INTERNAL PRESSURE AND BACKFILL LOAD RESISTANCE CHARACTERISTICS OF "POPIT" LIFT HOLE PLUGS

CONCRETE PIPES WITH A MECHNICAL OR ROUGH LIFT HOLE

(Note : This report is prepared of information to readers only)

October 2012

Professor A. Abolmaali
Y. Park, Ph.D.

Center for Structural Engineering Research and Simulation
The University of Texas at Arlington
Arlington, Texas 76012

Submitted to:
POPIT, Inc.
922 S. Woodbourne Road , PMB #333,
Levittown, PA 19057
Tel: 215-945-5201

OBJECTIVE

The objective of this testing program is to evaluate the pressure resistance characteristics of the installed POPIT plugs with two different types of lift holes, Mechanical (smooth) and Handmade, subjected to coupled backfill and internal pressure. The key point when installing the POPIT plug is to make certain that the “ribs” grab onto the inside of the hole, which will secure the plug in place. Since the POPIT plug is neither watertight nor airtight, the goal of this study is to subject the installed POPIT plug to internal pressure while subjected to 30 ft of backfill.

TEST SETUP

Figure-1 shows the schematic flow chart of the testing program in two types of commonly used lift holes tested. A hydrostatic test is a way in which pressure vessels such as pipelines and fuel tanks are commonly tested for joint performance. The test involves filling the pipe system with a liquid; usually water, which may be dyed to aid in visual leak detection, and pressurization of the pipe to the specified test pressure. Shutting off the supply valve and observing pressure loss is mean of identifying a product’s capability to resist pressure. Hydrostatic testing is the most common method employed for testing concrete pipe joints.

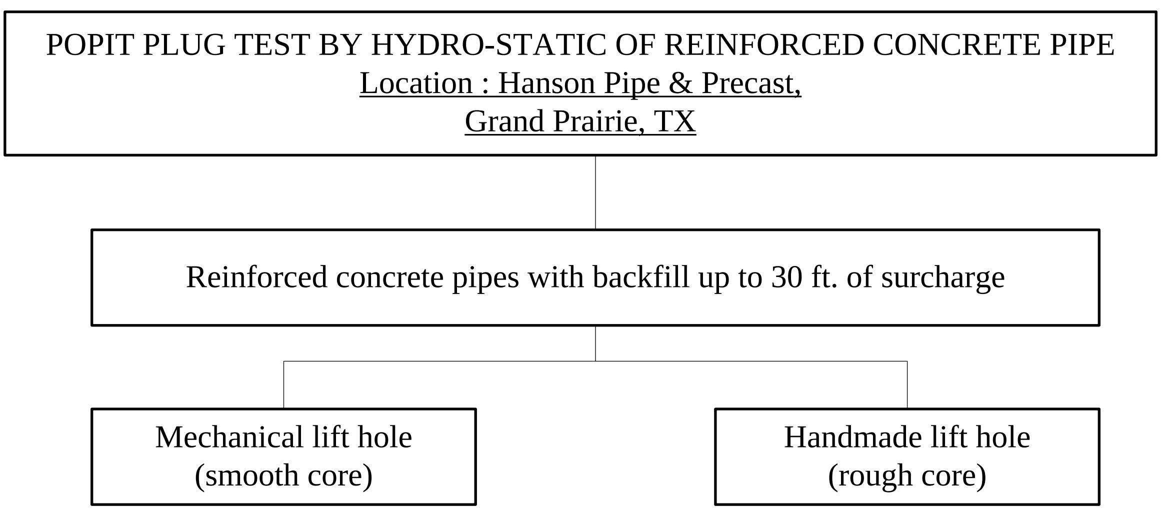

Figure 1 Schematic test flow

There are currently no standard specifications for testing products such as POPIT plugs installed on concrete pipes when subjected to internal pressure and backfill height. Thus, a testing procedure was developed for the first time for performance evaluation using the POPIT lift hole plugs.

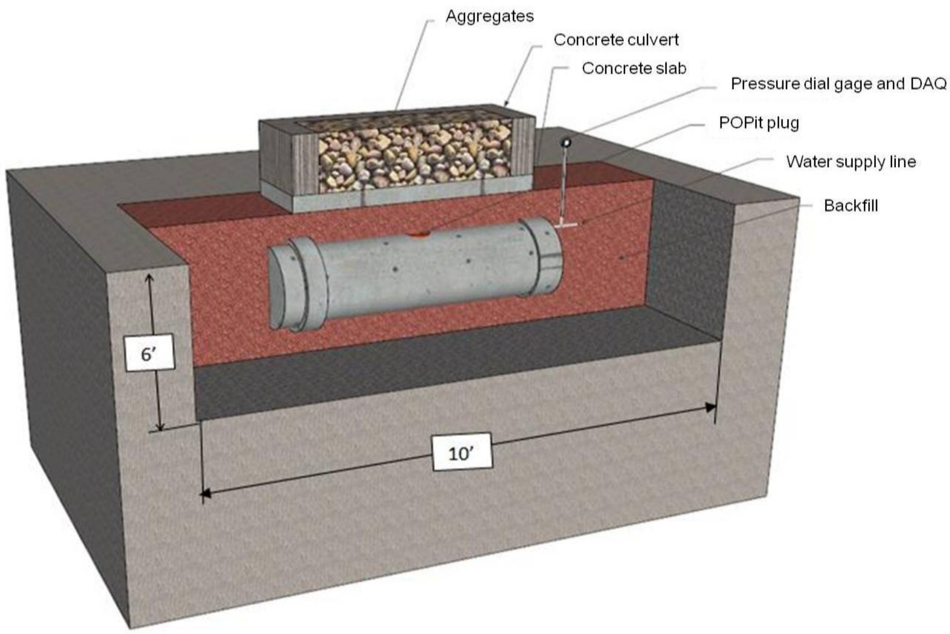

Figure 2 Pipe setup in trench installation

<u>Test with simulated backfill</u> : 24-in diameter pipe, Wall B, CL-III , Joint length 6ft

Figure-2 shows the schematic of the test set-up, which encompasses hydrostatic internal pressure and up to 30 ft of backfill surcharge load simultaneously. This figure shows the test pipe is placed on the trench and backfilled to the ground surface. A rigid concrete slab was designed and placed on te ground surface with dimensions identical to the dimensions of the pipe joint length and trench width. This slab was placed on top of the trench so the load is only transferred to the to the pipe. A concrete box culvert was placed on the top of the slab and filled with select fill (aggregate) to simulate surcharge load of up to 30 ft of fill height.

To ensure water tightness at both ends of the pipe, concrete bulkheads were installed at each pipe end similar to those used hydrostatic test (ASTM C497) as shown in Figure 3. One joint of a gasket pipe was tested with bulkhead installed on each side for water tightness without backfill.

Ten 24 in. concrete pipes with man-made rough lift holes were randomly selected which represented a range of the lift hole dimensions. Introduction of lift holes in 24 in. pipes would represent one of the most critical conditions when compared with pipes with larger diameters.

A special pressure controlled loading procedure was designed in this testing program in which the pressure was increased in a stepwise function (Figure 4) in an increment of 1.0 psi. At each pressure increment, the pressure was held up to one minute. This loading history was continued until the pressure could not be increased.

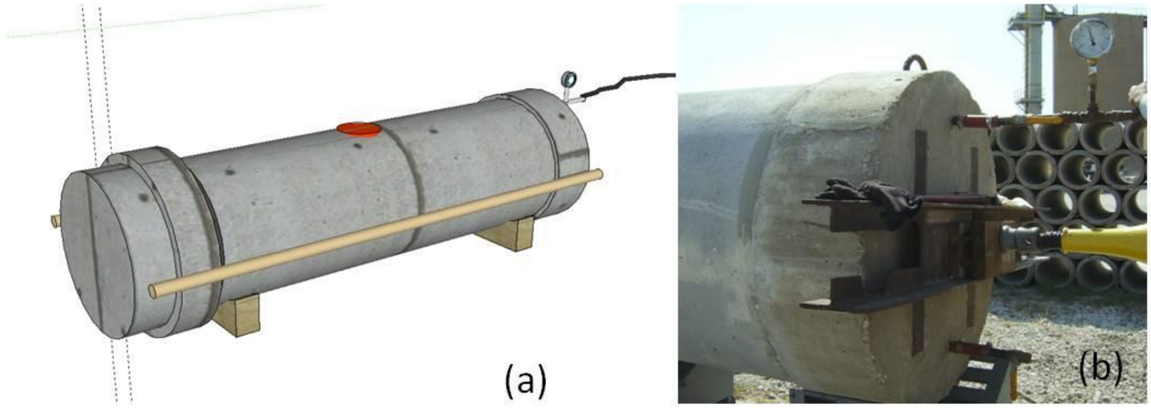

Figure 3 (a) Pipe setup for hydrostatic test, (b) bulkhead and pressure dial gage

Increasing internal pressure was applied simultaneously with the surcharge of 36,000 lbs to simulate the backfill height of 30 ft based on the trench dimension and pipe joint length as described above.

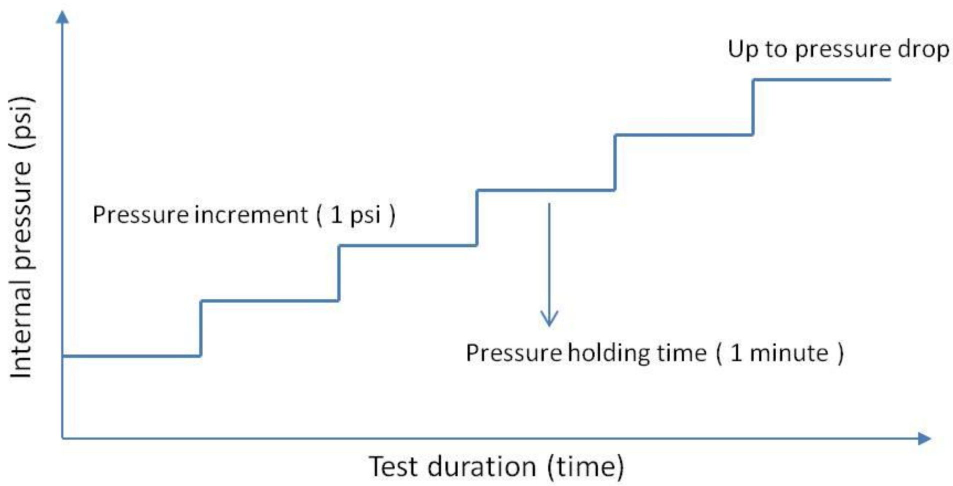

Figure 4 Schematic loading history

For data collection and observation during the test, not only a laptop and the Vishay scanner (Model 5100) installed with Smart-strain program, but also pressure transducers were used as shown in Figure-5. The test setup for trench installation is shown in Figure 6. The pipe with bulkheads at each end and POPIT plug were installed in the trench with 8 ft. (width) × 15 ft. (length) × 6 ft. (depth). Surcharge load was applied using 7 ft. × 7 ft. × 5.3 ft. box culvert on top of fulfilled soil and rigid concrete slab. The concrete box was filled with aggregates to compensate for the necessary surcharge load of 36,000 lbs for class-III ASTM C76 concrete pipe. Internal pressure was increased until a sudden drop in pressure was observed. Once the test was completed, the pipe was excavated and the conditions of the POPIT plugs were examined. The photographs of the test setup at different stages are presented in Figure 6.

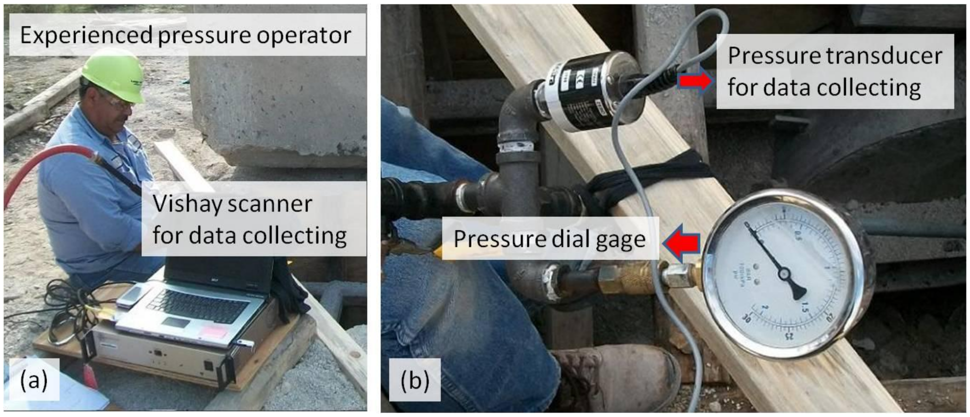

Figure 5 (a) Data acquisition system and (b) pressure sensors

Figure 6 Test setup of construction stage with backfill

TEST RESULTS

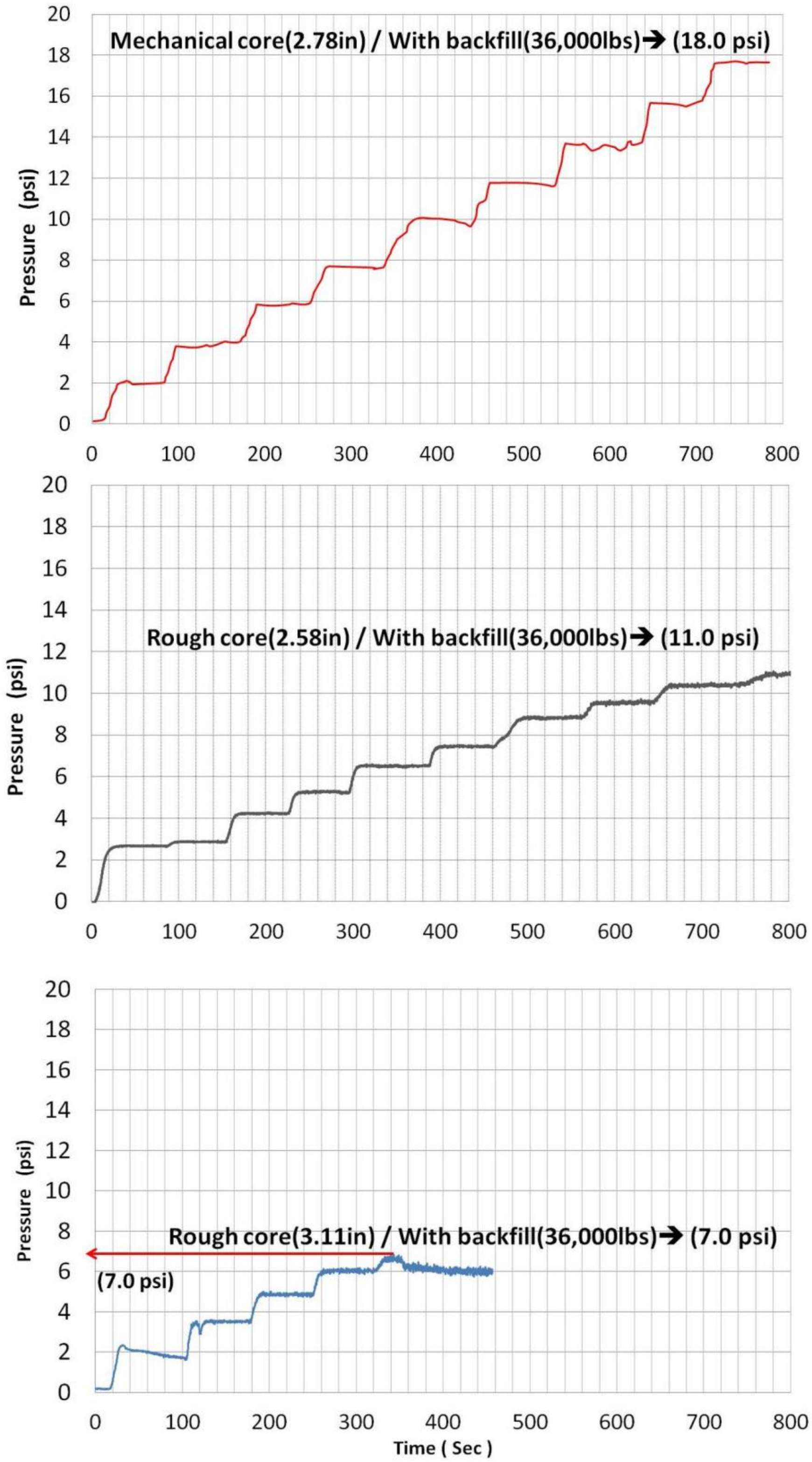

Figure 7 Internal pressure of reinforced concrete pipes tests with POPIT lift hole plugs

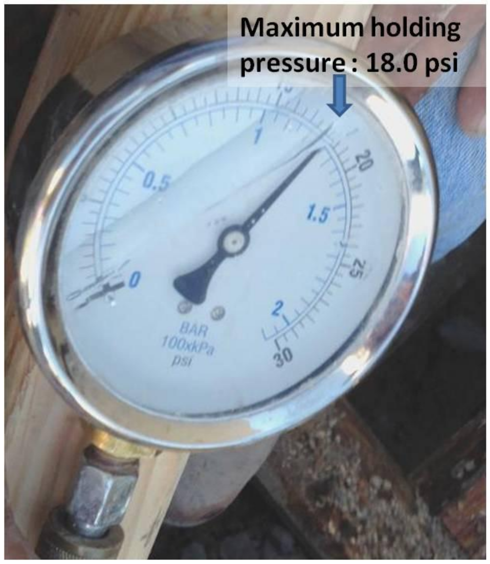

Figure 8 Maximum holding pressure in 24 in. RCP with a mechanical core of 2.78 in

The plots of pressure versus time for each test are shown in Figure 7. The following test results are at the forefronts of findings:

1. In the test with POPIT plug installed in the mechanical core (smooth core), the POPIT sealed the lift hole for pipe to hold 18 psi of pressure with 30 ft of fill height.

2. In the tests with rough holes, the POPIT sealed the lift hole for pipe to hold pressures in the range of 7.0 psi to 11.0 psi depending on the variation of lift hole size.

It should be noted that random variations of the lift hole sizes were considered in this study. Therefore, the range of pressure presented above for rough lift holes should be valid for most concrete pipes with POPIT plugs. In the case of smooth mechanical lift holes; the range of variation of the lift hole sizes needs not to be considered since this range in controlled mechanical holes is negligible.

VISUAL OBSERVATIONS AFTER EXCAVATION

At the end of the experiment, the pipeline was excavated and visually inspected. Figure-9 illustrates the change of POPIT plug that developed after the test. Both in the mechanical core and the rough core, it was observed that after the test the POPIT plugs were projected insignificant amounts of 0.38 in. and 0.45 in., respectively. It was noted that *no damage, tear, fracture or bending* was observed in the POPIT plugs after removal of internal pressure and backfill load in all tests. In general, the plugs maintained their structural integrity after removal of internal significant amount of pressure and backfill load, and remained flush to the structure.

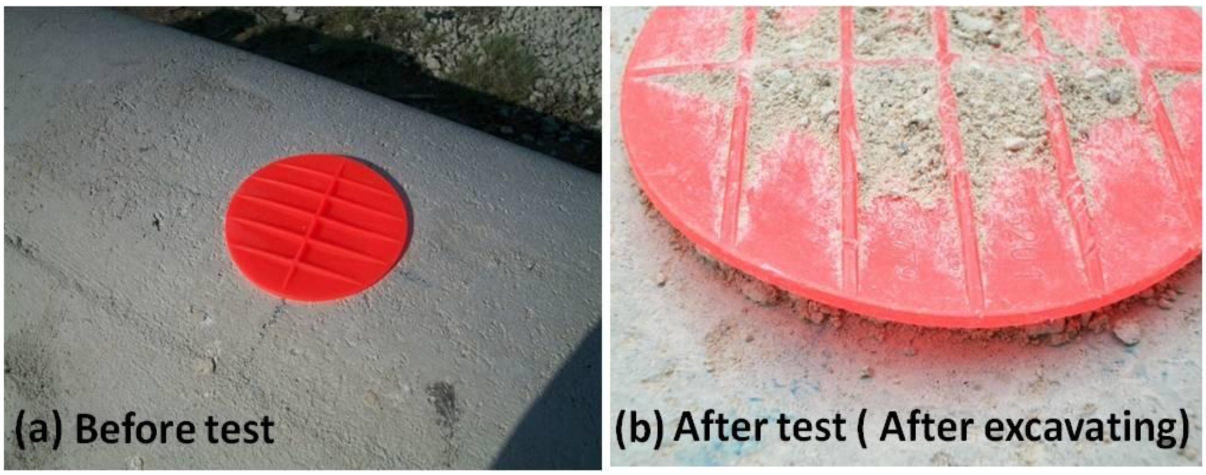

Figure 9 POPIT plug condition before / after load removal

MEASUREMENT OF SIZE OF CORES (BEFORE TESTS)

As seen in the Figure-10, the randomly selected lift holes indicated variation in quality and smoothness in 24 in. diameter pipes before the tests. The shapes of surfaces and diameter were irregular. Because of this defect, visible gaps between the POPIT plug and concrete surface were easily observed. However, POPIT plugs were able to withstand internal pressure between 7 to 11 psi with rough holes. This is considered an excellent resistance of POPIT to both internal pressure and backfill load.

Obviously, the internal pressure-carrying capacity of POPIT plug with the rough hole was smaller than those with the mechanical (smooth) hole. However, resisting internal pressure in the range of 7 to 11 psi is indicative of high pressure resistance capability of POPIT plugs. The result of measurement of rough lift holes is shown in the Table-1. Among the randomly selected pipes, the maximum diameter of a rough core was measured of 3.26 in. and minimum of one was measured of 2.56 in.

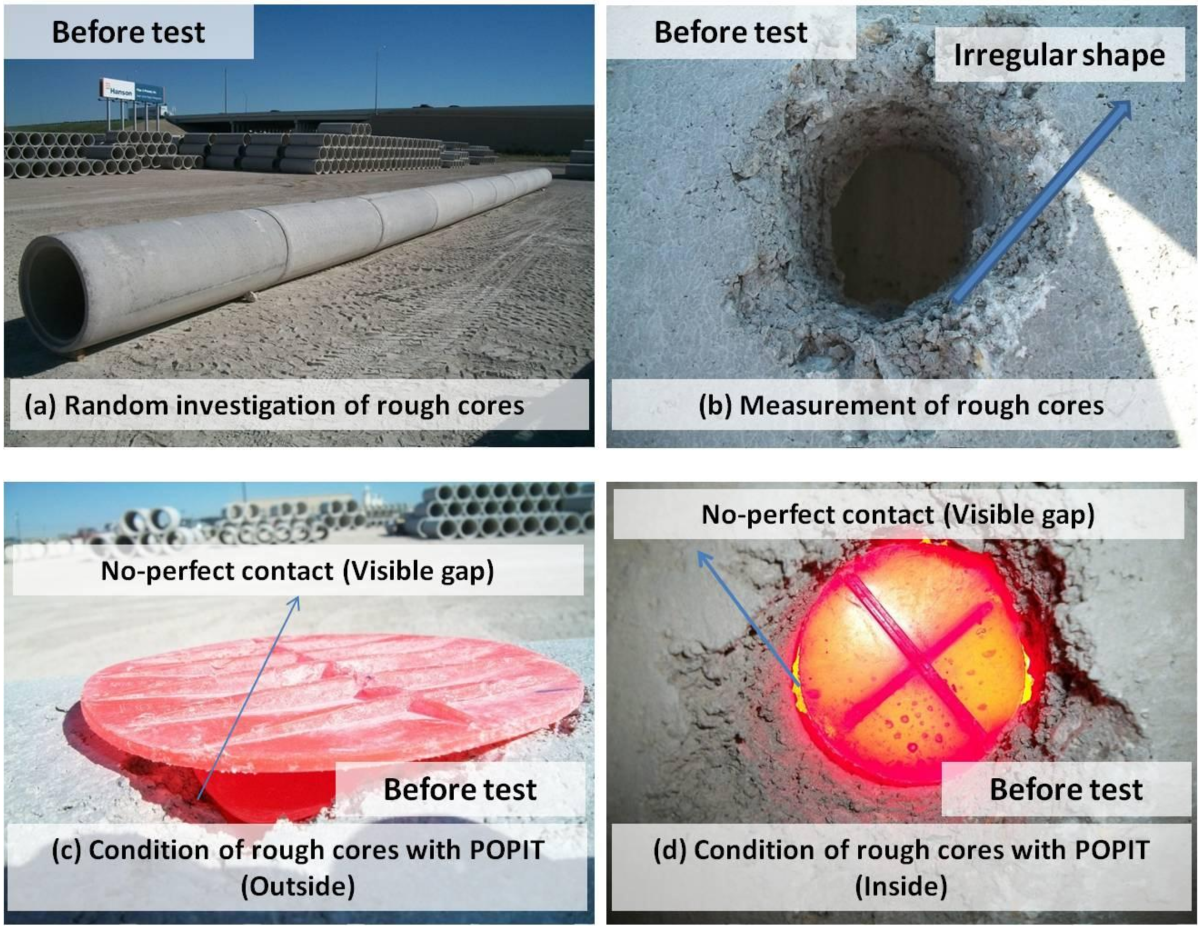

Figure 10 Investigation of rough cores (Before tests)

Table 1 Distribution of the diameter of rough cores among randomly selected concrete pipes

No.	Diameter of the lift hole (in)
1	**2.56 (Min)**
2	2.88
3	2.76
4	3.11
5	3.19
6	2.99
7	**3.26 (Max)**
8	2.63
9	2.75
10	2.59
Average	**2.87**

CONCLUSION

This report focused on the evaluation of the pressure resistance characteristics of the POPIT plug with two different types of Mechanical (smooth) and Handmade (rough) lift holes.

Based on the three tests conducted, it is concluded that POPIT plugs have high resistance to internal pressure and backfill surcharge loads of up to 30 ft of backfill height. For the rough man-made lift holes with high degree of irregularities, the POPIT plugs are able to hold internal pressures in the range of 7 to 11 psi. For smooth mechanical holes, the internal pressure resistances of POPIT plugs are as high as 18 psi. After removal of internal pressure and backfill load, *no damage, tear, fracture or bending* was observed in the POPIT plugs, and their structural integrity were maintained.

Based on the results of this study and parameters presented, the POPIT plugs have excellent resistance to internal pressure coupled with backfill surcharge loads of up to 30 ft of backfill height. The dimensions of rough lift holes were measured in a randomly selected pipe samples to compare the range of the lift hole sizes with those conducted in this study, which showed that that the results of this study represent the POPIT performance in most concrete pipes. It should be noted that the range of variation for rough lift holes dimensions of pipe diameters larger than 24 in. should be similar or smaller than those presented in Table-1 due to their higher bending action compared to hoop action for smaller diameter pipes. Therefore, this study is also valid for larger diameter pipes.