2 Basic design data: People and space

KEY POINTS:

- *Certain dimensions are crucial to individual use and health*
- *Satisfying the average situation is unlikely to help the majority*
- *Each case must be carefully considered with all classes of users, particularly people with different disabilities, in mind*

Contents

1 Introduction
2 Anthropometrics
3 Ergonomics
4 Disabled people
5 Circulation spaces
6 References

1 INTRODUCTION

In this chapter will be found basic data which are needed for the design of most types of buildings. However, some basic matters are dealt with in later chapters, principally the following:

- Sanitary provision and activity spaces in Chapter 5
- Requirements for vehicles in Chapter 31
- External and landscape design in Chapter 7
- Eating and drinking in other than domestic situations in Chapter 17.

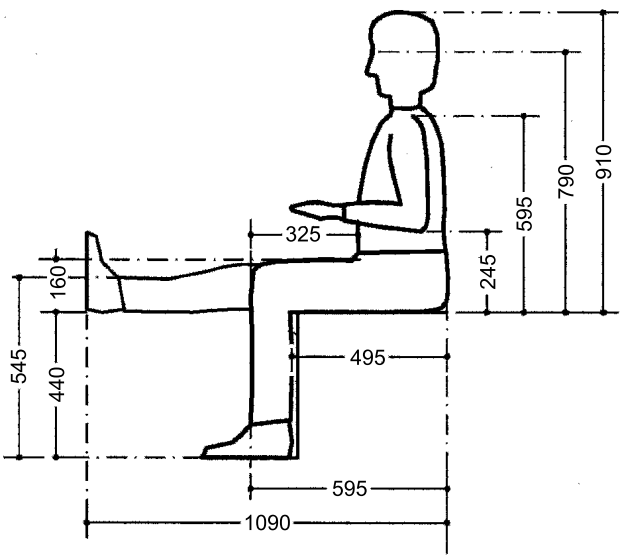
2 ANTHROPOMETRICS

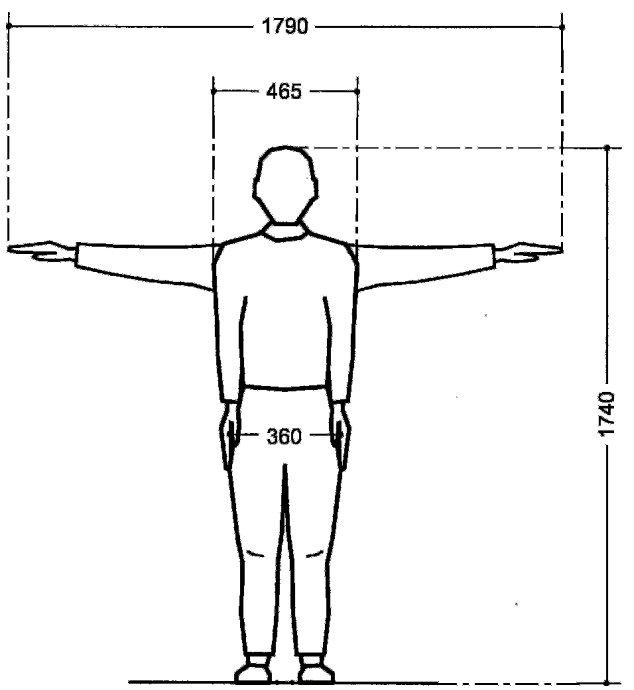
2.01

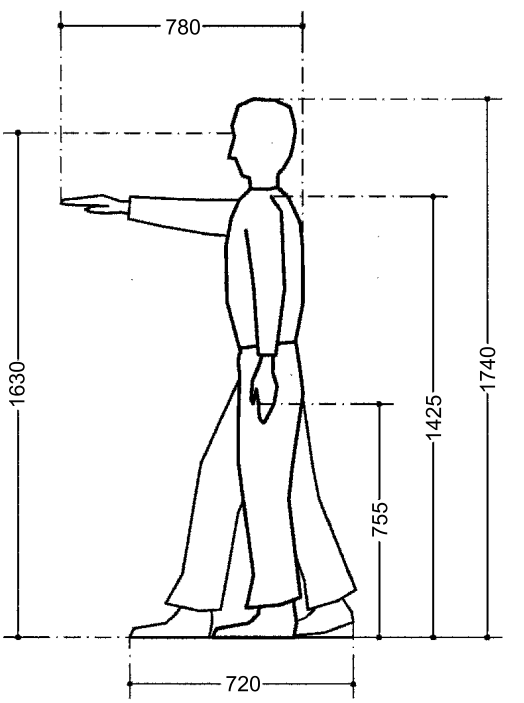
Anthropometrics is the science concerned with the measurement of humankind. Inevitably it is bound up with statistics, as people vary considerably in most dimensions. Anthropometrics is of crucial importance to architects as the ultimate basis of the design of most buildings must be the size of the people using them. Average dimensions for British adults are given in **2.1** and **2.2**, but in most cases the use of an average dimension will not produce satisfaction for the majority of users.

2.02 Normal distribution

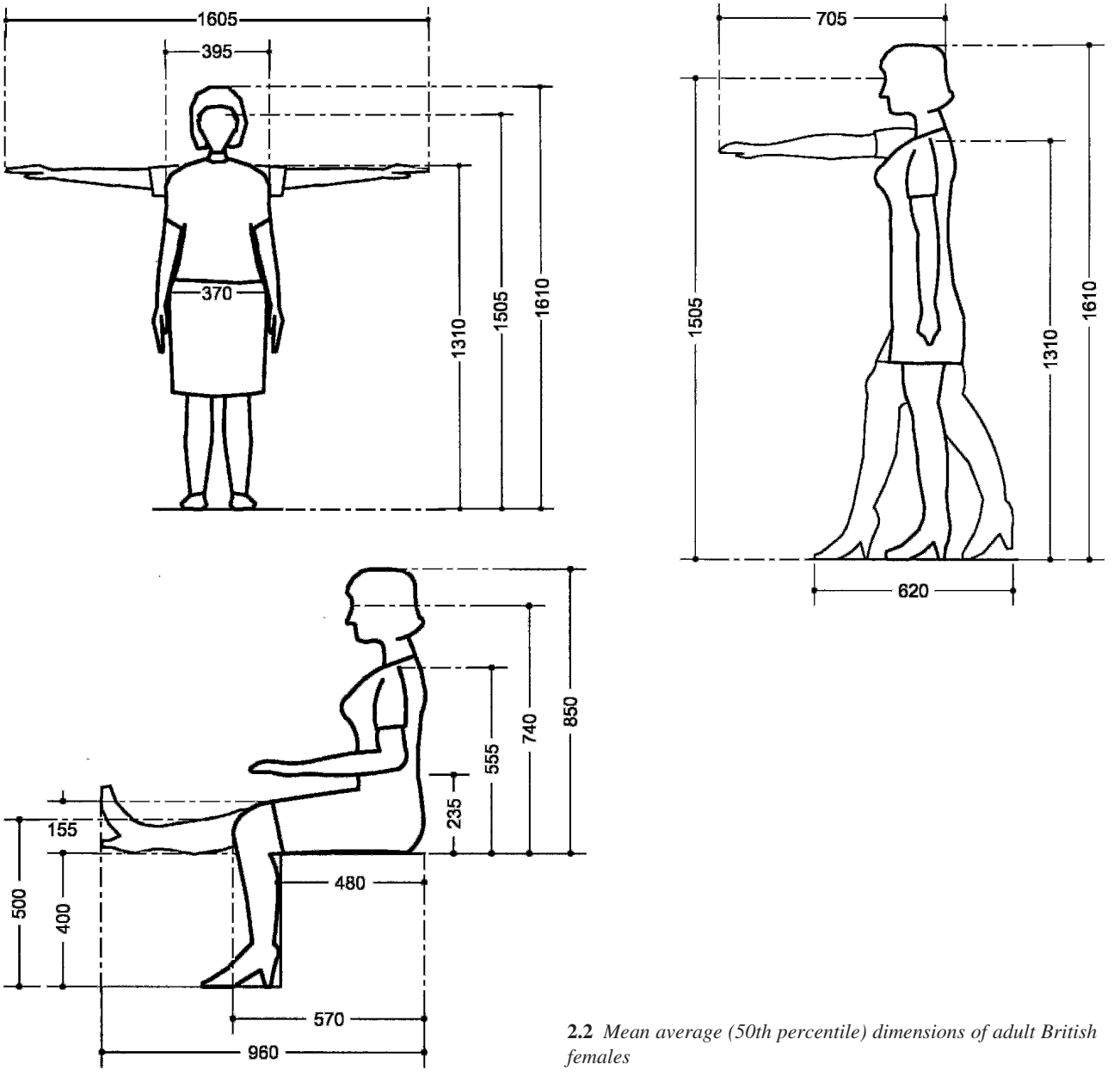
When surveys are taken of adult males, for example, they show a 'normal distribution' curve: the traditional statistical bell shape,







2.1 *Mean average (50th percentile) dimensions of adult British males*



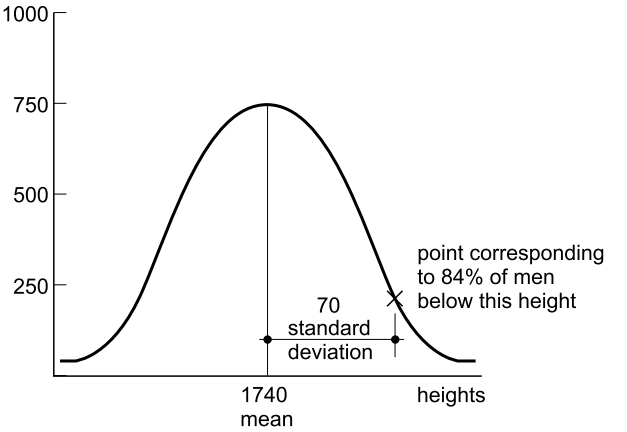
2.2 *Mean average (50th percentile) dimensions of adult British females*

2.3. This shape is totally definable by the two parameters, mean and standard deviation (SD). The mean (in this case) is the average already discussed. For the purposes of the architect, the standard deviation can be taken as the difference from the mean within which 84 per cent of the population are included. The percentage included is called the 'percentile', and it has become accepted (with certain exceptions) that designers generally seek to accommodate those within the band between the 5th and 95th percentile – that is, they do not attempt to satisfy the last 10 per cent of the people. In each case it is the job of the architect to decide whether in fact this will be acceptable.

Table II gives the principal dimensions as shown in **2.4** for men and women, for the 5th, 50th and 95th percentiles.

When a survey of a non-cohesive group (such as of mixed-age adolescents, or men and women together) is taken, a normal distribution curve is not obtained. We cannot predict the percentile dimensions for these populations, and this is why the tables here and elsewhere segregate populations into groups. Within these groups the dimensions are calculable given the mean and the SD, using the formula:

$$X_{(p)} = \text{mean} + \text{SD} \times z$$



2.3 *Normal distribution 'bell' curve. The y-axis plots the numbers of men (in this example) in a group who are the height given on the x-axis (within certain limits). In a normal distribution the average, the mean and the median are all equal*

where: $X_{(p)}$ is the value of the dimension for the pth percentile
z is a factor from Table I

In the tables the standard deviation is not directly given, but may itself be calculated from the values of the 50th (or mean) and 95th percentiles: e.g.

$$X_{(95)} - \text{mean} = \text{SD} \times 1.64 \text{ (the value of } z \text{ for } p = 95)$$

Example: A doorway is to be designed to accommodate 99.9 per cent of British men. We see from Table II that the mean stature is 1740 mm and the SD is $(1855 - 1740) \div 1.64 = 70$. The height that will fulfil the 99.9 per cent criterion is thus $1740 + (70 \times 3.09) = 1956$ mm, a considerable increase on the value of 1855 mm which accommodates the 95th percentile. In both cases the addition of a further 25 mm would be necessary to allow for footwear (see Table III).

2.03 Clothing

The tables are all consistent in giving the dimensions of the unclothed body. Increases due to clothing vary considerably but Table III gives the normally acceptable values.

2.04 Other nationalities

Dimensional surveys taken elsewhere show considerable variations. Table IV gives the range of stature found in various countries. For most purposes other dimensions can be approximately derived by proportionality with Table II, but more accurate figures can be obtained from the References at the end of this chapter.

2.05 Children and adolescents

Statures (or equivalents) for various ages in Britain are given in Table V. Here proportionality may not give sufficient accuracy, and reference should be made to one of the references for other dimensions.

Table I Selected p and z values for the normal distribution curve

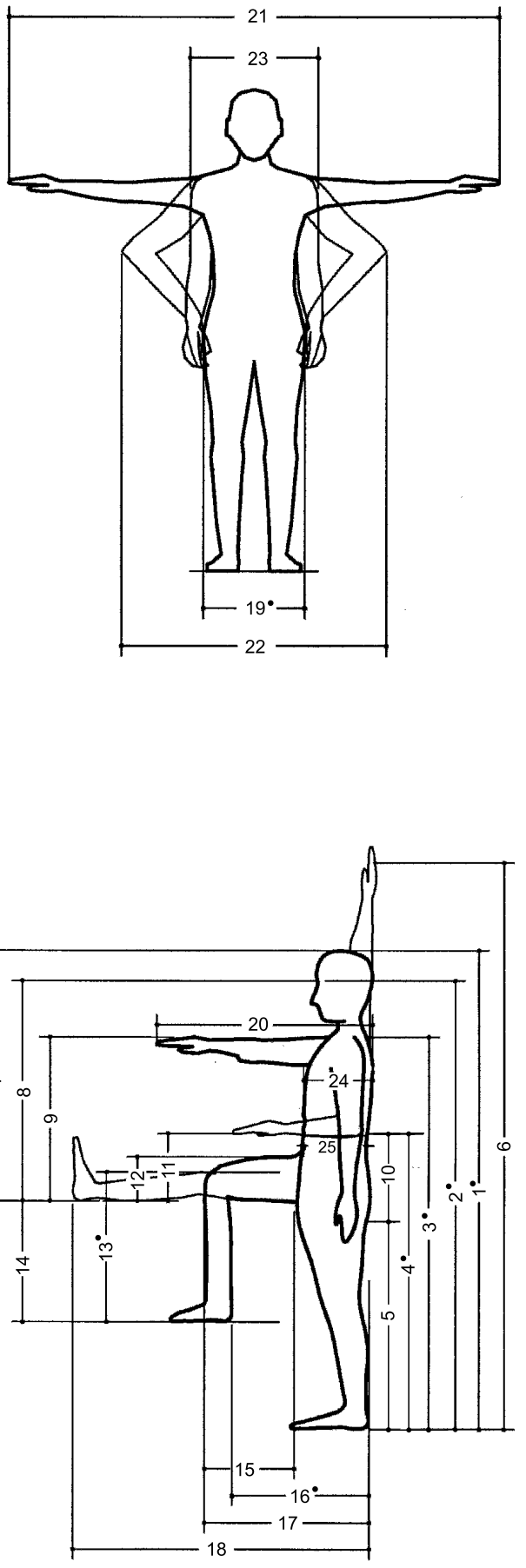
p	z
0.001	−4.26
0.01	−3.72
0.1	−3.09
0.5	−2.58
1	−2.33
2	−2.05
2.5	−1.96
3	−1.88
4	−1.75
5	−1.64
10	−1.28
20	−0.84
25	−0.67
30	−0.52
40	−0.25
50	0
60	0.25
70	0.52
75	0.67
80	0.84
90	1.28
95	1.64
96	1.75
97	1.88
97.5	1.96
98	2.05
99	2.33
99.5	2.58
99.9	3.09
99.99	3.72
99.999	4.26

2.06 Elderly people

People tend to shrink slightly with age. More significantly, the body tends to be less flexible in regard to adapting to dimensionally unfavourable situations. It is therefore more important that design allows for elderly people where that is appropriate, accepting that younger people may be slightly disadvantaged. Table VI gives dimensions for people between the ages of 65 and 80.

Table II Dimensions of British adults

	Men Percentiles			Women Percentiles			
	50th	50th	95th	50th	50th	95th	
Standing							
1 Stature	1625	1740	1855	1505	1610	1710	95th: minimum floor to roof clearance; allow for shoes and headgear in appropriate situations
2 Eye height	1515	1630	1745	1405	1505	1610	50th: height of visual devices, notices, etc.
3 Shoulder height	1315	1425	1535	1215	1310	1405	5th: height for maximum forward reach controls worktop height (see para. 302)
4 Elbow height	1005	1090	1180	930	1005	1085	controls worktop height (see para. 302)
5 Hand (knuckle) height	690	755	825	660	720	780	95th: maximum height of grasp points for lifting
6 Reach upwards	1925	2060	2190	1790	1905	2020	5th: maximum height of controls; subtract 40 mm to allow for full grasp
Sitting							
7 Height above seat level	850	910	965	795	850	910	95th: minimum seat to proof clearance; may need to allow for headgear
8 Eye height above seat level	735	790	845	685	740	795	50th: height of visual devices above seat level
9 Shoulder height above seat level	540	595	645	505	555	610	50th: height above seat level for maximum forward reach
10 Length from elbow to fingertip	440	475	510	400	430	460	50th: easy reach forward at table height
11 Elbow above seal level	195	245	295	185	235	280	50th: height above seat of armrests or desk tops
12 Thigh clearance	135	160	185	125	155	180	95th: space under tables
13 Top of knees, height above floor	490	545	595	455	500	540	95th: clearance under tables above floor or footrest
14 Popliteal height	395	440	490	355	400	445	50th: height of seat above floor or footrest
15 Front of abdomen to front of knees	253	325	395	245	315	385	95th: minimum forward clearance at thigh level from front of body or from obstruction, e.g. desktop
16 Buttock – popliteal length	440	495	550	435	480	530	5th: length of seat surface from backrest to front edge
17 Rear of buttocks to front of knees	540	595	645	520	570	620	95th: minimum forward clearance from seat back at height for highest seating posture
18 Extended leg length	985	1070	1160	875	965	1055	5th (less than): maximum distance of foot controls, footrest, etc. from seat back
19 Seat width	310	360	405	310	370	435	95th: width of seats, minimum distance between armrests
Sitting and standing							
20 Forward grip reach	720	780	835	650	705	755	5th: maximum comfortable forward reach at shoulder level
21 Fingertip span	1655	1790	1925	1490	1605	1725	5th: limits of lateral fingertip reach, subtract 130 mm to allow for full grasp
22 Width over elbows skimbo	865	945	1020	780	850	920	95th: lateral clearance in workspace
23 Shoulder width	420	465	510	355	395	435	95th: minimum lateral clearance in workspace above waist
24 Chest or bust depth	215	250	285	210	250	295	
25 Abdominal depth	220	270	320	205	255	305	



2.4 *Key dimensions listed in Table II. These figures are based on surveys of unclothed volunteers, and in using them allowances should be made for the wearing of clothes and shoes (see Table III). Dimension references marked • are most commonly used*

Table III Allowance for clothing

	Men	Women
Shoe height	25 mm	45 mm
Hat height	75 mm	100 mm

Table IV Statures of the adults of various nationalities

	Men Percentiles			Women Percentiles		
	5th	50th	95th	5th	50th	95th
British	1625	1740	1855	1505	1610	1710
US	1640	1755	1870	1520	1625	1730
French	1600	1715	1830	1500	1600	1700
German	1645	1745	1845	1520	1635	1750
Swedish	1630	1740	1850	1540	1640	1740
Swiss	1535	1690	1845	1415	1590	1765
Polish	1595	1695	1795	1480	1575	1670
Japanese	1560	1655	1750	1450	1530	1610
Hong Kong Chinese	1585	1680	1775	1455	1555	1655
Indian	1535	1640	1745	1415	1515	1615

Table V Statures (or equivalents) for Britons in various age groups

	Percentiles		
	5th	50th	95th
New-born infants	465	500	535
Infants less than 6 months old	510	600	690
Infants 6 months to 1 year old	655	715	775
Infants 1 year to 18 months	690	745	800
Infants 18 months to 2 years	780	840	900

	Boys/men Percentiles			Girls/women Percentiles		
	5th	50th	95th	5th	50th	95th
Children, 2 years old	850	930	1010	825	890	955
Children, 3 years old	910	990	1070	895	970	1045
Children, 4 years old	975	1050	1125	965	1050	1135
Children, 5 years old	1025	1110	1195	1015	1100	1185
Children, 6 years old	1070	1170	1270	1070	1160	1250
Children, 7 years old	1140	1230	1320	1125	1220	1315
Children, 8 years old	1180	1280	1380	1185	1280	1375
Children, 9 years old	1225	1330	1435	1220	1330	1440
Children, 10 years old	1290	1390	1490	1270	1390	1510
Children, 11 years old	1325	1430	1535	1310	1440	1570
Children, 12 years old	1360	1490	1620	1370	1500	1630
Children, 13 years old	1400	1550	1700	1430	1550	1670
Children, 14 years old	1480	1630	1780	1480	1590	1700
15 years old	1555	1690	1825	1510	1610	1710
16 years old	1620	1730	1840	1520	1620	1720
17 years old	1640	1750	1860	1520	1620	1720
18 years old	1660	1760	1860	1530	1620	1710
Aged 19–25	1640	1760	1880	1520	1620	1720
Aged 19–45	1635	1745	1860	1515	1615	1715
Aged 19–65	1625	1740	1855	1505	1610	1710
Aged 45–65	1610	1720	1830	1495	1595	1695
Aged 65–85	1575	1685	1790	1475	1570	1670
Elderly people	1515	1640	1765	1400	1515	

3 ERGONOMICS

3.01

This is the discipline that deals with the dimensions of people at work, including activities not directly connected with earning a living. Such matters as the space required by people using motor-cars, flying aeroplanes and operating machinery come under this heading. Many of the dimensions required for this will be found in Table II.

Table VI Dimensions for British people aged 65 to 80

	Men Percentiles			Women Percentiles		
	5th	50th	95th	5th	50th	95th
Standing						
1 Stature	1575	1685	1790	1475	1570	1670
2 Eye height	1470	1575	1685	1375	1475	1570
3 Shoulder height	1280	1380	1480	1190	1280	1375
4 Elbow height	975	895	975	740	810	875
5 Hand (knuckle) height	670	730	795	645	705	760
6 Reach upwards	1840	1965	2090	1725	1835	1950
Sitting						
7 Height above seat level	815	875	930	750	815	885
8 Eye height above seat level	705	760	815	645	710	770
9 Shoulder height above seat level	520	570	625	475	535	590
10 Length from elbow to fingertip	425	460	490	390	420	450
11 Elbow above seat level	175	220	270	165	210	260
12 Thigh clearance	125	150	175	115	145	170
13 Top of knees, height above floor	480	525	575	455	500	540
14 Popliteal height	385	425	470	355	395	440
15 Front of abdomen to front of knees	210	280	350	325	295	365
16 Buttock – popliteal length	430	485	535	430	480	525
17 Rear of buttocks to front of knees	530	580	625	520	565	615
19 Seat width	305	350	395	310	370	430
Sitting and standing						
20 Forward grip reach	700	755	805	640	685	735
21 Fingertip span	1605	1735	1860	1460	1570	1685
23 Shoulder width	400	445	485	345	385	380

3.02 Worktop heights

The most common ailment after the common cold is probably the 'bad back'. Many believe that this can be caused by working on a surface that is too low, causing stooping. Both when standing and sitting to work, it is important that the worktop should be as follows:

- For manipulative tasks involving moderate degrees of both force and precision: between 50 and 100 mm below elbow height of the person concerned
- For delicate tasks: between 50 and 100 mm above elbow height
- For heavy tasks, particularly those involving downward pressure on the workpiece: between 100 and 300 mm below elbow height.

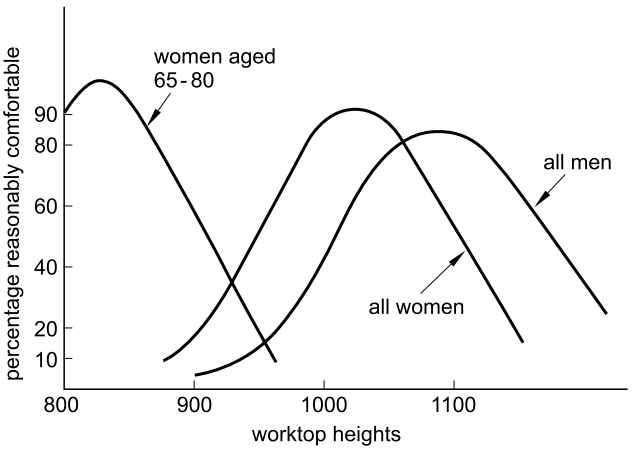
3.02 Standing worktops

Worktops at which people stand are found in factories and in the home kitchen. Since women are generally shorter in stature than men, the heights of these respective surfaces have tended to reinforce the traditional roles of the sexes: factory worktops at 1050 mm being seen as too high for many women and kitchen worktops at 900 mm (or lower) being too low for men. It is possible in factories to provide small moveable platforms to assist women workers, but this type of solution is not available where the worktop is too low for the user.

In **2.5** the percentage comfortable at each worktop height is plotted assuming that the users are wearing shoes and comfort is achieved with tops between 50 mm above elbow height and 100 mm lower. It can be seen that the standard kitchen worktop height of 900 mm actually seems to suit no-one. 850 mm would be a good height where only elderly women are likely to use it. The surprising thing is that 900 mm is uncomfortable for 84 per cent of all women! 1000 mm is ideal for most women, but only for 40 per cent of men. The traditional men's height of 1050 mm appears to satisfy both 76 per cent of men and 84 per cent of women.

3.03 Sink heights

One of the most common domestic chores is washing up. It is customary for sinks to be set into worktops, or fitted with their rims level with them. Since the effective working surface in this case is the base of the sink, usually about 100 mm lower than the rim, this further worsens the situation. It is recommended that sink surrounds should be fitted at least 75 mm above normal worktop height.



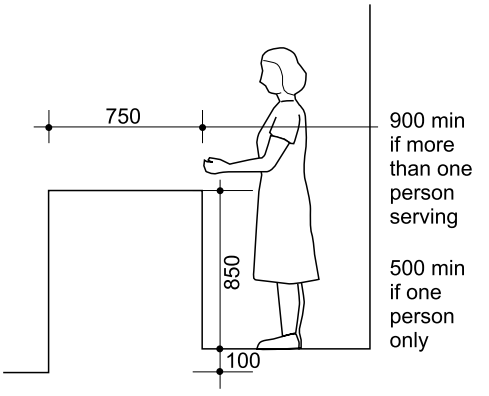
2.5 *Graphs of percentages comfortable at each worktop height. These assume that the worktop is between 50 mm above and 100 mm below elbow height, and that shoes are worn*

3.04 Serveries

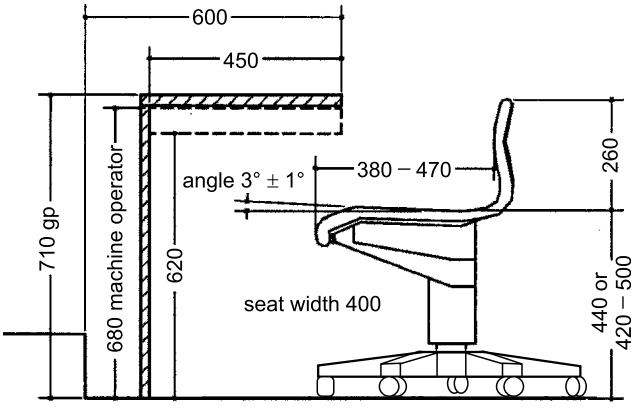
A particular type of standing worktop is a counter, **2.6**. This can be in a shop, restaurant or public house, or be a reception counter in an office or a hotel. There is often no good reason why the same height is needed on each side, and it is common for the non-public side to be higher than the other. Details of such can be found in the appropriate specialist chapters.

3.04 Sitting worktops

Traditionally, writing desks are standard in height at 710 mm, **2.7**. Desks for typewriters and word processors (where the working



2.6 *Serving counter*

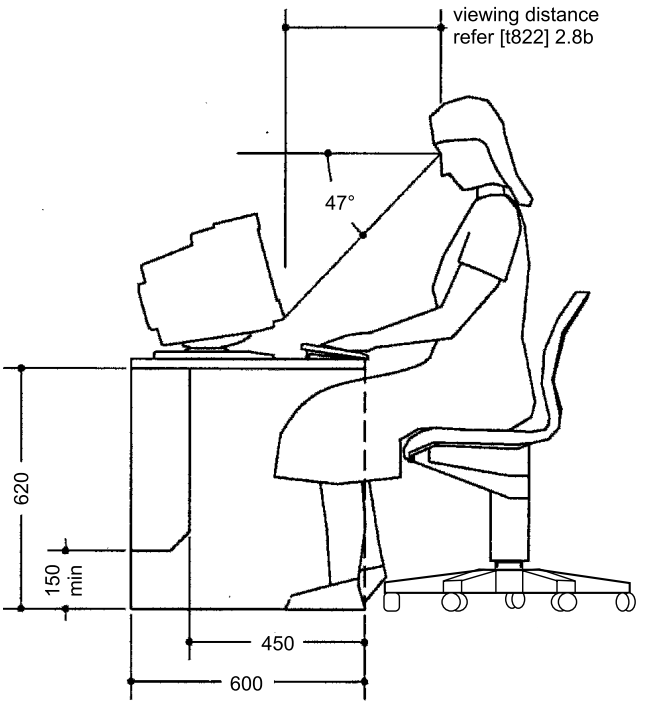


2.7 *Sitting worktop*

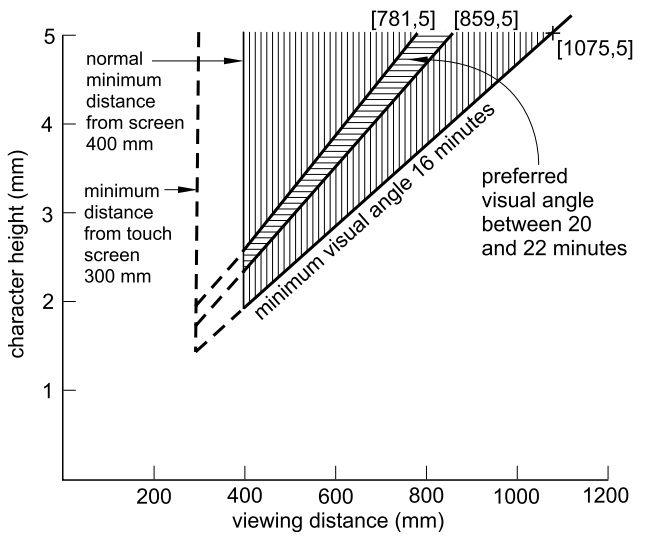
surface is the top of the keyboard) are available 30 mm lower. Chairs for sitting workers are now by legislation required to provide for vertical adjustment so that each individual can find the right relationship with the worktop. However, it is important that the feet remain in contact with the ground, and where this is not possible, footrests should be provided.

3.05 Computer work stations

Many office workers now work with visual display units (VDUs), and these introduce further requirements for comfortable and healthy working. People often find working at a screen tiring to the eyes. **2.8** gives the recommended dimensions for minimising fatigue; some people may need special spectacles. Most VDUs are placed at or above eye level so that normal bifocals do not help. Opticians are now used to supplying 'intermediate' spectacles with the normal bifocal facility for viewing the keyboard and material on the desk, with the upper part allowing focus on the near distance. This permits the VDU to be placed between 900 to 1000 mm distant from the user.



2.8 a *Computer workstation*



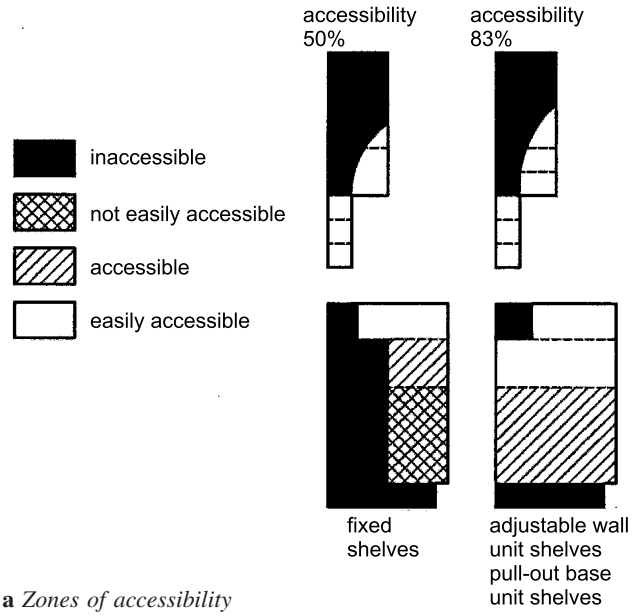
2.8 b *Viewing distance*

3.06 Storage

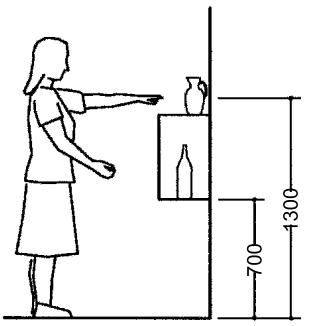
Two of the commonest operations at work and in the home is the stowage and retrieval of items into and from storage. **2.9** shows the recommended heights for various storage areas for general use; **2.10** gives particular requirements where elderly people are concerned.

3.07 Maintenance

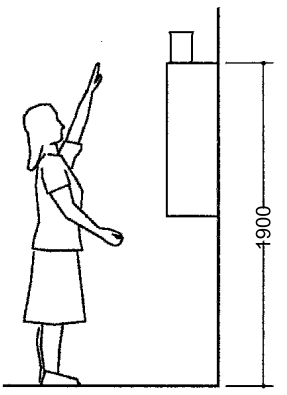
Buildings and the services and plant therein need constant maintenance. Something frequently forgotten is the need for easy access to certain areas. It is reasonable to assume that people employed on maintenance work will be sufficiently agile and not greatly above average size. The dimensions shown in **2.11** to **2.18** are therefore less than would be required for use by the general public.



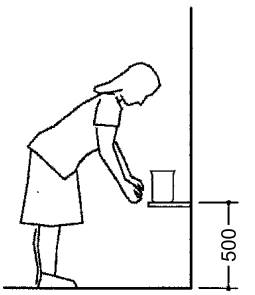
a *Zones of accessibility*



b *Frequently needed articles*

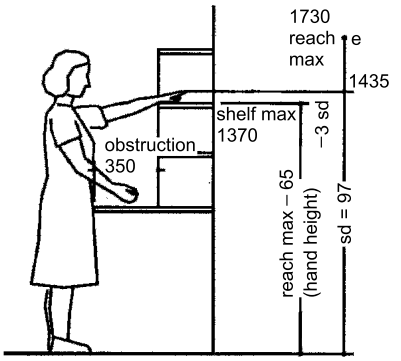


c *Less frequently needed articles higher*

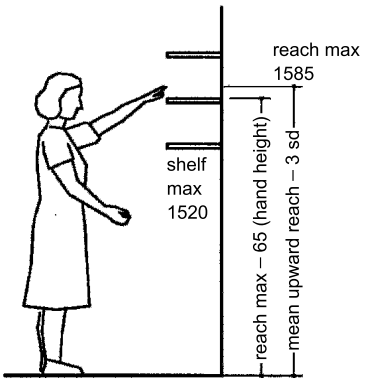


d *Less frequently needed articles lower*

2.9 *Accessibility of storage*

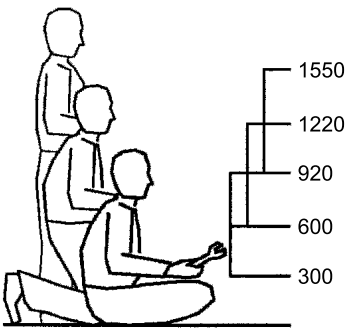


a *Maximum reach over worktop*

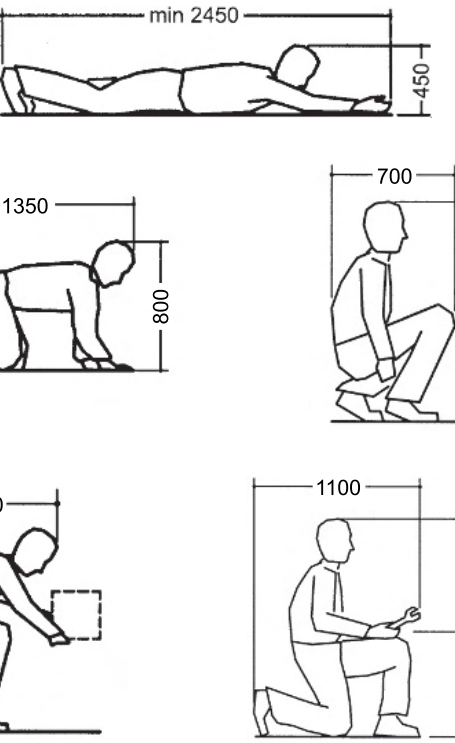


b *Maximum reach to unobstructed wall-mounted cupboard*

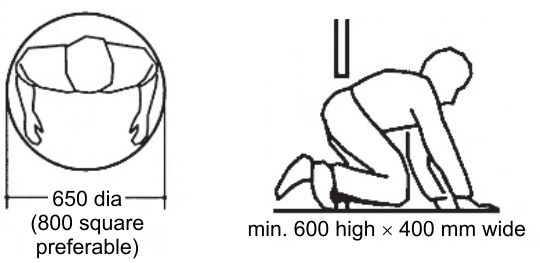
2.10 *Accessibility of storage used by elderly people*

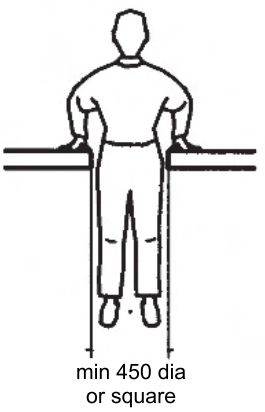


2.11 *Body clearance: maintenance reach levels*

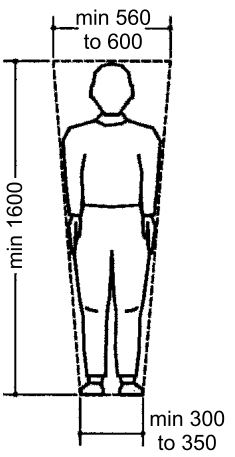


2.13 *Body clearances*

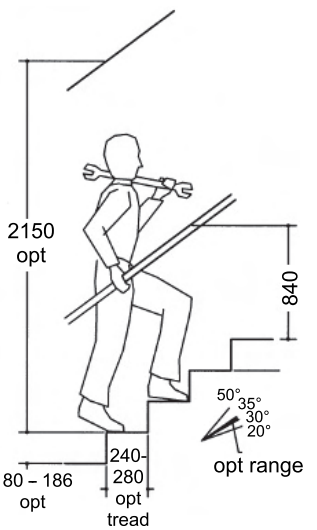




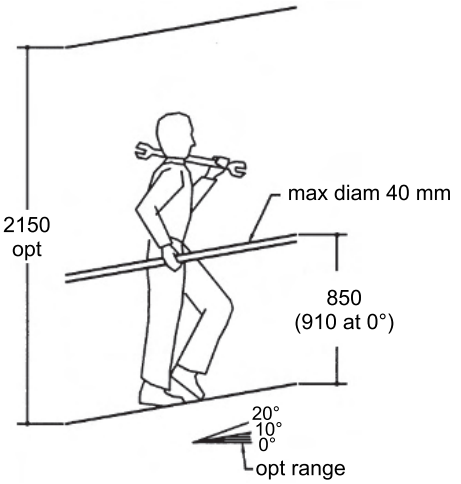
2.12 *Service accesses*



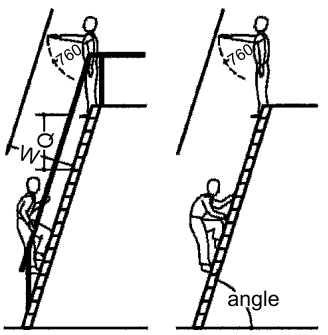
2.14 *Service access: catwalk*



2.15 *Service access: stairs*



2.16 *Service access: ramps*



recommended for angles 50° to 75°
handrails are required on both sides if risers are not left open or if there are no side walls
widths: 500 mm to 600 mm with handrails
600 mm min between side walls

angle	W(mm)	Q(mm)
50°–55°	1620°–1570°	880
57°–60°	1500°–1450°	900
63°–66°	1370°–1320°	910
69°–72°	1270°–1200°	920
74°–77°	1150°–1050°	950

recommended riser 180 mm to 250 mm
tread 75 mm to 150 mm
45 mm diam max for handrail

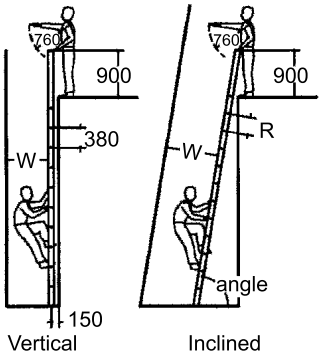
2.17 *Service access: step ladders*

4 DISABLED PEOPLE

4.01

At any one time about 8 per cent of people in Britain are in one way or another disabled. The principal disabilities of concern to the architect are those that mean the person has to use a wheelchair for most or all of the time. That person is handicapped by this in two significant ways: first, the eyes and arms are permanently at sitting rather than standing level, and second, the wheelchair itself takes up to five times the space needed by an ambulant person. While people in wheelchairs constitute only about one quarter of one per cent of the population, society has rightly decided that the design of most buildings should take their needs into account.

There are other forms of disability that are of importance to the building designer. People on crutches can be disadvantaged by ramps provided for wheelchairs, and all ramps should normally be paralleled by steps. Provision for blind people needs to be made



generally suitable for vertical movements from 75° to 90° ladder frame should extend 900 mm above platform
widths: 380 mm min, 450 mm desirable
600 mm min between side walls
150 mm toe space

angle	R(mm)	W(mm)
75.0°	330	1150
78.0°	335	1050
80.5°	340	1000
83.0°	350	950
85.0°	360	900
87.5°	370	850
90.0°	380 max 300 min	800

provide back guard over 6000 mm high

2.18 *Service access: rung ladders*

in the design of signs, raised letters being preferable to Braille, particularly in lifts. Lifts should ideally provide audible as well as visual indication of floor level.

Chapter 44 of this Handbook described inclusion design in greater detail.

4.02 People in wheelchairs

Wheelchairs are of three main types:

- Manually self-propelled
- Propelled by motor
- Propelled by attendant.

It is the manually self-propelled chair that is used by most active disabled people, and needs to be routinely catered for in buildings. **2.19** gives the dimensions relevant to this type of chair, and **2.20** and **2.21** has dimensions of men and women in such a chair.

4.03 Ramps

The most common provision made for wheelchairs is a ramp. However, most such ramps are difficult to use, both in mounting and in descending. Except for very short ramps (less than 0.5 m) they should be no steeper than 8 per cent (preferably 6 per cent) and unbroken lengths of ramp no longer than 10 m. For a rise of only 650 mm, therefore, a good ramp would take up a considerable area, **2.22**. The use of a chair lift or of ordinary lifts is therefore often preferable to a ramp, although these suffer from the need for adequate maintenance, and problems arise when they break down. Details of lifts designed for use by elderly and disabled people are given in Chapter 5.

4.04 Width of corridors

The other necessity for wheelchair users is adequate width and design of corridors and doorways. The width of a corridor should not be less than 900 mm for a self-propelled wheelchair, or 1.8 m if two wheelchairs are likely to want to pass each other, **2.23** to **2.26**.