Rainwater questions about Part 3 of BS EN 12056

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Introduction

This paper is the result of a technical seminar presented to the CIBSE Society of Public Health Engineers on 21st April 2009, at the Building Centre, London. Several of the presentation slides included images from Part 3 which are subject to copyright law and therefore cannot be made available electronically. There were some interesting contributions from ‘the floor’, which I have reflected on prior to preparing this paper. To avoid a cumbersome use of text, there is a list of abbreviations and a bibliography at the end of this paper. The diagrams in this paper should not be considered in isolation from the explanatory text.

Is there any specific recommendation in relation to gutters likely to be subjected to repeated deposition from foliage and other debris due to the proximity of trees?

Part 3 and the ADH make no reference to design or installation allowances to combat foliage problems, such as the provision of leaf guards. Interestingly there is no specific requirement for harvesting systems in the UK, although some American Codes prohibit trees higher than the roof within a 6m radius. All gutters designed in accordance with Part 3 are required to include a 0.9 freeboard factor (reducing the capacity of the gutter to 90%). This should ensure that gutters can still convey the design flow with limited deposition. If it was considered that the gutter is likely to suffer from large amounts of deposition, the designer could specify leaf guards or increase the freeboard factor to say 0.8. This factor would follow the ethos in Table NA.14 of BS EN 752. Whatever measures are included, the client needs to be made aware that debris removal must be part of the routine planned maintenance.

What is a ‘typical roof’ having a 2 minute time of concentration?

The time of concentration is the time taken for the water to run from the furthest part or the roof to the rainwater system. Therefore a two minute duration can be considered typical for tiled or slated pitched roofs and traditional flat roofs having a flat finish. A glazed pitched roof would be expected to produce a shorter duration and an inverted or green roof would be expected to produce a longer duration. The designer needs to make a professional judgement about what is relevant to the rainwater design.

What storm return period should be used for a standard building having a flat roof enclosed by parapets?

Some engineers consider that a 1 year return storm is adequate. Conversely, for many users, Part 3 implies that a 1 year return storm is not sufficient, because this type of roof is theoretically a type roof with no natural escape route for excess water. The ADH implies that a 1 year return is not adequate and refers to Part 3. Although the text in Part 3 actually states that 1 year storm is the minimum that should be used for fascia gutters and flat roofs. There is a design example in the IoP (now CIPHE) Design Guide where a flat roof for a ‘typical spec office block’ is assigned a 60 year return storm, although there is no mention of any emergency overflow facilities. In order to form a rational view we need to recognise that typical flat roof conditions during a severe storm are very different to other types of entrapped collection areas where the water is forced to converge at restrictive areas.

How many flat roofs are there in the UK that were designed on the basis of 75mm/hr, built 30 years ago or longer, with no overflow provision, and have never suffered from flooding due to the intensity of the storm exceeding the design basis? Probably many thousands! The reason for this satisfactory history is the fact that flat roofs behave very differently than valley, parapet or boundary wall gutters, where the run-off from the catchment area is concentrated at a ‘channel’. It can be shown by basic calculation that the quantity of water falling (in excess of a 2 min M1 event) on a typical flat roof area served by one outlet (say 12 x 12m) during storms up to M200 would result in the water level at the outlet increasing by only a few millimetres in depth. This is because the volume of water would form a pond around the outlet, with the size of the pond being determined by the water volume and the inverted pyramid that is typically formed by the roof gradient around an outlet. If the pond does not compromise the structural safety and the weathering system then it can be considered to be acceptable. The standard for structural roof design BS 6399, requires that roofs must be safe when subjected to the worst case scenario created by either, uniform snow loading, loading created by snow drifting, a minimum concentrated load or a minimum uniform load. The requirements suggest that typical roofs can easily tolerate some ponding around an outlet. It is also interesting to note that something as important as structural safety is normally based on a snow ‘probability of exceedance of 0.02’ (50 years).
The conclusion is that if an overflow outlet is provided for a typical flat roof outlet, the overflow function is unlikely to operate in the majority of storms exceeding the design because the overflow water level will rarely be reached, if ever! Although it remains important to provide an overflow in case flow through the main outlet is impeded for any reason. So given the foregoing, a suitable return period needs to be determined.

We know that 75mm/hr has been used for decades, but the 1 year return map gives intensities that equate to less than this for some regions. We should also consider that BS 6399 recommends 75mm/hr as a minimum design figure, and we should not forget the possible effects of climate change.

Considering all factors the suggestion is that a 5 year return could be regarded as a minimum value, which will be suitable for the majority of flat roof applications. It is also interesting to note that in Germany, DIN 1986 requires that flat roofs are protected from a 100 year storm as a minimum requirement.

If a 2 min M5 event was used for a flat roof in London, the intensity is 0.036 L/s/m², and if overflow outlets of equal capacity as the main outlets was provided, the combined capacity would be 0.072 L/s/m². This would provide protection for more than a 100 year storm.

What are the problems associated with the determination of risk category and building life to determine a return period?

Several current and previous standards make it clear that the design engineer is ultimately responsible, although the clients view on building life and the required level of assurance will need to be considered. The risk assessment should strike a suitable balance between too low or too high investment. The problems associated with this judgement are shown in Table 1 opposite:

CIRIA notes that events occurring with a frequency of 200 years or more are regarded as ‘catastrophic’ incidents by insurers. Examples of such incidents are a hurricane, earthquake or tornado: These are disastrous events which often result in demolition or major reconstruction. This would suggest that rainwater systems should not be based on a storm of 200 years or longer unless there is a specific reason to justify the cost and environmental impact, such as:

- The building will house ‘priceless’ or irreplaceable objects.
- The building will house important records or equipment of national or strategic importance.
- The organisations management plan requires increased protection of the facility to meet business operational requirements.

The foregoing logic suggests that Category 3 and 4 should only be used in extremely sensitive applications.

To address the ‘low investment’ issues noted in Table 1, there seems to be a consensus amongst PH Engineers that there should be a national minimum storm return period for valley, parapet and boundary wall gutters. This would give designers a ‘base line’, although they would be able to increase this value where appropriate. A storm return period of 50 years might be considered to be an absolute minimum for these type of applications.

Part 3 does not explain whether it is acceptable to consider the combined flow resulting from the main outlets and overflow outlets in order to satisfy the design storm conditions and protect the building. Many siphonic system specialists recommend that these systems are not subjected to a high design intensity (0.03 L/s/m² is often used as a maximum value) otherwise there is a danger that the siphonic system will operate under gravity flow conditions through long periods of use leading to deposition and other problems. Consequently when a high design intensity is required for a building to be drained by a siphonic system it is often necessary to use a primary and a secondary (overflow) system to meet the design flow conditions.

Table 1: Risk assessment issues

<table>
<thead>
<tr>
<th>High investment</th>
<th>Low investment</th>
</tr>
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<tbody>
<tr>
<td>High installation cost, which may have a ‘knock-on’ effect to drainage work or associated builders work.</td>
<td>Part 3 has no minimum prescribed level, anything is possible, e.g:</td>
</tr>
<tr>
<td>Ly = 10 yrs</td>
<td>Ly = 10 yrs</td>
</tr>
<tr>
<td>Category = 2</td>
<td>Category = 2</td>
</tr>
<tr>
<td>Return = 15 yrs</td>
<td>Return = 15 yrs</td>
</tr>
<tr>
<td>Low flow rates leading to a self-cleansing velocity rarely being achieved.</td>
<td>Neither the designer nor the approving authority has a minimum level of acceptability.</td>
</tr>
<tr>
<td>Conflict with good sustainability. e.g. Increased energy consumed to manufacture, transport and install a larger pipe than is required.</td>
<td>The designer might be forced into using low design data in a design/build or in a speculative build situation. The eventual purchaser has no idea about the likely reliability of the design.</td>
</tr>
</tbody>
</table>
Will a building be safe for 50 years if a 50 year storm is used as the design basis?

If 50 years is the required design protection period, this needs to be multiplied by the Category 2 or 3 safety factors, depending on the level of assurance required. The design method in Part 3 is based on statistics. Therefore it is possible that a storm in excess of the design could occur a short time after handover of the project, although this is statistically unlikely. The statistical risk is related to the selected design Category.

The 1.5 and 4.5 values assigned to Category 2 and 3 respectively are safety factors, providing an increased measure of assurance that the building will be protected for a determined period of time.

Can the NB.2.2 method for assessing different design intensities or durations other than the 2 minute typical value be clearly explained?

Some readers have found it difficult to understand the process outlined in the UK annex of Part 3. This is best explained by using the same Sheffield design example (where \( T = 180 \text{ m years} \) for 3 mins duration) and identifying six design steps as follows:

1. Use the map Fig NB.6 to determine the 2min M5 value for the site location (4.0 mm).
2. Use Table NB.1 to determine the adjustment factor for the duration of the storm (1.33).
3. Multiply values in step 1 x step 2 (5.32 mm).
4. Refer to the graph in Fig NB.7
   a) on the bottom scale find the T value (180 years) and extend a line vertically upwards
   b) on the R/H scale find the value obtained in step 3 and project the curved line to the left, proportionally following the other curvatures
   c) Find where (a) and (b) intersect, then project a horizontal line to the scale on the left to obtain the value (2.0)
5. Calculate the depth of water in relation to the storm return period: Multiply the values from step 3 x step 4 (10.64 mm)
6. Convert the depth in step 5 to a flow rate by dividing this by the number of seconds in the chosen duration
   \( 10.64 \div 3 \times 60 = 0.059 \text{ L/s/m²} \)

Why does NB.2.3.2 incorporate a cautionary text in relation to the above method?

A similar method was included in BS 6367, but there was no cautionary wording, the additional commentary in Part 3 is intended to explain the limitations of this method: That it produces an estimate of an event, largely due to the difficulty of extracting accurate values by interpolation of the graph Fig NB.7. A plot of a range of results using this method suggests that with very careful use, an accuracy of ± 10% can be expected. For large sites where more precise figures would be pertinent, designers should seek data from alternative sources, such as the Met Office.

Is it necessary to provide emergency overflow outlets on roofs?

Emergency roof overflows have been recommended since 1983 (BS 6367) and are mentioned in Part 3. The BS 6399 also recommends that flat roofs are provided with overflows, although they are not mentioned in the ADH. From a simplistic viewpoint, the performance of the overflow outlet should be similar to the main outlet, so that it can drain the roof in the event that the main outlet has ceased to operate (see Fig 2, on the next page). The required flow performance of the overflow outlet should therefore be known, and the product selected with this in mind. Some products that have traditionally been used for overflow outlets have a reduced hydraulic capacity when compared to a normal outlet of equal spigot size. Examples of these are horizontal parapet outlets (often called scuppers in the USA) and standard outlets that are fitted with upstand pipes. A more hydraulically satisfactory arrangement is to use a standard outlet fitted with an external circular weir attachment (see Fig 1), as this will not compromise the original hydraulic performance of the outlet body shape.

![Circular weir attachment fitted around standard outlet](Diagram by courtesy of Dallmer Ltd)
Fig 2: Diagram showing basic alternative overflow concepts

Fig 3: Diagram showing insufficient emergency overflow provision
(Q numbers relate to the relative discharge capacity)

Fig 4: Diagram showing reduced numbers of emergency overflow outlets
(Q numbers relate to the relative discharge capacity)
On a large roof, do equal numbers of primary and secondary outlets need to be provided?

The answer to this question really depends on the constructional arrangements of the roof and on the configuration of the pipework serving the primary outlets.

a) Considering the first point: If one secondary outlet is going to act an emergency facility for two or more primary outlets then the pond of water created by the failure of the primary outlet must be able to safely reach a level that will initiate the secondary outlet without adversely affecting the integrity of the structure or the water proofing system.

b) The second point requires consideration with respect to the effect or various blockage locations. For example if 3 primary outlets discharge to the same RWP or branch drain (see Fig 3), then the source of one blockage could impede all 3 outlets, and in this situation one emergency outlet would not provide adequate protection.

However, a reduced number of secondary outlets might be regarded as adequate if the effect of a blockage would only impeded some of the primary outlets. In Fig 4 we can see that 2 secondary outlets could be considered adequate because if there was a blockage affecting the drain serving the whole roof the gully/gullies would act as emergency outlets and provide a warning.

If the designer is satisfied that both the above points (a) and (b) have been considered, then the number of overflow outlets does not have to equal the number of primary outlets.

Is it necessary to provide warning pipes on internal rainwater pipes?

Warning pipes have been recommended since 1983 (BS 6367) and are included in Part 3 however, they are not mentioned in the ADH. Their purpose is to prevent excessive static pressure being generated at the base of a downpipe or on a branch drain, due to a blockage occurring. It is recommended they are positioned not more than 6m above the invert of the drain connection. Historically, warning pipes are rarely provided due to one or more of the following reasons:

- They are only ‘recommended’.
- There is a lack of awareness (they are not mentioned in the ADH).
- There may be aesthetic objections about their termination points.
- There may be practical difficulties in routing them to a suitable discharge point outside the building.

It is possible to generate the necessary warning signal electrically by installing a water presence probe or an air pressure switch on a short ‘dry’ branch upstand, thus avoiding the difficulties of providing a physical indication. If such devices are used they should be BMS linked and provided with adjacent access pipes to facilitate routine alarm testing.

Can different storm intensities be used on different parts of a building?

It is perfectly acceptable to use different storm intensities on the same building, e.g. 1 year for fascia gutters generally and say 50 year return for a valley gutter. This assumes that the rainwater piping is kept separate for roofs areas designed to cope with different storm intensities.

Should all the rainwater falling on catchment areas be assumed to reach the drainage system?

Several decades ago it was customary to apply ‘C’ (coefficient) values to account for the different water absorption characteristics of various catchment surfaces when designing underground drainage systems. For hard landscaped areas, the method recommended by several standards today is to assume 100% run-off within the building curtilage. BS EN 752 incorporates some curious C values for roofs; 1.0 for small flat roofs (>100m²) and 0.5 for large flat roofs (<10,000m²).

For green roofs, the German FLL Guide gives C values from 0.1 to 0.7 depending upon the depth and type of planting substrate, and suggests 0.8 for roofs with a gravel layer. Consequently the UK Environment Agency suggests that green roofs may be considered for attenuation purposes.

Is there any concern about above and below ground systems being designed to different storm intensities?

Throughout most of the previous century above and below ground systems (within the building curtilage) have typically been based on a 1 year storm intensity; consequently the design flows could be described as ‘in balance’. During recent decades, return periods have been greatly increased for some above ground applications, sometimes to more than a 100 year storm. In these circumstances there is an imbalance in the design ethos, which does need to be considered.

Where rainwater gullies (or other inlets) are included on the below ground system, these will act as emergency outlets in the event of the underground drainage system becoming overwhelmed by the surface water flow in
severe storm conditions, and paved areas may be subjected to short term ponding. However, where a surface water drain runs inside or under the building and serves internal rainwater pipes CIRIA recommend that it is designed for a higher degree of protection than might normally be provided (otherwise surcharge conditions causing internal flooding may occur). Where a branch drain (without an emergency outlet) serves an internal RWP that is provided with a warning pipe or device, the branch drain should be able to convey the rainwater design flow. If not, then under design storm conditions water may back-up at the foot of the RWP and could wrongly indicate that the pipe was blocked as the warning pipe/device may be activated.

It is worthwhile to remember that whilst different storm intensities may be assigned across the whole project, precipitation during any storm will result in the same ‘blanket’ coverage on all catchment areas.

Where ponding cannot be tolerated on paved areas or where there are no inlets on the below ground drainage system that can act as emergency outlets, the design of the drainage system should be modified to consider the increased risk of consequential damage (refer to BS EN 752).

What is the correct rationale for allowing for run-off from walls?

Part 3 recommends that half the area of the wall (up to a maximum vertical height of 10m) should be allowed as run-off onto lower catchment areas. Half the area is used because this allows for the effect of wind driven rain (26°). There is no coefficienty data provided to allow for the effects of differential run-off from various materials, e.g. glass wall or clay brick. When BS 6367 (the previous standard) was published it was acknowledged that more research was required on this subject; twenty-five years on and designers are still waiting for additional guidance. However, Plumbing Engineers in the USA have the same dilemma! In the absence of further information, designers should follow Part 3, and apply their own professional judgement as considered appropriate for the project.

Should the run-off from walls be included for the drainage of paved areas?

There is no guidance within BS EN 752 or Part 3, although this question was covered in several older standards; BS 6367 and BS 8301. It was recommended that run-off should be included from ‘tower buildings’ where ponding of paved areas cannot normally be tolerated. Designers would therefore need to use there own professional judgement to make allowances.

The increased use of SUDS techniques means that soakaways and other infiltration methods are being used more frequently, does this require any additional considerations for rainwater systems?

The risk of soakaway and infiltration system performance becoming adversely affected by silting-up needs to be considered. Methods to prevent silt and floating debris being conveyed to these discharge points should be incorporated. This will normally require the inclusion of a catch pit or some proprietary above or below ground intercepting device. The ADH recommends that either ‘gully pots of suitable size’ or catchpits are used to prevent debris from entering the drainage system. BS EN 752 also recommends measures to protect ‘pit soakaways’ and ‘infiltration trenches’ (catchpit arrangements that are appropriate to DN 100 and DN 150 drains are provided in Fig NA.7 and clause NA.12.4.9). For ‘shallow’ applications the minimum chamber size might be considered to be 450mm diameter for a DN 100 drain, and 600mm diameter for a DN 150 drain size. It is worthwhile to note that the interception of debris from rainwater pipes is just as important as the run-off from ‘hard landscaping’.

Abbreviations

SWD Surface Water Drain  
SWG Surface Water Gully  
PRWO Primary Rainwater Outlet  
SRWO Secondary Rainwater Outlet  
ERWD Emergency Rainwater Discharge Point

Bibliography

BS 6367 (1983) Code of practice for drainage of roofs and paved areas (now obsolete)  
BS 8301 (1985) Code of practice for building drainage (now obsolete)  
BS EN 752 (2008) Drain and sewer systems outside buildings  
CIPHE Chartered Institute of Plumbing and Heating Engineering, see ‘Plumbing Engineering Services Design Guide’ (2002)  
CIRIA Construction Industry Research and Information Association, see Drainage of development sites – a guide (2004)  
DIN 1986 Drainage systems on private ground – Part 100 (2008) Specifications in relation to DIN EN 752 and DIN EN 12056 (only in German)  
FFL The Landscaping and Landscape Research Society E.V. (Germany) see ‘Guidelines for the Planning, Execution and Upkeep of Green-roof sites’ (2002) www.ffl.de  

The author is unable to answer individual questions about this article; any feedback should be directed to SoPHE.