DESTRUCTIVE LABORATORY TESTS WITH PVC PUSH-FIT JOINTS

A. M. Arsénio [1, 2], J. H. G. Vreeburg [1,2], F. Bouma [3], J. C. van Dijk [2]
1. KWR – Watercycle Research Institute, Nieuwegein, the Netherlands, andre.arsenio@kwrwater.nl, jan.vreeburg@kwrwater.nl
2. Technische Universiteit Delft, Delft, the Netherlands, j.c.vandijk@tudelft.nl
3. DYKA B.V., Steenwijk, the Netherlands, fbouma@dyka.com

INTRODUCTION

In 2010 the Dutch drinking water network stretched for almost 116,000 km supplying water to more than 16 million people. Almost 50% was made of PVC. The analysis of the failure registration of 5 Dutch drinking water companies showed that ca. 29 % of the total number of failures in the PVC Dutch network is detected at joints. In the Netherlands, the PVC joints are single pieces with two rubber rings. This system is used instead of the bell-and-spigot and allows more rotation on the joint.

A condition assessment procedure for buried PVC push-fit joints analysing its 3D-alignment has been developed within this project. This approach uses non-destructive evaluation equipment (e.g. close-circuit camera, CCTV). The 3D-alignment is used to derive information about the current condition of the inspected joints. However, in order to correctly characterize the current condition of a joint it is necessary to have information on its threshold conditions, e.g. limit bending angle before leakage.

This paper will present the laboratory tests performed to characterize the threshold condition of PVC push-fit joints. These tests were performed together with a Dutch pipe manufacturer.

METHODOLOGY

Objectives

The objectives of performing the tests are: observe the way in which joints fail under different loading regimes (bending and axial pull-out), and therefore characterizing the present condition of an inspected joint. All tests were triplicated. The parameters that were obtained from these tests were:

i. Threshold bending angle of PVC push-fit joints

PVC PN10 pipes (110 mm and 315 mm) were tested. PVC PN10 stand-alone push-fit joints with double rubber o-rings, typically used in the Netherlands, were used in the tests. Inside the PVC joints, a PVC ring separates both pipes and creates a gap between them (Figure 2).

ii. Influence of pressure:

The tests were performed under two different pressure values (4 bar and 0.2 bar). The 4 bar pressure was achieved with water at 20 °C, while the 0.2 bar pressure was achieved with air. The 4 bar tests simulate a typical real-life situation. The objective of the 0.2 bar tests is to determine whether a joint with a certain bending angle, for example, is still sealed from intrusion of exterior water, when the pressure in the system decreases. Therefore, to determine these parameters ca. 200 tests have already been performed together with a Dutch pipe manufacturer using the installation presented in Figure 1. This installation was specially designed to perform the tests.

iii. Influence of level of insertion of the pipe inside of the joint:

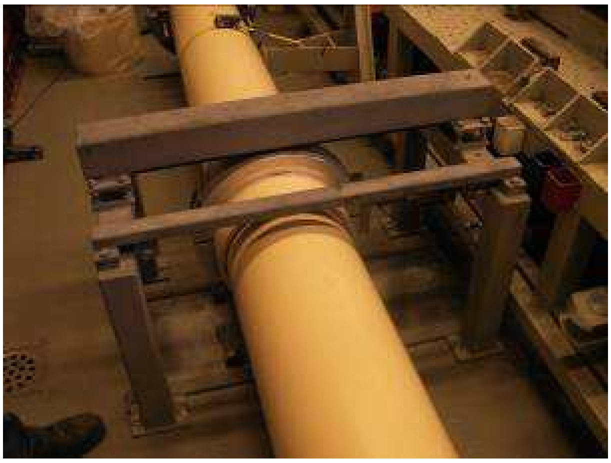
Three level of insertion were tested for this work: the pipes completely inserted inside the joint (both pipes touching the inner PVC-ring), the pipes almost pulled apart and a half-way situation.

RESULTS

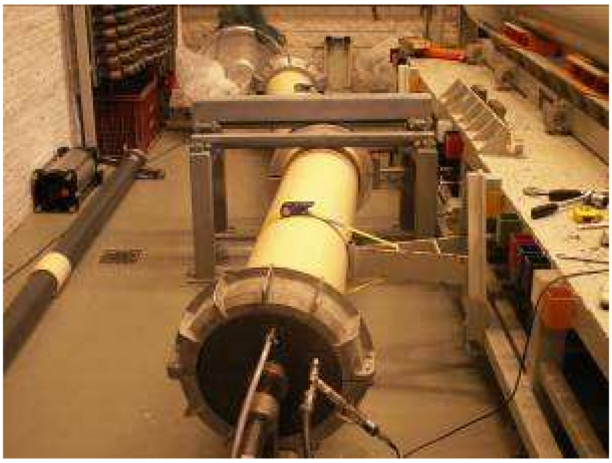
In Figure 3 to Figure 5 are given the results of several tests done with 110 mm PVC pipes. All presented tests were done under 4 bar water pressure. All tests were replicated 6 times: 3 times with one pipe and 3 times with a second pipe. In the X-axis is given the bending angle in degree (the angle between the two pipes inside of the joints) and in the Y-axis is given the bending force (kN).

- It can be seen that the force necessary to bend the pipes around the joint increases with the increase of the insertion - at 15 degree bending: maximum insertion (ca. 2 kN, Figure 3), half-way insertion (ca. 1.25 kN, Figure 4) and minimum insertion (ca. 0.75 kN, Figure 5).
- The results show that for all testing conditions there is a steep increase of the applied force until ca. 1 degree. This is due to the inertia necessary to start bending both the water filled pipe and its supporting structure (Figure 3, Figure 4 and Figure 5)
- For the maximum insertion, after the first steep increase, there are two regions in the plot (Figure 3). The first region is detected for angle values between ca. 1 and ca. 2 degree. This region is governed by the free bending of the pipes around the joint and the bending force is kept almost constant with changes of bending angle. Above ca. 2 degree the force necessary to bend the pipe increases linearly with the applied angle (second region). The turning point is due to a combination of pipes overlapping the PVC ring and pipes starting to touch each other inside the joint.
- For half-way insertion, after the initial steep increase, two regions are also found on the plot (Figure 4). The first region is detected for angle values between ca. 1 and ca. 3 degree. For this region the applied bending force is kept almost constant for changes in the bending angle. As before, above ca. 3 degree the force necessary to bend the pipe increases linearly with the applied angle (second region). As before, the turning point is a combination between pipes overlapping the PVC ring and starting to touch each other. This insertion leads to lower bending forces and overlapping starting for higher bending angles.
- For the minimum insertion, after the initial steep increase, only one region is detected on the plot (Figure 5). With minimum insertion, the distance between the two pipes allows them to bend without touching each other or the inner PVC ring.
- When the pipes start rotating around the joint, depending on the insertion level they can overlap the inner PVC ring and each other. This situation creates stress on both pipes. This is avoided with minimum insertion. It can be argued that defining a maximum bending angle for pipe installation, as is made by some pipe manufacturers, is insufficient information to assume that a pipe is installed in good conditions. The maximum bending at a joint should be supplied together with the level of insertion.

FIGURES



(a) A 315 mm PN10 PVC pipe ready to be tested.



(b) The pipe caps used to bend the pipe under 4 bar pressure.

(c) General view of the testing system.

(d) A 110 mm PN10 PVC pipe ready to be tested.

Figure 1 – Test setup to perform the destructive laboratory tests with PVC pipes and joints.

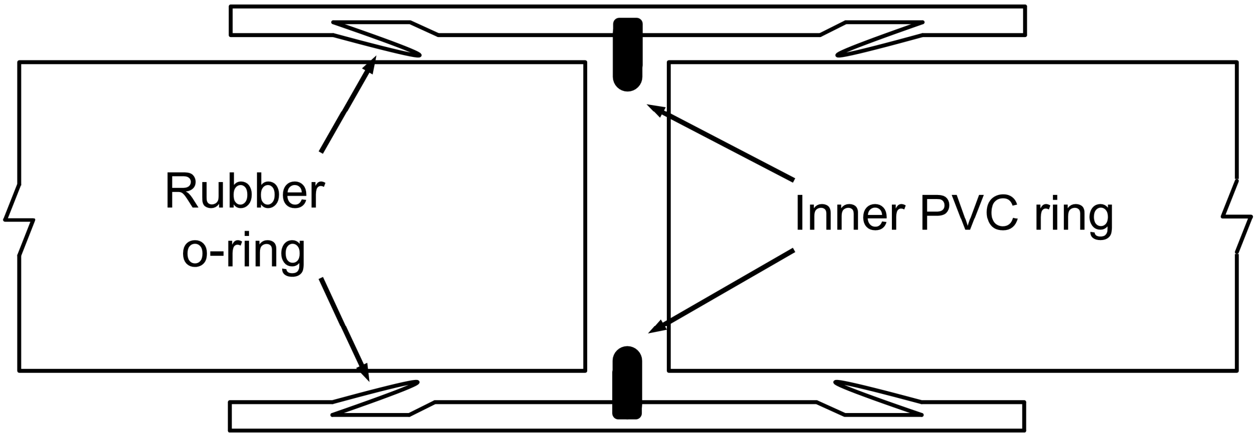


Figure 2 – Scheme of typical Dutch PVC joint with double rubber ring. Both the rubber o-ring and inner PVC ring are shown. Image not at scale.

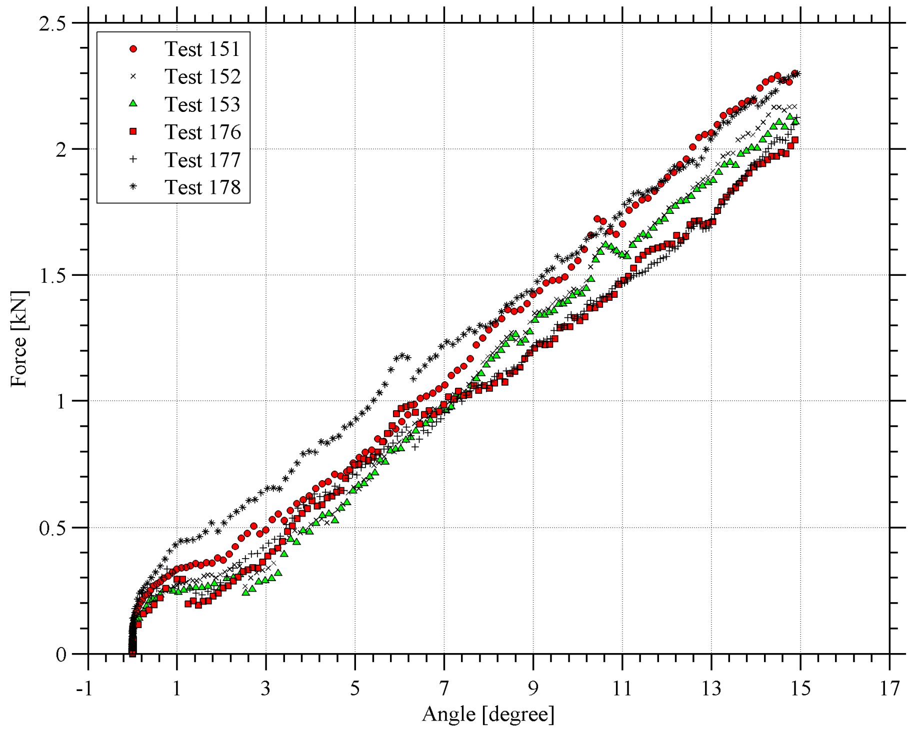


Figure 3 – Applied force versus bending angle for a 110 mm under 4 bar water pressure with maximum insertion.

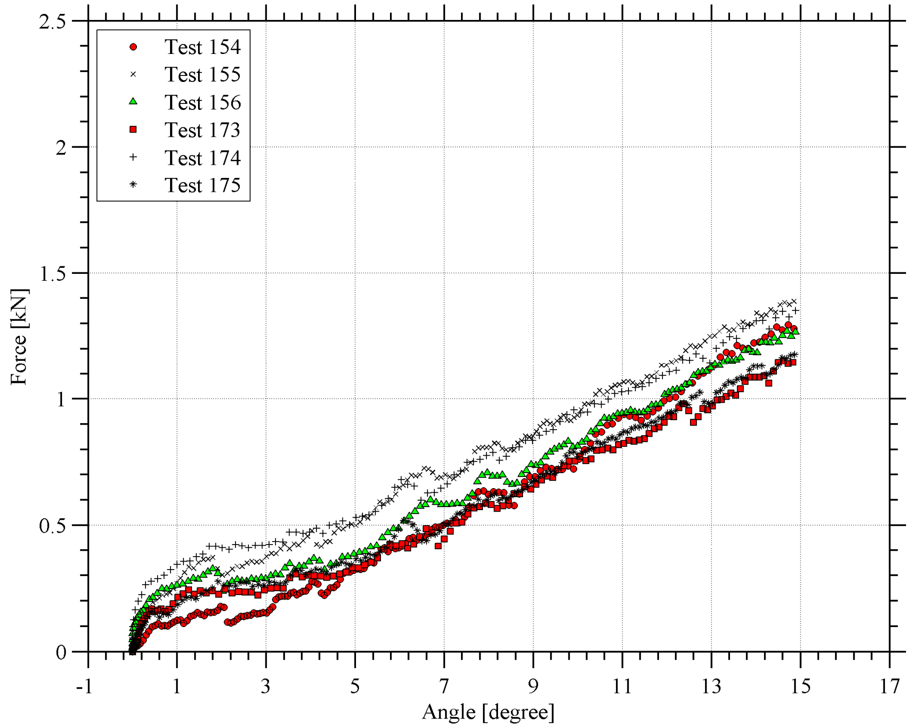


Figure 4 – Applied force versus bending angle for a 110 mm under 4 bar water pressure with half-way insertion.

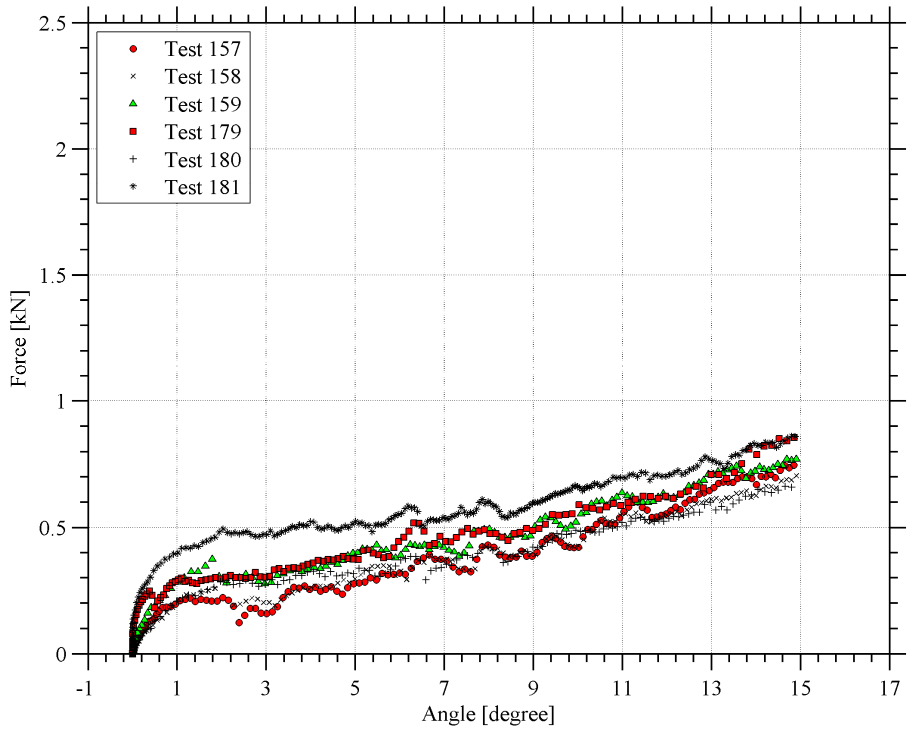


Figure 5 – Applied force versus bending angle for a 110 mm under 4 bar water pressure with minimum insertion.