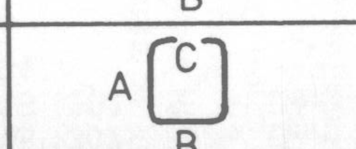
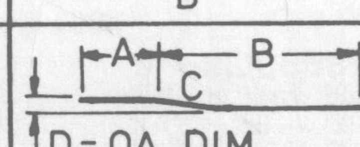
TABLE 3.2
Bar Bending Shapes

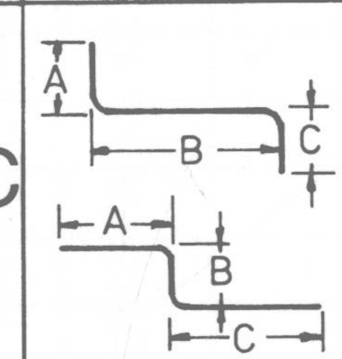
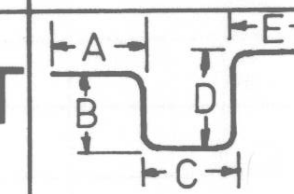
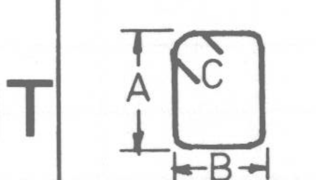
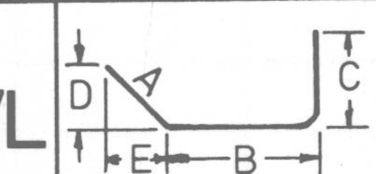
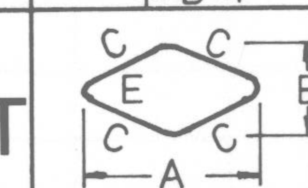
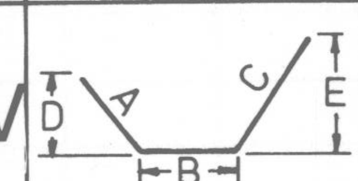
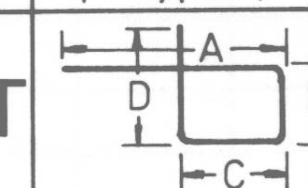
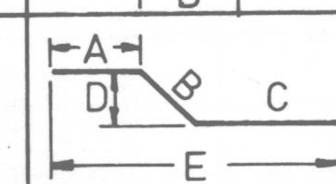
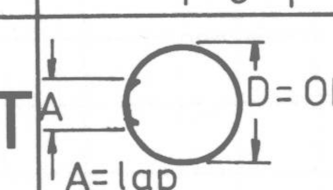
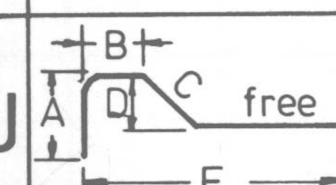
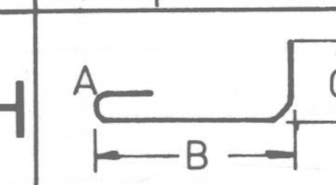
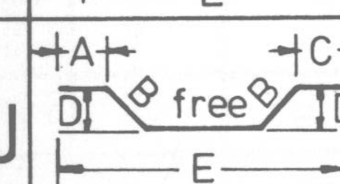
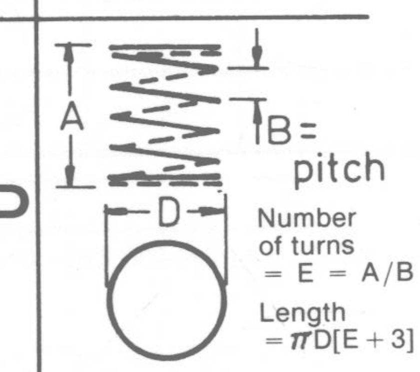
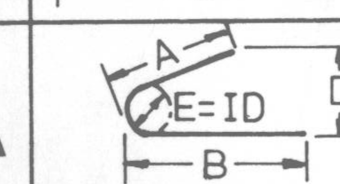
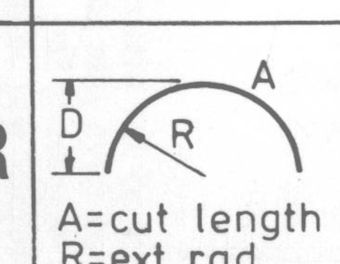
FIRST PREFERENCE BAR BENDING SHAPES

Notes: 1 All dimensions are to intersection of straight portions at the outside of all types of bends.
2 "L" is the sum of the individual out-to-out dimensions "A", "B", etc.

Name	Code	Diagram	Essential Dimensions	Comment
Straight	S		A	A is also the length L
L-shape One 90° bend	L		A B A L B L	A + B = L A would be critical B would be critical
Double L-shape Two 90° bends	LL		A B C	A + B + C = L A and C should both be specified even if equal
Hooked bar One 180° bend	H		A B B L B	A + B = L When A is standard, it may be omitted
Double hooked Two 180° bends	HH		A B C B L B	A + B + C = L A = C = 0, 5 [L-B] A & C standard
Fabric Only if flat sheet	F		A B	A is length of main wires (6000 mm max) B is extent of cross-wires including side laps
V-shape Bend less than 90°	V		A B D A B C A D L A C L	Give C when angle θ exceeds 70° A is critical always B may be omitted only if not critical
U-shape 180° bend only	U		A B C A C D	Specify U-shape not LL-shape when B is less than 20 bar diameters
Tie for beams or columns	T		A B C A B	L = 2[A + B + C] C is a cog length L may be omitted generally; C also
Stirrup for beams [hooks in]	SH		A B C A B	L = 2A + B + 2C C is a hook length L & C may be omitted generally
Stirrup for beams [cogs in]	SC		A B C A B	L = 2A + B + 2C C is a cog length L & C may be omitted generally
Cranked column bar for lap splice	CC		A B C D A C D L	L = A + B where A is a lap-splice length, $C \geq 6\ d_b$ $D \geq 2\ d_b$

SECOND PREFERENCE BAR BENDING SHAPES

Notes: 1 All dimensions are to intersection of straight portions except where shown.
2 First preference shapes with hooks and cogs are to be included here.

Name	Code	Diagram	Name	Code	Diagram
Right-angled Crank Shape	RC		**Right-angled Truss Shape**	RT	
			135° Hooked Tie	HT	
V-plus L-shape	VL		**Diamond Shaped Tie** for columns	DT	
Double V-shape	VV		**Cross-over Tie**	XT	
Joist Bar or bent-up bar	J		**Circular Tie** for columns	CT	
L-bend added to J-shape	LJ		**Link** for columns	LH	
Double J-shape or truss bar	JJ		**Spiral or Helix**	SP	
Acute Angle Bend more than 90°	A				
Radiused Bar	R		**Non-Standard Shapes**	NS	All shapes are to be drawn and dimensioned in full

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