3
Structures

A good relationship is essential between an Architect and a Structural Engineer. In very rough terms, an architect says what a building looks like and the Structural Engineer make sure it doesn't fall down! There should be a feeling of a team, with both working to the same aim. An Architect needs to appreciate the structural challenges that the scheme imposes. An Engineer needs to appreciate the Architect's requirement for form and function. Both consultants aim to provide the client with what they want and within the budget available.

Design of structural elements can be carried out by permissible stress or ultimate limit state (ULS). Permissible stress limits the loading to a predetermined safe working stress, commonly known as elastic design as deformation of the element is recoverable (elastic). ULS factors the loads (partial safety factors) to be carried and the design is related to the potential ultimate failure of the structural element. Deflection of the structural element is limited to the elastic deformation of the material and the effect on what is being carried. There are different deflection limits for different materials.

Structural members are now generally designed to Eurocodes and are more suited for computer applications.

The structural Eurocodes are pan-European structural design codes for building and civil engineering works. They are replacing national standards.

Eurocodes are designed to create a unified approach throughout Europe with regards to construction design. Each Eurocode has a corresponding National Annex document. This documents and clarifies laws or standards applicable to each particular country.

Eurocodes

Eurocode 0	Basis of structural design	EN1990
Eurocode 1	Actions on structures	EN1991
Eurocode 2	Design of concrete structures	EN1992
Eurocode 3	Design of steel structures	EN1993
Eurocode 4	Design of composite steel and concrete structures	EN1994
Eurocode 5	Design of timber structures	EN1995
Eurocode 6	Design of masonry structures	EN1996
Eurocode 7	Geotechnical structures	EN1997
Eurocode 8	Design of structures for earthquake resistance	EN1998
Eurocode 9	Design of aluminium structures	EN1999

Examples given are using the less complicated permissible stress design based on Codes of Practice and British Standards that are being withdrawn in favour of the Eurocodes.

Information given is for guidance only and should give an indication of the size of structural members required to assist with developing a scheme. All structural elements should be checked by a qualified Chartered Structural Engineer for Building Regulation and construction purposes. Consultation with a Chartered Structural Engineer is advised at an early design stage to ensure structural feasibility of the proposals.

Foundation types

When determining the type and depth of foundations required for a low rise residential project it is necessary to take into account the founding material and type and distance of trees – both existing and proposed. Simple trial holes can sometimes be sufficient to determine the depth to a suitable bearing level. The usual minimum acceptable depth to the formation level of foundations is 1m, to be below the level of frost susceptibility. If the founding material is clay and there are trees close by it will be necessary to determine the potential for shrinkage/swelling of the clay (as the trees affect the moisture content of the clay) and compare this with the height and variety of trees. This can increase the depth of the foundations significantly.

Ground that is liable to swell following removal of existing trees can damage foundations and measures to protect footings and slab need to be put in hand. The use of a compressible layer against the face of the foundations is usual, as is provision of a void below the slab.

An experienced engineer will be able to advise of the type of foundations and any protection measures required.

Simple strip/trench fill foundations

This style of foundation is suitable for depths up to 2.5 m (subject to stability of the sides of the excavations). It is recommended that trench fill be used for foundations deeper than a metre so that the concrete level for laying blocks, etc. is high enough not to require protection against collapse of the excavation sides.

Piled foundations

This style of foundation is suitable for building on filled or soft ground or ground requiring deep foundations to overcome the problems of swelling/shrinkage. Detailed site investigations are required to determine the ground conditions at depth and are best undertaken by a specialist geotechnical firm. The piles are used to support reinforced ground beams and/or slab.

Raft foundations

Rafts are used when the ground conditions are such that strip footings would need to be very wide or there is high risk of settlement. The raft distributes the loads over a very large area. It is essential that the ground conditions are uniform under the raft to eliminate the risk of differential settlement. It is necessary to ensure services entering or leaving have a flexible connection – such as rocker pipe in the foul drains.

Masonry structures

The majority of the existing building stock in the UK is masonry built and a large proportion of smaller scale new buildings are still built in masonry. Timber frame structure has a growing share, even though much is masonry clad.

Masonry structural design is based on Eurocode 6 BSEN 1996-1-2, partly derived from BS 5628.

Masonry structural solutions for small buildings include:

1 Insulated cavity walling: traditional cavity walls with masonry inner and outer leaves and tied cavities with full or partial insulation.
2 Insulated solid walling: usually aerated concrete or hollow clay block walling with external or internal insulation in addition.
3 Concrete-filled insulated shuttering systems (a masonry/monolithic hybrid): tied shuttering 'blocks' of polystyrene or woodwool slab assembled dry and filled with pumped concrete; should maximize insulation externally to achieve some degree of thermal mass internally.

Masonry walling relies on bonding of the individual blocks or bricks to distribute loading and provide continuity in the wall, and on the mortar to distribute stress between individual units.

Traditional masonry design relies on 'normal' arrangement and proportions of solid walling to window and door openings; where design requirements require departures to achieve cantilevers, open corners, or simply very large openings, masonry design is hybridized usually with steel – occasionally concrete – beams and posts. Long panels of masonry may need stiffening with wind posts within the wall construction in order to resist lateral loads. Where floor joists span parallel to external walls (i.e. not built-in) it is necessary to strap the walls to the floors in order to give lateral stability against wind loads. Sometimes movement joints are introduced to control thermal and shrinkage movement. These joints need to be supported laterally – by wind posts or return walls. As a general rule movement joints should be at 6 m centres in blockwork and 12 m in clay brickwork.

The use of lime mortars can increase the flexibility of masonry construction and reduce the need for movement joints, but also reduces the strength of the wall panels for vertical and horizontal loads.

Timber frame construction

Timber frame is a method of construction, not a system of building. Timber frame construction uses softwood vertical studs and horizontal rails, and a wood-based panel sheathing to form a structural frame and transfer them to the foundations. The sheathing provides resistance to lateral wind loads (known as racking resistance). At openings, such as doors and windows, the vertical loads are carried by timber lintels over the opening and through additional supports, known as cripple studs, at each end of the lintel. The outer cladding provides decoration and weather protection. The exterior cladding is non-load bearing, although it may contribute to wind resistance; it is used to weatherproof the building and provide the desired external appearance. Thermal insulation is usually incorporated in the spaces between the studs of external walls and various protective membrane materials may also be required, depending on the design of the wall.

Wall panels in the UK are usually factory-produced. Their size and degree of prefabrication varies between:

- Open panels comprising studs, rails, sheathing and an external breather membrane. The thermal insulation, internal vapour control membrane (where needed) and lining are all installed on site, and
- Closed panels as above but with insulation, protective membranes, linings, external joinery and sometimes even services already installed.

Additional layers of insulation and board materials are added to provide higher levels of sound insulation and additional fire protection where required, e.g. party walls between houses and party walls between flats.

The choice of floor and roof construction for timber frame is the same as for other building types. Ground floors can be of concrete or timber. Intermediate floors are of timber joists or prefabricated panels. The joists or prefabricated panels are usually installed on top of the wall panels and provide a platform from which to build subsequent storeys – hence the term *platform frame*.

Roofs are frequently trussed rafters, but other types are also suitable, including prefabricated panel types.

Completion of a weatherproof shell for a two-storey house using manual erection with a team of four men typically can be achieved within a working week and using crane erection, in one or two days. Once the timber frame shell is completed, work can continue inside the building regardless of weather conditions. Depending upon the degree of prefabrication of the timber frame panels, this may comprise installation of:

insulation, vapour control layer and wall linings in external walls; internal non-load bearing walls; floor decking and ceilings; internal joinery; services and fittings

Externally, the cladding is applied. Brick or stone cladding is erected as a separate skin, linked to the timber frame studs by stainless steel wall ties. Differential movement is likely to occur between the timber frame and brick or block cladding and the design detailing must make allowance for this. Tile and timber cladding is fixed on timber battens fixed through to the studs of the wall panels.

External joinery is fixed into openings in the timber frame, not into the cladding.

Roof slates or tiles are fixed to tiling battens and external works completed.

Source: *Timber Frame Construction, TRADA. www.trada.co.uk*

Weights of materials (for further information, see BS 648)

Material	Description	Quantity of unit	kg/m^2	kg/m^3
aluminium	cast			2770
aluminium roofing	longstrip	0.8 mm	3.70	
asphalt roofing	with vapour barrier	20 mm	47.00	
ballast	loose, graded			1600
bituminous felt roofing	3 layers + vapour barrier		11.10	
blockboard	sheet	18 mm	10.50	
blockwork	high strength	100 mm	220.00	
	aerated	100 mm	64.00	
	lightweight	100 mm	58.00	
	foundation	255 mm	197.00	
brass	cast			8425
brickwork	blue	115 mm	276.60	2405
	engineering	115 mm	250.00	2165
	sand/cement	115 mm	240.00	2085
	London stock	115 mm	212.00	1845
	fletton			1795
calcium silicate board	sheet	6 mm	5.80	
cement				1440
chalk				2125
chipboard	flooring grade C4	18 mm	13.25	
	furniture grade C1A	18 mm	11.75	
chippings	flat roof finish	1 layer	4.75	
clay	undisturbed			1925
concrete	reinforced 2% steel			2400
	plain			2300
concreting ballast				1760
copper	cast			8730
copper roofing	longstrip	0.6 mm	5.70	
cork	granulated			80
cork flooring	tiles	3.2 mm	3.00	
cork insulation	board	50 mm	6.50	
felt	roofing underlay		1.30	
glass	clear float	4 mm	10.00	
	clear float	6 mm	15.00	
	clear float	10 mm	25.00	
glass wool	quilt	100 mm	1.02	
gravel	loose			1600
hardboard	medium	6.4 mm	3.70	
hardboard	standard	3.2 mm	2.35	

Weights of materials – continued

Material	Description	Quantity of unit	kg/m^2	kg/m^3
hardwood	greenheart			1040
	oak			720
	iroko, teak			660
	mahogany			530
hardwood flooring	boards	23 mm	16.10	
iron	cast			7205
lead	cast			11 322
	sheet	code 4	20.40	
	sheet	code 7	35.72	
lime	lump			705
	quick			880
linoleum	sheet	3.2 mm	4.50	
MDF	sheet	18 mm	13.80	
mortar	lime			1680
parquet	flooring	15 mm	7.00	
partitions	plastered brick	115 + 25 mm	250.00	
	plastered block	100 + 25 mm	190.00	
	p/b & skim on timber studs	100 + 25 mm	120.00	
patent glazing	alum. bars @ 600 mm c/c	single	19.00	
	alum. bars @ 600 mm c/c	double	35.00	
pea shingle				1500
perspex	corrugated sheets		4.90	
plaster	lightweight – 2 coat	13 mm	10.20	
	hardwall – 2 coat	13 mm	11.60	
	lath and plaster		29.30	
plasterboard	gyproc wallboard	9.5 mm	9.00	
	plaster skimcoat	3 mm	2.20	
plywood	sheet	6 mm	4.10	
polystyrene	expanded, sheet	50 mm	0.75	
PVC roofing	single ply membrane	2 mm	2.50	
quarry tiles	laid in mortar	12.5 mm	32.00	
roofing tiles	clay – plain	100 mm gauge	77.00	
	clay – single pantile	315 mm gauge	42.00	
	concrete – double roman	343 mm gauge	45.00	
	concrete – flat slate	355 mm gauge	51.00	
rubber stud flooring	tiles	4 mm	5.90	

Weights of materials – continued

Material	Description	Quantity of unit	kg/m^2	kg/m^3
sand	dry			1600
sarking	felt		1.30	
scalpings				2000
screed	cement/sand	50 mm	108.00	
shingle	coarse, graded, dry			1842
shingles	roof, untreated	95 mm gauge	8.09	
	tantalized	95 mm gauge	16.19	
slate	slab	25 mm	70.80	
slate roofing	best	4 mm	31.00	
	medium strong	5 mm	35.00	
	heavies	6 mm	40.00	
snow	fresh			96
	wet, compact			320
softboard	sheet	12.5 mm	14.45	
softwood	pitch pine, yew			670
	spruce			450
	western red cedar			390
softwood flooring	boards	22 mm	12.20	
soil	compact			2080
	loose			1440
stainless steel roofing	longstrip	0.4 mm	4.00	
steel	mild			7848
	sheet	1.3 mm	10.20	
stone	Bath			2100
	granite			2660
	marble			2720
	slate			2840
	York			2400
stone chippings				1760
tarmac		25 mm	53.70	
terrazzo	paving	16 mm	34.20	
thatch	including battens	300 mm	41.50	
timber	see hardwood softwood			
vinyl flooring	tiles	2 mm	4.00	
water				1000
weatherboarding	softwood	19 mm	7.30	
		25 mm	8.55	
woodwool	slabs	50 mm	36.60	
zinc	cast			6838
zinc roofing	longstrip	0.8 mm	5.70	

Newtons

The unit of force, the *newton*, is derived from the unit of mass through the relationship that force is equal to mass times the gravitational pull of 9.81 metres *per second per second* (9.81 m/s^2), in the direction of the force, e.g. 1 kilogram f = 9.81 newtons.

For approximate purposes 100 kgf = 1 kN.

Alternatively one newton is that force which, if applied to a mass of one kilogram, gives that mass an acceleration of one metre *per second per second* (1 m/s^2) in the direction of the force, so 1 N = 1 kg × 1 m/s^2.

When calculating the weight of materials for structures, the kilograms must be multiplied by 9.81 to get the equivalent figure in newtons (or 9.81 ÷ 1000 for kN).

As a general rule, the following expressions are used:

superimposed loads	kN/m^2
mass loads	kg/m^2 or kg/m^3
stress	N/mm^2
bending moment	kNm
shear	kN

1 N/mm	=	1 kN/m
1 N/mm^2	=	1×10^3 kN/m^2
1 kNm	=	1×10^6 Nmm

Imposed loads

Imposed floor loads (for further information, see BS 6399 Part 1)

Floor type	Distributed load **kN/m²***	Concentrated load **kN***
Houses and blocks of flats not more than three storeys, no more than four self-contained units per floor	1.5	1.4
Bedrooms and dormitories except for those in single family dwelling units and in hotels and motels	1.5	1.8
Hotels bedrooms, hospital wards, toilet areas	2.0	1.8
Public, institutional and communal dining rooms, lounges, cafes and restaurants	2.0	2.7
Billiard rooms		
Operating theatres, X-ray rooms, utility rooms, reading rooms with no book storage	2.0	4.5
Offices for general use	2.5	2.7
Garages for vehicles under 2500 kg	2.5	9.0
Classrooms, chapels, banking halls	3.0	2.7
Hotel kitchens and laundries, laboratories	3.0	4.5
Offices with fixed computing equipment	3.5	4.5
Assembly buildings with fixed seating	4.0	3.6
Shop floors for retailing	4.0	3.6
Hotel bars	5.0	3.6
Assembly buildings without fixed seating, gymnasia, dance halls	5.0	3.6
Factories, workshops and similar buildings	5.0	4.5
Garages, parking and workshops for vehicles exceeding 2500 kg	To be determined for specific use	
Boiler rooms, plant rooms including weight of machinery	7.5	4.5
Bookstores, warehouses (per metre of storage height)	2.4	7.0
Stationery stores (per metre of storage height)	4.0	9.0

Imposed floor loads – continued

Floor type		Distributed load **kN/m²***	Concentrated load **kN***
Corridors, hallways and aisles, etc. in institutional-type buildings (not subjected to crowds or wheeled vehicles), hostels, guest houses, residential clubs and communal areas in flats over three storeys. Foot traffic only		3.0	4.5
Stairs and landings as above		3.0	4.0
Corridors, hallways and aisles, etc. in all other buildings including hotels, motels and institutional buildings. Foot traffic only		4.0	4.5
Stairs and landings as above		4.0	4.0
Corridors, hallways and aisles, etc. in all other buildings including hotels, motels and institutional buildings. Foot traffic only		5.0	4.5
Balconies	Single family dwelling units and communal areas in blocks of flats with limited use (no greater than three storeys)	1.5	1.4
	Guest houses, residential clubs and communal areas in blocks of flats over three storeys	Same as rooms to which they have access, but with a minimum of 3.0	1.5/m run concentrated at the outer edge
	All others	Same as rooms to which they have access, but with a minimum of 4.0	1.5/m run concentrated at the outer edge

* Whichever produces the greater stress or deflection

Reduction in total distributed imposed floor load

Number of floors including roof carried by member	1	2	3	4	5–10	10+
Percentage reduction in total distributed load on all floors carried by member	0	10	20	30	40	50 max
Area supported m^2	40	80	120	160	200	250
Percentage reduction in total distributed imposed load	0	5	10	15	20	25 max

Imposed roof loads (for further information, see BS 6399 Part 3)

Roof type	Comments	Distributed load **kN/m²***		Concentrated load **kN***
All roofs	Where access is needed in addition to that needed for cleaning and repair	1.5	or	1.8
Flat roofs and sloping roofs up to 30°	Where no access is needed except for cleaning and repair	0.6	or	0.9
Roof slopes between 30° and 60° (α°) measured on plan	Where no access is needed except for cleaning and repair	$0.6\,(60 - \alpha)/30$	or	0.9
Roof slopes 60° or more	0	0		0.9

* Whichever produces the greater stress

Where access is needed for cleaning and repair, these loads assume spreader boards will be used during work on fragile roofs.

For buildings in areas of high snowfall, snow loading should be taken into consideration. The snow loading is a function of location, altitude and roof pitch. For buildings with parapets, valleys or changes in roof level, there can be local accumulation of snow from drifting. See BS 6399 Part 3 for further guidance.

Fire resistance

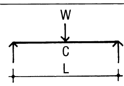
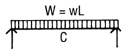
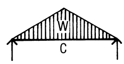
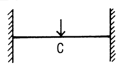
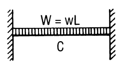
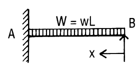
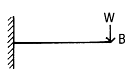
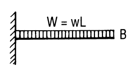
Minimum periods for elements of structure (minutes)

Building type		Basement storey		Ground and upper storeys			
		more than 10 m deep	less than 10 m deep	less than 5 m high	less than 20 m high	less than 30 m high	more than 30 m high
Flats and maisonettes		90	60	30[a]	60[c]	90[b]	120[b]
Houses		n/a	30[a]	30[a]	60[g]	n/a	n/a
Institutional[d], residential		90	60	30[a]	60	90	120[e]
Offices	without sprinklers	90	60	30[a]	60	90	X
	with sprinklers	60	60	30[a]	30[a]	60	120[e]
Shops & Commercial	without sprinklers	90	60	60	60	90	X
	with sprinklers	60	60	30[a]	60	60	120[e]
Assembly & Recreational	without sprinklers	90	60	60	60	90	X
	with sprinklers	60	60	30[a]	60	60	120[e]
Industrial	without sprinklers	120	90	60	90	120	X
	with sprinklers	90	60	30[a]	60	90	120[e]
Storage & other non-residential	without sprinklers	120	90	60	90	120	X
	with sprinklers	90	60	30[a]	60	90	120[e]
Car parks for light vehicles	open sided park	n/a	n/a	15[f]	15[f]	15[f]	60
	any other park	90	60	30[a]	60	90	120[e]

X = not permitted
a Increased to 60 minutes for compartment walls separating buildings.
b Reduced to 30 minutes for any floor within a maisonette, but not if that floor contributes to the support of the building.
c As b above and, in the case of existing houses, of no more than three storeys being converted into flats. This may be reduced to 30 minutes providing the means of escape conform to section 2 of requirement B1.
d Multi-storey hospitals should have a minimum 60 minutes standard.
e Reduced to 90 minutes for elements not forming part of the structural frame.
f As 'a' above and increased to 30 minutes for elements protecting the means of escape.

Source: *Building Regulations Approved Document B vol 2 –* Table A2.

Bending moments and beam formulae

Type of beam	Loading diagram	Maximum bending moment	Maximum shear	Maximum deflection d
Freely supported with central load		$\frac{WL}{4}$	$\frac{WL}{2}$	$dc = \frac{WL^3}{48EI}$
Freely supported with distributed load		$\frac{WL}{8}$	$\frac{W}{2}$	$dc = \frac{WL^3}{384EI}$
Freely supported with triangular load		$\frac{WL}{6}$	$\frac{W}{2}$	$dc = \frac{WL^3}{60EI}$
Fixed both ends with central load		$\frac{WL}{8}$	$\frac{W}{2}$	$dc = \frac{WL^3}{192EI}$
Fixed both ends with distributed load		$\frac{WL}{12}$	$\frac{W}{2}$	$dc = \frac{WL^3}{384EI}$
One end fixed, the other end freely supported		$\frac{WL}{8}$	$SA = \frac{5W}{8}$ $SB = \frac{3W}{8}$	$d = \frac{WL^3}{185EI}$ at x = 0.42 L
Cantilever with end load		WL	W	$dB = \frac{WL^3}{3EI}$
Cantilever with distributed load		$\frac{WL}{12}$	W	$dB = \frac{WL^3}{8EI}$

W = total load
w = kN/m
L = length
E = modulus of elasticity
I = moment of inertia
S = shear

↓ = point load
 = distributed load
↑ = free support
 = fixed support

Safe loads on subsoils (BS 8004: 1986)

Presumed allowable bearing values under static loading

Subsoil	Type	Bearing **kN/m²**
Rocks	Strong igneous and gneissic rocks in sound condition	10 000
	Strong limestones and sandstones	4000
	Schists and slates	3000
	Strong shales, mudstones and siltstones	2000
Non-cohesive soils	Dense gravel, dense sand and gravel	>600
	Medium dense gravel, medium dense sand and gravel	<200 to 600
	Loose gravel, loose sand and gravel	<200
	Compact sand	>300
	Medium dense sand	100 to 200
	Loose sand	<100
Cohesive soils	Very stiff boulder clays, hard clays	300 to 600
	Stiff clays	150 to 300
	Firm clays	75 to 150
	Soft clays and silts	<75

Notes:

1. These values are for preliminary design only. Foundations always require site investigation first.
2. No values are given for very soft clays and silts; peat and organic soils; made-up or filled ground as presumably these would be thought unsuitable for any building.
3. Values for **Rocks** assume that foundations are carried down to unweathered rock.
4. Widths of foundations for **Non-cohesive soils** to be not less than one metre.
5. **Cohesive soils** are susceptible to long-term settlement.
6. Generally foundations should not be less than 1.0 to 1.3 m depth to allow for soil swell or shrink, frost and vegetation attack.

Timber (BS 5268: Part 2: 1996)

Grade stress and moduli of elasticity for various strength classes

Strength Class	Bending parallel to grain N/mm²	Tension parallel to grain N/mm²	Compression parallel to grain N/mm²	Compression* perpendicular to grain N/mm²		Shear parallel to grain N/mm²	Modulus of elasticity Mean N/mm²	Modulus of elasticity minimum N/mm²	Density average Kg/m³
C14	4.1	2.5	5.2	2.1	1.6	0.60	6800	4600	350
C16	5.3	3.2	6.8	2.2	1.7	0.67	8800	5800	370
C18	5.8	3.5	7.1	2.2	1.7	0.67	9100	6000	380
C22	6.8	4.1	7.5	2.3	1.7	0.71	9700	6500	410
C24	7.5	4.5	7.9	2.4	1.9	0.71	10 800	7200	420
TR26	10.0	6.0	8.2	2.5	2.0	1.10	11 000	7400	450
C27	10.0	6.0	8.2	2.5	2.0	1.10	12 300	8200	450
C30	11.0	6.6	8.6	2.7	2.2	1.20	12 300	8200	460
C35	12.0	7.2	8.7	2.9	2.4	1.30	13 400	9000	480
C40	13.0	7.8	8.7	3.0	2.6	1.40	14 500	10 000	500
D30	9.0	5.4	8.1	2.8	2.2	1.40	9500	6000	640
D35	11.0	6.6	8.6	3.4	2.6	1.70	10 000	6500	670
D40	12.5	7.5	12.6	3.9	3.0	2.00	10 800	7500	700
D50	16.0	9.6	15.2	4.5	3.5	2.20	15 000	12 600	780
D60	18.0	10.8	18.0	5.2	4.0	2.40	18 500	15 600	840
D70	23.0	13.8	23.0	6.0	4.6	2.60	21 000	18 000	1080

Notes:
C14–C40 are for softwoods
C16 is considered to be sufficient for general use (former classification = SC3)
C24 is a good general quality timber (former classification = SC4)
TR26 is for manufactured softwood trusses
D30–40 are for hardwoods
* Where the specification prohibits wane at bearing areas, use the higher value

Rectangular timber beam formula (uniformly distributed load)

1 Obtain the total imposed and dead loading for the beam (W) in kN.
2 Select a strength class of timber to define bending stress (σ) in N/mm^2 and modulus of elasticity (E) in N/mm^2.
3 Choose breadth of beam (b) in mm.
4 Calculate the maximum bending moment (M) in kNm.

Check stress (σ):

$$M = \frac{WL}{8}$$

$$M = \sigma Z, \text{ and } Z = \frac{bd^2}{6}$$

$$\therefore \quad M = \sigma\frac{bd^2}{6} \text{ or } db^2 = \frac{6M}{\sigma}$$

$$\text{hence } d = \sqrt{\frac{WL \times 6 \times 10^6}{8 \times b \times \sigma}}$$

Check deflection (δ):

For spans up to 4.67 m, maximum deflection allowable is span × 0.003. Above 4.67 m deflection is limited to 14 mm for domestic floors.

For a single member, use E_{min}

$$\delta = L \times 0.003 = \frac{5WL^3}{384EI}, \text{ and } I = \frac{bd^3}{6}$$

$$\text{hence } d = \sqrt{\frac{WL^2 \times 52.08 \times 10^3}{E \times b}}$$

The depth of the section to use will be the greater of those calculated for stress or deflection.

Where:

b = breadth of beam, mm; d = depth of beam, mm; f = flexural stress, N/mm^2; L = clear span, m; M = bending moment, kNm; W = total load, kN; Z = section modulus, mm^3; I = second moment of area, mm^4; E = modulus of elasticity, N/mm^2

Timber floor joists

(For further information [such as spans for C24] see TRADA Span tables for solid timber members in floors, ceiling and roofs [excluding trussed rafter roofs] for dwellings).

Maximum clear spans for C16 grade softwood (m)

Dead load (kN/m^2)	<0.25		0.25 to 0.50		0.50 to 1.25	
Joist centres (mm)	400	600	400	600	400	600
Joist size (b × d) (mm)	**Maximum Clear Span (m)**					
47 × 97	2.03	1.59	1.93	1.47	1.67	1.23
47 × 120	2.63	2.26	2.52	2.05	2.22	1.66
47 × 145	3.17	2.77	3.04	2.59	2.70	2.15
47 × 170	3.71	3.21	3.55	3.00	3.14	2.56
47 × 195	4.25	3.64	4.07	3.41	3.56	2.91
47 × 220	4.75	4.08	4.58	3.82	3.99	3.26
75 × 120	3.07	2.69	2.94	2.57	2.65	2.29
75 × 145	3.70	3.24	3.54	3.10	3.19	2.78
75 × 170	4.32	3.79	4.14	3.63	3.73	3.23
75 × 195	4.87	4.34	4.72	4.15	4.27	3.67
75 × 220	5.32	4.82	5.15	4.67	4.77	4.11

Dead loads exclude the self-weight of the joist.
The table allows for an imposed load of not more than 1.5 kN/m^2 and a concentrated load of 1.4 kN, but not for concentrated loads from trimmers, partitions, etc.
All joists beneath a bath should be doubled.

Floor decking (See NHBC Standards 6.4 –D14)

Joist centres (mm)	400	450	600
	Thickness of decking (mm)		
T & G softwood boarding	16	16	19
Chipboard	18	18	22
Plywood	12	12	16
Oriented strand board	15	15	18/19

Note: Oriented strand board should be laid with the stronger axis at right angles to the support.

Timber ceiling joists

(For further information [such as spans for C24] see TRADA Span tables for solid timber members in floors, ceiling and roofs [excluding trussed rafter roofs] for dwellings.)

Maximum clear spans for C16 grade softwood (m)

Dead load (kN/m^2)	<0.25		0.25 to 0.50	
Joist centres (mm)	400	600	400	600
Joist sizes (b × d) (mm)	**Maximum Clear Span (m)**			
38 × 72	1.15	1.11	1.11	1.06
38 × 97	1.74	1.67	1.67	1.58
38 × 120	2.33	2.21	2.21	2.08
38 × 145	2.98	2.82	2.82	2.62
38 × 170	3.66	3.43	3.43	3.18
38 × 195	4.34	4.05	4.05	3.74
38 × 220	5.03	4.68	4.68	4.30
47 × 72	1.27	1.23	1.23	1.18
47 × 97	1.93	1.84	1.84	1.74
47 × 120	2.56	2.43	2.43	2.27
47 × 145	3.27	3.08	3.08	2.87
47 × 170	4.00	3.74	3.74	3.46
47 × 195	4.73	4.41	4.41	4.07
47 × 220	5.47	5.08	5.08	4.67

The table allows for an imposed load of not more than 0.25 kN/m^2 and a concentrated load of 0.9 kN.
No account has been taken for other loads such as water tanks or trimming around chimneys, hatches, etc.
Minimum bearing for ceiling joists should be 35 mm.

Engineered joists and beams

Engineered timber joists (TJI joists) allow for increased spans and reduced shrinkage in timber floor structures as well as more efficient use of material. Their higher cost means they compete with sawn timber only on larger spans and larger projects; typical savings in cross-section of section for a given joist depth as compared to sawn C24 softwood would be 20 to 30 per cent.

Parallam Beams (parallel strand lumber) have a vastly improved permissible stress and modulus of elasticity allowing of the order of 50 per cent increase in span on equivalent section of C24 softwood.

Prefabricated Timber Trusses

For simple rectangular roofs with flat ceilings at eaves level, a prefabricated roof is the easiest solution. Trusses are design and erected by a truss manufacture. The inner leaf of the cavity wall is used to support the trusses. Truss centres are generally at 600 and there is a nominal allowance for access into the ceiling void. The internal arrangement of timbers makes it hard to store items in the loft space. Access should be restricted to maintenance (such as dealing with cables, plumbing, etc). An allowance for water tanks is generally made.

More complicated shapes such as intersecting roofs can be achieved, as well as hip ends. Multiple trusses are used to support monopitch trusses forming the hips.

For further information see http://www.tra.org.uk (The Trussed Rafter Association).

Brickwork and blockwork (BS 5628: Part 1: 1992)

Slenderness ratio of load bearing brickwork and blockwork walls

The slenderness ratio involves the thickness and height and the conditions of support to the top and bottom of a wall, pier or column. It is defined as effective height ÷ effective thickness.

Effective height of walls
When the floor or roof spans at right angles to the wall with sufficient bearing and anchorage:
effective height = ¾ of actual height between centres of supports
For concrete floors having a bearing on walls, irrespective of the direction of span:
effective height = ¾ of actual height
For floors or roof spanning parallel with wall without bearing (but wall restrained to floor/roof plane with lateral restraint straps):
effective height = actual height
For walls with no lateral support at top:
effective height = 1½ times actual height

Effective thickness of walls
For solid walls:
effective thickness = actual thickness
For cavity walls:
effective thickness = 2/3 × (thickness of one leaf + thickness of the other) or thickness of outer or inner leaf, whichever is greatest.

The slenderness ratio should never exceed 27, except in cases of walls less than 90 mm thick where it should not exceed 20.

For more information see Building Regulation Approved Document A.

Concrete (BS 8500-1: 2002)

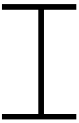
The grade of concrete required depends on several factors such as exposure, chemical attack and whether the concrete is reinforced. The cover to the reinforcement depends on the grade of concrete, exposure and potential chemical attack (from de-icing salts and ground water).

The following information is extracted from Table A.7 of BS 8500-1: 2002 (Guidance on the selection of designated and standardized prescribed concrete in housing and other applications). For concrete subjected to sulphates and hydrostatic head of ground water, refer to a Chartered Structural Engineer.

Application (concrete containing embedded metal should be treated as reinforced)	Designated concrete	Standardized prescribed concrete
Foundations		
Blinding and mass concrete fill	GEN1	ST2
Strip footings	GEN1	ST2
Mass concrete footings	GEN1	ST2
Trench fill foundations	GEN1	ST2
Fully buried reinforced foundations	RC30	N/A
General applications		
Kerb bedding and backing	GEN0	ST1
Drainage works to give immediate support	GEN1	ST2
Other drainage works	GEN1	ST2
Oversite below suspended slabs	GEN1	ST2
Floors		
House floors with no embedment metal		
– Permanent finish to be added, e.g. screed of floating floor	GEN1	ST2
– No permanent finish to be added e.g. carpeted	GEN2	ST3
Garage floors with no embedded metal	GEN3	ST4
Wearing surface: light foot and trolley traffic	RC30	ST4
Wearing surface: general industrial	RC40	N/A
Wearing surface: heavy industrial	RC50	N/A
Paving		
House drives and domestic parking	PAV1	N/A
Heavy-duty external paving with rubber tyre vehicles	PAV2	N/A

Steelwork

Universal beams – Safe distributed loads (kN) for grade 43 steel



Beam serial size* **mm**	Mass **kg/m**	Spans (m)										
		2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	7.0	Lc
		Deflection co-efficients										
		112.0	71.68	49.78	36.57	28.00	22.12	17.92	14.81	12.44	9.143	m
406 × 140	46	**513**	**411**	**342**	**293**	**257**	*228*	*205*	*187*	*171*	147	2.58
	39	**414**	**331**	**276**	**236**	**207**	*184*	*165*	*150*	*138*	118	2.41
356 × 171	67	**662**	**567**	**472**	*405*	*354*	*315*	*283*	*258*	*236*	202	3.72
	57	**574**	**473**	**394**	*338*	*296*	*263*	*237*	*215*	*197*	169	3.50
	51	**519**	**420**	**350**	**300**	*263*	*234*	*210*	*191*	*175*	150	3.38
	45	**453**	**363**	**302**	**259**	*227*	*201*	*181*	*165*	151	130	3.23
356 × 127	39	**377**	**302**	**252**	*216*	*189*	*168*	*151*	*137*	126	108	2.33
	33	**311**	**248**	**207**	*177*	*155*	*138*	*124*	*113*	104	89	2.18
305 × 165	54	**479**	**398**	**331**	*284*	*249*	*221*	*199*	181	166	142	3.69
	46	**412**	**342**	**285**	**244**	*214*	*190*	*171*	155	143	122	3.53
	40	**370**	**296**	**247**	**212**	*185*	*165*	*148*	135	123	106	3.38
305 × 127	48	**404**	*323*	*269*	*231*	*202*	*180*	*162*	147	135	115	2.59
	42	**351**	*280*	*234*	*200*	*175*	*156*	*140*	127	117	100	2.45
	37	**311**	*249*	*207*	*178*	*156*	*138*	*124*	113	104	89	2.37
305 × 102	33	**274**	*219*	*183*	*156*	*137*	*122*	*110*	100	91	78	1.90
	28	**232**	*185*	*154*	*132*	*116*	*103*	*93*	84	77	66	1.79
	25	**190**	*152*	*127*	*109*	*95*	*84*	*76*	69	63	54	1.64
254 × 146	43	**333**	**267**	*222*	*191*	*167*	148	133	121	111	95	3.41
	37	**286**	**229**	*191*	*164*	*143*	127	115	104	95	82	3.22
	31	**233**	*186*	*155*	*133*	*117*	104	93	85	78	67	2.96
254 × 102	28	*203*	*163*	*135*	*116*	*102*	90	81	74	68	58	2.01
	25	*175*	*140*	*117*	*100*	*88*	78	70	64	58	50	1.87
	22	*149*	*119*	*99*	*85*	*74*	66	60	54	50	43	1.75
203 × 133	30	**184**	*147*	*123*	*105*	92	82	74	67	61	53	3.03
	25	*153*	*122*	*102*	87	77	68	61	56	51		2.80
203 × 102	23	*136*	*109*	*90.6*	*77.7*	*68.0*						2.22
178 × 102	19	*101*	*80.8*	*67.3*	*57.7*	*50.5*						2.21
152 × 89	16	*72.6*	*58.1*	*48.4*	*41.5*	*36.3*						2.01
127 × 76	13	*49.6*	*39.6*	*33.0*	*28.3*	*24.8*						1.82

* Note that serial size is NOT actual size. Manufacture of beams of different weights of a given serial size involves moving the rollers in or out. The depth between the inside faces of the flanges remains constant, so the flange thickness and overall height vary.

Notes: See p. 125

Steel joists (RSJ) – Safe distributed loads (kN) for grade 43 steel

(Please note that these sections are not frequently rolled – check for availability.)

Joist nominal size **mm**	Mass **kg/m**	Spans (m) 1.50	1.75	2.0	2.25	2.50	2.75	3.0	3.25	3.5	4.0	Lc
		Deflection co-efficients 199	146	112	88.5	71.7	59.2	49.8	42.4	36.6	28.0	m
254 × 203	82				**518**	**500**	**454**	**416**	**304**	*357*	*312*	5.80
203 × 152	52	**362**	**356**	**311**	**277**	*249*	*226*	*207*	*191*	178	156	4.47
152 × 127	37	*210*	*180*	*158*	*140*	*126*	115	105	97	90	79	3.79
127 × 114	30	*136*	*116*	*102*	90	81	74	68	63	58	51	3.55
127 × 114	27	*131*	*112*	*98*	87	79	71	65	60	56	49	3.61
102 × 102	23	*84*	72	63	56	51	46	42	39	36	32	3.48
89 × 89	19	*61*	52	46	41	36	33	30	28	26	23	3.33
76 × 76	13	37	31	27	24	22	20	18	17	16	14	2.95

Notes:
These safe loads are designed in accordance with BS 449 (permissible stresses) and assume that the compression flange of the beam is laterally restrained if the span of the beam exceeds Lc. Sufficient lateral restraint can be achieved by positive mechanical fixing of floor joists to the flange (i.e. using cleats or straps). Skew nailing to timber plates or blocking into the web is generally not acceptable.
Loads printed in **bold** type may cause overloading of the unstiffened web, the capacity of which should be checked.
Loads printed in *italic* type do not cause overloading of the unstiffened web, and do not cause deflection exceeding span / 360.
Loads printed in ordinary type should be checked for deflection.

Source: British Constructional Steelwork Association Ltd

Steel hollow sections

Hot formed structural hollow sections (SHS) are manufactured to BS 4360: 1990 and BS 4848 Part 2: 1991.

The square and rectangular sections have tight corner radii which have higher geometric properties and therefore a higher load carrying capacity in compression than cold formed sections.

Cold formed hollow sections (CFHS) are manufactured to BS 6363: 1989.

The square and rectangular sections have larger corner radii which give lower geometric properties than hot formed sections of the same size and thickness. Cold formed hollow sections must NOT be substituted in a direct size-for-size basis for hot formed hollow sections without checking the design. Where structural properties are not critical, CFHS provide a cheaper solution.

SHS = structural hollow section
CHS = circular hollow section
RHS = rectangular hollow sections including square sections
CFHS = cold formed hollow section

Structural steel hollow sections
External sizes in mm

Hot formed			Cold formed		
circular	**square**	**rectangular**	**circular**	**square**	**rectangular**
26.9	40 × 40	50 × 30	26.9	25 × 25	50 × 25
42.4	50 × 50	60 × 40	33.7	30 × 30	50 × 30
48.3	60 × 60	80 × 40	42.4	40 × 40	60 × 30
60.3	70 × 70	90 × 50	48.3	50 × 50	60 × 40
76.1	80 × 80	100 × 50	60.3	60 × 60	70 × 40
88.9	90 × 90	100 × 60	76.1	70 × 70	70 × 50
114.3	100 × 100	120 × 60	88.9	80 × 80	80 × 40
139.7	120 × 120	120 × 80	114.3	90 × 90	80 × 60
168.3	140 × 140	150 × 100	139.7	100 × 100	90 × 50
193.7	150 × 150	160 × 80	168.3	120 × 120	100 × 40
219.1	160 × 160	200 × 100	193.7	140 × 140	100 × 50
244.5	180 × 180	200 × 120	219.1	150 × 150	100 × 60
273.0	200 × 200	200 × 150	244.5	160 × 160	100 × 80
323.9	250 × 250	250 × 100	273.0	180 × 180	120 × 40
406.4	300 × 300	250 × 150	323.9	200 × 200	120 × 60
457.0	350 × 350	300 × 100	355.6	250 × 250	120 × 80
508.0	400 × 400	300 × 200	406.4	300 × 300	140 × 80
		400 × 200	457.0		150 × 100
		450 × 250	508.0		160 × 80
		500 × 300			180 × 80
					180 × 100
					200 × 100
					200 × 120
					200 × 150
					250 × 150
					300 × 100
					300 × 200
					400 × 200

Seamless Hot formed hollow sections also available with thicker walls 457 to 771 mm Ø
Jumbo Hot formed square hollow and rectangular sections also available with thicker walls 350 to 750 mm square

Source: Corus: tubes and pipes

Lintels

There are many suppliers of lintels, both precast concrete and pressed metal. Precast lintels can be either composite or non-composite. Composite lintels rely on brickwork being built on top of the 65 deep lintels. Particularly for longer spans, this allows safer handling on site of lighter lintels. Such lintels MUST be propped until the brickwork over has cured. Similarly, all long span lintels should be propped until masonry over has cured.

Lintels are rarely, if ever, cast on site.

Lintel selector guides are available on the websites of the various manufacturers. You will need to know the thickness of the inner and outer leaves, the width of the cavity, clear span and loads to be carried.

The following is just a small example of what is available on the web. It is advisable to check the websites periodically as the products are revised:

Precast concrete lintels

Stowell Concrete Limited (www.stowellconcrete.co.uk)

COMPOSITE lintel maximum uniformly distributed load for clear span kg/m (including self-weight of lintel)

Section w × h	No. of courses	0.60 m	0.75 m	0.90 m	1.05 m	1.20 m	1.35 m	1.50 m	1.65 m	1.80 m	1.95 m	2.10 m	2.25 m	2.40 m	2.55 m	2.70 m	2.85 m
100 × 65 mm	2	2033	1407	1029	785	617	497	408	340	288	246	212	185	162	143	127	133
	5	2743	1900	1392	1062	836	674	554	463	392	336	291	254	223	197	175	156
	8	4166	2889	2118	1618	1275	1030	849	711	603	516	449	393	347	308	274	246
150 × 65 mm	2	2168	1498	1094	833	653	524	430	357	301	257	221	191	166	146	129	–
	5	4002	2773	2030	1550	1219	983	809	676	572	490	424	370	325	288	245	–
	8	5837	4046	2967	2266	1785	1442	1188	994	844	725	628	549	484	429	383	–
220 × 65 mm	2	2377	1639	1193	904	706	565	459	380	317	269	228	196	169	147	127	–
	5	5940	4115	3015	2300	1811	1460	1201	1004	851	729	631	560	484	428	381	–
	8	8195	5679	4161	3177	2501	2019	1661	1389	1178	1010	875	764	672	596	530	–

NON-COMPOSITE lintel maximum uniformly distributed load for clear span kg/m (including self-weight of lintel)

Section w × h	0.75 m	0.90 m	1.05 m	1.20 m	1.35 m	1.50 m	1.65 m	1.80 m	1.95 m	2.10 m	2.25 m	2.40 m	2.55 m	2.70 m	2.85 m	3.00 m	3.15 m	3.30 m	3.75 m	4.05 m
150 × 100 mm	2381	1937	1282	1006	808	662	551	464	395	340	295	257	226	199	176	157	140	125	–	–
100 × 150 mm	3590	2628	1880	1480	1191	976	816	691	638	511	458	390	344	302	272	244	219	198	–	–
140 × 150 mm	–	–	3564	2806	2263	1862	1557	1319	1131	979	855	751	665	592	529	476	429	389	–	–
100 × 215 mm	–	–	–	–	2952	2694	2413	2140	1882	1624	1402	1202	1122	1004	856	812	723	664	517	423

Naylor precast concrete lintels (www.naylorlintels.co.uk/lintelsselector.asp)

Hi-Spec Range Lintel: R6	
Section Properties	
Height	145 mm
Width	100 mm
M_S	5.564 kNm
M_U	9.609 kNm
$M_{U/1.5}$	6.406 kNm
Limiting M_R	5.564 kNm
Effective depth	95 mm
Self-weight	35 Kg/m

Load Table

Clear Span (mm)	**Overall Length** (mm)	**Effective Span** (mm)	**Allowable Load (kN/m)**			
			M_R	S_{R100}	S_{R150}	Limiting
700	900	795	70.07	50.74		50.74
900	1100	995	44.61	40.47		40.47
1000	1200	1095	36.77	36.74		36.74
1200	1500	1295	26.19		32.88	26.19
1500	1800	1595	17.14			17.14
1800	2100	1895	12.04			12.04
2100	2400	2195	8.89			8.89
2400	2700	2495	6.80			6.80
2700	3000	2795	5.34			5.34
3000	3300	3095	4.29			4.29
3200	3600	3295	3.75			3.75

Naylor precast concrete lintels – continued

Hi-Spec Range Lintel: R8	
Section Properties	
Height	215 mm
Width	140 mm
M_S	14.259 kNm
M_U	25.710 kNm
$M_{U/1.5}$	17.140 kNm
Limiting M_R	14.259 kNm
Effective depth	141.67 mm
Self-weight	72 Kg/m

Load Table

Clear Span (mm)	**Overall Length** (mm)	**Effective Span** (mm)	**Allowable Load (kN/m)**			
			M_R	S_{R100}	S_{R150}	Limiting
700	900	800	177.51	100.57		100.57
900	1100	1000	113.35	80.31		80.31
1000	1200	1100	93.55	72.95		72.95
1200	1500	1341	62.64		62.22	62.22
1500	1800	1641	41.60		50.72	41.60
1800	2100	1941	29.53			29.53
2100	2400	2241	21.97			21.97
2400	2700	2541	16.93			16.93
2700	3000	2841	13.40			13.40
3000	3300	3141	10.83			10.83
3200	3600	3341	9.49			9.49

Steel lintels for cavity walls

Lintels are made from galvanized steel with polyester powder corrosion-resisting coating. Single lintels are available with the steel bent into a 'top hat' shape using the cavity to give height to the lintel, but these form a thermal bridge across the cavity and may cause local condensation, so separate lintels for each leaf are advisable. To support masonry to the outer leaf, angle lintels are used, typically in conjunction with a separate box lintel to the inner leaf.

Bases of internal leaf lintels are slotted for plaster key.

Other profiles

Rebated combined lintels – for window/door frames set back in reveals.

Lintels for closed eaves – for windows tight under sloping roofs.

Lintels for walls with masonry outer skin and timber frame inside.

Lintels for masonry outer skin where inner skin is carried by concrete lintel.

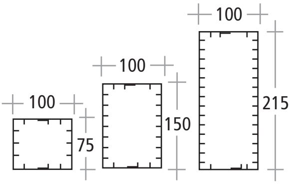
Lintels for internal partitions and load bearing walls.

Special profiles for various styles of arches and cantilevered masonry corners.

If thermal bridging is an issue, each leaf could be supported on a box lintel. If the external leaf is facing brick, then an angle would be required.

Box 100

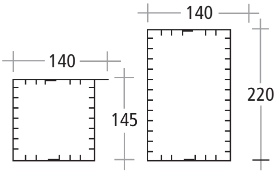
For internal openings, eaves or 100 block and tile hanging.



Manufactured length 150 mm increments	0600 1500	1650 1800	1950 2400	2550 2700	2850 3600	3750 4200	4350 4800
Height 'h'	75	150	150	150	215	215	215
Thickness 't'	2	1.6	2	2	2.5	2.5	2.5
Total allowable UDL (kN)	18	18	25	20	30	25	20

Box 140

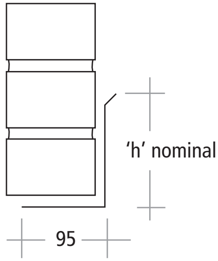
For internal openings, eaves or 140/150 block and tile hanging.



Manufactured length 150 mm increments	0600 1500	1650 1800	2250 2400	2550 2700	2850 3600	3750 4200	4350 4800
Height 'h'	145	145	145	145	220	220	220
Thickness 't'	1.6	2	2	2	2.5	2.5	2.5
Total allowable UDL (kN)	15	30	25	20	34	30	25

L10

For use with single 102 mm brickwork wall construction. Light duty loading condition.



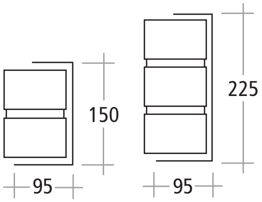
Note: This lintel must be propped during construction.
To achieve loading figures indicated, lintel must be built-in with brickwork/blockwork as shown. In addition, it must be suitably restrained during construction. Heavier duty variants available.

Heavy duty and wider masonry variants available.

Manufactured length 150 mm increments	**0600 1200**	**1350 1800**	**1950 2700**
Height 'h'	60	110	210
Thickness 't'	3.0	3.0	28
Total allowable UDL (kN)	14	8	10

L11

For use with single leaf face brick or block wall.



Note: This lintel must be propped during construction.
To achieve loading figures indicated, lintel must be built-in with brickwork/blockwork as shown. In addition, it must be suitably restrained during construction. Heavier duty variants available.

Heavy duty and wider masonry variants available.

Manufactured length 150 mm increments	**0600 1800**	**1950 2400**	**2550 3000**
Height 'h'	150	225	225
Thickness 't'	2.5	2.5	3.0
Total allowable UDL (kN)	16	20	22

Wind loads – simple calculation

BS 6262: 1982 CP describes a simple method of obtaining wind loads. This can be used for buildings less than 10 m above ground level and where the design wind speed is less than 52 m per second (m/s). This method should not be used for cliff-top buildings.

Find the basic wind speed from the map on p. 1. Multiply by a correction in Table 1 to get the design wind speed (m/s). Find the appropriate maximum wind loading from Table 2.

This should only be used for wind loads applied to glazing units and not the whole building. For more detailed wind calculations, refer to BS 6399: Part 2.

Table 1: Correction factors for ground roughness and height above ground

Height above ground	Category 1	Category 2	Category 3	Category 4
3 m or less	0.83	0.72	0.64	0.56
5 m	0.88	0.79	0.70	0.60
10 m	1.00	0.93	0.78	0.67

Category 1 Open country with no obstructions. All coastal areas.
Category 2 Open country with scattered wind breaks.
Category 3 Country with many wind breaks, e.g. small towns, city outskirts.
Category 4 Surfaces with large and frequent obstructions, e.g. city centres.

Table 2: Wind loading – probable maximum

Design wind speed m/s	Wind loading N/m^2	Design wind speed m/s	Wind loading N/m^2
28	670	42	1510
30	770	44	1660
32	880	46	1820
34	990	48	1920
36	1110	50	2150
38	1240	52	2320
40	1370		

Precast concrete floors

Precast concrete floors are used for ground floors over sloping or made-up ground where in-situ slabs may not be economic, and for upper floors where fire-resisting and sound insulating construction is needed, between flats for example. They can be used in a fully precast, 'dry' construction with a floating floor finish, or in a composite way with an in-situ structural topping or screed, which can improve structural performance and acoustic insulation. Crane handling of the beams is normally required so they are less used on smaller projects.

There are two main types of precast concrete floor: wideslab (sometimes known as hollowcore) and beam and block.

Bearing required is generally 75 mm onto steelwork and 100 mm onto masonry. Where shared bearing is required on a masonry wall, the wall should be 215 mm thick (except for short span beam and block floors where staggered bearing might be possible).

Wideslab floors are precast slabs 1200 mm wide with hollow cores (150 thick slab minimum). The depth of unit can vary from 100 mm–450 mm, depending on span and loading.

Beam and block floors are inverted T sections, 150–225 deep, with concrete blocks spanning between units. The blocks can span short or long direction (or alternate), depending on span and loading. All beams are sometimes required under partitions.

There are many manufacturers of precast concrete floors who provide a design and supply service. The following information is a small example of what is available on the internet. It is advisable to check the websites periodically as the products are revised.

Milbank Floors

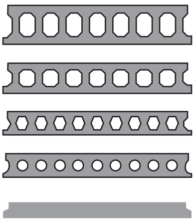
(www.milbank-floors.co.uk)

The load/span tables show the maximum clear span for both domestic and other loading conditions, such as nursing homes, hotels and commercial developments. These tables are provided as a guide only. Please contact Milbank Floors for specific information.

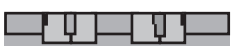
Wideslab/Hollowcore

Prestressed Hollowcore Plank Load Span Table			Maximum span in metres. Spans below allow for characteristic service (live) loads + self weight + 1.5 kN/m^2 finishes and 1.5 kN/m^2 partitions							
Unit reference	Unit depth (mm)	Self weight (kN/m^2)	**Imposed live load kN/mm^2**							
			0.75	1.5	2.0	2.5	3.0	4.0	5.0	7.5
PS-250	250	3.46	10.0	9.53	9.25	8.96	8.74	8.30	7.93	7.14
PS-200	200	2.97	8.87	8.41	8.14	7.89	7.67	7.27	6.92	6.24
PS-150H	150	2.95	7.05	6.68	6.47	6.27	6.09	5.77	5.90	4.95
PS-150L	150	2.48	7.42	7.00	6.76	6.54	6.34	5.99	5.69	5.11
PS-100s	100	2.35	5.18	4.89	4.71	4.56	4.41	4.17	3.95	3.54

SECTION



Beam and Block

150 mm deep T beam (based on 1/2 hour fire resistance) Medium density infill blocks 1350 kg/m^2 − 65 mm screed finish			Spans below allow for characteristic service (live) load +self weight + 1.5 kN/m^2 finishes + 1.5 kN/m^2 partitions Imposed live load kN/mm^2							
Beam centres*	** Type of block spacing	Self weight (kN/m^2)	0.75	1.5	2.0	2.5	3.0	4.0	5.0	7.5
			Maximum span in metres							
	W	1.76	4.07	3.82	3.67	3.54	3.42	3.21	3.04	2.54
	A	1.88	4.56	4.20	4.12	3.97	3.84	3.61	3.42	3.04
	N	2.09	5.27	4.95	4.77	4.61	4.46	4.20	3.98	3.55
	W	2.10	5.02	4.74	4.57	4.41	4.27	4.02	3.81	3.40
	A	2.27	5.46	5.16	4.98	4.81	4.66	4.39	4.17	3.73
	N	2.52	6.02	5.71	5.51	5.33	5.17	4.89	4.64	4.16
	N	2.76	6.37	6.05	5.85	5.66	5.50	5.20	4.95	4.44

** W = Wide (440 mm) A = Alternate (440 + 215 mm) N = Narrow (215 mm)

225 mm deep D Beam (based on 1 hour fire resistance) Medium density infill blocks 1350 kg/m^2 − 65 mm screed finish			Spans below allow for characteristic service (live) load +self weight + 1.5 kN/m^2 finishes + 1.5 kN/m^2 partitions. Imposed live load kN/mm^2							
Beam centres	* Type of block spacing	Self weight (kN/m^2)	0.75	1.5	2.0	2.5	3.0	4.0	5.0	7.5
			Maximum span in metres							
	W	2.36	6.31	5.94	5.73	5.54	5.37	5.07	4.81	4.30
	A	2.62	6.95	6.57	6.34	6.14	5.96	5.63	5.35	4.80
	N	3.08	7.84	7.39	7.20	6.98	6.78	6.43	6.12	5.52
	W	3.03	7.49	7.09	6.86	6.66	6.46	6.13	5.84	5.26
	A	3.35	8.00	7.60	7.36	7.15	9.95	6.60	6.29	5.68
	N	3.84	8.63	8.22	7.98	7.76	7.55	7.19	6.87	6.23
	N	4.22	8.95	8.54	8.30	8.08	7.88	7.51	7.19	6.54

** W = Wide (440 mm) A = Alternate (440 + 215 mm) N = Narrow (215 mm)