1 Design Factors

1.1 FALLS AND DRAINAGE

INTRODUCTION

It is generally accepted as good practice for flat roofs to be designed to clear surface water as rapidly as possible and it would be exceptional nowadays for a roof to be designed without falls.

The ponding of rainwater is often observed on old flat roofs. As well as being unsightly and increasing the dead load on the roof, the consequences of waterproofing failure are obviously more serious if the area involved is not properly drained and allows a reservoir of water to collect, ready to feed into the building.

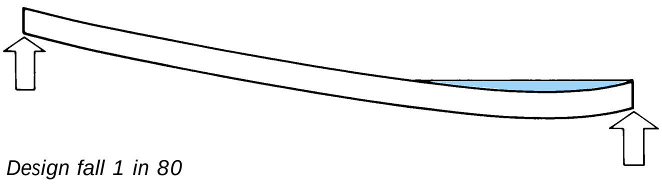
Falls may be formed in the structure or can be created within the specification above the deck. Falls in the structure can be achieved by adjusting the height of supporting beams or purlins, by using tapered supports, or by the addition of firring pieces before the deck is laid. The latter method is normally used with decks such as woodwool, timber, precast concrete and metal decking. In the case of an in-situ cast concrete slab, falls are normally provided by the use of a screed.

Preformed tapered insulation boards also provide a useful method of forming falls on a level roof deck, though they may not be suitable if a complex pattern of falls and cross falls is required.

DESIGN OF FALLS

Flat roofs should be constructed to a minimum fall of 1 in 80. To achieve this the designer needs to adopt a design fall which will allow for deflections and inaccuracies in construction.

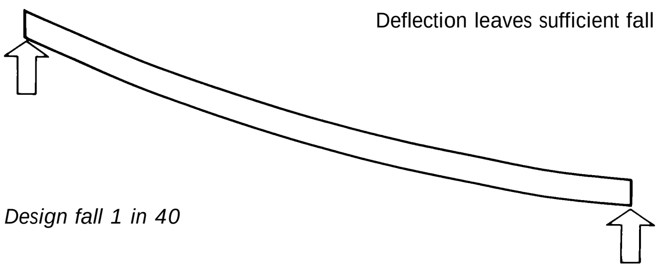
Deflection can produce ponding



Design fall 1 in 80

Some designers arbitrarily double the finished fall and adopt 1 in 40 as the design fall, assuming that this will always produce a finished fall of at least 1 in 80. An alternative approach is to choose an intermediate figure of 1 in 60.

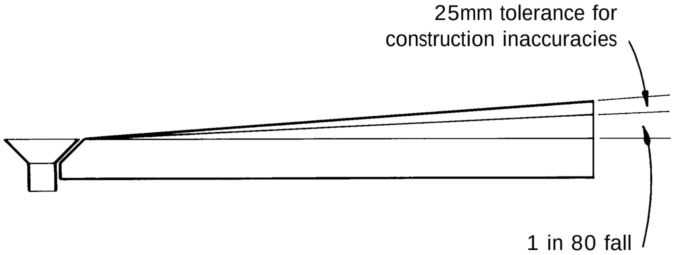
Deflection leaves sufficient fall



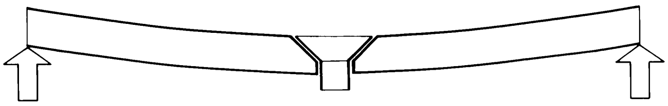
Design fall 1 in 40

On many occasions it is both practical and economic to design falls to 1 in 40, but on some buildings it will prove an unnecessarily severe design criterion. With screeded roofs in particular, doubling the screed depth at the highest points merely to allow for inaccuracies in the construction could cause an unnecessary increase in the thickness and cost of the roof system.

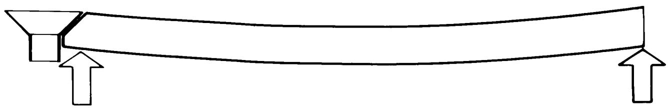
As an alternative, the designer should consider the accuracy and deflection of the roof in question and may find a reasonable compromise would be to take 1 in 80 as the finished fall, and add an arbitrary adjustment for construction inaccuracies, such as 25mm for concrete roofs or 15mm for metal decks.



Having chosen a minimum finished fall and an allowance for inaccuracies, consideration should then be given to the effects of deck deflection which may have a favourable or adverse effect on drainage flow.



Mid-span deflection of deck aids drainage

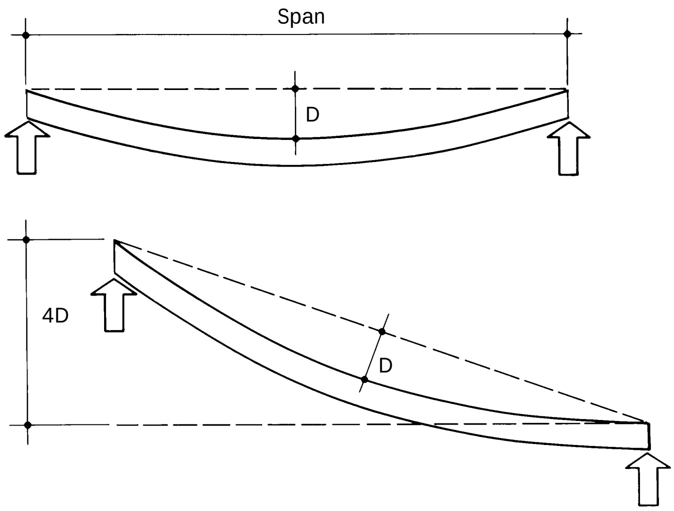


Mid-span deflection of deck restricts drainage

Outlets in the central area of the roof may be positioned at or near the point of maximum deflection of the deck, and any deflection would therefore assist the drainage flow. In practice, however, there is usually a need to position internal downpipes against columns or walls for support and protection, and this will mean that the outlets will be positioned away from the natural low point of roof deflection. Under these circumstances, the effect of mid-span deflection will be to reduce the fall to the outlet, and this should be taken into account when calculating the design fall.

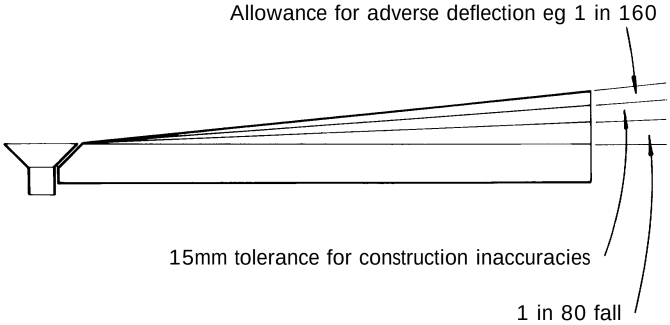
When allowing for these deflections it should not normally prove necessary to allow for deflections from imposed loads on the roof. The falls will ensure there is no significant load from standing water, and it is only necessary to take account of the dead load deflection.

Assuming that the deck takes a circular shape when deflecting, a reverse fall will be avoided entirely by raising one end of the deck by four times the deflection. For example a typical deflection for metal deck under dead load is span/650 in which case an additional fall of 4/650 or approximately 1 in 160 will compensate for deflection adverse to drainage. Some decks however are so stiff that their deflection due to dead load can be ignored.

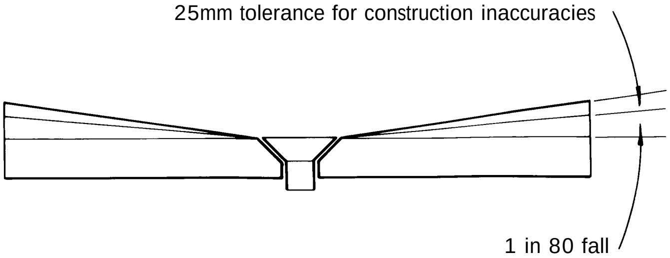


When the falls are provided by screeding, the deck deflection will be taken out by the application of the screed and no allowance need be made for deflection.

Where deflection is favourable to drainage, it should only be necessary to include an allowance for construction inaccuracies. The design fall could be reduced in line with the anticipated deflection but this would not be wise unless the designer is confident that the dead load deflection can be accurately predicted and the construction can be completed within design tolerances.



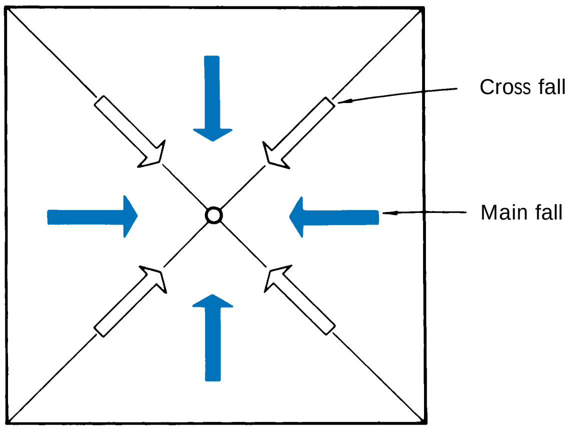
Adjustment of fall for adverse deflection



Adjustment of fall for favourable deflection

CROSS FALLS

At the junction of two roof surfaces with different directions of fall, a valley will be formed, known as a cross fall, and the effective slope of this will be less than that for the main falls.



Many designers favour the adoption of 1 in 80 for the cross fall, which on a square roof produces a main fall of 1 in 56. Similarly, if 1 in 40 is adopted for the cross fall, the main fall will be 1 in 28. The implications of this approach are a substantially increased volume and cost of screed and an increased parapet height to accommodate the extra depth of screed.

The alternative approach is to accept that a small reduction in the cross fall will not impair the efficiency of drainage. Assuming a finished fall of 1 in 80 to the main area, the cross fall will be 1 in 113 which is unlikely to cause any great volume of residual water after rainfall.

CONVERSION TABLE FOR FALLS

The fall is most commonly expressed as a ratio, such as 1 in 80, or as an angle, although it is sometimes convenient to describe it in terms of a percentage slope where by definition 1 in 100 is 1%. This is convenient for calculation as it expresses the fall in centimetres per metre run.

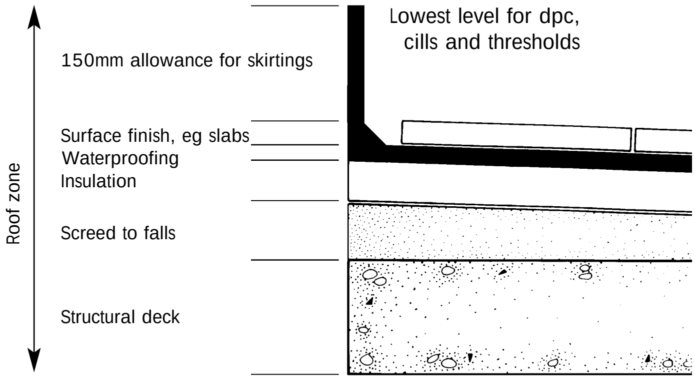
The relationship between falls, angles and percentage slope is indicated in table 1.1.

TABLE 1.1

Fall ratio	Slope angle	% Slope
1 : 120	0.5°	0.8
1 : 100	0.6°	1.0
1 : 80	0.7°	1.3
1 : 60	1.0°	1.7
1 : 40	1.4°	2.5
1 : 38.2	1.5°	2.6
1 : 28.6	2.0°	3.5
1 : 19.1	3.0°	5.2
1 : 14.3	4.0°	7.0
1 : 11.4	5.0°	8.7
1 : 9.5	6.0°	10.5
1 : 8.1	7.0°	12.3
1 : 7.1	8.0°	14.1
1 : 6.3	9.0°	15.8
1 : 5.7	10.0°	17.6

ROOF DRAINAGE

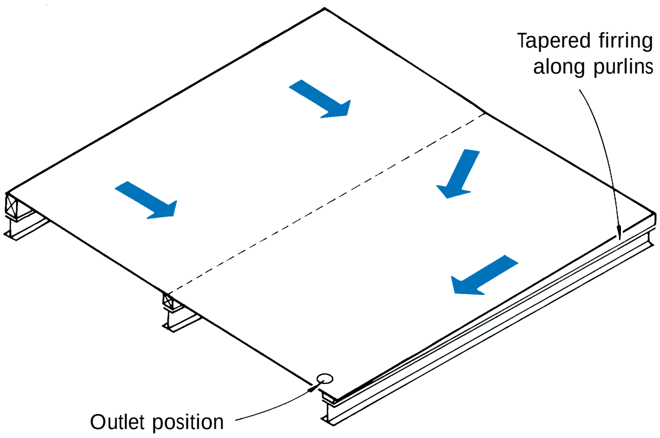
The design of falls and drainage patterns will have a considerable influence on the depth of the total roof construction or roof zone, which should be a fundamental consideration at the very earliest stages of conception of a building. It is only after assessing the depth of roof zone that the designer can decide the levels of all other aspects of construction above the level of the flat roof.



It is a common mistake to underestimate the depth of the roof zone, and only too often it is found on site that skirtings under windows and thresholds are too low and falls are inadequate. Unfortunately, designers tend to compromise on these aspects rather than increase the height of the higher level construction or decrease the size of windows or doors to ensure that good design principles can be adopted for an adjoining flat roof.

Flat roofs may be drained by two basic methods: towards the outer edges and into external gutters, or towards internal gutters or outlets within the main roof area. Straight falls to external gutters are simple to form by sloping the roof deck, by screeding or by using tapered insulation boards. Internal drainage will be achieved by straight falls to gutters or a pattern of falls and cross falls to outlets.

When the falls are created by a screed, it should always be possible to drain the whole roof efficiently, with falls and cross falls to outlets and without the use of gutters. If the falls are formed in the structure, a pattern of falls and cross falls will be difficult to achieve and straight falls to a gutter or to outlets will normally be incorporated. Falls between outlets can be provided by the addition of tapered firrings to the purlins between outlets or by introducing a fall in the purlins themselves.

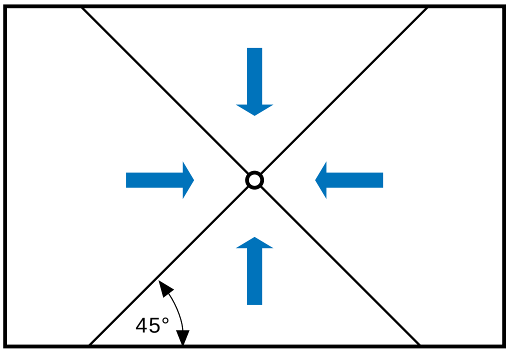


Where internal gutters are to be used, they should also be laid to falls and this may lead to a considerable depth of gutter at the low point. Dead level gutters are not normally recommended as they can hold a considerable quantity of standing water. It is better to omit the gutter and accept a construction which has flat sections of roof between outlets. Indeed, one of the advantages of flat roofs is the opportunity to avoid gutters and include a continuous wall-to-wall waterproof covering. As a generalisation, a well designed flat roof will contain a good number of outlets and no internal gutters.

TAPERED INSULATION

Most major insulation suppliers are able to design and supply suitable tapered insulation systems. These provide both insulation and falls and are of particular importance for re-roofing existing roofs, many of which do not have sufficient falls and probably do not have sufficient insulation.

Tapered insulation can provide falls in one direction to a gutter or level valley. Also falls in two directions to form falls and cross falls, but the intersection should be at 45° to avoid complex geometry.



Tapered insulation can be used to produce falls and crossfalls

Skirting heights are often a limiting factor for added insulation as it is necessary to leave a skirting height of 150mm whilst being sure that the top of the skirting does not rise above damp course level. If it is not possible to keep below damp course level the scheme should be abandoned or the entire wall face above the skirting should be fully protected from rainfall. The protection can be metal cladding or in the case of low parapets, the waterproofing can be taken to the top of the parapet and tucked in underneath the damp course beneath the coping. If this leads to a doubtful detail the waterproofing can be taken up and over the top of the wall.

Another possible design solution is to introduce a gutter along the foot of the skirting with little or no additional insulation in the sole of the gutter. This gutter may not be well drained and may suffer ponding but at least the rest of the roof can be to satisfactory falls and cut to falls insulation can displace ponding water on the majority of the roof area.

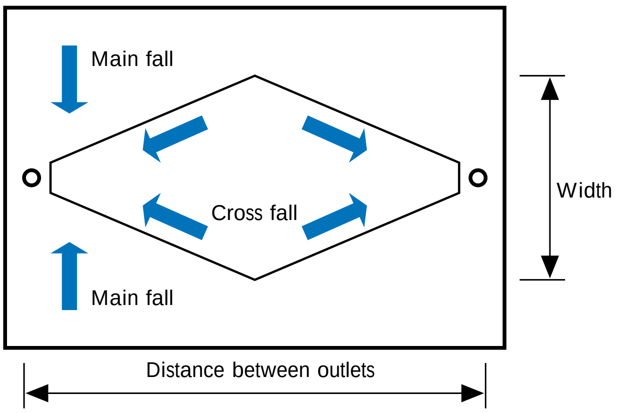
DRAINAGE CRICKETS

Drainage saddles or crickets may be used to improve drainage between outlets where a roof is installed to straight falls to an otherwise level valley. Crickets will displace standing water and provide a modest fall between outlets. They do not form fully efficient falls and cross falls and cannot be expected to completely eliminate ponding. In effect, crickets introduce a new valley with improved falls.

Pre-cut crickets are usually made available as part of a cut to falls service by insulation suppliers. The main falls are formed with tapered insulation, to falls of 1:60 or other suitable design fall. The crickets are wedge shaped to a fairly steep slope, probably 1:40. These are overlaid on the main insulation to a diamond shape on plan.

In practical terms there will be a limit to the maximum width of cricket between outlets, and this will limit the effective fall which can be achieved.

Table 1.2 gives the maximum width of cricket required in a valley, for a range of distances between outlets, the main fall of the roof and the crossfall required. In all cases the design fall will only be achieved if the original substrate is level, and the outlets are not positioned at high spots in the construction.



Crickets can also be used to improve local areas of ponding on existing roofs, particularly when re-roofing. In this case it will be necessary to carry out a survey of the levels involved, and to design special crickets accordingly.

DRAINAGE LAYOUTS

Internal rainwater pipes are usually positioned against the main columns and the options for positioning outlets will be limited. The outlets should be positioned to divide the roof into convenient drainage areas so far as this is possible.

If the level at the outlets is taken as zero, then the pattern of drainage can be drawn and the levels at the high points of the roof calculated.

There are many different approaches to the design of drainage patterns. The four typical drainage layouts overleaf show solutions for the design of drainage for a rectangular roof with two outlets.

For illustration purposes dimensions are based on a finished fall of 1 in 60 and any allowance for construction tolerances and deflections will depend on the type of specification used.

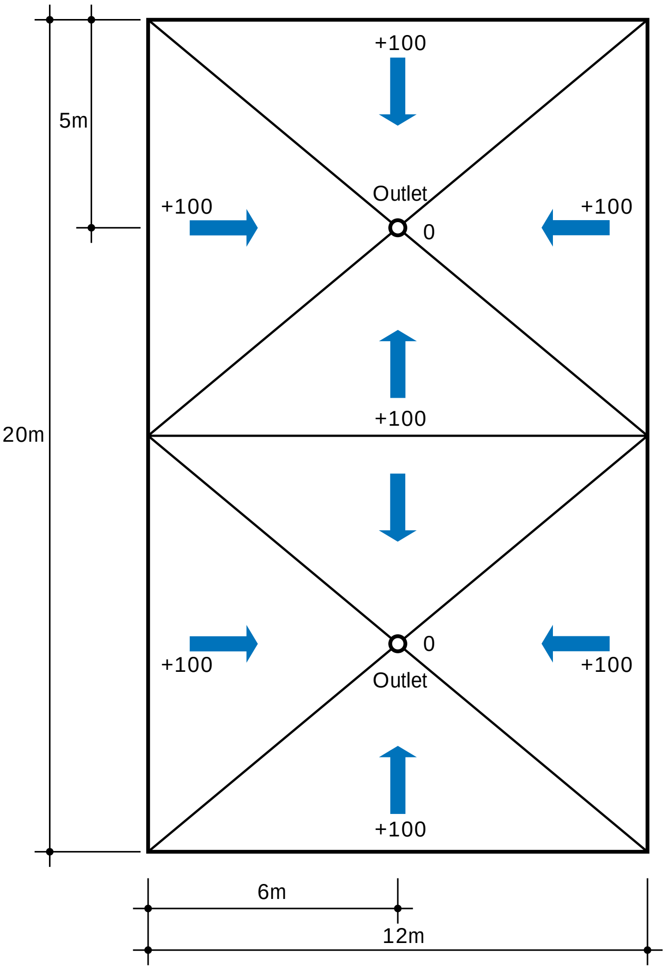
It can be seen that the effect of the gutter is to increase the height of the roof zone.

Maximum width of cricket required in valley (m)

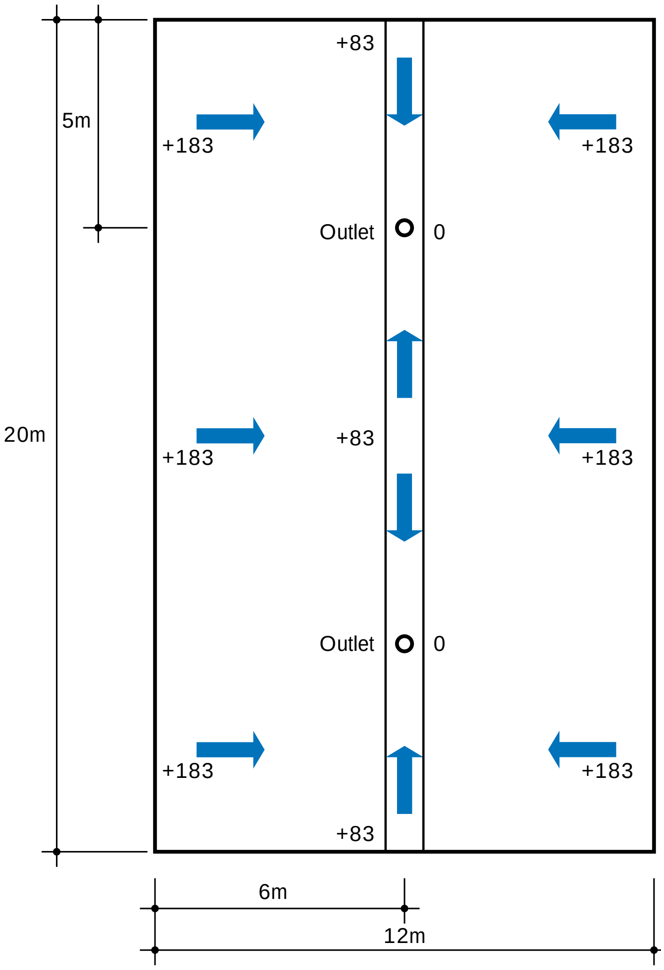
TABLE 1.2

Main fall 1:		40				60				80			
Cross fall 1:		100	110	120	130	100	110	120	130	100	110	120	130
Distance between outlets (m)	5	2.2	2.0	1.8	1.6	3.8	3.3	2.9	2.6	6.7	5.3	4.5	3.9
	10	4.4	3.9	3.5	3.2	7.5	6.5	5.8	5.2	13.3	10.6	8.9	7.8
	15	6.5	5.9	5.3	4.9	11.3	9.8	8.7	7.8	20.0	15.9	13.4	11.7
	20	8.7	7.8	7.1	6.5	15.0	13.0	11.5	10.4	26.7	21.2	17.9	15.6
	25	10.9	9.8	8.8	8.1	18.8	16.3	14.4	13.0	33.3	26.5	22.4	19.5
	30	13.1	11.7	10.6	9.7	22.5	19.5	17.3	15.6	40.0	31.8	26.8	23.4

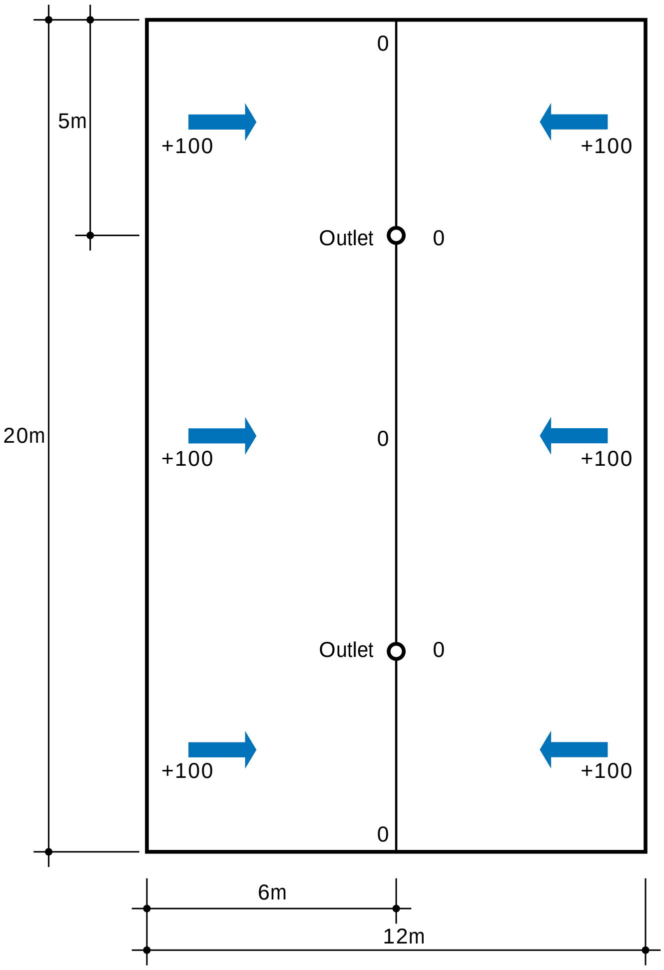
Typical drainage layouts



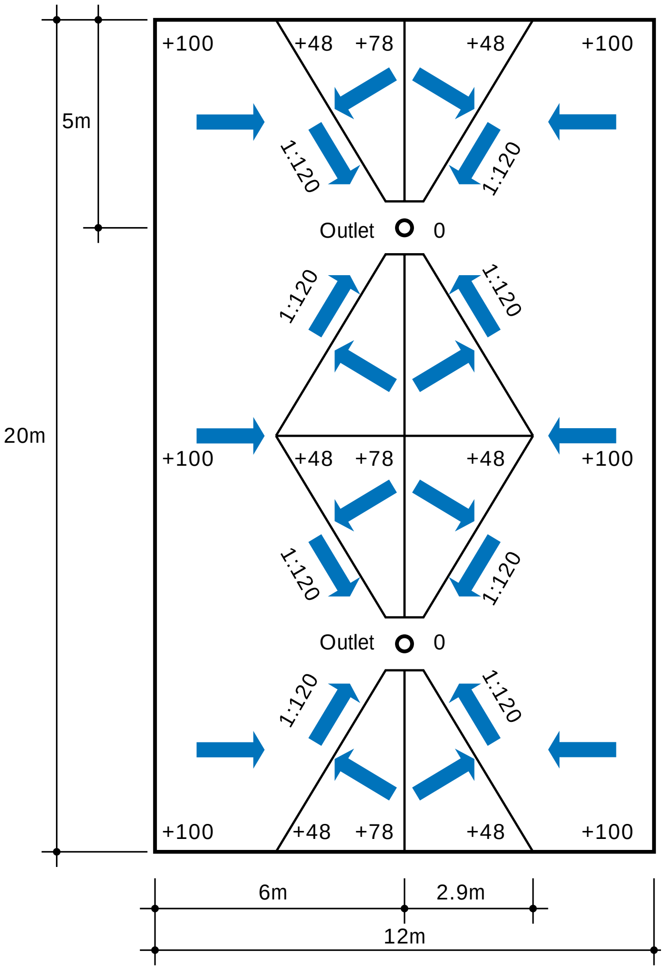
1. Screeded roof with main falls and cross falls



2. Straight fall to internal gutter. Gutter should also be to falls



3. Straight falls to valley gutter



4. Falls formed by tapered insulation, with crickets between outlets

RAINWATER OUTLETS

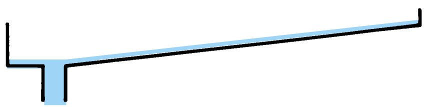
BS 6367:1983 Code of practice for drainage of roofs and paved areas, and the Plumbing Engineering Services Design Guide issued by the Institute of Plumbing give advice on calculation methods employed to design the roof drainage.

It is normal to adopt a rainfall rate of 75mm per hour as the basis of design for flat roofs in the UK, provided that any overflow will not cause damage to the building or its contents. The likelihood of this rate of rainfall occurring for two minutes is shown in rainfall map 1. It can be seen that there is less likelihood of this rate of rainfall being exceeded in Northern Ireland, Wales, Scotland and the north of England than in the rest of England. From the rainfall maps, it can be seen that, surprisingly, it is in the drier areas of the UK that the intensity of short bursts of rainfall is greatest.

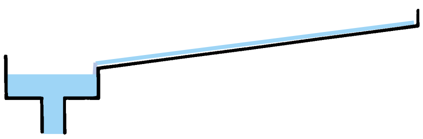
The industry intends to move towards standard rainfall rates expressed in litres per second and related to specific return periods. Work is proceeding on the preparation of a suitable presentation of data and is likely to be available with the appropriate European standard in due course.

The rainwater will flow over the roof area as a relatively thin surface film, perhaps only a few millimetres deep, depending on the length of run to the outlet, the texture of the roof surface and the fall. The recommended fall of 1 in 80 will ensure that the water remains a thin layer on the roof if suitable outlets are provided.

Rainwater discharges into the outlets at a rate depending on the head of water at the outlet. It will collect in the gutter or on the roof until the head of water at the outlet has built up sufficiently to discharge the rainwater as fast as it falls on the roof. A small increase in the head of water will produce a substantial increase in the rate of flow and it does not matter whether the head is produced on a dead level roof, a roof to falls or in gutters or sumps.



Roof to falls



Gutter or sump

The flow of the water into the outlet can be of two types; weir flow or orifice flow. Weir flow is the free flow of water over an edge with an unrestricted drop. The flow of water into outlets will be by weir flow when the water is relatively shallow, and can be assumed to act when the depth of water does not exceed half the top diameter of the outlet. For greater depths of water, weir flow is prevented and orifice flow takes over. Orifice flow causes a vortex or swirl to form and the efficiency of the outlet is reduced.

Tapered outlets are more efficient than those with a uniform diameter. If the vertical dimension of the taper is at least equal to the top opening and if the diameter of the top opening is not more than one and a half times the downpipe size, the calculation of flow can be based on the top diameter. This is called the effective diameter.

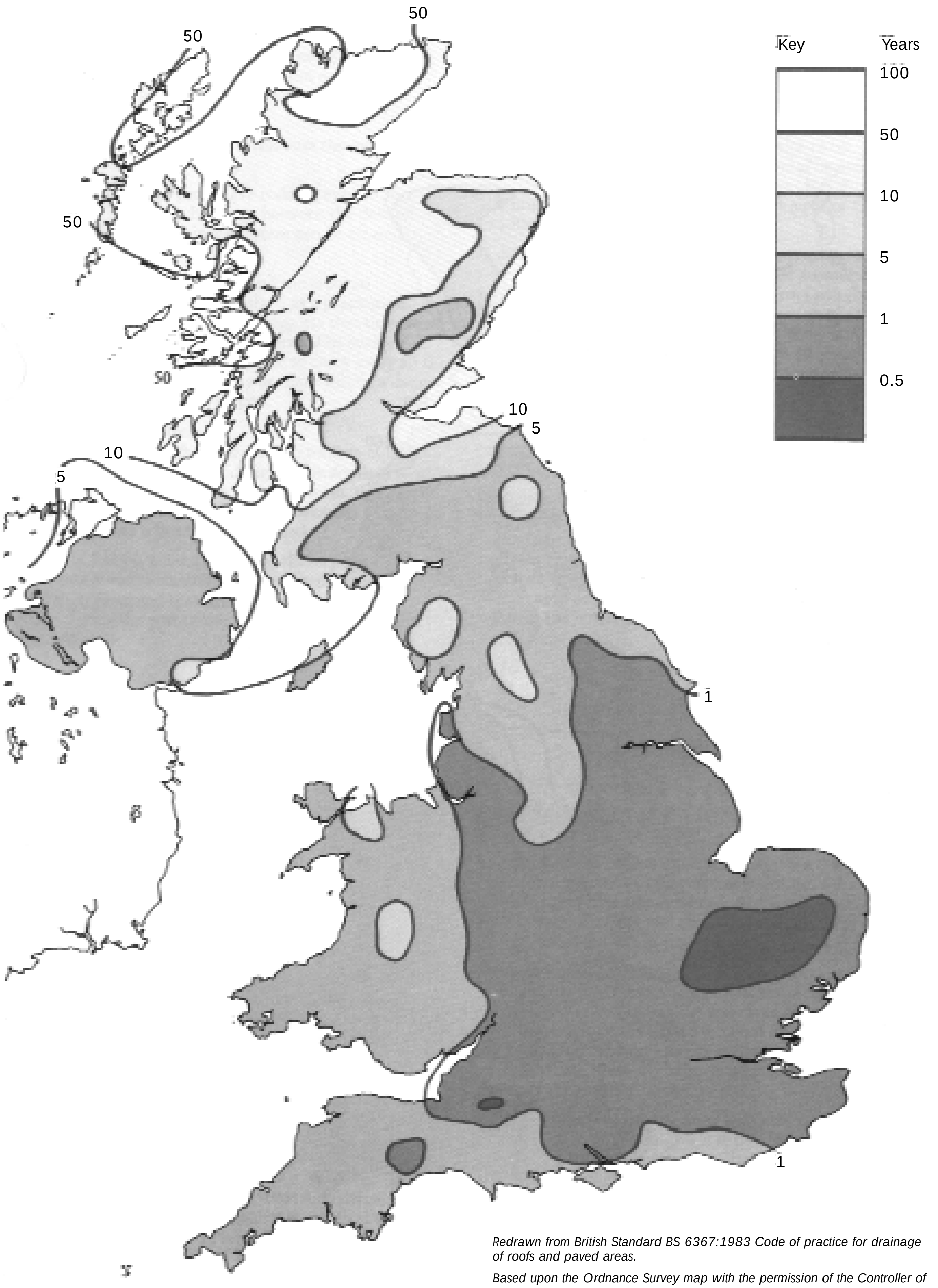
If the taper of the outlet is greater than that given above, calculations for flow should be based on a maximum design outlet diameter of one and a half times the diameter of the downpipe. The alternative is to subject the outlet to hydraulic tests to establish the relationship between the rate of flow of the water and the depth of water above the outlet. Most manufacturers of proprietary systems will supply information on flow rates, quoted in litres per second. Table 1.3 shows the relationship between area drained and flow rate for a rainfall rate of 75mm and 150mm per hour.

Roof area drained for different flow rates (m^2)

TABLE 1.3

Flow rate L/s	Design rainfall mm/hr	
	75	150
1	48	24
2	96	48
3	144	72
4	192	96
5	240	120
6	288	144
7	336	168
8	384	192
9	432	216
10	480	240
11	528	264
12	576	288

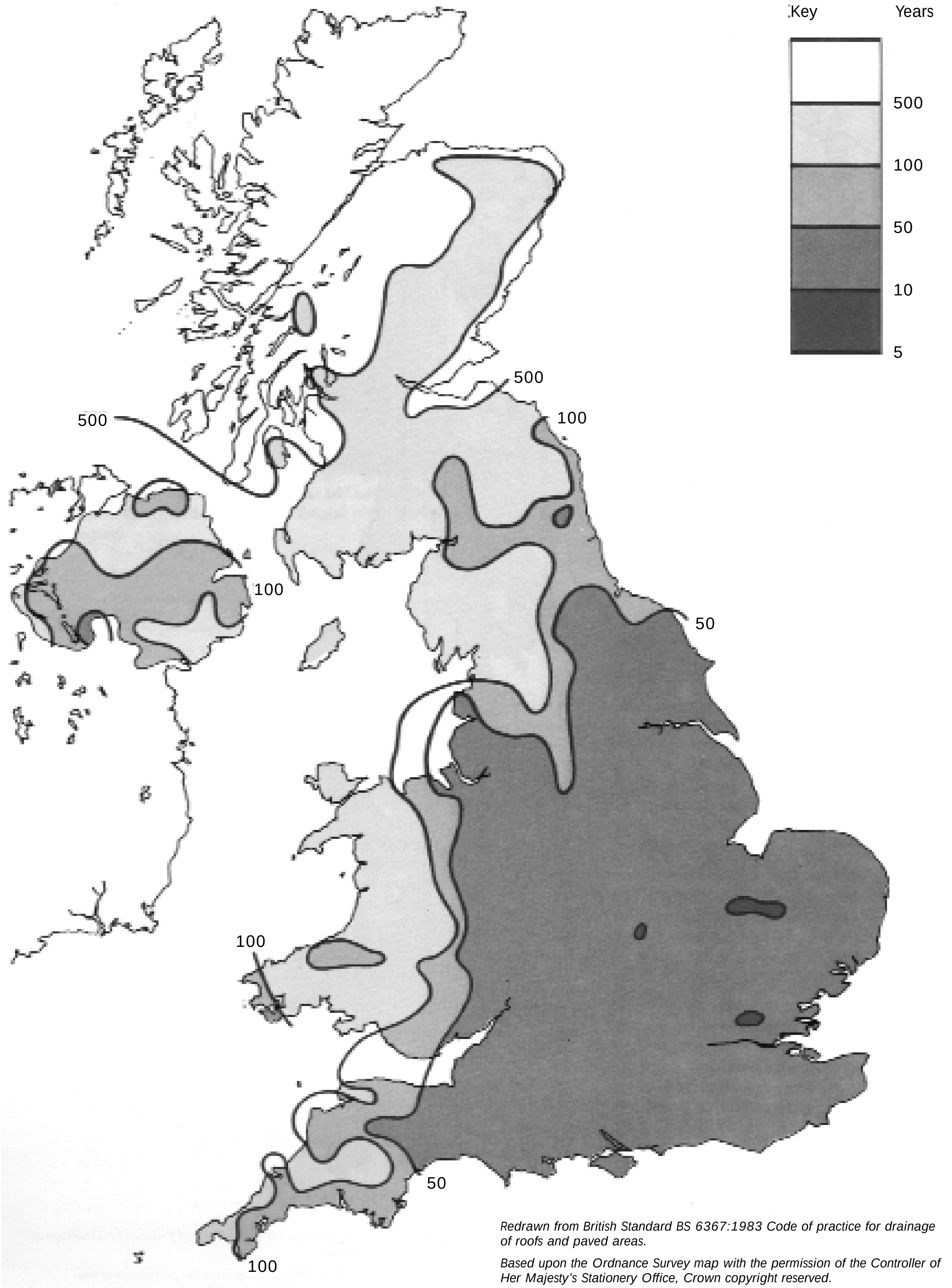
Rainfall map 1: Period in years between events of 75mm per hour for 2 minutes



Redrawn from British Standard BS 6367:1983 Code of practice for drainage of roofs and paved areas.

Based upon the Ordnance Survey map with the permission of the Controller of Her Majesty's Stationery Office, Crown copyright reserved.

Rainfall map 2: Period in years between events of 150mm per hour for 2 minutes



Redrawn from British Standard BS 6367:1983 Code of practice for drainage of roofs and paved areas.

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GRAVITY SYSTEM

The traditional rainwater disposal system allows rainwater to fall freely through the downpipes under the influence of gravity. The size and position of downpipes is chosen so that water drains fast enough to prevent an excessive head of water at the outlet. The rainwater pipes do not fill up with water and the flow is by "trickle down" the sides of the pipes. The proportion of water in the downpipes at maximum design flow is in the order of one third full, the remaining two thirds is air.

Bends in the downpipes and horizontal runs are kept to a minimum. Horizontal runs which cannot be avoided should be installed to falls.

All internal downpipes should have rodding eyes at floor level, positioned so that a blockage between the downpipe and the surface water drainage system can be cleared by rodding.

The junction between the outlet and the internal downpipe should be sealed or caulked as a precaution against backing up, but experience suggests that these seals are not always effective in the long term. The surface water drains must be of sufficient size to carry away all the water from the roofs immediately or there will be a danger of water backing up the downpipes.

The traditional gravity system usually entails a large number of downpipes from roof to ground. A comprehensive system of ground drains is also required to connect up with all the downpipes.

GRAVEL GUARDS

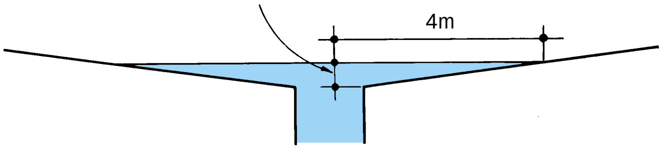
Gravel guards are normally necessary on all outlets where the downpipe size is less than 150mm diameter. If the downpipe is 150mm diameter or more and it discharges as a straight drop from the outlet with a single bend to the main surface water drainage system, it may well be regarded as a self-cleansing system. Although gravel guards will normally be used they are not necessarily required and may be omitted if the downpipe can be regarded as self-cleansing.

The provision of gravel guards introduces the need for routine inspection and cleaning.

AREA DRAINED BY OUTLETS

The majority of flat roofs are drained to rooftop outlets only, and the crucial aspect of design is the depth of water at the outlet. On a roof to falls during a storm, the water will collect over the roof area local to the outlet to form a natural sump, and a head of water will be formed.

If the fall is 1 in 80, a head of 50mm will be provided by a natural sump which extends 4 metres from the outlet. It should be appreciated that this will only occur for a few minutes during the part of the storm which gives rain at 75mm per hour.



The roof area drained by a single outlet can be calculated in accordance with BS 6367:1983. Alternatively as an aid to design, table 1.4 gives the roof areas which will be drained by straight drop outlets or tapered outlets. The table is based on a rainfall rate of 75mm per hour taking into account weir and orifice flow as appropriate, and the capacity of the downpipe. For a rainfall rate of 150mm per hour, the values in the tables should be halved. A similar pro-rata adjustment can be made for other rainfall rates.

Where there is a substantial area of wall projecting above the level of the roof and draining onto the roof, this must be allowed for when calculating the total area to be drained. In the case of only one wall, the effective additional area can be taken as half the exposed vertical area of the wall. Further guidance for other configurations of walls is given in BS 6367:1983.

Flow through gravel guards can only be accurately predicted by hydraulic testing. In the absence of test information, it is generally accepted that a flow reduction of 50% can be taken as a reasonable safe assumption. Table 1.4 is worked on this basis to show the nominal effect of gravel guards.

The flow of water through outlets will be reduced if water cannot approach them from all directions. Table 1.4 can be taken to represent the case of an outlet which is placed sufficiently far from a wall or sides of a gutter to allow a flow of water between the wall and the outlet.

It will be seen from the table that the roof area to be drained is influenced more by the head of water at the outlet than by other factors. BS 6367:1983 recommends a design head of up to 30mm but an increased head will provide increased flow and may well be appropriate with large outlet sizes. It is suggested that 30mm be used for the design head of water at outlets with downpipes up to 100mm, and 50mm design head for downpipes of 125mm to 150mm.

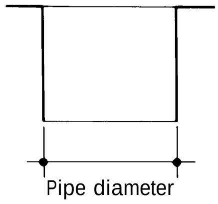
These design heads will be associated with a significant load from the depth of water on the roof. 30mm of water produces a load of 0.3kN/m^2, and 50mm produces 0.5kN/m^2.

Areas of roof drained by outlets

TABLE 1.4

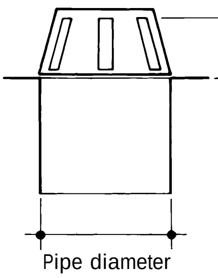
Area of roof drained (m^2) by one straight drop outlet without gravel guard

Pipe dia. mm	Head of water mm 15	20	25	30	35	40	45	50
50	19	29	40	44	47	51	54	57
65	24	37	52	68	80	86	91	96
75	28	43	60	79	99	114	121	127
100	37	57	80	105	133	162	193	226
150	56	86	120	158	199	243	290	339



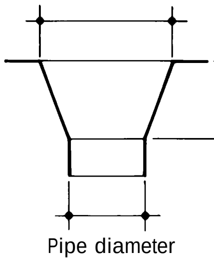
Area of roof drained (m^2) by one straight drop outlet with gravel guard

Pipe dia. mm	Head of water mm 15	20	25	30	35	40	45	50
50	9	14	20	22	24	25	27	28
65	12	19	26	34	40	43	45	48
75	14	21	30	39	50	57	60	64
100	19	29	40	53	66	81	97	113
150	28	43	60	79	99	121	145	170



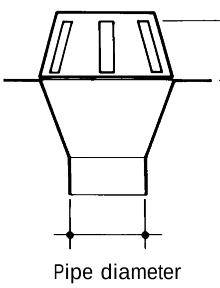
Area of roof drained (m^2) by one tapered outlet without gravel guard

Pipe dia. mm	Head of water mm 15	20	25	30	35	40	45	50
50	28	43	60	79	85	85	85	85
65	36	56	78	103	129	158	170	170
75	42	64	90	118	149	182	217	250
100	56	86	120	158	199	243	290	339
150	84	129	180	237	298	364	435	509



Area of roof drained (m^2) by one tapered outlet with gravel guard

Pipe dia. mm	Head of water mm 15	20	25	30	35	40	45	50
50	14	21	30	39	50	57	60	64
65	18	28	39	51	65	79	94	108
75	21	32	45	59	75	91	109	127
100	28	43	60	79	99	121	145	170
150	42	64	90	118	149	182	217	255



SYPHONIC SYSTEMS

The drainage layouts of large buildings can often benefit from the use of a syphonic disposal system. The syphonic principle normally uses short drops from outlets to exposed horizontal pipes under the roof deck. These discharge rainwater into a downpipe to ground. The pipes run at full bore at the design flow rate.

Rainwater is collected through specially designed outlets which are open only at the periphery, and include a central baffle. This arrangement allows water to enter by weir flow and prevents air entering the outlet through the centre. Additional vertical baffles can be incorporated to prevent the formation of a vortex or swirl.

In practice under fast flowing conditions the outlet is covered over with turbulent water at a quite substantial head. The head to drive fully efficient syphonic flow needs to be in the order of 50mm to 80mm depending on the design of the outlet. In order to produce this head, it is common practice to place the syphonic outlet in a gutter or sump.

When rain is not falling heavily, the outlet will not be covered over with water, and a sufficient head for syphonic flow may not develop. Air will enter the downpipes through the outlets and the system will remain a traditional gravity system with "trickle down" drainage. In heavy rain the amount of air contained in the pipes will reduce and syphonic flow will develop when the proportion of air is down to about 40%. The air will then move along with the water, and when maximum storm conditions occur the pipes will be almost full of water with very little air content.

The entire syphonic system will usually feed into only one or two downpipes. The individual outlets feed into horizontal pipes located immediately under the roof. A large number of outlets can be connected by the horizontal run into a single downpipe. The syphonic system is designed with relatively small diameter outlets feeding into carefully designed horizontal and vertical runs which are sufficiently restricting to ensure the system runs with pipes full of water, and with a minimum of included air. The speed of flow is restrained only by the friction of the water against the pipe walls, and the restriction formed by bends and junctions. It is the careful design of the friction and resistance which controls the flow rate and maintains the syphonic action. The essence of the design is to make sure the pipework is small enough for the system to run at full bore.

The design procedure is complex and will normally be carried out using technology and computer programmes developed by suppliers of proprietary systems.

The increased efficiency of syphonic systems generally allows a reduction in the number or size of outlets on a roof, but the location of the outlets needs careful design in order to maintain a balanced system. It will be wise to consult the suppliers at an early stage.

The pipework of a syphonic system is under significant positive or negative pressures and the system must be balanced to avoid excessive pressures which could cause severe damage. All joints are sealed and may be welded, usually in the factory, with completed sections delivered to site with special connectors for site connection and welding. The extra cost of the relatively sophisticated units is offset by the reduced numbers of outlets and downpipes and the greatly simplified ground drainage.

Syphonic outlets are designed to give specific flow rates when the system is at full bore. Standard outlets with flow rates of 6 litre/s and 12 litre/s are common. At a rainfall rate of 75mm per hour these can drain a flat roof area of 288m^2 and 576m^2 respectively providing the system has been designed accordingly.

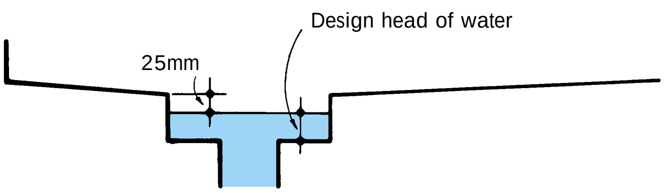
The depth of coverage of a syphonic roof outlet will determine its capacity, at 35mm its capacity is typically half its normal rating, at 50mm it is equal to its nominal rating, and at 80 to 100mm its capacity may in suitable circumstances be increased to twice its nominal rating.

With a syphonic system it is particularly important to choose an appropriate design rainfall rate, because the system will usually have only a small margin of excess capacity above its designed capacity.

Any enclosed roof area should be drained by at least two outlets to allow for the risk of blockage. Regular inspection is necessary to ensure gratings are kept clean and clear.

SUMPS AND GUTTERS

Sumps and gutters allow a shallow flow of water over a long periphery into a deep collection space. The depth of water can then build up to form a substantial head at the outlet to drive the maximum amount of water into the rainwater drainage system. In order to achieve weir flow, the depth of the sump or gutter must be equal to the design head of water at the outlet plus at least 25mm.



During a 75mm per hour storm lasting for a few minutes, sumps and gutters will fill extremely fast until the depth of water is equal to the design head. At this stage an equilibrium will form and the water will discharge down the outlets as quickly as it arrives.

AREA DRAINED BY SUMPS

The area drained by an outlet/sump assembly needs to be considered in two stages. The area drained by the outlet itself must first be calculated or taken from table 1.4. Secondly, the sump size must be chosen so that the rate of drainage into the sump is matched to the rate of drainage through the outlet.

Table 1.5 gives the area drained by a given head and periphery of sump. From this it is possible to judge the periphery which is necessary to discharge water into the sump at the same rate as the outlet discharges water into the downpipe. There is no reason why sumps should be made larger than this and no increased flow will result from the outlet/sump assembly, unless the size of the outlet is also increased.

As with rooftop outlets, the designer must decide what design head he will allow for flow of water into sumps and again this is a rather arbitrary decision. BS 6367:1983 recommends 30mm or less.

The area of roof which will drain to sumps of the size given in table 1.5, assumes that the flow of water is from all directions.

When the sump is positioned in such a way that the flow of water to one or more sides is obstructed, the effective perimeter of the sump will be reduced pro-rata and reference should be made to the effective periphery column.

Area of roof (m²) drained into sumps

TABLE 1.5

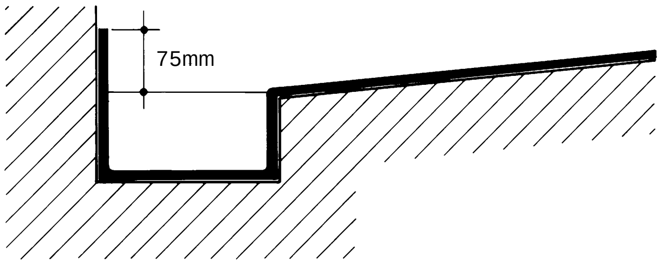
Sump size mm	Effective periphery mm	Head of water mm					
		5	10	15	20	25	30
500x500	2000	45	126	232	358	500	657
600x600	2400	54	152	279	429	600	789
700x700	2800	63	177	325	501	700	920
800x800	3200	72	202	372	572	800	1052
900x900	3600	80	228	418	644	900	1183
1000x1000	4000	89	253	465	716	1000	1315

GUTTERS

Gutters have such a long edge that shallow weir flow over the side will always take place regardless of the roof area to be drained and there is no need to check this by calculation. It is only necessary to calculate the size of outlet to discharge water at the required rate.

Lined gutters are no more than a waterway and the size of the gutter is immaterial other than the provision of a suitable depth to provide the design head of water in the gutter plus 25mm to ensure free weir flow into the gutter. If lined gutters are thought to be necessary, it is important to make sure that they are suitably shaped for the installation of a satisfactory waterproofing. It is recommended that the sole of the gutter is at least twice the maximum depth of the gutter and not less than 300mm wide after insulation and waterproofing.

Parapet gutters should have the skirting height against the parapet at least 75mm higher than the main roof area to accept overfilling of the gutter.



It must be remembered that if designing for 75mm per hour, the design depth is likely to be exceeded occasionally in the southern part of England where 150mm per hour will occur from time-to-time. In these areas a reserve of head will occasionally prove useful and a flat roof will always provide this by forming a reservoir if the gutter overflows. The level of water building up on the roof is only likely to rise a few millimetres, not enough to cause any concern and not enough to call the height of upstands into question.

If the roof membrane is not taken continuously through an internal gutter, but is merely turned into it with a drip edge, there must be a risk of rainwater entering the building in the event of overflow of the gutter. Under these circumstances a rainfall rate of 75mm per hour will not be sufficient, and the rate to be used for design will depend on probability based on the design life of the building and safety factor required as given in BS 6367:1983. An emergency overflow should be included in the design to ensure that in the event of overfilling, the overflow of water is to the outside of the building in a position which will cause no harm. The overflow should be arranged to operate at 5mm above the water level associated with the design head.

Sumps and gutters may tend to block from silting up or from blown or washed leaves, twigs or industrial residues and regular maintenance inspection becomes even more important.