



## Large Diameter HDPE Pipe for Highway Drainage Development of New Specifications

# RESEARCH PROJECT SUMMARY

Historically, the Texas Department of Transportation (TxDOT) has used Reinforced Concrete Pipe (RCP) and Corrugated Metal Pipe (CMP) for highway drainage applications. In recent years, high density polyethylene (HDPE) pipe in large diameter (36in and larger) has emerged in the market place as a viable alternative. This type of pipe offers a number of advantages over its more traditional counterparts. Its primary advantages are lower pipe price, and lighter weight that allows their installation with a smaller construction crew and equipment. Generally, when granular backfill is used HDPE pipe can be installed at lower cost. However, there are some drawbacks in the use of HDPE pipe. Its primary drawback stems from its sensitivity to installation conditions. HDPE pipe is flexible, and requires good support from surrounding backfill to withstand loads. To ensure good backfill support, existing AASHTO and ASTM specifications recommend the use of compaction control based on minimum field density requirements. The installation guidelines for

HDPE pipe require pipe deflection measurements as well. It is neither customary nor practical for highway agencies to use such elaborate QC/QA measures in their routine pipe installation projects. Therefore, as an alternative to this approach, TxDOT required flowable fill in all HDPE pipe installations with the exception of side road and driveway culverts. Flowable fill eliminates the need for compaction control in the field. However, it increases the cost of pipe installation significantly. This research was initiated with the primary objective of iden-

tifying alternative backfill materials, such as granular fill that would provide both reliability and economy in HDPE pipe installations.

### What We Did .....

Our research plan for developing new specifications included following tasks:

- (a) Survey of other state DOTs  
As a first step, a survey was conducted among other highway agencies to establish the current state-of-practice on the use of large diameter HDPE pipe. 32 out of the 50 state DOTs con-



Figure 1. HDPE Pipe Installation on US-83, San Angelo



tacted responded.

(b) Draft specifications A Draft specification for the installation of HDPE pipe was developed based on existing AASHTO, ASTM and other state DOT specifications, but with tighter control on backfill gradation.

(c) Pilot Construction Projects 8 TxDOT pipe installation projects representing the broad range of climatic and soil conditions that are found within the state were monitored. These installations included: single barrel and multiple barrel installations, 36 in, 42 in, and 48 in diameter pipes and pipe products from 3 different manufacturers.

(d) Constructibility Review A constructibility review was performed based on the information collected during pipe installation projects. Necessary changes were incorporated in the draft specifications.

(e) Economic Analysis An economic analysis was conducted to determine how HDPE pipe prices compare with RCP and CMP prices. Also, the prices of granular backfill, flexible base aggregates, cement stabilized backfill, and flowable fill in various geographical regions within Texas were examined. Analysis was conducted to compare the as-installed costs of HDPE pipe vs. RCP.

(f) Full Scale Load Tests 21 full scale load tests were conducted at Texas Tech field research site. The testing included 36in and 48in diameter pipe. These tests simulated two types of loading situations: (i) maximum fill height loading, and (ii) construction vehicle wheel loading under minimum cover situations. Pipe backfill material was varied so that the entire range of mate-

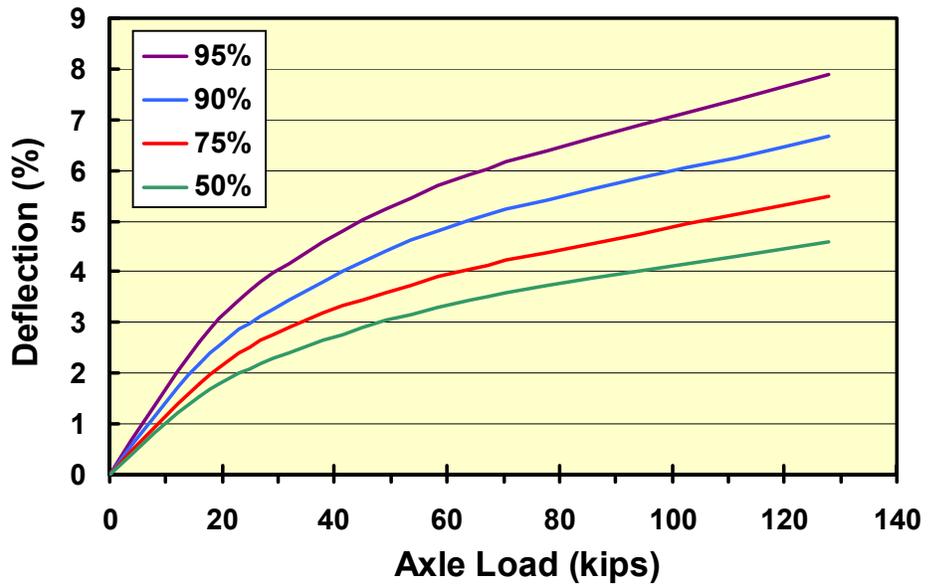


Figure 2. Pipe Deflection versus Axle Load; 1 Ft Cover

rials allowed by the specifications is represented in field testing. Field compaction levels were varied from very loose (no compaction) to very dense (4 passes of impact rammer).

(g) Data Analysis The final task in this project involved analysis of data collected from field testing. The data were used to back-calculate backfill material properties using the CANDE (Culvert Analysis and Design) program. Subsequently, the program was run in a forward sense to generate maximum fill height and minimum cover charts for HDPE pipe.

### What We Found ....

#### State DOT Survey

According to the data collected from the State DOT survey 18 out of 32 states that participated in the survey indicated that they have specifications in place to allow the use of large diameter HDPE pipe. However, 14 out of those 18 states allowed use of HDPE pipe

only up to 36in diameter. California, New York, Florida (max. 48in) and Ohio (max. 60in) were exceptions to this rule. Most states reported positive experience with the use of this type of pipe. They stated that the majority of the problems that they have experienced are not unique to HDPE pipe. Among the problems unique to HDPE pipe, difficulty in maintaining line and grade during installation and finding qualified contractors were cited most often.

#### Pilot Construction Projects

All 8 pilot installation projects were completed successfully. The contractor's familiarity with the specifications and care taken during pipe installation varied significantly from one site to another. Areas where significant variability was observed were lift thickness of backfill and level of compactive effort used. In spite of such construction variability, none of the vertical deflection measurements exceeded the acceptable limit of 5%. These measurements varied from a



minimum of -0.75% to a maximum of 3%. The -0.75% deflection represents an increase in vertical diameter due to lateral compression. In addition to deflection measurements, pipes were also examined for cracking and other distresses, evidence of joint failure, backfill erosion, and backfill settlement. Inspections revealed no significant problems in these areas.

### Construction Variability

To investigate pipe performance under good, fair and poor backfill conditions, full scale field load tests were conducted at Texas Tech University. Based on field observations, 2 passes of impact rammer on 8 inch thick lifts was considered to be the best compaction that could be realistically expected in a field installation. Poor compaction control was simulated by pouring loose, granular material into the pipe trench with no compaction at all. Pipe deflections measured during load tests were then used in the finite element program CANDE to determine the statistical distribution of backfill stiffness parameters. From the statistical distribution, the 5<sup>th</sup>, 10<sup>th</sup>, 25<sup>th</sup>, and 50<sup>th</sup> percentiles of backfill stiffness were determined. These parameters were then used in forward simulations to predict pipe response under various extreme loading conditions. For e.g. the pipe deflections under construction vehicle loads when with a 1.0ft of cover is shown in Figure 2. In this chart, 95% reliability curve represents the pipe deflection that you may anticipate when backfill stiffness parameters correspond to the 5<sup>th</sup> percentile.

### Economics

HDPE pipe is significantly cheaper than

Table 1. Recommended Backfill Gradation

Sieve No.	Percent Retained (Cumulative)
1 inch	0-5
7/8 inch	0-35
1/2 inch	0-75
3/8 inch	0-95
No. 4	35-100
No. 10	50-100
No. 200	90-100

RCP. However, unlike RCP that can be installed with native soil, HDPE requires special backfill that may have to be obtained at a cost and transported to the site. To compare the two types of pipe on an as-installed cost basis, analyses were made considering cost of backfill, labor, equipment, rate of installation etc. The findings revealed that when granular backfill material is available at \$20/cu.yd. or less, then HDPE is likely be the more cost effective option in most situations. However, when flowable or cement stabilized backfill is used, their as-installed costs are higher than RCP pipe with native backfill.

### The Researchers Recommend...

Based on the findings from this study, the researchers concluded that there is benefit in allowing large diameter (up to 48in diameter) HDPE as a biddable alternative in TxDOT construction projects. The proposed specifications allow the use of three types of backfill: (a) Granular Backfill, (b) Cement Stabilized Backfill and (c) Flowable Fill. Granular fill provide the best economy

and therefore, should be used whenever possible. The recommended gradation band for granular backfill is shown in Table 1. Although the specifications allow the use of material with uniform gradation, preference should be given to well-graded materials when such material is easily available. Cement Stabilized Backfill and flowable fill may be used to meet special project requirements. When coarse, granular materials are used designer should consider using concrete rip rap and/or other suitable end treatment.

The specification developed in this research is largely based on the data collected from full-scale load tests and limited experience gained from 8 pilot construction projects. It is further recommended that initial implementation of the specification be carried out under the careful control of a monitoring program, so that further fine-tuning of the specification can be accomplished to get the maximum benefit from the use of this product.



## *For More Details...*

The research is documented in the following report:

Report No. TX-99/1809-3, *Evaluation of Backfill Materials and Installation Methods for High Density Polyethylene Pipe*, by Priyantha W. Jayawickrama, Aruna L. Amarasiri, Pedro E. Regino, and M. Didarul Alam, February 2001, 262p.

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**To obtain copies of the reports, contact the Research and Technology Implementation Office, (512) 465-7403.**

## **TXDOT IMPLEMENTATION STATUS**

**July 2001**

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The results of this research will be presented by the Bridge Division of the Texas Department of Transportation (TxDOT) to TxDOT's Administration for use in formulating a policy on HDPE Pipe.

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## **Your Involvement is Welcome...**

This research was performed in cooperation with the Texas Department of Transportation and the U.S. Department of Transportation, Federal Highway Administration. The content of this report reflects the views of the authors, who are responsible for the facts and accuracy of the data presented herein. The contents do not necessarily reflect the official view or policies of the FHWA or TxDOT. This report does not constitute a standard, specification, or regulation, nor is it intended for construction, bidding, or permit purposes. Trade names were used solely for information and not for product endorsement.

