GUIDANCE NOTES ON ROAD PAVEMENT DRAINAGE DESIGN

Research & Development Division

RD/GN/035
May 2010
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1. **Introduction**

This set of Guidance Notes updates and replaces the 1994 version of Road Note 6 as the standard for road pavement drainage design.

2. **Background**

2.1 Road Note 6 was firstly published in 1983 and was based on Transport Research Laboratory (TRL) Report No. LR 277\(^1\). A revised version of the Road Note was published in 1994 to include findings obtained from TRL Reports LR 602\(^2\) and CR 2\(^3\). These Reports have since been replaced by the Advice Note HA 102/00\(^4\) of the Design Manual for Roads and Bridges issued by the Highways Agency of UK. Since the publication of the 1994 version of the Road Note, more local experience and research findings on the design of road drainage have been gained and details of new drainage inlet facilities used in other countries have also been obtained. This set of Guidance Notes therefore includes the latest information and findings from extensive full scale physical testing under the collaboration study between Highways Department and the Hong Kong Road Research Laboratory of the Hong Kong Polytechnic University, for the design of road pavement drainage to meet current requirements.

2.2 This new design standard provides:-
   a) updated requirement of design flooded widths\(^5\) under serviceability state;
   b) updated rainfall intensities and anticipated flooded widths for different return periods;
   c) revised roughness coefficients for different types of pavement surface;
   d) updated requirement in the allowance for reduction in the flow efficiency due to blockage of gully gratings by debris;
   e) additional guidance on provision of double gullies;
   f) additional guidance on provision of edge drain;
   g) additional guidance on drainage at junction with steep road;
   h) additional guidance on Y-junction connection with carrier drain;
   i) additional guidance on design of outlet pipes; and
   j) updated design charts.

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\(^1\) LR277 : Laboratory Report 277 - The Hydraulic Efficiency and Spacing of B.S. Road Gullies
\(^2\) LR602 : Laboratory Report 602 – Drainage of Level or nearly Level Roads
\(^3\) CR2 : Contractor Report 2 – The Drainage Capacity of BS Road Gullies and a Procedure for Estimating their Spacing
\(^4\) HA 102/00 : Design Manual for Roads and Bridges, Volume 4, Section 2, Part 3, HA 102/00 – Spacing of Road Gullies
\(^5\) Flooded width : The width of water flow measuring from the kerbline to the flow’s outer-edge. This flow of water is designed to be drained into the drainage system via the gullies
2.3 Details of the installation of gully assemblies are given in relevant HyD Standard Drawings. These requirements should be complied with.

3. **Design Considerations**

3.1 **Rainfall Intensity**

The drainage system should in principle be designed to accommodate a rainfall intensity for heavy rainstorms with a probability of 1 in 50 years occurrence to tally with the design return period for carrier drains. As shown in Table 1 below, the rainfall intensity varies significantly following the change in occurrence probability. Correspondingly different design flooded widths will be incurred. For design in accordance with this set of Guidance Notes, the design flooded width on Expressways remains within the hard shoulders (of minimum width 2.5 metres) even for heavy rainstorms of a probability of occurrence of 1 in 50 years. If gullies are provided to limit flooded width to 0.75 metre for Normal Roads\(^6\) at the design rainfall intensity of 120mm/hour, it is expected that the design flooded width will be exceeded not more than 2 times per year and will not exceed 0.81 metre by 1 time per year. This is considered acceptable in view of the infrequent occurrence and the 0.75 metre flooded width will not encroach to the wheel track thus causing water splashing.

<table>
<thead>
<tr>
<th>Storm Occurrence</th>
<th>Maximum Intensity</th>
<th>Maximum Flooded Width</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Normal Roads</td>
</tr>
<tr>
<td>1 in 50 years</td>
<td>270 mm/h</td>
<td>1.20 m</td>
</tr>
<tr>
<td>1 in 5 years</td>
<td>195 mm/h</td>
<td>1.04 m</td>
</tr>
<tr>
<td>1 per year</td>
<td>140 mm/h</td>
<td>0.81 m</td>
</tr>
<tr>
<td>2 per year</td>
<td>120 mm/h</td>
<td>0.75 m</td>
</tr>
</tbody>
</table>

Note: Intensities for 1 in 50 years and 1 in 5 years are determined based on the 1956 – 2005 rainfall data; and intensities 1 per year and 2 per year storms are determined based on the 1985 – 2005 rainfall data. The maximum intensities are peak values in 5 minutes duration.

Table 1: Maximum Rainfall Intensities and Flooded Widths for Different Storm Frequencies

3.2 **Serviceability State Considerations**

3.2.1 The spacing of road gullies should be designed so that the flow of water in the kerb side/ hard shoulder/ marginal strip channel is limited to a maximum

---

\(^6\) Normal Roads : Roads other than expressways and expressways with a hard shoulder of less than 2.5 metres.
tolerable width (flooded width) commensurate with the function of the road even under heavy rainfall conditions (to be defined in section 3.2 below). Cost is also a relevant consideration. It would generally require 2 to 5 times more gullies in order to reduce the flooded width by 50%. Consequently, a modest improvement in flow condition would involve significant additional cost. Therefore, the design flooded width should represent a compromise between the need to restrict water flowing on the carriageway to acceptable proportions, and the additional costs associated with higher standards of road drainage.

3.2.2 The principle is to limit the likelihood of water flowing under the wheel paths of vehicles travelling at high speed, and splashing over footways while travelling at low speed. In general for flat and near flat Normal Roads, a design flooded width of 0.75 metre under heavy rainfall condition is adequate. This flooded width will imply that stormwater will just begin to encroach into the wheel paths of vehicles, or would be restricted within the marginal strip, if provided.

3.2.3 For Normal Roads with moderate to steep gradients, a smaller flooded width is desirable. This is because when there is a large quantity of water flowing in the channel on a steep gradient, any partial blockage of the inlet will result in a considerable proportion of the flow by-passing the gully. This, in turn, will increase the loading on the next and subsequent gullies. For this reason, the maximum design gully spacing shall be limited to 25 metres, and the design flooded width shall be reduced in accordance with the gradient of the road (Table 2 refers). The effect of this reduction in design flooded width has been taken into consideration in the preparation of the Design Chart 1A.

<table>
<thead>
<tr>
<th>Longitudinal Gradient</th>
<th>Design Flooded Width</th>
</tr>
</thead>
<tbody>
<tr>
<td>2% or less</td>
<td>0.75 m</td>
</tr>
<tr>
<td>from 2% to 3%</td>
<td>transition from 0.75 m to 0.70 m</td>
</tr>
<tr>
<td>from 3% to 5%</td>
<td>transition from 0.70 m to 0.68 m</td>
</tr>
<tr>
<td>from 5% to 7.5%</td>
<td>transition from 0.68 m to 0.66 m</td>
</tr>
<tr>
<td>more than 7.5%</td>
<td>gradually reduce from 0.66 m downwards</td>
</tr>
</tbody>
</table>

Notes: 1. In any circumstance, the maximum gully spacing is limited to 25 metres.
2. Curves in Design Chart 1A are derived from the above design flooded width except for curves of longitudinal gradient more than 7.5%. Curve of 10% longitudinal gradient in Design Chart 1A is based on 0.66m design flooded width.

Table 2: Design flooded widths for Normal Roads (roads other than Expressways)

3.2.4 A larger flooded width can be permitted on the slow lane sides of expressways
where hard shoulder of minimum width of 2.5 metres is provided. The design flooded width can be increased to 1.0 metre under heavy rainfall conditions, which will ensure that there is no encroachment onto the adjoining traffic lane. Again, there is a need to limit the flooded width on expressways with moderate and steep gradients. In this respect, under no circumstances should gully spacing exceed 25 metres or drained area of gully be larger than 600m².

3.2.5 Note that a 1.0 metre design flooded width does not apply to those sides of expressways without a hard shoulder of minimum width 2.5 metres nor to the fast lane sides where only a marginal strip is provided. In this case, they should be treated as Normal Roads.

3.3 Climatic Considerations

3.3.1 To represent a compromise between the need to restrict water flowing on the carriageway to acceptable proportions, and the additional costs associated with higher standards of road drainage, the designer should equate heavy rainfall condition for serviceability state design to be the intensity of a rainstorm (5 minutes or more in duration) having a probability of occurrence of not more than 2 times per year. According to the rainfall data from the Hong Kong Observatory, this corresponds to an intensity of 120 mm/hour. It should be noted that a rainfall intensity of 120 mm/hour or more would be such that most motorists would consider it prudent to slow down owing to lack of visibility.

3.4 Ultimate State Considerations

3.4.1 Under the kerb and gully arrangement when a fixed number of gullies have been constructed, the flow width and flow height will increase with the rainfall intensity. If the flow height is too great, the kerb may be overtopped and in certain situation, the surface water may cause flooding to adjoining land or properties. This should be avoided even in exceptionally heavy rainstorms.

3.4.2 The purpose of the ultimate state design is to prevent the occurrence of such overtopping. In this design standard, the ultimate state is taken to be the rainfall intensity of 270 mm/hour for a 5-minute rainstorm with a probability of occurrence of 1 in 50 years. To have a further safety margin, a factor of safety of 1.2 is applied to the flow height under the ultimate state before checking against the available kerb height. The flow height $H_{ult}$ is therefore given by Equation (1):

---

7 Drained area: The effective area of pavement being drained into gully or other drainage inlet facilities.
\[ H_{ult} = 1.2 \times 10 \times W_{ult} \times X_{fall} \]  \hspace{2cm} (1)

where \( H_{ult} \) = flow height in mm
\( W_{ult} \) = flooded width at ultimate state
\( X_{fall} \) = crossfall of pavement in %

\( H_{ult} \) = flow height in mm
\( W_{ult} \) = flooded width at ultimate state
\( X_{fall} \) = crossfall of pavement in %

3.4.3 This requirement can be satisfied in most cases. The flow height will exceed the standard kerb height of 125 mm only if the crossfall is more than 6.1% for hard shoulder flow on expressways or 8.7% on Normal Roads. If the flow height exceeds the kerb height, the drainage design should be revised.

3.4.4 When the limiting flow height is exceeded, either the crossfall or the kerb height has to be adjusted. Given that these two parameters cannot be adjusted in most circumstances, the ultimate state requirement can be met by adjusting the gully spacing (determined by Equation 5) by multiplying it with a reduction factor \( RF_{ult} \) given by Equation (2):

\[ RF_{ult} = \frac{H_{kerb}}{12 \times W_{ult} \times X_{fall}} \]  \hspace{2cm} (2)

where \( RF_{ult} \) = reduction factor for ultimate state
\( H_{kerb} \) = kerb height in mm
\( X_{fall} \) = crossfall of pavement in %
\( W_{ult} \) = flow width at ultimate state
\( H_{kerb} \) = kerb height in mm
\( W_{ult} \) = flow width at ultimate state

3.4.5 A kerb height of 125 mm can be assumed at standard dropped kerb crossings as the footway should have sufficient fall to contain any overtopping within a localised area. However, in exceptional cases with non-standard dropped kerb crossings where the footway falls away from the kerb, the actual kerb height should be used and special attention should be paid in the design to cater for ultimate state flow.

3.4.6 Where a continuous channel is provided along the edge of the carriageway for surface drainage, the capacity of the channel should be sufficient to cater for the ultimate state rainfall intensity.
3.5 **Crossfall**

3.5.1 Crossfall should be provided on all roads to drain stormwater to the kerb side channels. On straight lengths of roads, crossfall is usually provided in the form of camber. On curves, crossfall is usually provided through superelevation.

3.5.2 A slight variation in crossfall will result in a significant effect in gully spacing in particular on flat sections. As illustrated in Figure 1 (section 3.7.2), an increase in crossfall from 2.5% to 3.0% can increase gully spacing by about 25%. Therefore a suitable crossfall should be adopted to avoid having gullies at unnecessarily close spacing. On roads with moderate or steep gradients, a suitable crossfall should be provided to ensure surface water flows obliquely to the kerb side channels rather than longitudinally along the length of the road. The Transport Planning and Design Manual suggests a standard crossfall of 2.5%. However, to facilitate surface drainage, a minimum crossfall shall be provided as given in Table 3, except where required along transitions.

<table>
<thead>
<tr>
<th>Longitudinal Gradient</th>
<th>Minimum Crossfall</th>
</tr>
</thead>
<tbody>
<tr>
<td>1% or less</td>
<td>3%</td>
</tr>
<tr>
<td>5% or more</td>
<td>3%</td>
</tr>
<tr>
<td>between 1% and 5%</td>
<td>2.5%</td>
</tr>
</tbody>
</table>

Table 3: Minimum Crossfalls

3.6 **Gully Spacing - Roads at a Gradient Greater Than 0.5%**

3.6.1 The design method adopted is based on CR 2. It is identical to the one in the 1994 version of Road Note 6.

3.6.2 There are different formulae in CR 2 for the 3 types of gullies below:

a) most upstream gully - the first gully from the crest;

b) terminal gully - the gully at the lowest or sag point; and

c) intermediate gully - any gully between a most upstream gully and a terminal gully.

3.6.3 For simplicity, a single formula (the one for intermediate gullies) is adopted in this set of Guidance Notes. It would be slightly conservative to use this formula for most upstream gullies but the effect is minimal. As regards terminal gullies that collect water from both sides, the gully spacing should be half of that calculated by the formula for intermediate gullies if only one gully is provided at
the sag point. However the recommendation in this set of Guidance Notes to provide at least 3 gullies at sag points has the effect of removing the need for a different formula for terminal gullies. The unadjusted gully spacing is given by Equation (3) below:

\[ L_u = \left( \frac{0.01}{n} \right) \times \frac{A}{W} \]  

(3)

where

- \( L_u \) = unadjusted gully spacing in metre
- \( n \) = roughness coefficient (Table 4)
- \( A \) = drained area in m² (Chart 1A for Normal Roads and Chart 1B for expressways)
- \( W \) = drained width in metre

3.6.4 This design formula can be directly applied when the section of road under consideration has a uniform crossfall and longitudinal gradient. For roads with varying crossfall and/or longitudinal gradient, it is necessary to divide the road into sections of roughly uniform gradient and crossfall for the purpose of calculation of gully spacing.

<table>
<thead>
<tr>
<th>Road Surface</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concrete without flat channel</td>
<td>0.015</td>
</tr>
<tr>
<td>Concrete with flat channel</td>
<td>0.013</td>
</tr>
<tr>
<td>Bituminous Wearing Course</td>
<td>0.013</td>
</tr>
<tr>
<td>Precast block paving</td>
<td>0.015</td>
</tr>
<tr>
<td>Stone Mastic Asphalt (SMA) Wearing Course and Friction Course</td>
<td>0.016</td>
</tr>
</tbody>
</table>

Table 4: Roughness Coefficients for Different Types of Road Surface

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8 Drained width: The average width of the area to be drained. It should include the width of both carriageway and footpath
3.7 Gully Spacing - Flat or Near Flat Roads at a Gradient not Greater than 0.5%

3.7.1 The design method given in CR 2 is not applicable to roads with longitudinal gradient of less than 0.5% as the flow in the channel will become deeper and the mode of flow will change from super-critical to sub-critical. The design method for flat or near flat roads is based on LR 602. The unadjusted gully spacing is given by Equation (4) below:

\[ L_u = L_o \times [1 + F (R - 1)] \quad (4) \]

where
- \( L_u \) = unadjusted gully spacing in metre
- \( L_o \) = gully spacing for roads of zero gradient in metre
  (Chart 2A for Normal Roads & Chart 2B for expressways)
- \( F \) = adjustment factor for different drained widths (Chart 3)
- \( R \) = multiplication factor for different crossfalls and gradients
  (Chart 4A for Normal Roads and Chart 4B for expressways)

3.7.2 Figure 1 illustrates the effect of longitudinal gradient on gully spacing. Note that there is a discontinuity (kink in the curve) at 0.5% longitudinal gradient, which is the changeover point from one design method to another.

![Figure 1 - Typical Gully Spacing for Drained Width of 12m (unadjusted)](image)

Note: Curves for longitudinal gradient greater than 0.5% are produced from Design Chart 1A based on method given in CR 2. Curves for longitudinal gradient not greater than 0.5% are produced from Design Charts 2A, 3 and 4A based on design method from LR 602.

Figure 1 – Typical Gully Spacing for Drained Width of 12m (unadjusted)
3.8 **Design Gully Spacing and Reduction Factors**

3.8.1 The design gully spacing is derived by applying reduction factors to the unadjusted gully spacing determined as described above. There are two reduction factors, one for gully efficiency and the other for blockage by debris:

\[ L = L_u \times (1 - RF_{\text{grating}}) \times (1 - RF_{\text{debris}}) \]  

(5)

where

- \( L \) = design gully spacing in metre
- \( L_u \) = unadjusted gully spacing in metre
- \( RF_{\text{grating}} \) = reduction factor for gully efficiency (Table 5)
- \( RF_{\text{debris}} \) = reduction factor for blockage by debris (Table 6)

**Gully Grating Efficiency**

3.8.2 The efficiency of road gully depends very much on the efficiency of the gully grating. Thus, the type of gully grating to be used is an important factor in the determination of gully spacings. The design charts in this set of Guidance Notes are prepared on the basis of the highly efficient double triangular grating (type GA1-450) installing on gully with the specified grating orientation (Figure 2 refers). Grating type GA1-450 shall be the standard gully grating. Note that installing the gully grating with reversed grating orientation will have a significant reduction (about 20%) of the efficiency.

**Figure 2 – Specified Grating Orientation**

3.8.3 Other grating type can be used in particular locations on elevated roads or cycle
tracks where it would be desirable to provide gully openings smaller than the standard type (despite the fact that more gullies may be needed). In such cases grating type GA2-325 can be used. A reduction factor of 15% shall be applied to the calculated gully spacing to account for the lower efficiency of grating type GA2-325. The following reduction factors for gully efficiency are applicable:

<table>
<thead>
<tr>
<th>Type of Grating</th>
<th>RF&lt;sub&gt;grating&lt;/sub&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>GA1-450</td>
<td>0%</td>
</tr>
<tr>
<td>GA2-325</td>
<td>15%</td>
</tr>
</tbody>
</table>

Table 5: Reduction Factors for Gully Efficiency

3.8.4 The measured gully efficiency and also the formulae for the calculation of gully spacing described above are based on the arrangement with single gully assemblies at each gully location. Note that the provision of double gullies at every location is in general not cost effective as there is little effect in increasing gully spacing.

Blockage by Debris

3.8.5 All grating designs are susceptible to blockage by debris, especially for flat gradients in the urban areas and road sections adjacent to amenity or landscaped areas. Some allowance should therefore be made in the calculated spacing for the reduction in discharge. An appropriate reduction factor on the discharge should be made according to the local conditions. As a general guidance, reduction factors should be applied as described in the following Table 6.
### Roads / Road Sections

<table>
<thead>
<tr>
<th>Expressways</th>
<th>RF_{debris}</th>
</tr>
</thead>
<tbody>
<tr>
<td>longitudinal gradient less than 0.5% or near sag points</td>
<td>15%</td>
</tr>
<tr>
<td>longitudinal gradient 0.5% or more</td>
<td></td>
</tr>
<tr>
<td>near amenity area</td>
<td>10%</td>
</tr>
<tr>
<td>other sections</td>
<td>5%</td>
</tr>
<tr>
<td>Normal Roads</td>
<td></td>
</tr>
<tr>
<td>longitudinal gradient less than 0.5%</td>
<td>20%</td>
</tr>
<tr>
<td>longitudinal gradient 0.5% or more</td>
<td></td>
</tr>
<tr>
<td>near sag points or blockage blockspots, e.g. streets with markets or hawkers</td>
<td>20%</td>
</tr>
<tr>
<td>near amenity area</td>
<td>20%</td>
</tr>
<tr>
<td>other sections</td>
<td>15%</td>
</tr>
</tbody>
</table>

Table 6: Reduction Factors for Blockage by Debris

### Double Gullies

3.8.6 Although provision of double gullies is in general not cost effective in increasing gully spacing as mentioned as section 3.8.4, they are considered beneficial in reducing the severity and the chance of blockage on gully grating by debris. Therefore, double gullies are recommended to be provided at locations suspected to be blocked by debris easily or at locations with change in gradient as mentioned in section 3.9.8.

### Edge Drains

3.8.7 For roads in developed urban area or in prestige area, the design flooded width may be required to be further reduced to not exceeding 0.5 metre due to particular reasons. In this case, edge drain may be considered as an auxiliary drainage facility. In locations where the surface layer are composed of open textured wearing course (e.g. Expressways), edge drain may be considered to be installed so that the surface water can be drained into the length of edge drain via the porous surface layer of the road pavement.\(^9\)

3.8.8 Edge drains are laid along the kerbside in full length from upstream gully to downstream gully such that the length of edge drain equals to gully spacing. To

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facilitate edge drain construction and further maintenance, edge drain is recommended to be constructed by pre-cast units. The pre-cast units shall be laid along the kerbs and follow the road gradient. Details of edge drain in pre-cast unit are shown in Sketch Nos. 1 and 2.

3.8.9 Although edge drain is efficient to collect surface runoff, it is constrained by its own drainage capacity, which depends on the road gradient only. The maximum lengths of edge drain based on the dimensions in the reference sketches under different drained width in associated with the required minimum crossfalls are tabulated in the following Table 7. Nevertheless, the maximum length shall be limited to 25 metres to facilitate cleansing of the blockage inside the edge drain and to match with the maximum allowable gully spacing (sections 3.2.3 and 3.2.4 refer).
<table>
<thead>
<tr>
<th>Road Gradient</th>
<th>Drained Width</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5m</td>
</tr>
<tr>
<td>0%</td>
<td>17.4 (3.3%)</td>
</tr>
<tr>
<td>0.05%</td>
<td>18.8 (3.1%)</td>
</tr>
<tr>
<td>0.1%</td>
<td>20.2 (3.1%)</td>
</tr>
<tr>
<td>0.2%</td>
<td>22.5 (3.1%)</td>
</tr>
<tr>
<td>0.3%</td>
<td>24.7 (3.1%)</td>
</tr>
<tr>
<td>0.4%</td>
<td>22.1 (3.1%)</td>
</tr>
<tr>
<td>0.5%</td>
<td>23.6 (3.1%)</td>
</tr>
<tr>
<td>0.6%</td>
<td>21.3 (3.1%)</td>
</tr>
<tr>
<td>0.8%</td>
<td>23.4 (3.1%)</td>
</tr>
<tr>
<td>1%</td>
<td>22.0 (3.1%)</td>
</tr>
<tr>
<td>1.5%</td>
<td>22.7 (3.1%)</td>
</tr>
<tr>
<td>2%</td>
<td>22.8 (3.1%)</td>
</tr>
<tr>
<td>3%</td>
<td>23.2 (3.1%)</td>
</tr>
<tr>
<td>4%</td>
<td>24.4 (3.1%)</td>
</tr>
<tr>
<td>5%</td>
<td>23.1 (3.1%)</td>
</tr>
<tr>
<td>7.5%</td>
<td></td>
</tr>
</tbody>
</table>

Notes: 1. The maximum lengths of edge drain are based on the dimensions shown in Sketch Nos. 1 and 2 i.e. the internal size of the edge drain is 0.11m (H) x 0.08m (W).
2. Length of edge drain equals to gully spacing.
3. The values in brackets are the minimum crossfalls to retain the flooded width not exceeding 0.5 metre.
4. For the maximum lengths below the bold line, the minimum crossfalls in Table 3 are adequate. Hence, minimum crossfalls have not to be specified in brackets.

Table 7: Maximum Lengths (m) of Edge Drain

3.8.10 When edge drain is provided as auxiliary drainage facility, gully spacing has to be adjusted accordingly. The higher value between the design gully spacing in equation (5) and the maximum length of edge drain in Table 7 shall be adopted as the gully spacing.

3.8.11 Edge drain is not recommended to be provided near landscaped and amenity areas as it is easily subjected to blockage by fallen leaves. Proper maintenance e.g. cleansing by pressure jet has to be carried out to ensure its proper
functioning.

3.8.12 Besides edge drain, other auxiliary drainage facilities such as slot drain (Sketch No. 3), kerb drain (Sketch No. 4) and other proprietary products can also be applied in road drainage design as long as sufficient documents are provided to prove the effectiveness of the design.

3.9 Details to Facilitate Entry of Surface Water

Kerb Overflow Weirs

3.9.1 Kerb overflow weirs serve two functions. Firstly the vertical opening is a kind of kerb inlet and would provide additional drainage path under normal circumstances. This is useful in roads with moderate or steep gradient where the higher flow velocity enables a certain amount of surface water to by-pass the gully through the very narrow inner edge of gully assemblies. The provision of overflow weirs on roads with moderate and steep gradient is recommended as they remove the inner edges and also provide additional inlet openings.

3.9.2 The second function is to provide a reserve inlet for surface water in case the gully grating is obstructed by plastic bags or other debris. The reserve inlets are necessary on flat roads and sag points, including blockage blackspots, where the likelihood of debris collecting on gratings and along channels is high. Overflow weirs shall be provided on roads with longitudinal gradient less than 0.5% or greater than 5%, or at sag points/blockage blackspots according to Table 8 below.

<table>
<thead>
<tr>
<th>Section of Road</th>
<th>Minimum Rate of Provision of Overflow weirs</th>
</tr>
</thead>
<tbody>
<tr>
<td>longitudinal gradient &gt; 7%</td>
<td>Every other gully</td>
</tr>
<tr>
<td>longitudinal gradient &gt; 5% but not more than 7%</td>
<td>Every third gully</td>
</tr>
<tr>
<td>longitudinal gradient between 0.5% and 5% inclusive</td>
<td>No overflow weir</td>
</tr>
<tr>
<td>longitudinal gradient &lt; 0.5%</td>
<td>Every third gully</td>
</tr>
<tr>
<td>Sag points or blockage blackspots.</td>
<td>Every gully</td>
</tr>
</tbody>
</table>

Table 8: Minimum Rate of Provision of Overflow Weirs

3.9.3 The drawback of overflow weirs is that they provide yet another passageway for
debris to enter the gully pot which may eventually cause blockage of the gully. It is therefore important to provide bars across the vertical opening to reduce the size of the openings and to prevent the entry of large particles. Where provided on roads with moderate or steep gradient, the bars should be horizontal or parallel to the length of the weir so as to maintain drainage efficiency. Where provided on flat roads or sag points, the bars should be vertical as this arrangement is more effective in preventing entry of debris.

Gullies at Sag Points (Minimum Triple Gullies)

3.9.4 Sag points can be the trough at the bottom of a hill or locally at bends created by superelevation. Any surface water not collected by the intermediate gullies will end up at the sag points. It is therefore important to provide spare gully capacity at sag points. A minimum of 3 gullies should be provided on all sag points. The first one collects surface water from one side of the trough, the last one collects surface water from the other side, and the middle gully (gullies) provides spare capacity.

3.9.5 The catchment area is the road area such that rain falling onto which may end up at the sag point. For hilly terrain the catchment area of a sag point could be very large. Note that surface water always follows the line of greatest slope rather than confined to one side of the carriageway. Hence when there are gullies at both sides of a road at a sag point, very often the two sets of gullies have catchment areas quite different in sizes unless the catchment area is a straight road with camber throughout.

3.9.6 If the catchment area concerned becomes larger, there is a higher chance for a certain amount of surface run-off bypassing any blocked intermediate gullies and eventually reaching the sag point. In such circumstances, surface water may accumulate at the sag point and cause flooding and hazard to traffic. In view of this, it is necessary to provide additional gullies at sag points to reduce the likelihood of such occurrence. It should be borne in mind, however, that the key for the proper functioning of the surface drainage system is the proper maintenance and clearance of blocked gullies rather than the addition of gullies. The number of additional gullies to be provided at sag points is affected by:

a) the likelihood of intermediate gullies being blocked;
b) the size and layout of the catchment area;
c) the relative importance of the road and the consequence of flooding; and
d) the presence of alternative outlets (perhaps at a slightly higher level).

3.9.7 As a general guideline, additional gullies should be provided at sag points based
on the size of the catchment area in accordance with Table 9 below:

<table>
<thead>
<tr>
<th>Catchment Area (m²)</th>
<th>No. of Gullies at Sag Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 600</td>
<td>3</td>
</tr>
<tr>
<td>600 - 1,999</td>
<td>4</td>
</tr>
<tr>
<td>2,000 - 3,999</td>
<td>5</td>
</tr>
<tr>
<td>4,000 - 5,999</td>
<td>6</td>
</tr>
<tr>
<td>6,000 - 9,999</td>
<td>7</td>
</tr>
<tr>
<td>10,000 - 14,999</td>
<td>8</td>
</tr>
<tr>
<td>15,000 - 19,999</td>
<td>9</td>
</tr>
<tr>
<td>&gt; 20,000</td>
<td>10 for the first 20,000 m², plus one for every extra 5,000 or less m²</td>
</tr>
</tbody>
</table>

Note: The capacity of outlet pipes should be assessed to avoid sterilizing the function of multiple gullies as mentioned in section 3.12

Table 9: Additional Gullies at Sag Points

Gullies Immediately Downstream of Moderate or Steep Gradients

3.9.8 On roads with moderate or steep gradient, surface water follows the line of greatest slope and flows obliquely towards the kerb side channel. There is no significant effect on the size of the drained area if it is a constant gradient or a gradual transition. However, if the road suddenly flattens out, the surface water bypassing the last gully on the steep section may overload the first few gullies on the flatter section due to the oblique flow.

3.9.9 Provision should be made to intercept such oblique flow when a road with moderate or steep gradient flattens out. As a general guide, the first 3 sets of gullies immediately downstream of a road section of longitudinal gradient 5% or more should be double gullies rather than single gullies. Also, adjacent gullies should be located at least one kerb length apart so that the portion of pavement between them can be properly constructed.

3.10 Drainage at Steep Road Junction

3.10.1 On roads with steep longitudinal gradient, surface runoff follows the gravity and runs in a diagonal path. When a steep road joins another road at a junction, a
portion of runoff cannot be intercepted by the last gully on the steep road and will overshoot pass the road junction (Figure 3 refers). Additional drainage load is therefore carried over from the steep road to the road junction and may cause flooding there.

![Diagram of Steep Road and Road Junction with additional catchment area]

Figure 3 – Additional Catchment Area at Road Junction

3.10.2 To collect the runoff from the additional catchment area, additional drainage has to be provided at the road junction. For simplification, additional gullies at the opposite side of the steep road are advised as shown in Figure 3. The guideline for the provision of the additional gullies is similar to that at sag points as mentioned in section 3.9.6 and Table 9. Checking for the outlet pipe capacity of the multiple gullies as mentioned in sections 3.11.8 to 3.11.10 is required. An example is shown in section 5.4 to illustrate the calculation of the additional catchment area.

3.10.3 Whenever the designer considers that provision of additional gullies is not appropriate due to site constraint or other reasons, provision of transverse drain at the end of the steep road may be considered. In such case, the transverse drain may be in the form of grated channel with adequate capacity to drain runoff under the ultimate state (i.e. a rainfall intensity of 270mm/hour).

3.11 Other Details

Footway Drainage

3.11.1 In general footways should have a crossfall towards the kerb to allow surface water to be collected by the kerb side gullies on the carriageway. The total
width of footway and carriageways should be used in determining the drained width.

3.11.2 Where the paved area adjacent to the carriageway is very wide, gullies at a very close spacing along the carriageway may be required. In such case, it may be more appropriate to provide a separate drainage system for the footway. One option for footways in rural area with low pedestrian volume is to drain surface water to separate open or covered channels at the back of the paved area.

Pedestrian Crossings

3.11.3 At pedestrian crossings where there are many pedestrian movements across the kerb side channel, it is worthwhile to spend extra effort in detailing the position of gullies to minimise inconvenience to the pedestrians. It is recommended that:

a) no gully should be located within the width of any pedestrian crossings;
b) for roads of longitudinal gradient 0.5% or above, a gully should be located at the upstream end of all pedestrian crossings; and
c) for roads of longitudinal gradient less than 0.5%, another gully (in addition to that required under (b)) should be provided at the downstream end.

Continuous Drainage Channel

3.11.4 For wide carriageway roads in flat areas or flood prone areas, gullies would need to be provided at very close spacing. For example, a flat 4 lane carriageway with a superelevation of 3% and with both adjacent footways shedding water to a single kerb side channel or a sag point with a large catchment could require gullies at a spacing of less than 5m. In such circumstances, drainage by means of covered continuous channels may be preferable. However, the susceptibility of damage by vehicles and the maintenance effort required should be considered thoroughly if continuous channel is proposed to be used.

Gully Pots

3.11.5 Untrapped gullies are preferred to the trapped ones because the latter is more susceptible to choking. Trapped gullies should be used when there is the possibility of having sewage discharged into the stormwater drain serving the gullies.

3.11.6 Precast/preformed gully pots should be used instead of in-situ construction except in very special cases where physical or other constraints do not allow their use. The following are some of the advantages of using precast/preformed
gullies:

a) easier to install and maintain;
b) smooth internal finish which allows easy cleansing (debris tends to adhere to rough in-situ concrete walls); and

c) where outfall trapping is required, the obvious choice is precast trapped gully pot as it is extremely difficult to build an acceptable trapped gully by in-situ construction.

Y-junction Connection

3.11.7 Gully outlet pipes should be properly connected to carrier drains in accordance with the relevant HyD standard drawing. The connection should be formed by means of either a manhole or a Y-junction/saddle connection fitting wherever practicable. Connecting an outlet pipe through an opening in an existing drain shall be avoided as far as practicable. Under extreme circumstances where connection of gully outlet pipe through an opening in an existing carrier drain is the only choice, the following measures shall be strictly followed:

a) Detail proposal of the works should be submitted to the department responsible for the maintenance of the carrier drain for agreement prior to execution of the works;

b) A short concrete pipe of maximum length 500mm should be used for connection to carrier drains. Flexible jointing should be adopted for the gully pipes in these circumstances. The 500mm length restriction is not required for PVC gully pipes;

c) Opening up of existing carrier drains must be handled with extreme care; over breaking shall be avoided;

d) The section of the carrier drain at the connection point shall be surrounded by in-situ concrete of at least 150mm thickness, to a length of not less than 300mm along the carrier drain on each side from the circumference of the opening. To control cracking, the surrounding concrete should be reinforced;

e) Upon completion of the connection works and final set of the surrounding concrete, the inside of the existing carrier drain shall be inspected either by direct visual inspection or by using CCTV to check for imperfections such as cracks, over breaking, intrusion of surrounding concrete, protrusion of gully outlet pipe, etc. Defects detected shall be made good either manually or by means of remote controlled device if necessary. Gully pipe protrusion must be cut to flush with the internal wall of the carrier drain; and

f) Details of the as-built works, checking certificate and CCTV record (for pipes too small to be entered by inspectors) shall be submitted to the department responsible for the maintenance of the carrier drain within one month upon completion of the works for record purpose.
3.11.8 Gullies in flexible pavements should be surrounded with bituminous paving material. The provision of concrete channels in front of kerbline for flexible pavements should be avoided as far as possible in order to minimize the risk of stormwater penetrating the interface between concrete channel and flexible surfacing. Water penetrating into the pavement will weaken the subgrade and eventually cause premature deterioration of the pavement structure.

3.11.9 Gullies in concrete pavements should be set in small, individual concrete slabs separated from the main pavement slab by box-out joints. Transverse joints in concrete pavements should be located with care so that they are either situated at least 2 metres away or in line with a box-out joint (for contraction joints only). Gully box-outs shall not be cast against expansion joints.

3.11.10 The brushed finish on flat concrete roads should be omitted in front of kerbs for a width of 425 mm, which should instead be trowel-finished to form a smooth channel to aid surface run-off. However, this flat channel should not be provided on roads with moderate or steep longitudinal gradients as it would be more desirable to limit the flow velocity and to remove the potential hazard of tyre skidding on the smooth concrete surface. It is recommended that no flat channel should be provided on roads with longitudinal gradient more than 5%.

3.12 Capacity of Outlet Pipes

3.12.1 As recommended in section 3.9.7, a series of gullies may be constructed at a single sag point to cater for the flow from the respective catchment. Since the gullies are closely spaced, it is convenient to connect all the gullies into a series for discharging at a single outlet pipe. However, to avoid sterilizing the function of multiple gullies, it is necessary to check the capacity of the outlet pipe. As the drainage system is designed to cater for the ultimate state (i.e. a rainfall intensity of 270mm/hour), the outlet pipe should therefore have sufficient capacity to convey the flow intercepted by the gully series under a rainfall intensity of 270mm/hour.

3.12.2 The capacity of an outlet pipe can be computed by using the Colebrook-White equation as shown in Equation (6):

\[
Q_p = -A_p \sqrt{\frac{32gRS_f}{f}} \log \left[ \frac{k_s}{14.8R} + \frac{1.255V}{R \sqrt{32gRS_f}} \right]
\]  
(6)
where $Q_p =$ pipe capacity (m$^3$/s),
$A_p =$ cross-sectional area of the pipe (m$^2$),
$g =$ gravitational acceleration (m/s$^2$) (the typical value is of 9.81 m/s$^2$),
$R =$ hydraulic radius (m) (= pipe diameter/4),
$S_f =$ slope of the pipe,
$k_s =$ roughness value of the pipe (m) (the typical values for concrete pipe and PVC pipe are 0.0006 m (i.e. 0.6 mm) and 0.00006 m (i.e. 0.06 mm) respectively), and
$\nu =$ viscosity of stormwater (m$^2$/s) (the typical value is of 1 x 10$^{-6}$ m$^2$/s).

3.12.3 For the required flow capacity of the outlet pipe, it can be computed by using Equation (7):

$$Q_G = AI$$

(7)

where $Q_G =$ required flow capacity of the outlet pipe for the gully series (m$^3$/s),
$A =$ design drained area of the gully series (m$^2$) (on conservative side, it may be assumed to be equal to the catchment area as defined in section 3.9.5), and
$I =$ 1 in 50 years rainfall intensity (m/s) (= 0.000075 m/s (i.e. 270mm/hr)).

In order not to sterilize the function of the gully series, $Q_p$ must be equal to or greater than $Q_G$.

For a particular material and specific site conditions, $Q_p$ can only be increased by enlarging the pipe diameter. If $Q_G$ evaluated from Equation (7) renders it necessary to provide an outlet pipe of inconvenient diameter (e.g. diameter exceeding 300mm), the designer may wish to provide an additional outlet pipe in the middle of the series so as to maintain using smaller diameter outlet pipes.
## 4. Design Workflow

| Step 1 - Determine | longitudinal gradient, \(G_{long}\)  
drained width, \(W\)  
crossfall, \(X_{fall}\)  
roughness coefficient, \(n\) (from Table 4) |
|-------------------|---------------------------------------------------------------|
| Step 2A (\(G_{long} \geq 0.5\%\)) | Step 2B (\(G_{long} < 0.5\%\))  
Read drained area, \(A\) from  
Chart 1A – Normal Roads flow  
Chart 1B – hard shoulder flow  
Read adjustment factor for different drained width, \(F\) from Chart 3  
Read multiplication factor for different crossfalls and gradients, \(R\) from  
Chart 4A – Normal Roads flow  
Chart 4B – hard shoulder flow |
| Step 3A (\(G_{long} \geq 0.5\%\)) | Step 3B (\(G_{long} < 0.5\%\))  
Determine unadjusted gully spacing, \(L_u\)  
\[
L_u = \left(\frac{0.01}{n}\right) \times \frac{A}{W} \tag{3}
\]  
Determine unadjusted gully spacing, \(L_u\)  
\[
L_u = L_o \times [1 + F (R - 1)] \tag{4}
\] |
| Step 4 - Determine design gully spacing, \(L\) |  
\[
L = L_u \times (1 - RF_{grating}) \times (1 - RF_{debris}) \tag{5}
\]  
where  
Reduction factor for gully efficiency, \(RF_{grating}\) from Table 5  
Reduction factor for blockage by debris \(RF_{debris}\) from Table 6 |
| Step 5 - Check flow height under the ultimate state, \(H_{ult}\) |  
Calculate  
\[
H_{ult} = 1.2 \times 10 \times W_{ult} \times X_{fall} \tag{1}
\]  
Where flooded width at ultimate state, \(W_{ult} = 1.71\)m for flow on hard shoulder on expressways  
\(= 1.20\)m for flow on Normal Roads edge  
Check against kerb height, \(H_{kerb}\)  
If \(H_{ult} \leq H_{kerb}\) o.k.  
If \(H_{ult} > H_{kerb}\),  
then a) Adjust \(H_{kerb}\) if \(H_{kerb} < 150\)mm; or  
b) Adjust design gully spacing by multiplying with a reduction factor for ultimate state, \(RF_{ult}\)  
\[
RF_{ult} = \frac{H_{kerb}}{12 \times W_{ult} \times X_{fall}} \tag{2}
\] |
| Step 6 - Related Considerations |  
a) Provision of edged drain  
(Table 7)  
b) Provision of overflow weirs  
(Table 8)  
c) Additional gullies at sag points  
(Table 9)  
d) Double gullies immediately downstream of 5% or more gradient  
(section 3.9.9)  
e) Location of gullies at pedestrian crossings  
(section 3.11.3)  
f) Design and required flow capacities of outlet pipe  
(Equation 6 and Equation 7) |
<table>
<thead>
<tr>
<th>Longitudinal Gradient</th>
<th>Minimum Crossfall</th>
</tr>
</thead>
<tbody>
<tr>
<td>1% or less</td>
<td>3%</td>
</tr>
<tr>
<td>5% or more</td>
<td>3%</td>
</tr>
<tr>
<td>between 1% and 5%</td>
<td>2.5%</td>
</tr>
</tbody>
</table>

Table 3: Minimum Crossfalls

<table>
<thead>
<tr>
<th>Road Surface</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concrete without flat channel</td>
<td>0.015</td>
</tr>
<tr>
<td>Concrete with flat channel</td>
<td>0.013</td>
</tr>
<tr>
<td>Bituminous Wearing Course</td>
<td>0.013</td>
</tr>
<tr>
<td>Precast block paving</td>
<td>0.015</td>
</tr>
<tr>
<td>Stone Mastic Asphalt (SMA) Wearing Course and Friction Course</td>
<td>0.016</td>
</tr>
</tbody>
</table>

Table 4: Roughness Coefficients for Different Types of Road Surface

<table>
<thead>
<tr>
<th>Type of Grating</th>
<th>RF&lt;sub&gt;grating&lt;/sub&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>GA1-450</td>
<td>0%</td>
</tr>
<tr>
<td>GA2-325</td>
<td>15%</td>
</tr>
</tbody>
</table>

Table 5: Reduction Factors for Gully Efficiency

<table>
<thead>
<tr>
<th>Roads / Road Sections</th>
<th>RF&lt;sub&gt;debris&lt;/sub&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expressways</td>
<td></td>
</tr>
<tr>
<td>longitudinal gradient less than 0.5% &amp; near sag points</td>
<td>15%</td>
</tr>
<tr>
<td>longitudinal gradient 0.5% or more</td>
<td></td>
</tr>
<tr>
<td>near amenity area or rural area</td>
<td>10%</td>
</tr>
<tr>
<td>other sections</td>
<td>5%</td>
</tr>
<tr>
<td>Normal Roads</td>
<td></td>
</tr>
<tr>
<td>longitudinal gradient less than 0.5%</td>
<td>20%</td>
</tr>
<tr>
<td>longitudinal gradient 0.5% or more</td>
<td></td>
</tr>
<tr>
<td>near sag points or blockage blackspot, e.g. streets with markets or hawkers</td>
<td>20%</td>
</tr>
<tr>
<td>near amenity area or rural area</td>
<td>20%</td>
</tr>
<tr>
<td>other sections</td>
<td>15%</td>
</tr>
</tbody>
</table>

Table 6: Reduction Factors for Blockage by Debris
5. **Worked Examples**

5.1 **Example 1 - Gullies under general road conditions**

Design parameters:
- Drained width, \( W = 12.0 \) m
- Crossfall, \( X_{fall} = 3.6\% \)
- Longitudinal gradient, \( G_{long} = 1.5\% \)
- Road surface: bituminous wearing course
- Kerb height, \( H_{kerb} = 125\)mm
- Blockage problem: not blackspot but near amenity area
- Gully type: GA1-450

From Table 4,
- Roughness coefficient, \( n = 0.013 \)

From Design Chart 1A,
- Drained area, \( A = 200 \) m\(^2\)

From Equation 3,
\[
L_u = (0.01/0.013) \times 200/12 = 12.8\text{m}
\]

From Table 5, \( RF_{grating} = 0 \)

From Table 6, \( RF_{debris} = 20\% \)

From Equation 5,
\[
L = 12.8 \times 1 \times 0.80 = 10.2\text{m}
\]

From Equation 1, \( H_{alt} = 1.2 \times 10 \times 1.20 \times 3.6 = 51.8\text{mm} \)

\( < H_{kerb} = 125\text{mm} \quad \text{o.k.} \)

5.2 **Example 2 - Gullies in Expressways**

Design parameters:
- Drained width (total width of carriageway, hard shoulder and verge), \( W = 20.0\)m
- Crossfall, \( X_{fall} = 3.6\% \)
- Longitudinal gradient, \( G_{long} = 1.5\% \)
- Road surface: friction course
- Kerb height, \( H_{kerb} = 125\)mm
- Blockage problem: without amenity area
- Gully type: GA1-450

From Table 4, roughness coefficient, \( n = 0.016 \)

From Design Chart 1B, Drained area, \( A = 384\text{m}^2 \)
From Equation 3,
\[ L_u = \frac{(0.01/0.016) \times 384}{20.0} \]
= 12.0m

From Table 5, \( RF_{grating} = 0 \)
From Table 6, \( RF_{debris} = 5\% \)

From Equation 5, \( L = 12.0 \times 1 \times 0.95 = 11.4m \)

From Equation 1, \( H_{ult} = 1.2 \times 10 \times 1.71 \times 3.6 \)
= 73.9mm
< \( H_{kerb} = 125\text{mm} \) o.k.

5.3 Example 3 - Gullies in flat roads

Design parameters:
- Drained width (total width of carriageway and footway), \( W = 12.0 \text{ m} \)
- Crossfall, \( X_{fall} = 3.6\% \)
- Longitudinal gradient, \( G_{long} = 0.4\% \)
- Road surface: concrete (with trowelled smooth roadside flat channel)
- Kerb height, \( H_{kerb} = 125\text{mm} \)
- Blockage problem: not blackspot
- Gully type: GA1-450

From Table 4, roughness coefficient, \( n = 0.013 \)

From Design Chart 2A,
- Gully spacing for roads of zero gradient, \( L_o = 7.4\text{m} \)

From Design Chart 3,
- Adjustment factor, \( F = 0.49 \)

From Design Chart 4A,
- Multiplication factor, \( R = 1.17 \)

From Equation 4,
- Unadjusted gully spacing, \( L_u \)
  \[ = 7.4 \times [1 + 0.49 \times (1.17 - 1)] \]
  = 8.0m

From Table 5, \( RF_{grating} = 0 \)
From Table 6, \( RF_{debris} = 20\% \)

From Equation 5, \( L = 8.0 \times 1 \times 0.8 \)
= 6.4m

From Equation 1, \( H_{ult} = 1.2 \times 10 \times 1.20 \times 3.6 \)
= 51.8mm
< \( H_{kerb} = 125\text{mm} \) o.k.

If edge drain is provided,
From Table 7, the maximum length of edge drain = 10.8m > L = 6.4m
And $X_{fall} = 3.6\% > 3.0\%$ (Table 3 refers) o.k
Hence, design gully spacing = 10.8m

5.4 Example 4 – Additional catchment area at road junction

Design parameters:
Location: Road junction (Figure 3 refers)
Crossfall of steep road = 3%
Longitudinal gradient of steep road = 7.5%
Road width of steep road = 11.7m

Additional catchment area
\[ = 11.7 \times (11.7/3 \times 7.5) / 2 \]
\[ = 11.7 \times 29.25 / 2 \]
\[ = 171 \, m^2 \]

From Table 9,
No. of additional gullies required = 3

5.5 Example 5 – Outlet pipe for gullies at sag point

Design parameters:
Location: Sag point
Catchment area, $A = 2,500 \, m^2$
Gully type: GA1-450
Outlet pipe type: PVC pipe (typical $k_s = 0.00006 \, m$)
Pipe diameter = 0.225m (cross-sectional area, $A_p = 0.03976 \, m^2$; and hydraulic radius, $R = 0.05625 \, m$)
Pipe gradient, $S_f = 0.1$ (i.e. 1:10)

From Table 9,
No. of gullies required = 5

From Equation 7,
Required flow capacity of the outlet pipe for the gully series, $Q_G$
\[ = 2,500 \times 0.000075 \]
\[ = 0.1875 \, m^3/s \]

From Equation 6,
Design flow capacity of the outlet pipe, $Q_P$
\[ = -0.03976 \times \sqrt{32 \times 9.81 \times 0.05625 \times 0.1 \times \log \left[ \frac{0.00006}{14.8 \times 0.05625} + \frac{1.255 \times 1 \times 10^{-6}}{0.05625 \times \sqrt{32 \times 9.81 \times 0.05625 \times 0.1}} \right]} \]
\[ = 0.2140 \, m^3/s \]
\[ > 0.1875 \, m^3/s \] o.k.
Design Chart 1A
General Calculation of Drained Area

Note: Under no circumstances should gully spacing exceed 25m or drained area be larger than 500m²
Design Chart 1B
Calculation of Drained Area for Hard Shoulder Flows

Note: Under no circumstances should gully spacing exceed 25m or drained area be larger than 600m²
Design Chart 2B - Gully Spacing (Lo)
Hard Shoulder Flows (Gradient < 0.5%)

Hard Shoulder Flows Only
Design Chart 3 - Adjustment Factor, F
(Gradient < 0.5%)

ADJUSTMENT FACTOR, F

DRAINED WIDTH (m)
Design Chart 4A - R Factor
Flat Roads (Gradient < 0.5%)

MULTIPLICATION FACTOR, R

LONGITUDINAL GRADIENT (%)
Design Chart 4B - R Factor
Hard Shoulder Flows (Gradient < 0.5%)

MULTIPLICATION FACTOR, R

0.6 0.5 0.4 0.3 0.2 0.1 0.0
0.6 0.5 0.4 0.3 0.2 0.1 0.0

LONGITUDINAL GRADIENT (%)
Sketch No. 1 – Edge Drain Details

Notes:
1. Dimensions are in millimetres.
2. Concrete for edge drain shall be grade 40/10.
3. Galvanized steel mesh reinforcement shall be provided on all sides.
4. Finish shall be U2 and F2.
Sketch No. 2 – Connection Unit between Edge Drain and Gully

Notes:
1. Dimensions are in millimetres.
2. Concrete for edge drain shall be grade 40/10.
3. Galvanized steel mesh reinforcement shall be provided on all sides.
4. Finish shall be U2 and F2.
Sketch No. 3 – Slot Drain

Sketch No. 4 – Kerb Drain