Co-UDlabs

Data Storage Report

CoUDlabs_WP8

Investigating geometrical effects on hydraulic energy losses during sewer to surface flow interactions during urban floods

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DOCUMENT TRACKS DETAILS

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Project title	Building Collaborative Urban Drainage research labs communities
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Dataset information	
Activity	Joint Research Activities
Dataset ID	CoUDlabs_WP8_T811_UOS_001
Work package number	WP8
Dataset title	Investigating geometrical effects on hydraulic energy losses during sewer to surface flow interactions during urban floods
Data sources	Data from laboratory experiment using a piped drainage system to surface flood flow through a manhole using different geometrical drainage grates. Dataset includes measurements of pressure, flow rate and depth from a physical model.
Content	Raw and processed flow time series: pressure (mm), flow rate (l/s). Grate characteristics and images of the experiments.

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Abstract

This document describes the dataset used in CO UD-labs JRA3 (WP 8) Task 8.1.1. This considers the hydraulic exchange (surcharge) from a piped drainage system to surface flood flow through a manhole. The dataset includes measurements of pressure, flow rate and depth from a physical scale model. The effect of changing the manhole lid properties on flow exchange (surcharge) and pressure in the experimental system is quantified over a range of flow rates.

1. Experimental setup

This section describes the (1.1) experimental scale model urban drainage system at UoS system, (1.2) grate geometries tested in this research and the (1.3) measured hydraulic conditions for the experimental tests conducted.

1.1. Scale model urban drainage system

The experimental tests described here utilise a 1:6 pipe/manhole/surface scale model at the water laboratory at the University of Sheffield (UK). It links a model surface floodplain to an urban drainage system via a manhole shaft (see fig 1). The floodplain surface is 4 m width, 8.2 m length, with a longitudinal slope of 1/1000. Connecting the surface to sewer pipes, the manhole shaft is made from vertical acrylic pipe, has a 0.478 m height, and an inner diameter of 0.24 m. Directly beneath the floodplain, connected by the manhole shaft, is the drainage system made from horizontal acrylic pipes, with an inner diameter of 0.075 m. The facility has been used for a number of previous studies of pipe/surface flow interaction, and more details can be found in, for example, Rubinato et al. (2017).

A pumping system in a closed-circuit supplies water within the facility. With inlet flows to the sewer pipe (Q3) and surface (Q1) being set independently by automated control valves operated via Labview software. The facility is equipped with a SCADA system (Supervision, Control and Data Acquisition) through Labview software that permits the monitoring and logging of the flow rates and pressure readings within the surface and sewer systems independently.

Pressure sensors (GEMS series 5000) provided the pressure head for upstream of the manhole, in the pipe and on the surface. Sewer pressure sensor is located 350 mm from the centre of the manhole and surface is 460 mm from manhole. The surface downstream outlet is a free outfall. Flow at the sewer outlet can also be controlled by a manual value. Given sufficient flow at Q3 and applying a restriction to Q4, results in net flow exchange from the sewer to the surface (+ve Qe).

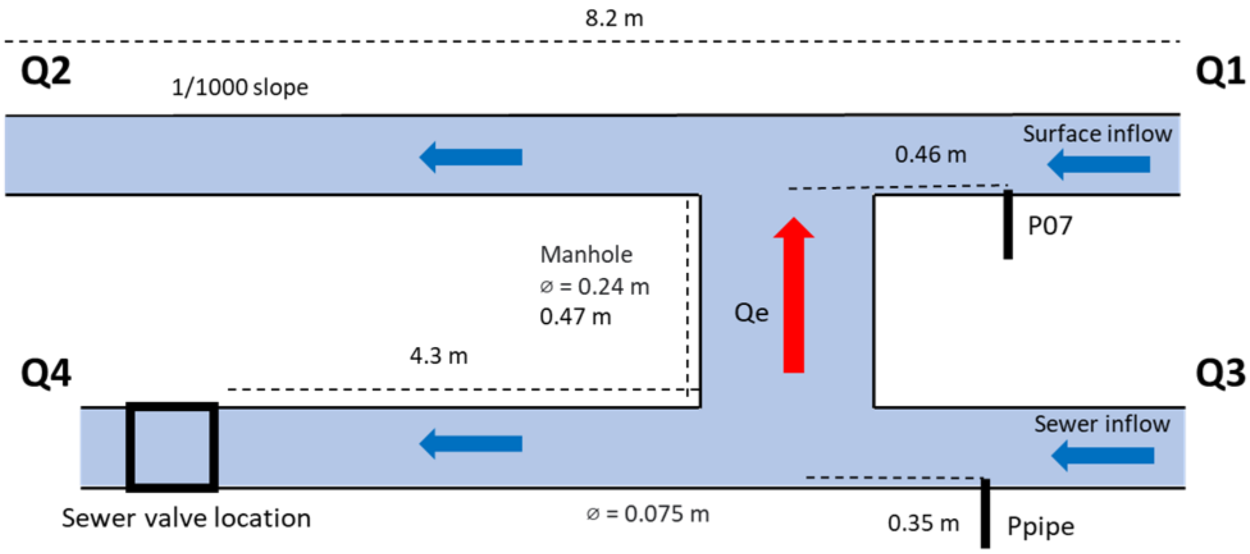

Figure 1. Diagram of the A/B rig structure (not to scale).

1.2. Grate geometry

Six acrylic grates (fig 2), previously constructed for Rubinato et al. (2018) study, were used for these experiments. These were designed in AutoCAD with known geometrical properties and installed in turn within the urban drainage model (on top of the manhole). For each of these grates, the total area of empty space and total effective edge perimeter length were obtained from the AutoCAD drawings in Rubinato et al. (2018) study and can be found in table 1.

Table 1. Details of the six grates used, from Rubinato et al (2018).

Grate	Area filled- Af (m^2)	Area of empty spaces- Ae (m^2)	Void ratio - Vr (%)	Effective perimeter - Ep (m)
No grate	0	0.0452	0	0
Small diameter	0.0254	0.0198	43.8	0.4408
1	0.0277	0.0175	38.03	1.8816
2	0.0307	0.0145	32.1	3.0364
3	0.0373	0.0079	17.48	1.3880
4	0.0435	0.0017	3.76	0.5128
5	0.0391	0.0061	13.5	2.2586
6	0.0385	0.0067	14.11	1.2428

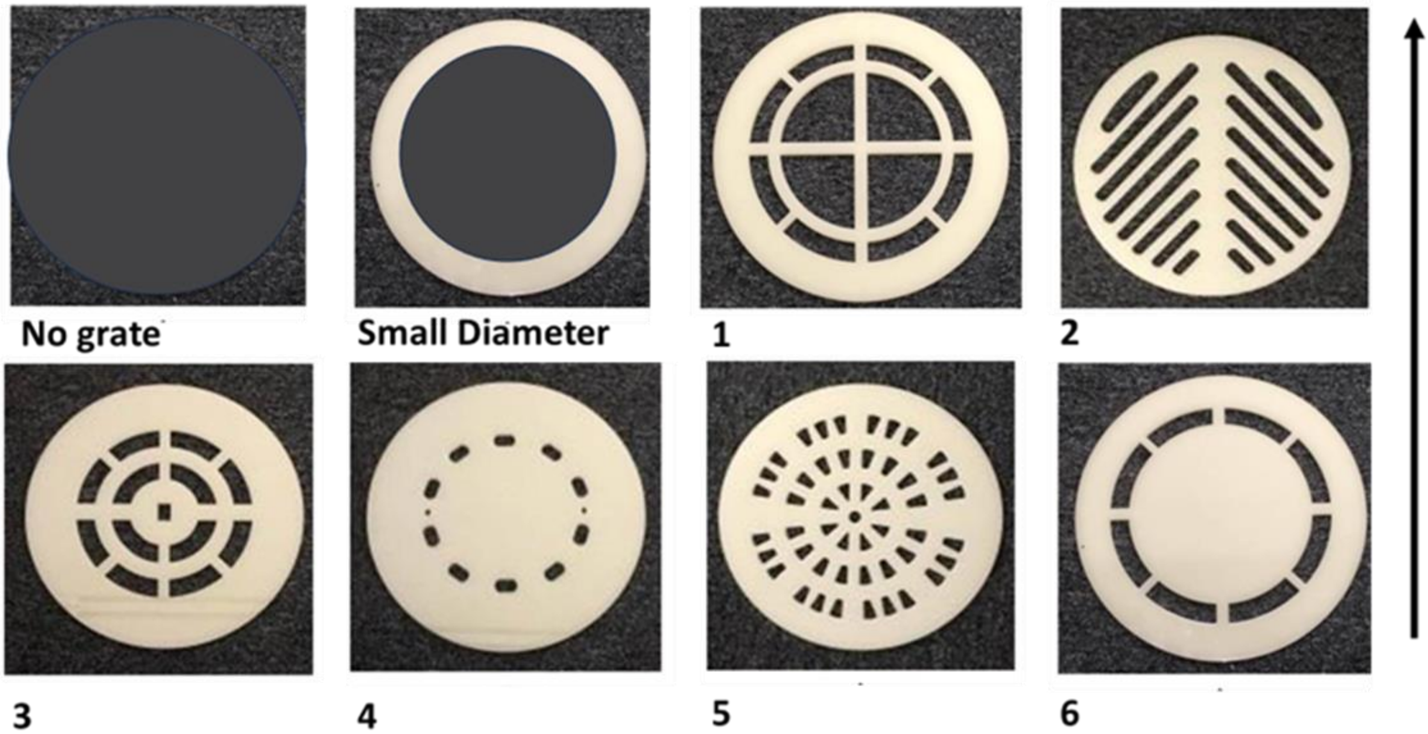

Figure 2. Grates applied on top of manhole. Black arrows indicate the orientation of each grate (Rubinato et al. 2018).

1.3. Hydraulic conditions

For each grate, a range of tests were conducted with varying degree of valve restrictions on the downstream sewer pipe (Q4) and a range of pipe inflow rates. All tests resulted in net surcharge to the surface (+ve Qe). For each test, flow exchange (Qe) is quantified by a mass balance established from the surface and sewer inflow and outflows.

As the downstream pipe flow could not be changed/quantified directly; therefore, the upstream valve (Q3) was initially set to a flow rate of 10 l/s and the flow in Q4 was manually restricted five times. This was done by tightening the valve on the downstream pipe until the flowmeter reduced to 9 l/s, 8 l/s, 7 l/s, 6 l/s and 5 l/s: increasing the pressure in the pipe and flow surcharge. Once the downstream pipe was restricted to the chosen variable (i.e., 5 l/s), the upstream valve was set to different flow rates, ranging from 4.5 l/s to 10.6 l/s for the sewer inflows (Q3). All tests in this work were conducted in steady flow conditions, this was established by establishing the flow at each setting and recording for an average of 180 seconds to ensure flow stabilisation and full convergence of measured parameters is achieved.

Once these experiments were conducted, surface flows (Q1) were also introduced. Repeating the exact same methodology, with the exception of surface inlet flows remaining at a constant of 10 l/s with no restrictions on downstream sewer pipe (Q4). With a second range of tests introducing surface flows to be 5 l/s whilst restrictions on Q4 were placed to 8 l/s on the sewer downstream flowmeter for all upstream sewer flow (Q3) tests across all grates. The outcomes from these tests provided an approximate estimation of the surface depth, determined to be 0.001 m from the measurements provided by P07, which is a pressure transducer on the surface plain (shown in figure 1).

2. Data structure

Data sets include temporal averages of sewer pipe and surface inflow and outflows, as well as the time averaged pressure head from the surface, upstream and downstream manhole pipe for each experimental test. The data sets are divided into the experiments with and without surface flows (Q1). The sewer inflow (Q3) remained consistent throughout, and the downstream sewer valve (Q4) was set to different restrictions.

The raw data will show the time series and pressure head for each experimental test. These have been labelled into experiments with surface flow and sewer flow (**SF**) and those with sewer flow only, no surface flows (**NSF**). For each grate, they have been labelled G1 for grate 1, or no grate is NG and small diameter is SD. This is followed by the test number, i.e. G4_3_SF, showing grate 4, test 3, with surface and sewer flows. More examples in table 2.

The averages of the parameters for each test have been calculated and placed into the 'combination' file, with each tab representing a grate geometry, i.e. grate 5, showing the time averaged flows and time averaged pressure head for each test under this grate geometry. Following same labelling as before.

Table 2. Showing examples of the data abbreviations used.

Abbreviation	Meaning
NG_1_NSF	No grate - test 1 - no surface flows
SD_SF	Small diameter – surface flows
G3_7_SF	Grate 3 – test 7- surface flows

References

Rubinato, M., S. Lee, R. Martins, and J. D. Shucksmith. 2018a. Surface to sewer flow exchange through circular inlets during urban flood conditions. J. Hydroinf. 20:564–576.