



**HYDRAULIC & DRAINAGE SYSTEMS DESIGN**

**GATIC<sup>®</sup>**  
**SLOT DRAIN**

# Hydraulic & Drainage Systems Design

## 1) Flow Rates and Slotdrain Sizing

Elkington Gatic has been closely involved with designing surface water drainage systems in partnership with consulting engineers for many years. It has become increasingly apparent throughout this period of time that due to the number of variables applicable to each individual project, the information contained in published capacity charts provides only a very limited amount of useful data. Any combination of the following variables will have a direct and significant impact upon the surface water drainage design:

- geographic location • rainfall intensity and duration • natural gradients on the site
- length of each channel run and outlet position • effects of adjoining runs or rainwater inlets
- permeability of surface material • specific local environmental requirements • Stormwater Attenuation

In view of these factors, Elkington Gatic, in conjunction with a leading drainage hydraulics consultancy, has developed the Slotdrain Interactive Design Software programme, a unique and extremely versatile surface water drainage design software tool. The design software enables all of the above criteria to be considered and provides comprehensive data sheets and CAD/pdf drawings for each individual run plus links to standard details for all channels and system components.

**To arrange a demonstration and free installation of the software please call +44(0)1304 203545.**



## 2) Methods of Calculating the Hydraulic Capacity of Drainage Channels

The established and universally accepted methodology for calculating the hydraulic performance of linear drainage channels is the HR Wallingford Report SR581 'Hydraulic Capacity of Drainage Channels with Lateral Inflows'. The Gatic Slotdrain Interactive Drainage Design Software has successfully incorporated this methodology since its launch, during which time the results produced have been routinely verified to be accurate by many external engineers.

Whilst the HR Wallingford method continues to be the tried, trusted and preferred methodology used by Elkington Gatic to calculate the hydraulic capacity for Gatic Slotdrain, evidence has recently emerged that an alternative method is now being used to provide drainage designs for a particular channel drain system.

This lesser-known alternative methodology uses the Saint-Venant Equation, which was originally used to calculate flows in rivers and canals, but when used in the context of drainage channels, produces hydraulic capacities much greater than those produced by HR Wallingford. In practical terms, this means that when the Saint-Venant Equation is used to calculate channel drain sizes, for any given hydraulic inflow conditions, the result will often indicate that a much smaller size channel (average 30% smaller) will be suitable.

In the interests of choice, and to enable you to make a more informed decision in respect of which methodology you would prefer to incorporate into your design, we have upgraded our design software to offer both methodologies.

If you routinely utilize other general drainage design software programmes for designing the remainder of the drainage network, to avoid any issues of inconsistency between the hydraulic capacities generated by the two methodologies in the Slotdrain software programme and your general design software, we would recommend that you run a simple check. For example, a 225mm Slotdrain laid to a 1/100 gradient should give a similar result to a typical 225mm pipe laid to the same gradient.

# Hydraulic & Drainage Systems Design Continued

Some typical examples for each methodology are set out below, together with a summary chart showing hydraulic capacities for the range of Slotdrain sizes. For the purpose of comparison, the following scenarios are all based upon 50mm/hour rainfall, 1 Year Return Period and a 5 minute Storm Duration.

## Scenario 1: Area drained (m<sup>2</sup>) by a 50m single size channel run

### HR Wallingford Methodology

Longitudinal Slope	0% Surface Slope			0.25% Surface Slope			0.5% Surface Slope			
	Channel Size	Maximum Capacity (l/s)	Maximum Area (m <sup>2</sup> )	Flow Velocity (m/s)	Maximum Capacity (l/s)	Maximum Area (m <sup>2</sup> )	Flow Velocity (m/s)	Maximum Capacity (l/s)	Maximum Area (m <sup>2</sup> )	Flow Velocity (m/s)
	100mm	2	140	0.2	3.8	270	0.5	5.3	370	0.6
	150mm	6.4	450	0.3	10.2	730	0.5	13.4	960	0.7
	225mm	18.8	1350	0.4	27.7	1990	0.6	34.6	2490	0.8
	300mm	39.9	2870	0.5	56.4	4060	0.7	68.6	4940	0.9
	400mm	84	6050	0.6	115	8290	0.8	138	9900	1
	500mm	149	10730	0.7	200	14400	0.9	237	17050	1.1
	600mm	328	23600	0.8	431	31000	1.1	501	36100	1.3

### Gradual Varied Flow (GVF)/Saint Venant Methodology

Longitudinal Slope	0% Surface Slope			0.25% Surface Slope			0.5% Surface Slope			
	Channel Size	Maximum Capacity (l/s)	Maximum Area (m <sup>2</sup> )	Flow Velocity (m/s)	Maximum Capacity (l/s)	Maximum Area (m <sup>2</sup> )	Flow Velocity (m/s)	Maximum Capacity (l/s)	Maximum Area (m <sup>2</sup> )	Flow Velocity (m/s)
	100mm	2.4	170	0.3	4.4	320	0.5	5.6	400	0.7
	150mm	9	650	0.5	14.3	1030	0.7	17.5	1260	0.9
	225mm	31.5	2270	0.7	45.3	3260	1	54	3890	1.2
	300mm	75.6	5440	1	102.6	7390	1.3	120	8630	1.5
	400mm	180	12950	1.3	233	16800	1.7	245	17630	1.9
	500mm	351	25260	1.6	420	30230	2	420	30230	2.2
	600mm	778	56000	1.9	896	64500	2.2	986	71000	2.5

## Scenario 2: Area drained (m<sup>2</sup>) by a 100m single size channel run

### HR Wallingford Methodology

Longitudinal Slope	0% Surface Slope			0.25% Surface Slope			0.5% Surface Slope			
	Channel Size	Maximum Capacity (l/s)	Maximum Area (m <sup>2</sup> )	Flow Velocity (m/s)	Maximum Capacity (l/s)	Maximum Area (m <sup>2</sup> )	Flow Velocity (m/s)	Maximum Capacity (l/s)	Maximum Area (m <sup>2</sup> )	Flow Velocity (m/s)
	100mm	1.3	90	0.2	4.1	300	0.5	6.7	480	0.8
	150mm	5.1	360	0.3	10.9	780	0.6	16	1150	0.8
	225mm	16.4	1180	0.4	28.9	2080	0.7	39.3	2830	0.9
	300mm	36.3	2610	0.5	58.2	4190	0.8	75.8	5460	1
	400mm	79	5650	0.6	118	8490	0.9	149	10700	1.1
	500mm	141	10180	0.7	204	14700	1	252	18150	1.2
	600mm	316	22780	0.8	436	31400	1.1	524	37700	1.3

### Gradual Varied Flow (GVF)/Saint Venant Methodology

Longitudinal Slope	0% Surface Slope			0.25% Surface Slope			0.5% Surface Slope			
	Channel Size	Maximum Capacity (l/s)	Maximum Area (m <sup>2</sup> )	Flow Velocity (m/s)	Maximum Capacity (l/s)	Maximum Area (m <sup>2</sup> )	Flow Velocity (m/s)	Maximum Capacity (l/s)	Maximum Area (m <sup>2</sup> )	Flow Velocity (m/s)
	100mm	1.7	125	0.2	4	290	0.5	5.2	370	0.6
	150mm	6.8	490	0.4	12.9	930	0.7	16.3	1170	0.8
	225mm	24.3	1740	0.6	40.3	2900	0.9	50	3590	1.2
	300mm	60	4240	0.8	91	6540	1.2	111	7980	1.4
	400mm	142	10220	1	206	14830	1.5	245	17630	1.8
	500mm	279	20070	1.3	388	27920	1.8	420	30230	2.1
	600mm	611	44000	1.5	736	53000	1.8	840	60500	2.1

## Scenario 3: Area drained (m<sup>2</sup>) by a 200m single size channel run

### HR Wallingford Methodology

Longitudinal Slope	0% Surface Slope			0.25% Surface Slope			0.5% Surface Slope			
	Channel Size	Maximum Capacity (l/s)	Maximum Area (m <sup>2</sup> )	Flow Velocity (m/s)	Maximum Capacity (l/s)	Maximum Area (m <sup>2</sup> )	Flow Velocity (m/s)	Maximum Capacity (l/s)	Maximum Area (m <sup>2</sup> )	Flow Velocity (m/s)
	225mm	11.7	840	0.3	31.3	2250	0.7	48.8	3510	1.1
	300mm	29.1	2090	0.4	61.8	4450	0.8	90.4	6500	1.2
	400mm	67.5	4860	0.5	123	8880	0.9	171	12290	1.2
	500mm	126	9070	0.6	212	15260	1	283	20360	1.3
	600mm	294	21150	0.7	447	32200	1.1	569	40990	1.4

### Gradual Varied Flow (GVF)/Saint Venant Methodology

Longitudinal Slope	0% Surface Slope			0.25% Surface Slope			0.5% Surface Slope			
	Channel Size	Maximum Capacity (l/s)	Maximum Area (m <sup>2</sup> )	Flow Velocity (m/s)	Maximum Capacity (l/s)	Maximum Area (m <sup>2</sup> )	Flow Velocity (m/s)	Maximum Capacity (l/s)	Maximum Area (m <sup>2</sup> )	Flow Velocity (m/s)
	225mm	18.2	1310	0.4	36.7	2640	0.9	46.9	3380	1.1
	300mm	44.9	3230	0.6	82	5910	1.1	103	7440	1.3
	400mm	110	7890	0.8	184	13220	1.3	229	16470	1.7
	500mm	217	15640	1	345	24830	1.6	420	30230	1.9
	600mm	462	33300	1.2	633	45600	1.8	740	53300	1.8

### 3) Benefits of Step Fall Designs

Gatic Slotdrain is uniquely available in 7 channel sizes ranging from a small and compact 100mm wide channel through to an extremely high capacity 600mm wide channel. Whilst single size channel runs may at times prove to be more suitable, there are significant improvements in hydraulic performance, invert depths and total installed cost where Slotdrain designs incorporate step falls.

For the purpose of comparison, the following scenarios are all based upon 50mm/hour rainfall, 1 Year Return Period and a 5 minute Storm Duration.

#### Scenario 1:

5,000 m<sup>2</sup> Area drained by a single 100m stepped fall Channel Run – Level Surface Area.

HR Wallingford Methodology	
Channel Size	Metres
150mm	16
225mm	30
300mm	39
400mm	15
<b>Total</b>	<b>100</b>

Saint Venant Methodology	
Channel Size	Metres
150mm	16
225mm	15
300mm	54
400mm	15
<b>Total</b>	<b>100</b>

Flow Velocity	0.9m/sec
Channel Capacity	129 L/sec
Discharge at Outlet	69.4 L/sec

Flow Velocity	1m/sec
Channel Capacity	139 L/sec
Discharge at Outlet	69.4 L/sec

#### Scenario 2:

5,000 m<sup>2</sup> Area drained by a single 100m stepped fall Channel Run - 1/200 (0.5%) Surface Gradient.

HR Wallingford Methodology	
Channel Size	Metres
150mm	22
225mm	36
300mm	42
<b>Total</b>	<b>100</b>

Saint Venant Methodology	
Channel Size	Metres
150mm	25
225mm	48
300mm	27
<b>Total</b>	<b>100</b>

Flow Velocity	1.1m/sec
Channel Capacity	81 L/sec
Discharge at Outlet	69.4 L/sec

Flow Velocity	1.4m/sec
Channel Capacity	109 L/sec
Discharge at Outlet	69.4 L/sec

#### Designing a step fall system:

- Generates an 'installed gradient' causing the channel invert to be steeper than the ground slope.
- Optimises the use of smaller channels running much closer to capacity.
- Provides greater self cleansing velocities.
- Increases flow capacities, often resulting in a reduction in channel sizes.
- Minimises invert depths at the outlet point.
- Reduces the amount of excavation and concrete surround required, by selecting the shallowest and most economical channel layout.



## 4) Slotdrain Inlet Capacity

The inlet capacity of each type of Gatic Slotdrain is much greater than would be required in almost all situations, despite the fact it only appears as a very neat 10 or 30mm wide slot in the pavement. The table below shows inlet capacities for Gatic Slotdrain being fed from both sides, or from one side only (flow interception on a slope):

Width of Slot	Inlet capacity (l/s per linear metre)*			
	Feed both sides	Feed one side only at cross slope		
		1:40	1:80	1:200
10mm	8.5	2.6	3.5	3.2
30mm Treadsafe	14	3.5	4.1	4.2
30mm Standard	14	5.0	5.5	5.5

\* Flow rates determined independently by CRM Rainwater Drainage Consultancy Ltd

To put the figures into perspective, even the smallest flow rate shown above indicates that the 10mm wide slot could cope with an upslope distance of 180m of paving area at 50mm/hr rainfall, which would represent an unrealistically large catchment area.

**Therefore in all cases, capacity of the Slotdrain system will be determined by the flow carrying capacity of the units, not the slot inlet capacity.**

## 5) Spillage Interception from Forecourt and Fuelling Areas

Regulation 6(4) of DSEAR states 'it is the duty of the site operator to put in place measures to collect and safely retain any spillages of dangerous substances'.

Gatic Slotdrain has been empirically tested at an operational filling-station forecourt by a leading Fire Service petroleum officer. The results demonstrated that Gatic UltraSlot with the 30mm throat orifice (standard or treadsafe) is eminently suitable for use in all forecourt and fuelling areas, as it provides a continuous interception slot that prevents wash-over of surface liquids. Whilst the test demonstrated that a single channel coped with almost all of the spillage, a strong recommendation was given to incorporate a twin, parallel run of drainage channels to ensure full compliance with the above regulation even in the event of a partial blockage or build up of silt in the channels.

Copies of the full Fire Service Test Report are available upon request.



## 6) Roughness

Gatic Slotdrain is manufactured from 3m lengths of galvanised steel, which leads to lower frictional losses from both the surface and joints, giving improved flow performance over some rougher concrete based products, or products supplied in shorter lengths requiring a greater number of joints.

## 7) Self-Cleansing Properties of Gatic Slotdrain

The hexagonal profile of Gatic Slotdrain ensures that self-cleansing is improved even with the smallest amount of rainfall. The v-shaped channel invert ensures that at low flows, water is channelled into a narrower cross section, increasing the flow depth and thus effective hydraulic gradient. Additionally, the flow is always running in the same well defined course, reducing the likelihood of siltation.

## 8) Watertightness

Gatic Slotdrain has been independently tested and certified by BSI to comply with the watertightness requirements of BS EN 1433:2002 - Drainage Channels for Vehicular and Pedestrian Areas. A test certificate is available upon request.

## 9) Procedure for the manual design of Gatic Slotdrain systems

If you do not have access to the Slotdrain Interactive Design Software, or would prefer to calculate or check Slotdrain sizes manually, please contact our technical department for a copy of our manual design procedure.

## Stormwater Attenuation and SuDS



### Attenuation

With the ever increasing development of greenfield sites, pressure on the storm drainage system has reached crisis point. Over the past few years, the Environment Agency, SEPA and their partners have pushed forward the concept of making drainage sustainable, by replicating natural processes (SuDS). The EA, SEPA and planning authorities now look for a drainage solution on most sites that will:

- Reduce the quantity of water flowing from site
- Improve the quality of water flowing from site
- Provide an amenity on site for people and wildlife

On most heavily developed sites (such as retail or distribution) it is only realistically possible to provide solutions to the first two of the key objectives, but this still provides enormous environmental benefits over a traditional approach.

### Designing for SuDS

There are many and varied ways of incorporating stormwater attenuation requirements into a drainage scheme. Unfortunately, many of the options available are:

- Complex for the engineer to design and specify accurately
- Complicated and time consuming for the contractor to install correctly
- Often difficult or practically impossible to access, maintain and remove silt build-up

**Gatic Slotdrain** offers an excellent, proven solution to all of these issues, providing all parties involved with a simple, effective and highly efficient method of storage and flow regulation.

**Gatic Slotdrain** can be utilised to provide an efficient and effective component of the SuDS strategy for any hard surfaced site. In most cases, a discharge restriction will be placed on site, which can limit flow to nearly seventy times less than the amount the site would have discharged with a traditional system. This reduced flow means that a large amount of the surface water on the site must be attenuated (stored for a period and slowly released). By utilising larger Gatic Slotdrains, surplus capacity can be generated, which can be used to provide attenuation very close to the source of run-off. A Gatic Slotdrain system can be designed to cope quite easily with the attenuation requirements for most small to medium sites. Whilst it may not be large enough to provide the full site attenuation requirements for very large developments, it can provide a valuable component of the storage network, particularly when positioned close to the source, where it can be used to store the peak short duration run-off, enabling pipe sizes across the site to be reduced.

### Flow Regulation

In order for water to be attenuated on site, a flow control must be introduced to slow the passage of water. There are a number of ways of controlling flow but the most suitable for a channel drain system is an orifice plate. The orifice plate is simply a sharp edged hole in a plate of metal, but its hydraulics are very well proven and well understood. By carefully designing the size of the hole, very accurate maximum flow levels can be established.

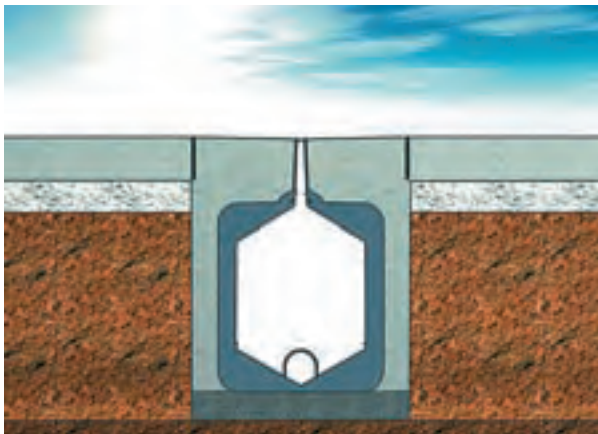
## Calculating the Outlet Orifice Size

The size of the outlet orifice is precisely calculated using the Slotdrain Interactive Design Software (available to engineers upon request) to exactly match the permissible discharge for each site. Furthermore, the software contains a unique 'Optimisation' tool that enables the designer to maximise utilisation of each controlled run, making it possible to reduce discharge rates further, which in turn may facilitate reductions in outlet pipe sizes and possibly the size of any fuel interceptors required.

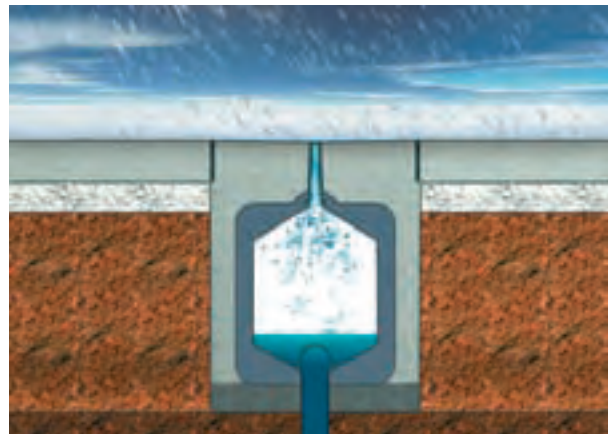
## Performance and Maintenance of the Flow Regulator

The Gatic Slotdrain flow regulator utilises a semi-circular sharp edged orifice, located at the invert position of the Slotdrain to ensure that in normal flow conditions there are no obstacles or restrictions to the flow. In the unlikely event of a blockage, an overflow weir, proportional to the outlet orifice is positioned at the top of the flow regulator. The regulator can be installed at any point where the Slotdrain discharges into an access, outlet or silt box, and thus flow can be regulated at any point on site. This is particularly useful on sloping sites, where water can be retained at all levels of site, rather than just at the bottom.

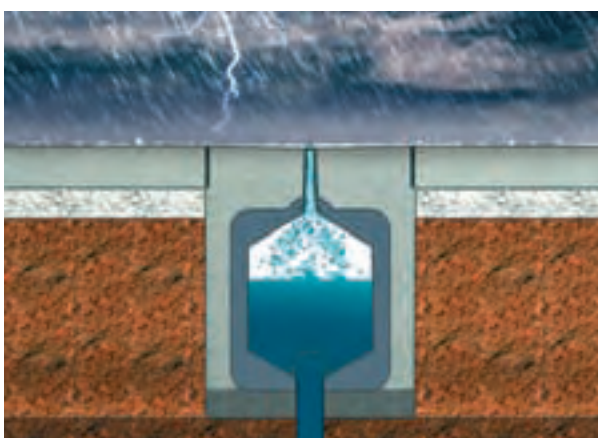
The Flow Regulator is in all cases neatly positioned on the inside wall of the appropriate outlet unit, enabling easy visual inspection and maintenance access (see pages 49-52).



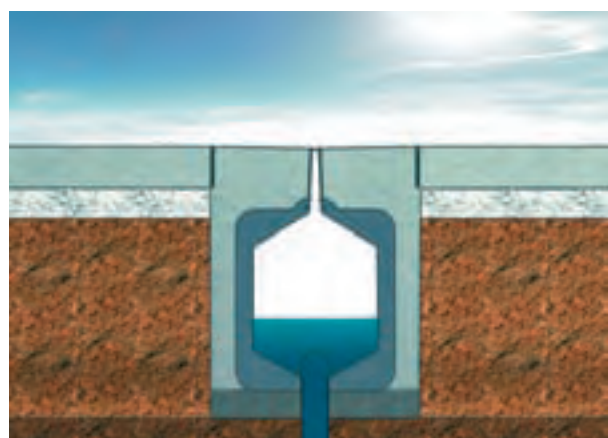
Dry weather conditions.



Rainfall starts, the Slotdrain begins to fill with water and discharges via the flow regulator.



Water level in the Slotdrain system rises as storm intensity increases. Outflow reaches designed regulated flow rate without flooding the surrounding area.



Storm ceases, controlled outflow continues and water level in the Slotdrain system falls.