UNITS AND SYMBOLS

	basic unit	unit symbol	definition based on	SI units in the definition
1 length	metre	m	wavelength of krypton radiation	
2 mass	kilogram	kg	international prototype	
3 time	second	s	duration period of caesium radiation	
4 electrical current	ampere	A	electrodynamic power between two conductors	kg, m, s
5 temperature	kelvin	K	triple point of water	
6 luminous intensity	candela	cd	radiation from freezing platinum	kg, s
7 quantity of matter	mole	mol	number of carbon atoms	kg

(1) **SI basic units**

The statutory introduction of SI Units took place in stages between 1974 and 1977. As from 1 January 1978 the International Measurement System became valid using SI Units (SI = Système Internationale d'Unités).

prefixes and their abbreviations are:							
T	(tera)	$= 10^{12}$	(billion)	c	(centi)	= 1/100	(hundredth)
G	(giga)	$= 10^{9}$	(US billion)	m	(milli)	$= 10^{-3}$	(thousandth)
M	(mega)	$= 10^{6}$	(million)	μ	(micro)	$= 10^{-6}$	(millionth)
k	(kilo)	$= 10^{3}$	(thousand)	n	(nano)	$= 10^{-9}$	(US billionth)
h	(hecto)	= 100		p	(pico)	$= 10^{-12}$	(billionth)
da	(deca)	= 10		f	(femto)	$= 10^{-15}$	(US trillionth)
d	(deci)	= 1/10	(tenth)	a	(atto)	$= 10^{-18}$	(trillionth)
no more than one prefix can be used at the same time							

(2) **Decimal multipliers**

area	$1\ m \times 1\ m = 1\ m^2$
velocity	$1\ m \times 1\ s^{-1} = 1\ ms^{-1} = 1\ m/s$
acceleration	$1\ m \times 1\ s^{-2} = 1\ ms^{-2} = 1\ m/s^2$
force	$1\ kg \times 1\ m \times 1\ s^{-2} = 1\ kgms^{-2} = 1\ kgm/s^2$
density	$1\ kg \times 1\ m^{-3} = 1\ kgm^{-3} = 1\ kg/m^3$

(3) **Examples of deriving SI units**

quantity	unit (symbol)	dimensions (M = mass, L = length, T = time)	relationships
area *A*	m^2	L^2	–
volume *V*	m^3	L^3	–
density *ρ*	kgm^{-3}	ML^{-3}	–
velocity *v*	ms^{-1}	LT^{-1}	–
acceleration *a*	ms^{-2}	LT^{-2}	–
momentum *p*	$kgms^{-1}$	MLT^{-1}	–
moment of inertia *I, J*	kgm^2	ML^2	–
angular momentum *L*	kgm^2s^{-1}	ML^2T^{-1}	–
force *F*	newton (N)	MLT^{-2}	$1\ N = 1\ kgm/s^2$
energy, work *E, W*	joule (J)	ML^2T^{-2}	1 J = 1 Nm = 1 Ws 1 kcal = 4186 J, 1 kWh = 3.6 MJ
power *P*	watt (W)	ML^2T^{-3}	1 W = 1 J/s
pressure, stress *p, σ*	pascal (Pa)	$ML^{-1}T^{-2}$	$1\ Pa = 1\ N/m^2$
			$1\ bar = 10^5\ Pa$
surface tension *γ*	Nm^{-1}	$ML^{-1}T^{-2}$	–
viscosity *η*	$kgm^{-1}s^{-1}$	$ML^{-1}T^{-1}$	–

(4) **Summary of main derived SI units**

symbol	name (unit)	meaning and relationships
I	ampere (A)	current
V	volt (V)	potential difference: 1 V = 1 W/A
R	ohm (Ω)	resistance: 1 Ω = 1 V/A
Q	coulomb (C)	charge: 1 C = 1 As
P	watt (W)	power
G	siemens (S)	conductance: 1 S = 1/Ω
F	farad (F)	capacitance: 1 F = 1 As/V
H	henry (H)	inductance: 1 H = 1 Vs/A
Φ	weber (Wb)	magnetic flux: 1 Wb = 1 Vs
B	tesla (T)	magnetic flux density: $1\ T = 1\ Wb/m^2$

(5) **Symbols and units: electromagnetism**

symbol	(unit)	meaning
t	(°C, K)	temperature (note: intervals in Celsius and kelvin are identical)
Δt	(K)	temperature differential
q	(J)	quantity of heat (also measured in kilowatt hours (kWh))
λ	(W/mK)	thermal conductivity (k-value)
λ′	(W/mK)	equivalent thermal conductivity
Λ	(W/m^2K)	coefficient of thermal conductance (C-value)
α	(W/m^2K)	coefficient of heat transfer (U-value)
k	(W/m^2K)	coefficient of heat penetration
1/Λ	(m^2K/W)	value of thermal insulation
1/α	(m^2K/W)	heat transfer resistance (R-value)
1/k	(m^2K/W)	heat penetration resistance
D′	(m^2K/W cm)	coefficient of heat resistance
c	(Wh/kgK)	specific heat value
S	(Wh/m^3K)	coefficient of heat storage
ß	(1/K)	coefficient of linear expansion
P	(Pa)	pressure
P_o	(Pa)	vapour pressure
g_o	(g)	quantity of steam
g_k	(g)	quantity of condensed water
ν	(%)	relative atmospheric humidity
μ	(–)	coefficient of diffusion resistance
μ d	(cm)	equivalent atmospheric layer thickness
Λ_o	(g/m^2hPa)	coefficient of water vapour penetration
$1/\Lambda_o$	(m^2hPa/g)	resistance to water vapour penetration
μλ	(W/mK)	layer factor
μλ′	(W/mK)	layer factor of atmospheric strata
P	(£,$/kWh)	heating cost

(6) **Symbols and units: heat and moisture**

symbol	(unit)	meaning
λ	(m)	wavelength
f	(Hz)	frequency
f_{gr}	(Hz)	limiting frequency
f_{η}	(Hz)	frequency resonance
E_{dva}	(N/cm^2)	dynamic modulus of elasticity
S′	(N/cm^3)	dynamic stiffness
R	(dB)	measurement of airborn noise reduction
R_m	(dB)	average measurement of noise reduction
R′	(dB)	measurement of airborn noise suppression in a building
L_n	(dB)	impact noise level standard
a	(–)	degree of sound absorption
A	(m^2)	equivalent noise absorption area
r	(m)	radius of reverberation
ΔL	(dB)	noise level reduction

(7) **Symbols and units: sound**

UNITS AND SYMBOLS

quantity	symbol	SI unit name	SI unit symbols	statutory unit name	statutory unit symbols	old unit name	old unit symbols	relationships
normal angle	α, β, γ	radian	rad	perigon degree minute second gon	pla ° ′ ″ gon	right angle old degrees new degrees new minute new second	L g a cc	1 rad = 57.296 = 63.662 gon 1 pla = 2π rad 1L = 1/4 pla = (π/2) rad 1 = 1L/90 = 1 pla/360 = (π/180) rad 1′ = 1 /60 1″ = 1′/60 = 1 /3600 1 gon = 1 g = 1L/100 = 1 pla/400 = π/200 rad 1 c = 10^{-2} gon 1 cc = 10^{-2}) c = 10^{-4} gon
length	*l*	metre	m	micron millimetre centimetre decimetre kilometre	μm mm cm dm km	inch foot fathom mile nautical mile	in ft fathom mil sm	1 in = 25.4 mm 1 ft = 30.48 cm 1 fathom = 1.8288 m 1 mil = 1.609 km 1 sm = 1.852 km
area: cross section of land plots	*A*	square metre	m^2	are hectare	a ha			square foot (= 0.092 m^2); acre (0.405 ha) still in use 1 a = 10^2 m 1 ha = 10^4 m
volume normal volume	*V*	cubic metre	m^3	litre	l	normal cubic metre cubic metre	Nm^3 cbm	1 l = 1 dm^3 = 10^{-3} m^3 1 Nm^3 = 1 m^3 in norm condition cbm = 1 m^3
time, time span, duration	*t*	second	s	minute hour day year	min h d a, y			1 min = 60 s 1 h = 60 min = 3600 s 1 d = 24 h = 86400 s 1 a = 1 y = 8765.8 h = 3.1557 × 10^7 s
frequency reciprocal of duration angular frequency angular velocity	f ω ω	hertz reciprocal second radians per second	Hz 1/s rad/s					1 Hz = 1/s for expressing frequencies in dimensional equations ω = 2 × *f* ω = 2 × *n*
no. of revs, speed of revolutions	n	reciprocal second	1/s	revs per second revs per minute	r/s r/min	revs per second revs per minute	r.p.s. r.p.m.	1/s = *t*/s = r/s
velocity	*v*	metres per second	m/s	kilometres per hour	km/h	knots	kn	1 m/s = 3.6 km/h 1 kn = 1 sm/h = 1.852 km/h
acceleration due to gravity	*g*	metres per second per second	m/s^2			gal	gal	1 gal = 1 cm/s^2 = 10^{-2} m/s^2
mass: weight (as a result of weighing	*m*	kilogram	kg	gram tonne	g t	pound metric pound ton	lb ton	1 g = 10^{-3} kg 1 t = 1 Mg = 10^3 kg 1 lb = 0.45359237 kg 1 metric pound = 0.5 kg 1 ton = 2240 lb = 1016 kg
force thrust	*F* *G*	newton	N			dyn pond kilopond megapond kilogram force tonne force	dyn p kp Mp kg/f t/f	1 N = 1 kg m/s^2 = 1 Ws/m = 1 J/m 1 dyn = 1 g cm/s^2 = 10^{-5} N 1 p = 9.80665 × 10^{-3} N
stress strength strength stress strength	σ σ	newtons per square per square newtons per square metre	N/m^2 N/m^2	newtons per square per square newtons per square millimetre	N/mm^2 N/mm^2	kiloponds per kiloponds per kiloponds per square cm/mm	kp/cm^2 kp/cm^2 kp/cm^2 kp/mm^2	1 kp/cm^2 = 0.0980665 N/mm^2 1 kp/cm^2 = 0.0980665 N/mm^2 1 kp/cm^2 = 0.0980665 N/mm^2 1 kp/mm^2 = 9.80665 N/mm^2
energy quantity of heat torque bending moment	*W*, *E* *Q* *M* M_b	joule joule newton metre or joule	J J Nm J	kilowatt hour	kWh	h.p. per hour erg calorie kilopond metre	h.p./h erg cal kpm	1 J = 1 Nm = 1 Ws = 10^7 erg 1 kWh = 3.6 × 10^6 J = 3.6 MJ 1 h.p./h = 2.64780 × 10^6 J 1 erg = 10^{-7} J 1 cal = 4.1868 J = 1.163 × 10^{-3} Wh 1 kpm = 9.80665 J
power energy current	*P*	watt	W			horsepower	h.p.	1 W = 1 J/s = 1 Nm/s = 1 kg m^2/s^3 1 h.p. = 745.7 kW
thermodynamic temperature Celsius temp. temperature interval and differential Fahrenheit temperature Reaumur temp.	*T* θ Δ*T* or θΔ $θ_F$ $θ_R$	kelvin	K K	degrees Celsius	C	deg. kelvin deg. Rankine deg. Fahrenheit deg. Réaumur	K R, Rk F R	R = 5/9 K θ = *T* − T_o (T_o = 273.15 K) Δθ = Δ*T*, therefore 1 K = 1 C = 1 deg. $θ_F$ = 9/5 θ + 32 = 9/5 *T* − 459.67 $θ_R$ = 4/5 θ, 1 R 5/4 C

(1) **SI and statutory units for the construction industry**

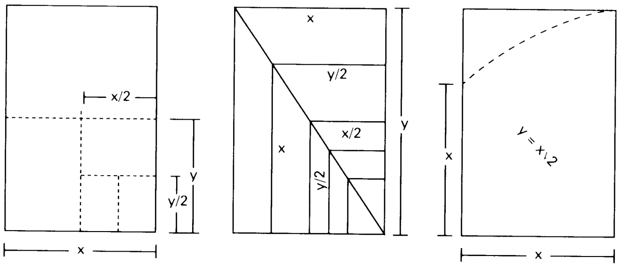
Mathematical symbols

- > greater than
- ≥ greater than or equal to
- < smaller than
- ≤ smaller than or equal to
- Σ sum of
- ∠ angle
- sin sine
- cos cosine
- tan tangent
- cotan cotangent
- |· on average
- = equals
- ≡ identically equal
- ≠ not equals
- ≈ roughly equals, about
- • congruent
- ~ asymptotically equal (similar) to
- ∞ infinity
- || parallel
- # equal and parallel
- ≢ not identically equal to
- × multiplied by
- / divided by
- ⊥ perpendicular
- V volume, content
- ω solid angle
- √ root of
- Δ final increment
- ≅ congruent
- △ triangle
- ↑↑ same direction, parallel
- ↓↓ opposite direction, parallel

Greek alphabet

- Α α (a) alpha
- Β β (b) beta
- Γ γ (g) gamma
- Δ δ (d) delta
- Ε ε (e) epsilon
- Ζ ζ (z) zeta
- Η η (e) eta
- Θ θ (th) theta
- Ι ι (i) iota
- Ι ι (i) iota
- Ι ι (i) iota
- Κ κ (k) kappa
- Λ λ (l) lambda
- Μ μ (m) mu
- Ν ν (n) nu
- Ξ ξ (x) xi
- Ο ο (o) omicron
- Π π (p) pi
- Ρ ρ (r) rho
- Σ σ (s) sigma
- Τ τ (t) tau
- Υ υ (u) upsilon
- Φ φ (ph) phi
- Ξ χ (ch) chi
- Ψ ψ (ps) psi
- Ω ω (o) omega

DOCUMENTATION AND DRAWINGS



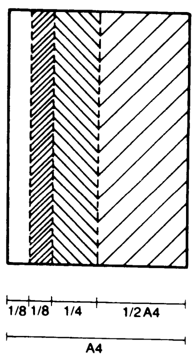
① - ③ **Basis of paper formats**

format	A series	B series	C series
0	841 × 1189	1000 × 1414	917 × 1297
1	594 × 841	707 × 1000	648 × 917
2	420 × 594	500 × 707	458 × 648
3	297 × 420	353 × 500	324 × 458
4	210 × 297	250 × 353	229 × 324
5	148 × 210	176 × 250	162 × 229
6	105 × 148	125 × 176	114 × 162
7	74 × 105	88 × 125	81 × 141
8	52 × 74	62 × 88	57 × 81
9	37 × 52	44 × 62	
10	26 × 37	31 × 44	
11	18 × 26	22 × 31	
12	13 × 18	15 × 22	

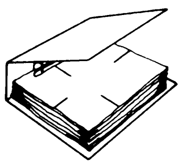
④ **Sheet sizes**

format	abbreviation	mm
half length A4	1/2 A4	105 × 297
quarter length A4	1/4 A4	52 × 297
one eighth A7	1/8 A7	9 × 105
half length C4	1/2 C4	114 × 324
etc.		

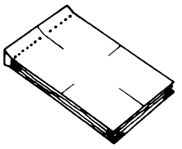
⑤ **Strip formats**



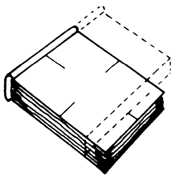
⑥ **Format strips in A4**



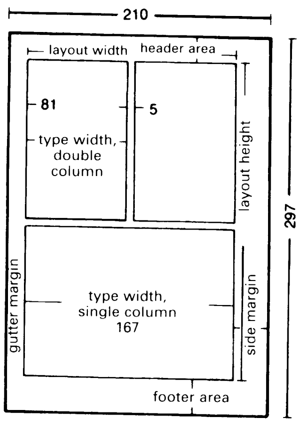
⑦ **Loose-leaf binder**



⑧ **Pads (including carbonless)**



⑨ **Bound and trimmed books**



⑩ → ⑪

The format of documentation (whether in the form of plans, reports, letters, envelopes etc.) has, apart from in the USA, generally been standardised to conform to the internationally accepted (ISO) series of paper sheet sizes in the 'A', 'B', 'C' and 'D' ranges. These standard paper formats are derived from a rectangular sheet with an area of 1 m^2. Using the 'golden square', the lengths of the sides are chosen as x = 0.841 m and y = 1.189 m such that:

$$x \times y = 1$$
$$x:y = 1:\sqrt{2}$$

This forms the basis for the A series. Maintaining the same ratio of length to width, the sheet sizes are worked out by progressively halving (or, the other way round, doubling) the sheet area, as would happen if the rectangular sheet was repeatedly folded exactly in half → ① - ③.

Additional ranges (B, C, and D) are provided for the associated products that require larger paper sizes, i.e. posters, envelopes, loose-leaf file binders, folders etc. The formats of range B are designed for posters and wall-charts. The formats in ranges C and D are the geometric mean dimensions of ranges A and B and are used to manufacture the envelopes and folders to take the A sizes. → ④ The extra size needed for loose-leaf binders, folders and box files will depend on the size and type of clamping device employed.

The strip or side margin formats are formed by halves, quarters, and eighths of the main formats (for envelopes, signs, drawings etc.) → ⑤ + ⑥.

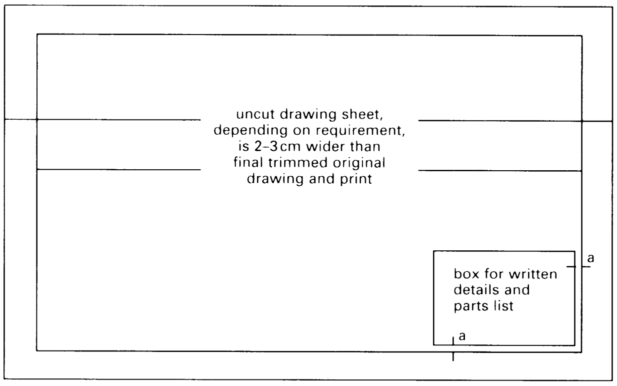
Pads and duplicate books using carbonless paper also have standard formats but may have a perforated edge or border, which means the resulting pages will be a corresponding amount smaller than the standard sheet size → ⑧.

During book-binding, a further trim is usually necessary, giving pages somewhat smaller than the standard format size. However, commercial printers use paper supplied in the RA or SRA sizes and this has an allowance for trimming, which allows the final page sizes to match the standard formats.

	picas		mm	
type area width	39.5	40.5	167	171
type area, height (without header/footer)	58.5	59	247	250
space between columns	1		5	
max. width, single column	39.5		167	
max. width, double column	19		81	
inside (gutter) margin, nominal			16	14
outer (side) margin, nominal			27	25
top (head) margin, nominal			20	19
bottom (foot) margin, nominal			30	28

⑪ **Layouts and type area with A4 standard format**

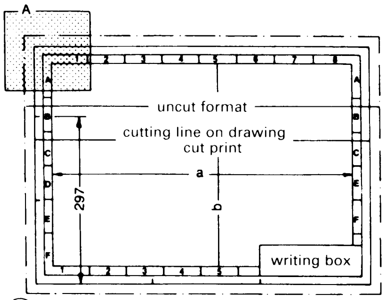
DOCUMENTATION AND DRAWINGS



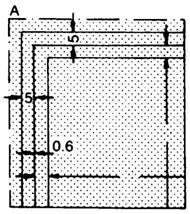
(1) **Standard drawing**

sheet sizes in acc. with ISO A series	ISO A0	ISO A1	ISO A2	ISO A3	ISO A4	ISO A5
uncut blank paper (mm)	880 × 1230	625 × 880	450 × 625	330 × 450	240 × 330	165 × 240
format trimmed, finished sheet (mm)	841 × 1189	594 × 841	420 × 594	297 × 420	210 × 297	148 × 210

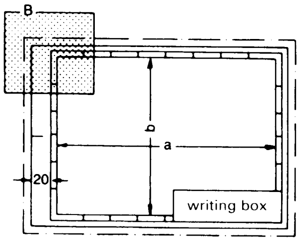
(2) **Sheet sizes**



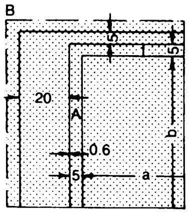
(3) **ISO size A2; A1; A0**



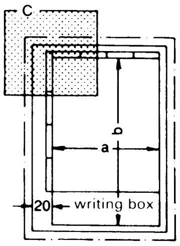
cut-out ISO A2, A1, A0



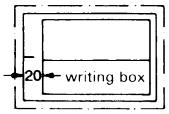
(4) **ISO size A3**



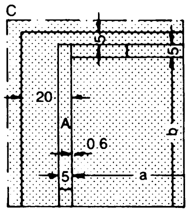
cut-out ISO A3



(5) **ISO size A4**



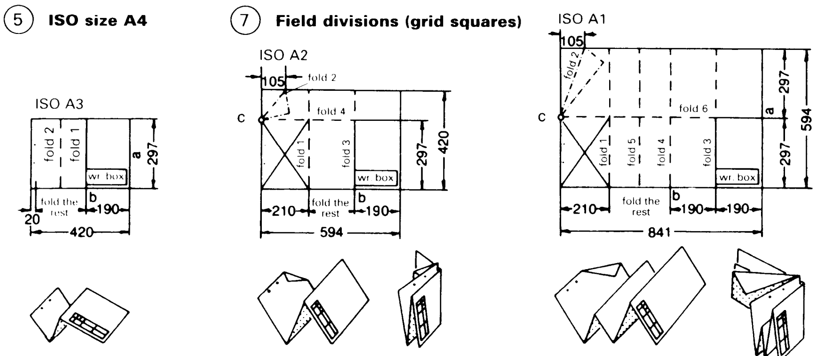
(6) **ISO size A5**

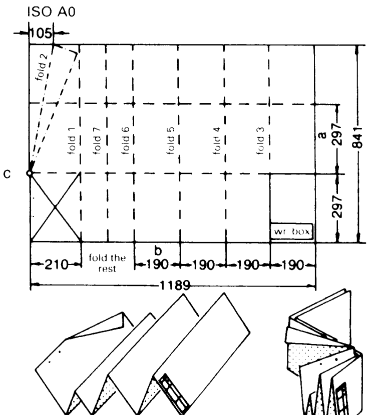


cut-out ISO A4

divisions for	no. of identical fields by sheet size A0	A1	A2	A3	A4
a	16	12	8	8	4
b	12	8	6	6	4

(7) **Field divisions (grid squares)**





(8) **Dimensions and scheme for folding**

The use of standard drawing formats makes it easier for architects to lay out drawings for discussion in the design office or on the building site, and also facilitates posting and filing. The trimmed, original drawing or print must therefore conform to the formats of the ISO A series. → (3) - (6)

The box for written details should be the following distance from the edge of the drawing:

for formats A0–A3 10 mm
for formats A4–A6 5 mm

For small drawings, a filing margin of up to 25 mm can be used, with the result that the usable area of the finished format will be smaller.

As an exception, narrow formats can be arrived at by stringing together a row of identical or adjacent formats out of the format range.

From normal roll widths, the following sizes can be used to give formats in the A series:

for drawing paper, tracing paper 1500, 1560 mm
(derived from this 250, 1250, 660, 900 mm)
for print paper 650, 900, 1200 mm

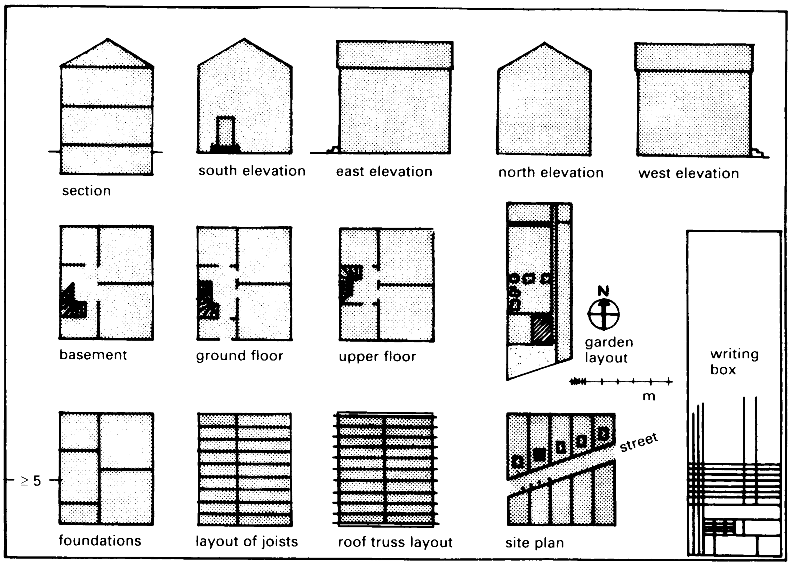
If all the drawing formats up to A0 are to be cut from a paper web, a roll width of at least 900 mm will be necessary.

Drawings which are to be stored in A4 box files should be folded as follows: → (8)

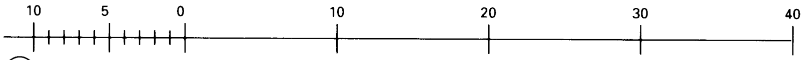
(1) The writing box must always be uppermost, in the correct place and clearly visible.
(2) On starting to fold, the width of 210 mm (fold 1) must always be maintained, and it is useful to use a 210 × 297 mm template.
(3) Fold 2 is a triangular fold started 297 mm up from the bottom left-hand corner, so that on the completely folded drawing only the left bottom field, indicated with a cross, will be punched or clamped.
(4) The drawing is next folded back parallel to side 'a' using a 185 × 298 mm template. Any remaining area is concertina-folded so as to even out the sheet size and this leaves the writing box on the top surface. If it is not possible to have even folds throughout, the final fold should simply halve the area left (e.g. A1 fold 5, A0 fold 7). Any longer standard formats can be folded in a similar way.
(5) The resulting strip should be folded from side 'b' to give a final size of 210 × 297 mm.

To reinforce holes and filing edges, a piece of A5 size cardboard (148 × 210 mm) can be glued to the back of the punched part of the drawing.

DOCUMENTATION AND DRAWINGS



① Suitable arrangement of a construction drawing



② Suitable arrangement of scale details

Arrangement

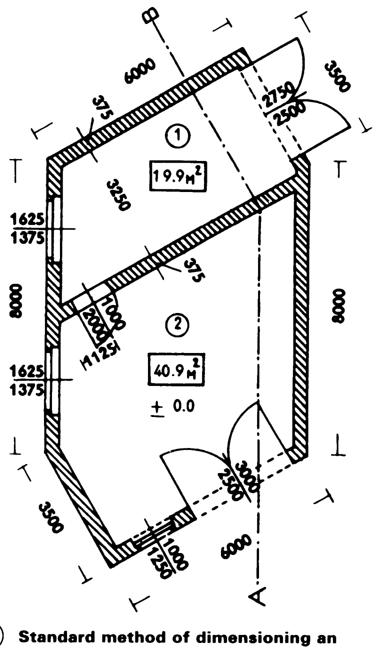
Leave a 5cm wide blank strip down the left-hand edge of the sheet for binding or stapling. The writing box on the extreme right → ① should contain the following details:

(1) type of drawing (sketch, preliminary design, design etc.)
(2) type of view or the part of the building illustrated (layout drawing, plan view, section, elevation, etc.)
(3) scale
(4) dimensions, if necessary.

On drawings used for statutory approvals (and those used by supervisors during construction) it might also contain:

(1) the client's name (and signature)
(2) the building supervisor's name (and signature)
(3) the main contractor's signature
(4) the building supervisor's comments about inspection and the building permit (if necessary on the back of the sheet).

A north-point must be shown on the drawings for site layouts, plan views etc.



③ Standard method of dimensioning an oddly shaped plan (measurements given are structural dimensions)

Scales

The main scale of the drawing must be given in large type in the box for written details. Other scales must be in smaller type and these scales must be repeated next to their respective diagrams. All objects should be drawn to scale; where the drawing is not to scale the dimensions must be underlined. As far as possible, use the following scales:

for construction drawings: 1:1, 1:2.5, 1:5, 1:10, 1:20, 1:25, 1:50, 1:100, 1:200, 1:250
for site layouts: 1:500, 1:1000, 1:2000, 1:2500, 1:5000, 1:10000, 1:25000.

Measurement Figures and Other Inscriptions

In continental Europe, for structural engineering and architectural drawings, dimensions under 1 m are generally given in cm and those above 1 m in m. However, recently the trend has been to give all dimensions in mm, and this is standard practice in the UK.

Chimney stack flues, pressurised gas pipes and air ducts are shown with their internal dimensions as a fraction (width over length) and, assuming they are circular, by the use of the symbol Ø for diameter.

Squared timber is also shown as a fraction written as width over height.

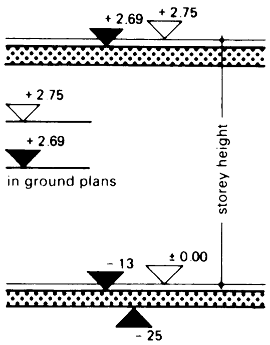
The rise of stairs is shown along the course of the centre-line, with the tread depth given underneath (→ p. 13).

Window and door opening dimensions are shown, as with stairs, along the central axis. The width is shown above, and the internal height below, the line (→ p. 13).

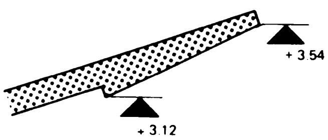
Details of floor heights and other heights are measured from the finished floor level of the ground floor (FFL: zero height ±0.00).

Room numbers are written inside a circle and surface area details, in m², are displayed in a square or a rectangle → ③.

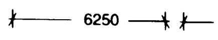
Section lines in plan views are drawn in chain dot lines and are labelled with capital letters, usually in alphabetical order, to indicate where the section cuts through the building. As well as standard dimensional arrows → ⑤ oblique arrows and extent marks → ⑥ + ⑦ are commonly used. The position of the dimensional figures must be such that the viewer, standing in front of the drawing, can read the dimensions as easily as possible, without having to turn the drawing round, and they must be printed in the same direction as the dimension lines.

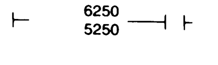


④ Heights as shown in sections and elevations

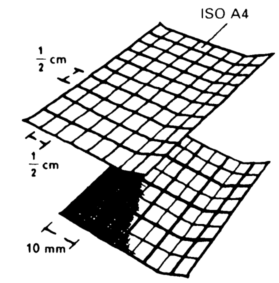


⑤

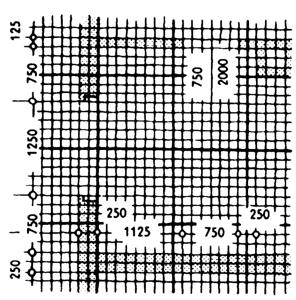
⑥


⑦


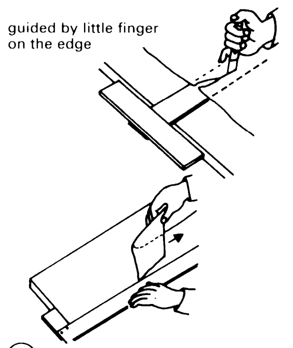
CONSTRUCTION DRAWINGS



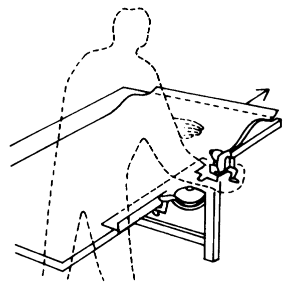
① Paper for sketching

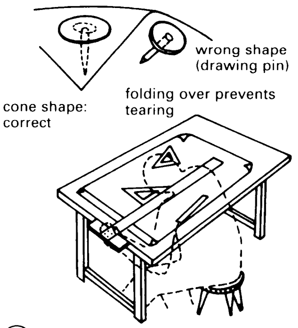


② Sketching: construction engineering grid

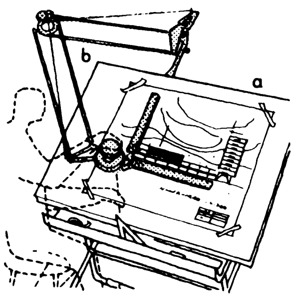


③ Cutting paper to size

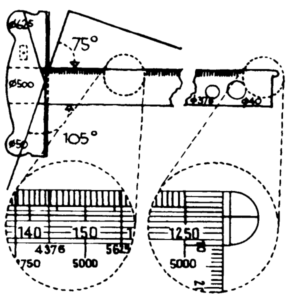

④ Taping edges



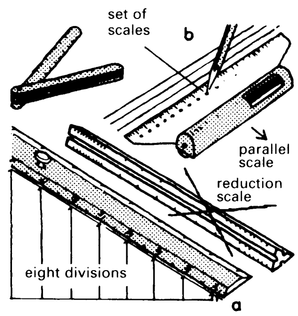
⑤ Drawing table



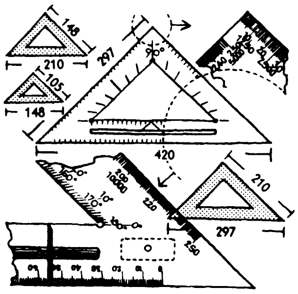
⑥ Specialist drawing board



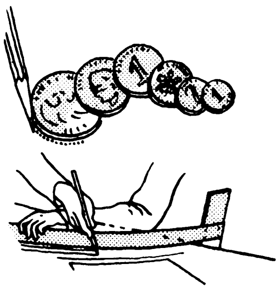
⑦ T-square



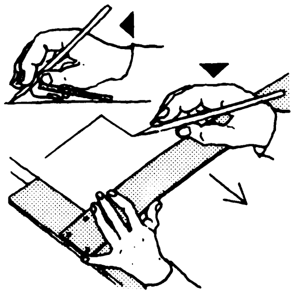
⑧ Drawing equipment

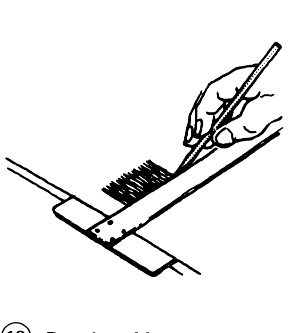


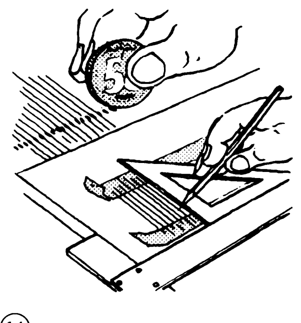
⑨ Set squares

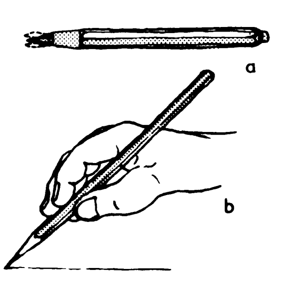

⑩ Drawing aids


⑪ French curves


⑫ Drawing movements


⑬ Drawing aids


⑭ Aid for hatching



⑮ Correct way of holding a pencil

Designers use drawings and illustrations to communicate information in a factual, unambiguous and geometric form that can be understood anywhere in the world. With good drawing skills it is simpler for designers to explain their proposals and also give clients a convincing picture of how the finished project will look. Unlike painting, construction drawing is a means to an end and this differentiates diagrams/working drawings and illustrations from artistic works.

Sketch pads with graph paper having 0.5cm squares are ideal for freehand sketches to scale → ①. For more accurate sketches, millimetre graph paper should be used. This has thick rules for centimetre divisions, thinner rules for half centimetres and fine rules for the millimetre divisions. Different paper is used for drawing and sketching according to standard modular coordinated construction and engineering grids → ②. Use tracing paper for sketching with a soft lead pencil.

Suitable sheet sizes for drawings can be cut straight from a roll, single pages being torn off using a T-square or cut on the underside of the T-square → ③. Construction drawings are done in hard pencil or ink on clear, tear-resistant tracing paper, bordered with protected edges → ④ and stored in drawers or hung in vertical plan chests.

Fix the paper on a simple drawing board (designed for standard formats), made of limewood or poplar, using drawing pins with conical points → ⑤. First turn over 2cm width of the drawing paper edge, which can later be used as the filing edge (see p. 4), for this lifts the T-square a little during drawing and prevents the drawing being smudged by the T-square itself. (For the same reason, draw from top to bottom.) The drawing can be fixed with drafting tape rather than tacks → ⑥ if a plastic underlay backing is used.

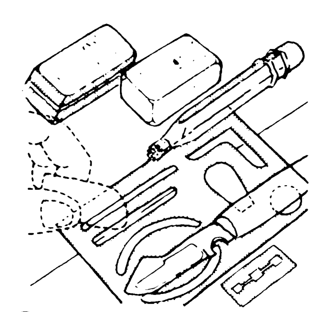
The T-square has traditionally been the basic tool of the designer, with special T-squares used to draw lines at varying angles. They are provided with octameter and centimetre divisions → ⑦. In general, however, the T-square has been replaced by parallel motion rulers mounted on the drawing board → ⑥. Other drawing aids include different measuring scales → ⑧, 45° set squares with millimetre and degree divisions, drawing aids for curves → ⑩, and French curves → ⑪.

CONSTRUCTION DRAWINGS

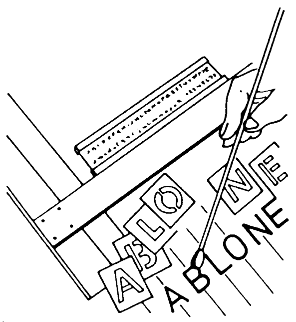
To maintain accuracy in construction drawings requires practice. For instance, it is essential to hold the T-square properly and use pencils and pens in the correct manner. Another important factor in eliminating inaccuracy is keeping a sharp pencil point. There are various drawing aids that can help: grip pencils, for example, are suitable for leads with diameters of 2 mm or more and propelling pencils are useful for thinner leads. Lead hardnesses from 6B to 9H are available. Many models of drafting pens are available, both refillable and disposable, and offer a wide range of line thicknesses. For rubbing out ink use mechanical erasers, erasing knives or razor blades whereas non-smear rubbers should be used for erasing pencil. For drawings with tightly packed lines use eraser templates → (1).

Write text preferably without aids. On technical drawings use lettering stencils, writing either with drafting pens or using a stipple brush → (2). Transfer lettering (Letraset etc.) is also commonly used. The international standard for lettering ISO 3098/1.

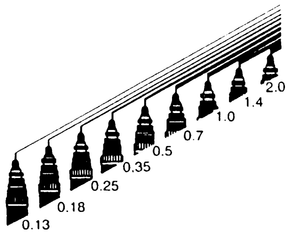
To make the designer's intentions clear, diagrams should be drawn to convincingly portray the finished building. Isometry can be used to replace a bird's eye view if drawn to the scale of ≤1:500 → (13) and perspective grids at standard angles are suitable for showing internal views → (16).



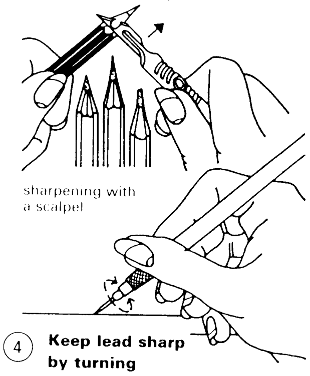
(1) Erasers, eraser template, eraser blades, etc.



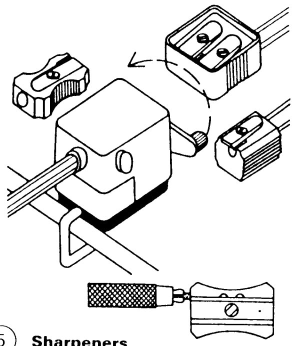
(2) Lettering stencils



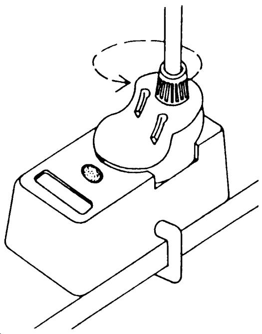
(3) Drafting pens



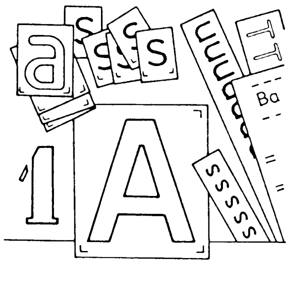
(4) Keep lead sharp by turning



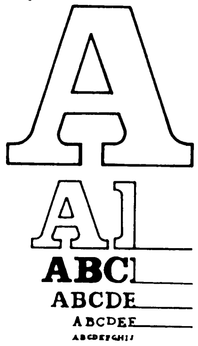
(5) Sharpeners



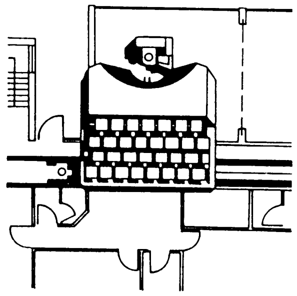
(6) Rotary pencil sharpener



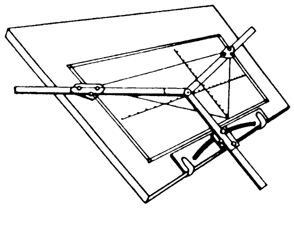
(7) Self-adhesive or Letraset lettering



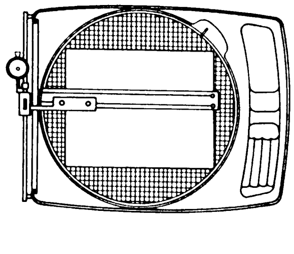
(8) Lettering sizes measured in points



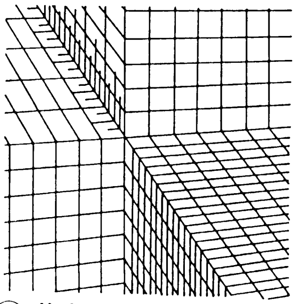
(9) Typewriter for lettering



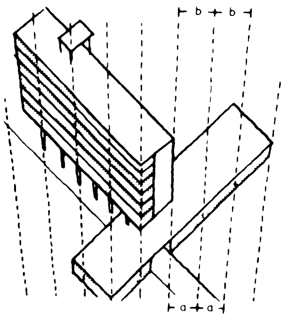
(10) Three-armed drawing instrument



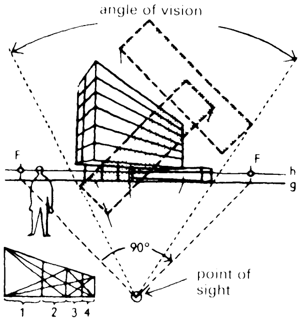
(11) Circular drawing board for perspective drawing



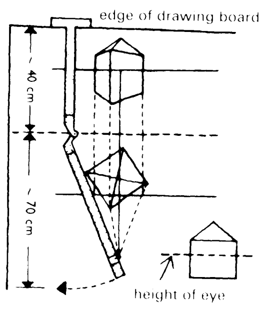
(12) Underlay for perspective drawing



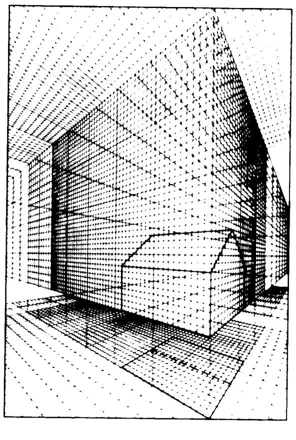
(13) Isometry



(14) Perspective method



(15) Reilesch's perspective apparatus



(16) Perspective grid

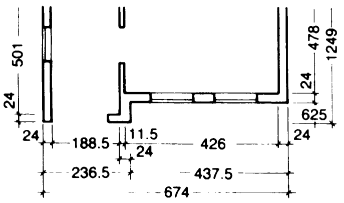
CONSTRUCTION DRAWINGS

line types (weight)	primary application	scale of drawings 1:1, 1:5, 1:10	scale of drawings 1:20, 1:25, 1:50	scale of drawings 1:100, 1:200
		line thickness (mm)		
solid line (heavy)	boundaries of buildings in section	1.0	0.7	0.5
solid line (medium)	visible edges of components; boundaries of narrow or smaller areas of building parts in section	0.5	0.35	0.35
solid line (fine)	dimension guide lines; dimension lines; grid lines	0.25	0.25	0.25
	indication lines to notes; working lines	0.35	0.25**	0.25
dashed line* (medium)	hidden edges of building parts	0.5	0.35	0.35
chain dot line (heavy)	indication of section planes	1.0	0.7	0.5
chain dot line (medium)	axes	0.35	0.35	0.35
dotted line* (fine)	parts lying behind the observer	0.35	0.35	0.35

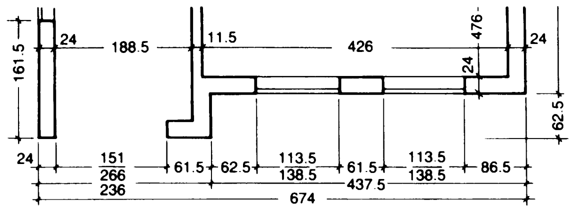
* dashed line - - - - - - dashes longer than the distance between them
dotted line .... dots (or dashes) shorter than the distance between them
** 0.35 mm if reduction from 1:50 to 1:100 is necessary

note: for plotter drawings using electronic data processing equipment and drawings destined for microfilm, other combinations of line widths may be necessary

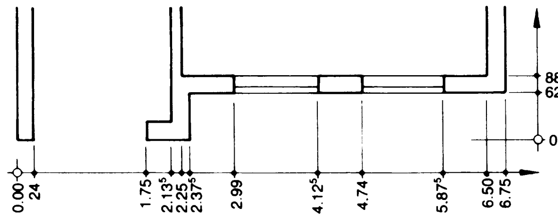
(1) **Types and thicknesses of lines to be used in construction drawings**



(2) **Dimensions given around the drawing (drawn at 1:100 cm; units = cm)**



(3) **Dimensions of piers and apertures (drawn at 1:50 cm; units = cm)**

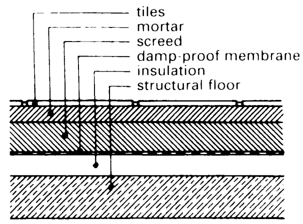


(4) **Dimensions given by coordinates (drawn at 1:50 cm, m; units = cm and m)**

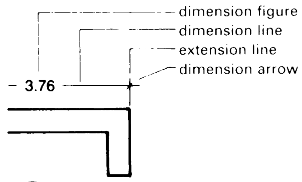
In some European countries the measurement unit used in connection with the scale must be given in the written notes box (e.g. 1:50 cm). In the UK, dimensions are given only either in metres or millimetres so no indication of units is required. Where metres are used it is preferable to specify the dimension to three decimal places (e.g. 3.450) to avoid all ambiguity.

	1	2	3	4
unit	dimensions			
	under 1 m e.g.			over 1 m e.g.
1 m	0.05	0.24	0.88	3.76
2 cm	5	24	88.5	376
3 m, cm	5	24	88⁵	3.76
4 mm	50	240	885	3760

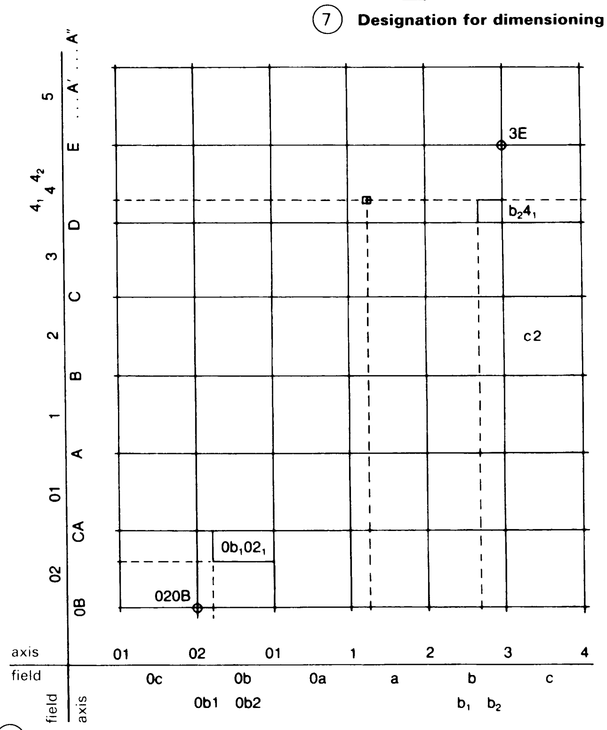
(5) **Units of measurement**



(6) **Indication lines to notes**



(7) **Designation for dimensioning**



(8) **Axis-field grid**

CAD application in architectural design

The acronym CAD usually means either computer-aided design or computer-aided draughting. CADD is sometimes used to mean computer-aided draughting and design. Computer-aided design is a highly valued technique because it not only enables a substantial increase in productivity but also helps to achieve neater and clearer drawings than those produced using the conventional manual drafting techniques described in the preceding pages. Standard symbols or building elements can be compiled as a library of items, stored and used to create new designs. There is also a possibility of minimising the repetition of tasks by linking CAD data directly with other computer systems, i.e. scheduling databases, bills of quantities etc.

Another advantage of CAD is that it minimises the need for storage space: electronic storage and retrieval of graphic and data features clearly requires a fraction of the space needed for a paper-based system. Drawings currently being worked on may be stored in the CAD program memory whereas finished design drawings that are not immediately required may be archived in high-capacity electronic storage media, such as magnetic tapes or compact disks.

A drawback relating to the sophisticated technology required for professional CAD has been the high expense of the software packages, many of which would only be run on large, costly computer systems. However, various cheap, though still relatively powerful, packages are now available and these will run on a wide range of low-cost personal computers.

CAD software

A CAD software package consists of the CAD program, which contains the program files and accessories such as help files and interfaces with other programs, and an extensive reference manual. In the past, the program files were stored on either 5¹/₄" or 3¹/₂" floppy disks. The low storage capacity of the 5¹/₄" floppy disks and their susceptibility to damage has rendered them obsolete. Besides their higher storage density, 3¹/₂" disks are stronger and easier to handle. Nowadays, the program files are usually stored on compact discs (CD-ROM) because of their high capacity and the ever increasing size of programs; they are even capable of storing several programs.

When installing a CAD program onto the computer system, the program files must be copied onto the hard disk of the computer. In the past, CAD was run on microcomputers using the MS-DOS operating system only. New versions of the CAD programs are run using MS-DOS and/or Microsoft Windows operating systems.

Hardware requirements

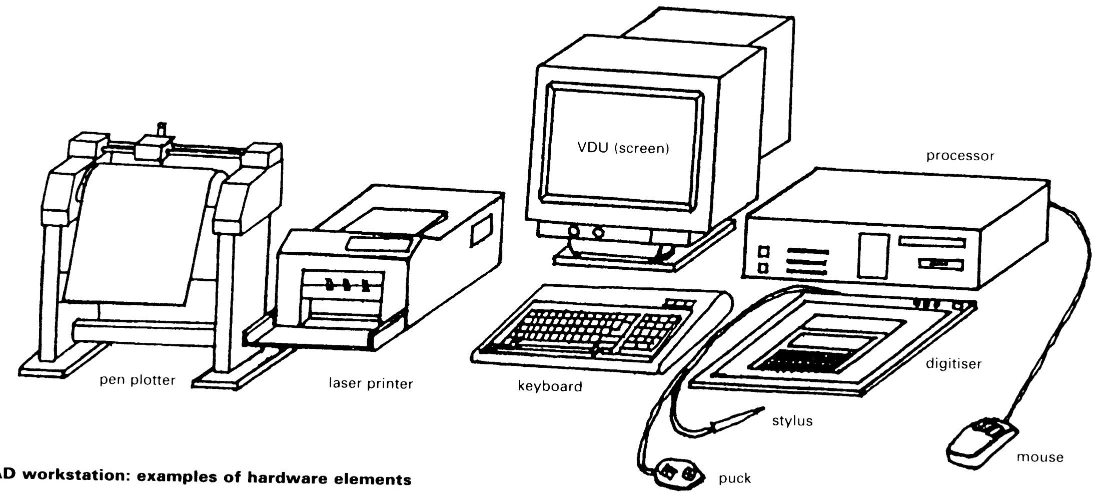
Once the desired CAD software has been selected, it is important to ensure that the appropriate hardware (equipment) needed to run the program is in place. A typical computer system usually includes the following hardware:

Visual Display Unit (VDU): Also called a screen or monitor, these are now always full-colour displays. The level of resolution will dictate how clear and neat the design appears on the screen. For intricate design work it is better to use a large, high-resolution screen. The prices of such graphic screens have fallen substantially in recent years making them affordable to a wide range of businesses and they are hence becoming commonplace. In the past, using CAD required two screens, one for text and the other for graphics. This is not necessary now because some of the latest CAD programs have a 'flip screen' facility that allows the user to alternate between the graphics and text display. In addition, the Windows version of some CAD programs also has a re-sizable text display that may be viewed in parallel with the graphics display.

Disk drives and disks: The most usual combination of disk drives for desktop CAD systems initially was one hard drive and one 3¹/₂" floppy drive. The storage capacity of hard disks increased rapidly throughout the 1990s, from early 40 MB (megabyte) standard hard drives to capacities measured in gigabytes (GB) by the end of the decade. The storage capability of floppy disks is now generally far too restrictive and this has led to the universal addition of compact disc drives in new PCs. These can hold up to 650MB. This storage limitation has also led to the use of stand-alone zip drives and CD writers (or CD burners) to allow large files to be saved easily.

Keyboard: Virtually every computer is supplied with a standard alphanumeric keyboard. This is a very common input device in CAD but it has an intrinsic drawback: it is a relatively slow method of moving the cursor around the screen and selecting draughting options. For maximum flexibility and speed, therefore, the support of other input devices is required.

Mouse: The advantage of the mouse over the keyboard as an input device in CAD is in speeding up the movement of the cursor around the screen. The mouse is fitted with a button which allows point locations on the screen to be specified and commands from screen menus (and icons in the Windows system) to be selected. There are several types of mouse, but nowadays a standard CAD mouse has two buttons: one used for PICKing and the other for RETURNing.



(1) **CAD workstation: examples of hardware elements**

Graphic tablet, digitising tablet (digitiser): A digitiser consists of a flat plate with a clear area in the centre, representing the screen area, the rest divided into small squares providing menu options. An electric pen (stylus) or puck is used to insert points on the screen and to pick commands from menus. The selection of a command is made by touching a command square on the menu with the stylus (or puck) and at a press of a button the command is carried out. Data can be read from an overlay menu or a document map or chart. The document should first be placed on the surface of the digitiser and its boundaries marked with the stylus or puck. The position of the puck on the digitiser may be directly related to the position of the cursor on the screen.

Most pucks have four buttons: they all have a PICK button for selecting the screen cursor position and a RETURN button for completing commands but, in addition, they have two or more buttons for quick selection of frequently used commands.

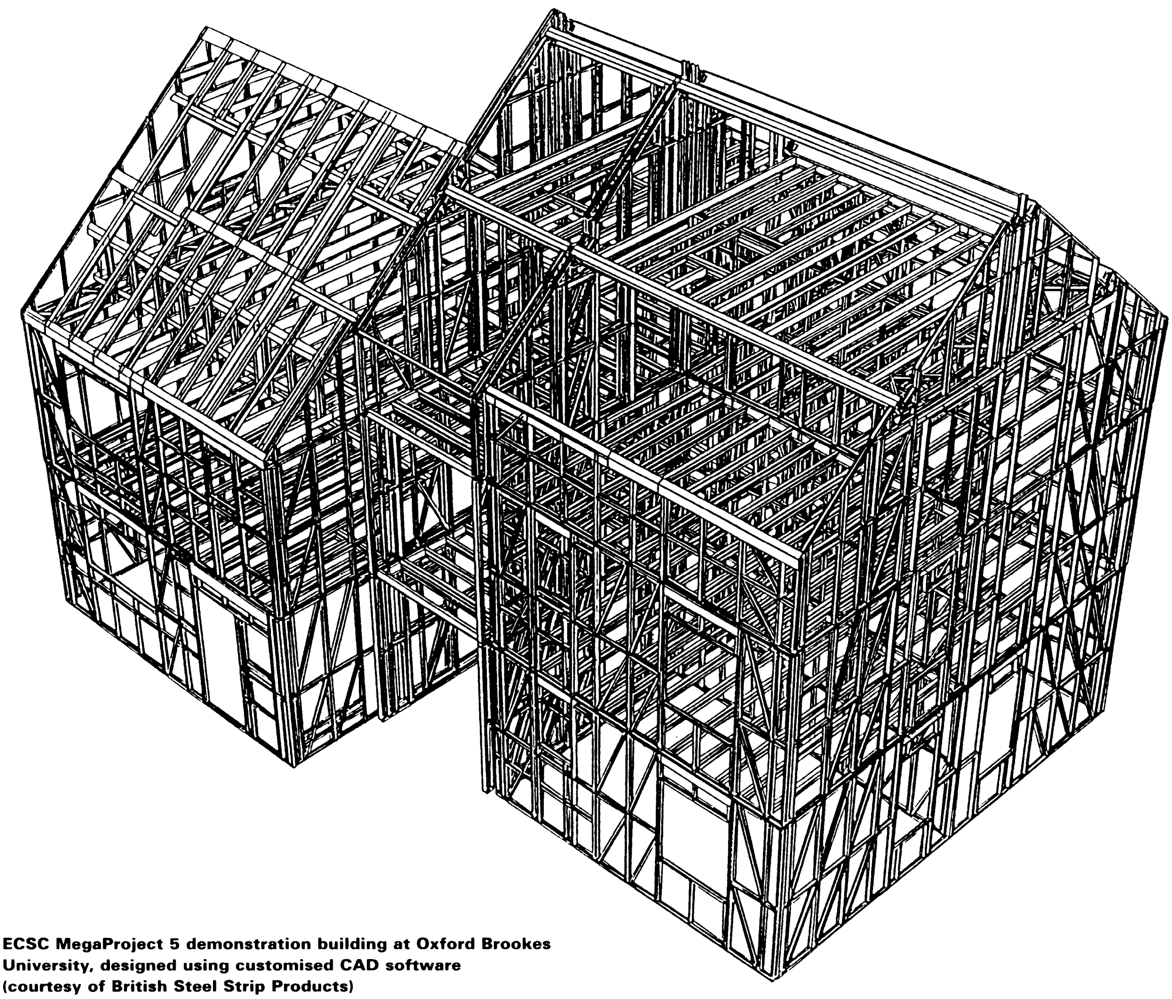
Printers: Hard-copy drawings from CAD software can be produced by using an appropriately configured printer. Printers are usually simple and fast to operate, and may also be used for producing hard copies from other programs installed in the computer. There are several types of printer, principally: dot-matrix, inkjet, and laser printers. The graphic output of dot-matrix printers is not of an acceptable standard, particularly when handling lines that diverge from the horizontal or vertical axes. Inkjet and laser printers are fast and quiet and allow the production of high-quality monochrome and coloured graphic diagrams up to A3 size. Colour prints are also no longer a problem since there is now a wide range of printers that can produce high-quality colour graphic prints at a reasonably low cost.

Plotters: Unlike printers, conventional plotters draw by using small ink pens of different colours and widths. Most pen plotters have up to eight pens or more. Usually the CAD software is programmed to enable the nomination of the pen for each element in the drawing.

Flat-bed plotters hold the drawing paper tightly on a bed, and the pens move over the surface to create the desired drawing. Although they are slow, their availability in small sizes (some with a single pen, for instance) means that a good-quality output device can be installed at low cost.

Rotary (drum) plotters operate by rolling the drawing surface over a rotating cylinder, with the pens moving perpendicularly back and forth across the direction of the flow. They can achieve high plotting speeds. With large-format drafting plotters, it is possible to produce drawings on paper up to A0 size. Depending on the plotter model, cut-size sheets or continuous rolls of paper can be used.

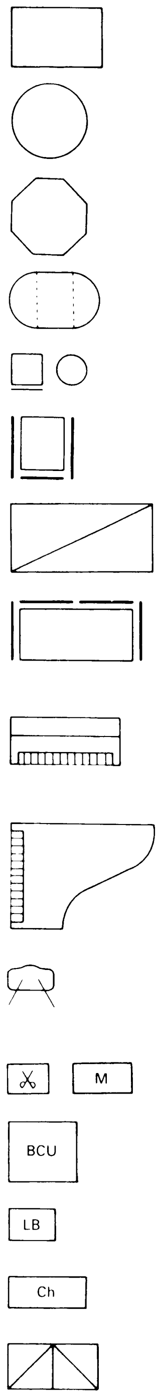
Modern printer technology has been used to develop electrostatic plotters, inkjet plotters and laser printer/plotters. These are more efficient and reliable, and produce higher line quality than pen plotters. As well as drawing plans and line diagrams, they can also be used to create large colour plots of shaded and rendered 3D images that are close to photographic quality.



(1) **ECSC MegaProject 5 demonstration building at Oxford Brookes University, designed using customised CAD software (courtesy of British Steel Strip Products)**

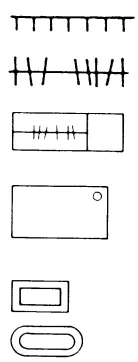
CONSTRUCTION DRAWINGS: SYMBOLS

Living room



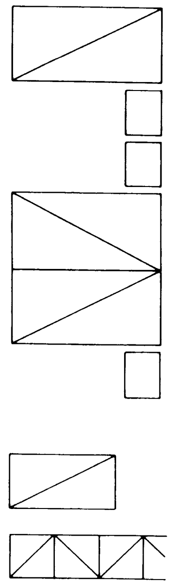
1. table 85 × 85 × 78 = 4 people, 130 × 80 × 78 = 6 people
2. round table Ø 90 = 6 people
3. shaped table 70–100
4. extending table
5. chair, stool Ø 45 × 50
6. arm chair 70 × 85
7. chaise-longue 95 × 195
8. sofa 80/1.75
9. upright piano 60/1.40–1.60
10. grand pianos: baby 155 × 114; drawing-room 200 × 150; concert 275 × 160
11. television
12. sewing table 50/50–70; sewing machine 50/90
13. baby's changing unit 80/90
14. laundry basket 40/60
15. chest 40/1.00–1.50
16. cupboard 60/1.20

Cloakroom



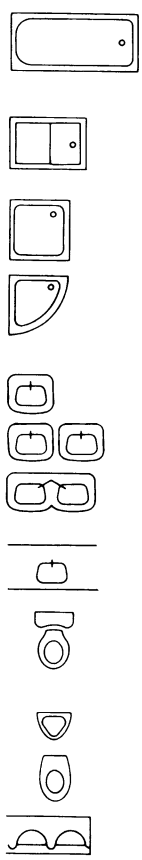
17. hooks, 15–20cm apart
18. coat rack
19. linen cupboard 50 × 100–180
20. desk 70 × 1.30 × 78, 80 × 1.50 × 78
21. flower stands

Bedroom



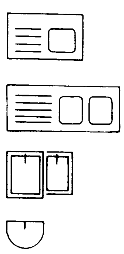
22. bed 95 × 195; bedside table 50 × 70, 60 × 70
23. twin bed 2(95 × 195, 100 × 200)
24. double bed 150 × 195
25. child's bed 70 × 140–170
26. wardrobe 60 × 120

Bathroom

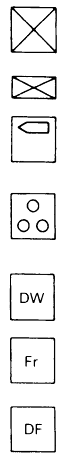


27. bath 75 × 170, 85 × 185
28. sit-up bath 70 × 105, 70 × 125
29. shower 80 × 80, 90 × 90, 75 × 90
30. corner shower 90 × 90
31. wash-basin 50 × 60, 60 × 70
32. two wash-basins
33. twin wash-basins 60 × 120, 60 × 140
34. built-in wash-basin 45 × 30
35. toilet 38 × 70
36. urinal bowl 35/30
37. bidet 38 × 60
38. row of urinals

Kitchen

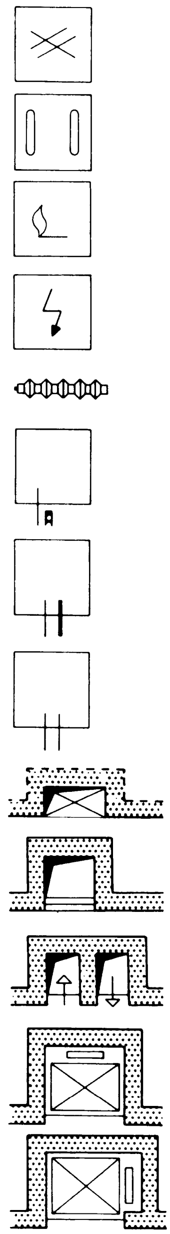


39. single sink and drainer 60 × 100
40. twin sinks, single drainer 60 × 150
41. stepped sinks
42. kitchen waste sink



43. cupboard/ base unit
44. top cupboard
45. ironing board
46. cooker
47. dishwasher
48. refrigerator
49. freezer

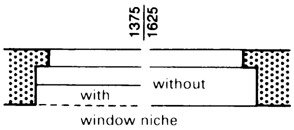
Other symbols



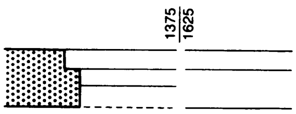
50. cookers/hobs fuelled by solid fuels
51. cookers/hobs fuelled by oil
52. cookers/hobs fuelled by gas
53. electric cooker/hob
54. central heating radiator
55. boiler (stainless)
56. gas fired boiler
57. oil fired boiler
58. refuse chute
59. laundry chute
60. ventilation and extraction shaft
61. GL = goods lift; PL = passenger lift; FL = food lift; HL = hydraulic lift

CONSTRUCTION DRAWINGS: SYMBOLS

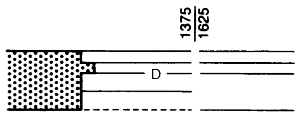
Windows set in reveals



(1) **Window frame set in internal reveal**

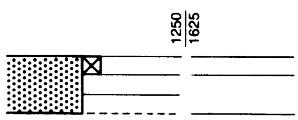


(2) **Window frame set in external reveal**



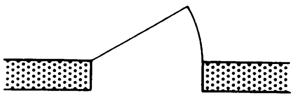
(3) **Window set on nib**

Windows without reveals

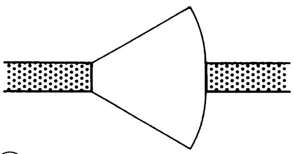


(4) **Window frame set in opening without reveals**

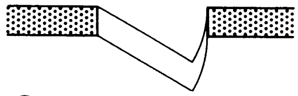
Doors



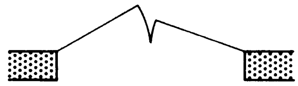
(5) **Single-leaf door**



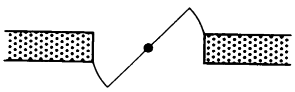
(6) **Single-leaf door pair**



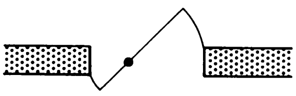
(7) **Single-leaf door pair**



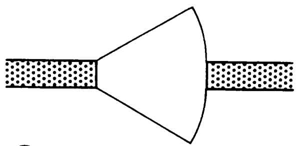
(8) **Double-leaf door**



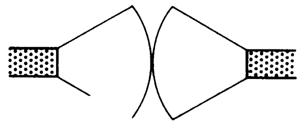
(9) **Pivoting door**



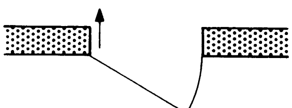
(10) **Pivoting door**



(11) **Swing door**



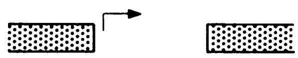
(12) **Double-leaf swing door**



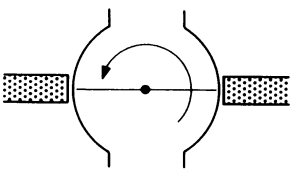
(13) **Rising butt single-leaf door**

(14) **Sliding door**

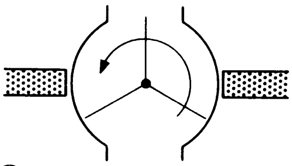
(15) **Double sliding door**



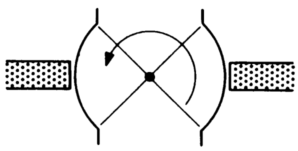
(16) **Sliding door with a lifting device**



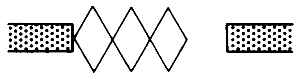
(17) **Revolving door, two flaps**



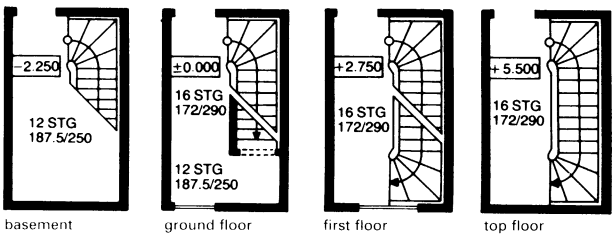
(18) **Revolving door, three flaps**



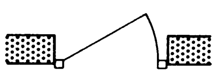
(19) **Revolving door, four flaps**



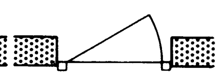
(20) **Folding partition**



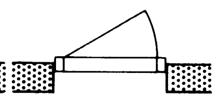
(21) **Single flight of stairs**



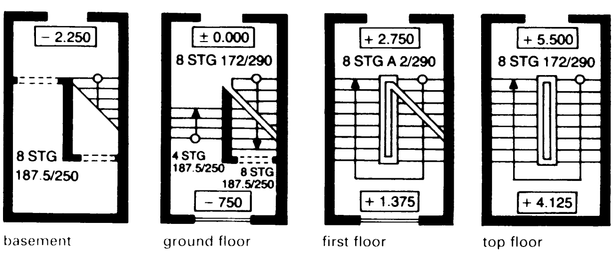
(23) **Without threshold**



(24) **With threshold**



(25) **Threshold both sides**



(22) **Double flight of stairs**

Windows are always drawn with the niche shown on the left-hand side but not on the right.

Revolving doors are often used in place of lobbies to give a draught-free entrance. However, they restrict through-traffic so the arrangement should allow the door flaps to be folded away during peak times.

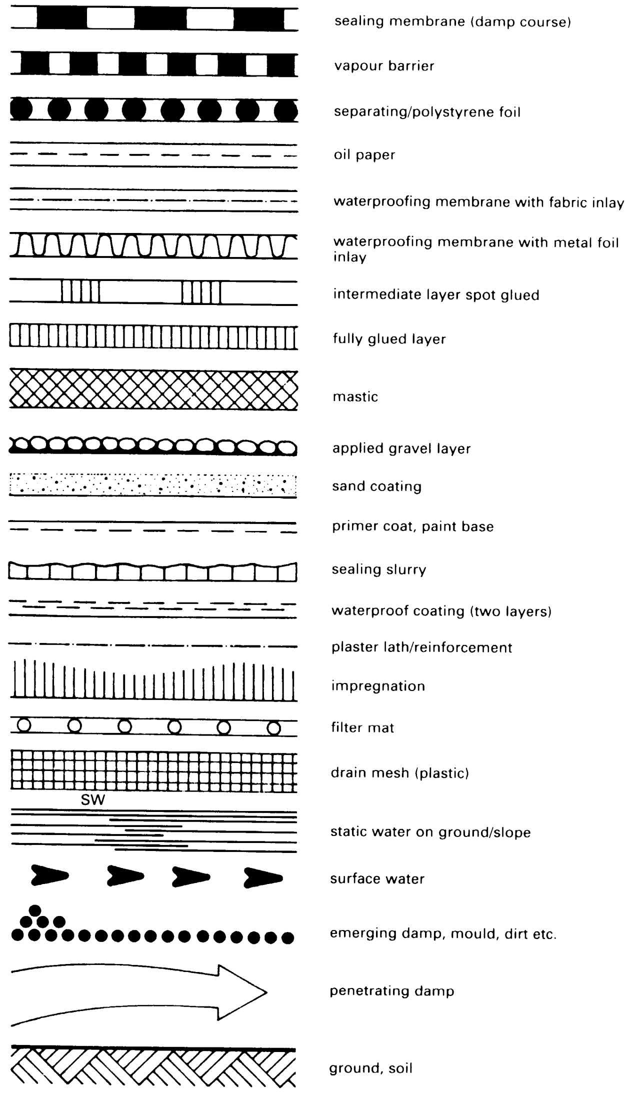
Wooden construction is suitable for single flights of stairs, whereas double flights generally require stone or concrete.

In every plan view of a storey, the horizontal section through the staircase is displayed about 1/3 of the storey height above the floor. The steps are to be numbered continuously from ±0.00 upwards and downwards. The numbers for the steps that lie below ±0.00 are given the prefix – (minus). The numbers start on the first step and finish on the landing. The centre-line begins at the start with a circle and ends at the exit with an arrow (including for the basement).

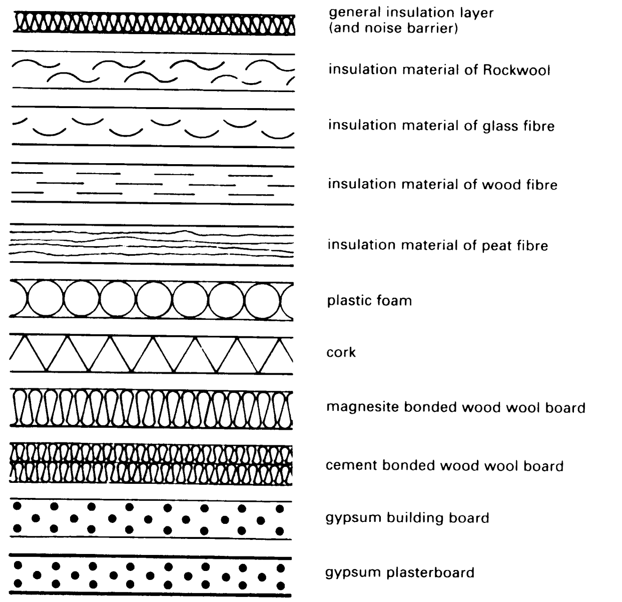
CONSTRUCTION DRAWINGS: SYMBOLS

monochrome display	coloured display	to be used for
	light green	grass
	sepia	ground peat
	burnt sienna	natural ground
	black/white	infilled earth
	red brown	brick walling with lime mortar
	red brown	brick walling with cement mortar
	red brown	brick walling with lime cement mortar
	red brown	porous brick walling with cement mortar
	red brown	hollow pot brick walling with lime cement mortar
	red brown	clinker block walling with cement mortar
	red brown	calcium-silicate brick walling with lime mortar
	red brown	alluvial stone walling with lime mortar
	red brown	walling of . . . stone with . . . mortar
	red brown	natural stone walling with cement mortar
	sepia	gravel
	grey/black	slag
	zinc yellow	sand
	ochre	floor screed
	white	render
	violet	pre-cast concrete units
	blue green	reinforced concrete
	olive green	non-reinforced concrete
	black	steel in a section
	brown	wood in section
	blue grey	sound insulation layer
	black and white	barrier against damp, heat or cold
	grey	old building components

(1) **Symbols and colours in plan views and sections**



(2) **Drawing conventions for waterproofing membranes and other roof and drainage layers**



(3) **Drawing conventions for thermal insulation**