Description of the UKCRIC National Distributed Water Infrastructure Facility at the University of Sheffield

The UK Collaboratorium for Research in Infrastructure in Cities (UKCRIC – www.ukcric.com) is a consortium of UK Universities that received over £120M from the UK government to set up a series of national research facilities focussed on supporting research in urban infrastructure. The government funding from UKCRIC was managed by the Sheffield University received almost £4M from EPSRC £1.5M from the EU and this was matched by £3.8M

The National Facility for Distributed Water Infrastructure will be based within a newly constructed building providing ≈600m^2 of new space. The key experimental infrastructure will comprise a test cell (1350 m^3) in which urban water infrastructure assets (e.g. interconnected water pipes, sewer pipes/chambers, inlet structures) and natural artefacts such as impermeable and permeable catchment surfaces, soil layers and voids can be created, with in-situ instrumentation to allow for their interactions with the urban water infrastructure assets to be studied. The test cell will be 45m long by 5m deep by 6m wide. The length includes allowances for free surface control and stilling sections for both sewer and ground water flows at entry and exit of pipes without the use of elbow fittings which would induce unwanted dynamic reflection points. This design will provide a straight test length of 38m. This length will be sufficient for studying hydraulic processes of interest in distributed urban water infrastructure. The depth and width of the test cell is necessary such that fully representative burial depths can be accommodated (up to 1.5m for water supply and 3m for sewers) and that surface loading effects can interact with such assets without distortion by boundary effects. A live wastewater feed is also to be provided.

This full-scale environment will then be subjected to a controlled regime of sub-surface, pipe and surface flows and physical and chemical loadings and then the performance of the representative part of the urban water infrastructure system will be monitored. The facility will be able to generate in-pipe and surface flows of up to 200 l/s and subject pipes to pressure transient shocks of up to 10 bar to create conditions for hydraulic capacity exceedance, pipe bursting and contaminant ingress. Complex cyclic loads of up to 10kN/m^2 will be imposed on the contained soil and pipes, via controlled actuators to simulate physical surface and axial loading so the test cell will have the ability to examine the role of various repeated and sustained loading types that cause the failure of a wide range of urban water assets.

Side of new laboratory building

Side of laboratory building showing door access to testing tank

Two Header Tank Systems supplying the Testing Tank – Flows up to 200 l/s

Testing Tank (45m×6m×5m)– looking from downstream end

Pressurised Pipe Pumping Stations

Full scale pipe loops for transient testing

Stop logs used to divide testing tank

Full Scale Pressurised Piping System

A key aspect of the UKCIRC National Distributed Water Infrastructure Facility is to explore large scale pressurised water distribution systems. To this effect the facility is equipped with a two pumping stations each capable of producing up to 55 m head and 14 l/s. The pumping stations can be coupled to buried pipe sections, and can be set to constant or variable hydraulic conditions to simulate real life flows conditions in networks. Realistic hydraulic loading is critical to explore the interaction of pipes in their buried environment. It is predicted that understanding how hydraulic transients interact with pipe networks will be an area of keen interest to industry and academia in the near future and the ability to safely generate and monitor these dynamic events has been designed into the system. High speed pressure and flow logging (up to 10 kHz) is possible as is automatically controlling fast acting valves. To facilitate exploration of real scale systems the buried pressurised pipe sections can be augmented with 4x100 m long, 100 mm ID HDPE pipe coils, configurable in a modular fashion, to extend their length or to add complexity. In this way the facility is able to represent the true dynamics found in water distribution systems. Combined with the surface, ground water, and

thermal loading potential of UKCRIC it will be possible to full explore the conditions which impact and cause degradation of our vital buried pressurised water systems.

Constant Head Tank System

The testing tank of the facility can be split into two – so as to run control experiments; two 38m long, 5 m deep and 3m wide cells are available. The testing tank is supplied by two constant head systems, each capable of delivering 100 l/s each. These systems are computer controlled and can deliver up to four independent measureable inputs to simultaneously represent groundwater flow, pipe flow and surface flows. The computer control means steady and time varying flows can be produced and continuously monitored. The two header tank systems can also be linked and controlled as a single unit in which case up to 200 l/s can be delivered.

Testing Tank

The testing tank has a working length of 38m, width of 6m and is 5m deep. It can be slit either longitudinally or laterally using a system of watertight stop logs that can be moved and placed by the facility's technical staff. The testing tank is normally filled with sand/soil so that soil/water/asset interactions can be studied. Again users can specify different types of sand/soil and the facility's technical staff can arrange for specific set ups to be constructed. This means that a wide combination of surface channel and buried pipe systems and their interactions can be studied.

The testing tank also has the capability for multiple steady and low frequency point loads of up to 250kN in size to be applied via a computer controlled actuator system. The system also has logging capabilities so that both short term and long term loading patterns can be applied to pipes and other drainage assets placed in the testing tank.

Wastewater Supply

The facility is connected to a local pumping station located in the city's combined sewer network. Therefore, flows of up to 10 l/s of raw wastewater can be introduced into piped systems located in the testing tank.

Instrumentation and Support

There is a large urban water research group and a large geotechnics and groundwater group at Sheffield. Staff in these groups carry out experimental research into a wide range of man-made water and natural aquatic systems. The technical staff at Sheffield have expertise and access to a wide range of sophisticated experimental measurement and analytical equipment.

Users of the National Distributed Water Facility will have access to this equipment and the training needed to use it successfully. For example the facility has access to Particle Image Velocimetry systems, Laser Doppler and Acoustic Doppler Anemometry and Digital Image Correlation equipment. The central campus laboratories have a wide range of analytical equipment. The facility is supported by a group of experienced technical staff with a wide range of expertise from supporting hydraulic and geotechnical experiments, to chemical and microbiological analysis and the development, manufacture of a wide range of data logging and sensing systems. Academic, technical and organisational support is available to any group that wishes to use the facilities.