In the pit

A capital of €60 billion in sewer drains lies buried in the Netherlands. These drains must gradually be replaced, but where to start? New inspection techniques may provide the answer.

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Nikola Stanić is convinced that the laser has the potential to become the new standard in sewer inspection.
Almost 100,000 kilometres of pipes buried under the streets of the Netherlands carry dirty water from households and rainwater from street drains to waste water treatment plants. The self-evident presence of this system is fairly recent. Until the 1930s, most people in the Netherlands still relieved themselves in buckets. City canals served as open sewers, which remained the case for houseboats in Amsterdam until 2013.

A sewer is likely to go unnoticed until it stops working – when the toilet overflows, or when the streets are flooded after heavy rainfall.

One of the topics addressed in the TISCA (Technological Innovation for Measuring the Strength and Condition of Waste Water Drains) sewage research programme, for which the STW doubled the allocation last spring to reach an amount of €1.5 million, focuses on the replacement of sewage systems. How is this done? Municipalities are responsible for sewer maintenance. They contract with sewer-service companies, which bring in a high-pressure sprayer and a moving camera to flush out and inspect the sewers. The company submits an inspection report to the municipality, in accordance with European standards. Damage, cracks, in-growth and residues are coded and graded (with 5 representing the highest level of contamination). The municipality uses this information to identify the most urgent problems. Unfortunately, blockage and collapse occur regularly (12 repairs per 100 kilometres), despite reassuring video inspections.

The human factor is part of the problem. In a comparative study of different inspectors, Dr ir. Jojanneke Dirksen (Waternet) showed there is confusion about cracks and fractures, as well as with regard to distinguishing between residue and sand washed into the system. Moreover, the inspectors often overlooked certain details (e.g. mechanical damage or protruding washers). Dirksen concluded that the coding system should be simplified considerably in order to produce unequivocal reports.

**Laser scanner**

In addition, video inspection has several inherent deficiencies, as explained by doctoral candidate ir. Nikola Stanić. Video images tell us little about pipe thickness or about the surrounding soil package. Moreover, information on the damage location is not specific (with a one-metre margin of error), as the video carriage is capable of little more than wiggling back and forth on the round base of the pipe.

‘Concrete sewer pipes become thinner over time’

Now, laser scanners offer a promising alternative. Stanić has worked in the laboratory on a prototype of a laser scanner assembled from a common video tractor with a protruding rod. A laser ray that is deflected by a rotating mirror on the end of the rod rapidly scans the interior of the sewer pipe. A lot of information can be derived from the position of the light circle - much more than is possible with a regular video image. One key measurement is the diameter of the pipe, which serves as a measure of thickness.

‘Concrete sewer pipes become thinner over time,’ explains Stanić. The bacteria inside excrements produce sulphur dioxide. In a watery environment, it forms an acid that dissolves the calcium in the pipe. The cement becomes brittle and, in some places, may be washed away when a cleaning water jet is forced through the pipe. ‘You can hear the pebbles that came loose when they are suctioning out the water,’ says Stanić. The pipe diameter can be used to determine the thickness that the pipe wall has lost. ‘Once it reaches 15-20 millimetres (of the total wall thickness of about 60 mm), there is a substantial loss of thickness, and thus of strength,’ Stanić comments.
Increasing pressure

In a laboratory at TU Eindhoven, he conducted strength measurements on old concrete sewer pipes from The Hague and Breda. He measured the diameter with the laser scanner, took core samples from around the pipe to test the strength of the material and compressed the pipe (from above and bilaterally) until the first cracks appeared. This occurred at a pressure of 20 tons. Stanić increased the pressure to find out when the pipe would collapse. The pressure was increased to 30 tons, until large, cracking fractures appeared and the test leader called out, 'Stop, stop!' fearing that the compression-test machine would fail.

The idea is to use a combination of geometry, material properties (derived from the core samples) and mechanical strain to develop a mathematical model of the sewer pipe. This model is expected to identify those factors that have the greatest impact on the strength and life expectancy of a pipe: internal environment, remaining wall thickness or, perhaps, external forces. Moreover, the strain to which sewer pipes are exposed in the sandy conditions of The Hague differs from that in the sagging subsoil of Amsterdam or Rotterdam.

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Although the laser scanner will not be able to address all the problems related to the ageing of sewer pipes, Stanić is convinced that the laser has the potential to become the new standard in sewer inspection, given the wealth of information produced by laser inspection. In addition to diameter, the system measures the coarseness of the pipe (with a resolution of 1 mm). Sludge and waste are localised precisely, and the depth of cracks and damages is recorded with great accuracy, as are their locations. This high degree of accuracy in localization is made possible by using the three-dimensional position of the video tractor to correct the images.

According to Stanić, the next step will involve developing a robust prototype video scanner and testing it in a sewer, but that will be after he has received his PhD.

Invitation to innovation

‘Sometimes, you have to lose something to become aware of its value,’ concludes the head of the research project, Dr ir. Jeroen Langeveld (CEG and research consultancy firm Urban Water). It was not until the sewer and urban water chair was facing elimination from the healthcare technology research group (Department of Water Management in the CEG faculty) that the industry came into action. The RIONED Foundation, the umbrella organisation for urban water management, raised funding to support the chair with a research programme (Prof. ir. François Clemens). In 2010, this resulted in the Urban Drainage knowledge programme, for which Jeroen Langeveld (associate professor at Clemens) is the head of the research project. When the first PhD candidates submitted their dissertations, Langeveld took the initiative to launch a supplementary programme entitled TISCA (Technological Innovation for Measuring the Strength and Condition of Waste water Drains). Last spring, the STW allocated €3 million to fund this programme for the next four years.

‘Video inspection is the current market standard, and the pricing pressure is making it difficult to develop anything new, even though it is sorely needed,’ says Langeveld. ‘The research programme aims to break this deadlock by developing new technologies that will allow us to take sewer inspections to the next level.’ Laser, acoustic, optical, radar - many technologies have the potential to predict sewer-pipe failure better than the current video inspection methods.

‘Now it’s up to the universities to present technologies that they would like to investigate further,’ explains RIONED director Hugo Gastkemper on the telephone. ‘The ultimate aim of this STW programme is to develop a broader range of inspection tools.’ If this succeeds, Langeveld also believes that the technology may have export value: ‘The entire EU is facing the same challenge: making the most efficient use of an outdated infrastructure. Everyone is currently using video inspection, but it is clearly inadequate.’