STEEL FIBER REINFORCED CONCRETE PIPES

Josh Beakley
American Concrete Pipe Association

NESMEA 2013
What Has Been Available

Designation: C76 – 11

Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe

Designation: C14 – 11

Standard Specification for Nonreinforced Concrete Sewer, Storm Drain, and Culvert Pipe
What has been available?

**Standard Specification for**

**Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe**

AASHTO Designation: M 170-12
ASTM Designation: C 76-11a

**Standard Specification for**

**Nonreinforced Concrete Sewer, Storm Drain, and Culvert Pipe**

AASHTO Designation: M 86M/M 86-09
ASTM Designation: C 14M-07 and C 14-07
ACPA’s Preliminary Look into FRCP

Final Report
On
A Study of
FIBER-REINFORCED CONCRETE PIPE
And
FIBER-CEMENT PIPE

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February 15, 2003
## Fibers Studied in 2003

Table 1. – Fiber Content in Concrete Matrix

<table>
<thead>
<tr>
<th>fiber type</th>
<th>wt. fraction (wt.%/cu yd)</th>
<th>vol. fraction (vol.%/cu yd)</th>
<th>fiber weight (lbs./cu yd)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type (P1) polypropylene fiber</td>
<td>0.12</td>
<td>0.35</td>
<td>5</td>
</tr>
<tr>
<td>polypropylene fiber</td>
<td>0.22</td>
<td>0.60</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>0.29</td>
<td>0.80</td>
<td>12</td>
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<tr>
<td>Type (P2) polypropylene fiber</td>
<td>0.08</td>
<td>0.25</td>
<td>3.2</td>
</tr>
<tr>
<td>polypropylene fiber</td>
<td>0.12</td>
<td>0.35</td>
<td>4.8</td>
</tr>
<tr>
<td></td>
<td>0.15</td>
<td>0.45</td>
<td>6.2</td>
</tr>
<tr>
<td>glass fiber</td>
<td>0.27</td>
<td>0.25</td>
<td>10.3</td>
</tr>
<tr>
<td></td>
<td>0.37</td>
<td>0.35</td>
<td>14.4</td>
</tr>
<tr>
<td></td>
<td>0.47</td>
<td>0.45</td>
<td>18.5</td>
</tr>
<tr>
<td>carbon fiber</td>
<td>0.85</td>
<td>0.70</td>
<td>32.7</td>
</tr>
<tr>
<td></td>
<td>1.25</td>
<td>1.00</td>
<td>48.1</td>
</tr>
</tbody>
</table>
Figure 14 – D-Load Strength With (P1) Poly. Fibers

Figure 15 – D-Load Strength With (P2) Poly. Fibers

Figure 16 – Pipe D-Load Strength with Glass Fibers

Figure 17 – Pipe D-Load Strength with Carbon Fibers
Brittle Failure

Figure (13c)  0.35% $V_f$

Figure (13d)  0/45% $V_f$

Figure 13 – Flexural Load / Deformation Relationship
European Standard for Steel Fiber Reinforced Concrete Pipe.

EUROPEAN STANDARD
NORME EUROPÉENNE
EUROPÄISCHE NORM

EN 1916
October 2002
ICS 23.040.50; 93.030

English version

Concrete pipes and fittings, unreinforced, steel fibre and reinforced
No Brittle Failure

\[ D_{\text{Load}} \]

\[ D_{\text{Ultimate}} \]

\[ D_{\text{Proof}} \]

- Red = Loading
- Green = Unloading
EXPERIMENTAL WORK AT THE UNIVERSITY OF TEXAS AT ARLINGTON

FULL SCALE PIPE TEST

- ASTM C497 THREE-EDGE BEARING (3EBT)
- ASTM C443 HYDROSTATIC JOINT
- ASTM C497 JOINT SHEAR

MATERIAL TESTING

- ASTM C1609 FLEXURAL BEAM
- ASTM C39 COMPR. CYLINDER
- DIRECT TENSION OF CONCRETE
PRODUCTION SITES

Northern Concrete Pipe

Hanson Building Products

Sherman Dixie

Rinker
PRODUCTION EQUIPMENT

HANSON PACKERHEAD

RINKER PETERSHAAB

NCP HAWKEYE

SHERMAN DIXIE SCHLUSSELBAUER
# PIPE SPECIMENS AND SITES

<table>
<thead>
<tr>
<th>TEST SITE</th>
<th>TYPE OF EQUIPMENT</th>
<th>NUMBER OF SPECIMENS</th>
<th>SIZES (in)</th>
<th>WALL THICKNESS</th>
</tr>
</thead>
<tbody>
<tr>
<td>HANSON</td>
<td>Packerhead</td>
<td>51</td>
<td>15,24,30,33,36,42,48</td>
<td>B,C</td>
</tr>
<tr>
<td>RINKER-CEMEX</td>
<td>Petershaab</td>
<td>16</td>
<td>24,36</td>
<td>B</td>
</tr>
<tr>
<td>NORTHERN CONCRETE PIPE</td>
<td>Hawkeye</td>
<td>27</td>
<td>24,36,48</td>
<td>B,C</td>
</tr>
<tr>
<td>SHERMAN DIXIE</td>
<td>Schlusselbauer</td>
<td>16</td>
<td>24,36,48</td>
<td>B,C</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td><strong>110</strong></td>
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<td></td>
</tr>
</tbody>
</table>
SFRCP FINISH

48 in. SFRCP, 88 lb/cyd

24 In. SFRCP, 22 lb/cyd
INSTRUMENTATION

Load Reading

Data Acquisition

Horizontal CDS

Vertical CDS
TYPICAL FAILED SPECIMEN

SFRCPO
NCP-36-C-66

SFRCPO
NCP-24-B-44
CRACK SIZE

HAN 24-B-1-#1
Cast: 06/03/2011
Test age: 14 days

SFRCP 24-B-44
¼ in. CRACK @ 5% DEFORMATION

SFRCP 36-C-66
½ in. CRACK @ 5% DEFORMATION
FIBERS AT LARGE CRACK
D-LOAD TEST RESULTS

Pipe Diameter (mm)

Pipe Diameter (in)

D-Ultimate (lb/ft²)

D-Ultimate (kN/m²)

- 22 lb/cy (13 kg/m²)
- 33 lb/cy (19 kg/m²)
- 44 lb/cy (26 kg/m²)
- 66 lb/cy (39 kg/m²)
- 88 lb/cy (52 kg/m²)
- × 110 lb/cy (65 kg/m²)

ASTM C76 Class IV
ASTM C76 Class III

D-LOAD TEST RESULTS

The graph illustrates the D-load test results for various materials and conditions, showing the relationship between displacement and load. The graph includes lines for different test classes and materials, with specific lines denoted for SHD24-B-C-66(1.5)-T1-DL Vertical, HAN 30-B-C-88(1.5)-T2-DL Vertical, HAN 30-B-C-88(1.5)-T2-DL Horizontal, NCP56-B-C-88(2)-T1-DL Vertical, and NCP56-B-C-88(2)-T1-DL Horizontal.
Standard Specification for
Steel Fiber Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe

This standard is issued under the fixed designation C1765; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.
CONSISTENT FACTOR OF SAFETY

Displacement, in

D_Load, lb/ft/ft

D_Service

D_Ultimate

SFRC

RCP
Future Possibilities

D-load vs. Parallel plate test (PPT)

Load (lbs/8 ft Sample Length) vs. Deflection (in)

- PP test: 36 TW (THK=1.75 in)
- D-load: 36 TW (THK=1.75 in)
- D-load: 54 TW (THK=2.0 in)
- PP test: 54 TW (THK=2 in)
- PP-test: 60 HDPE (THK=3.34 in)
- PP-test 48 HDPE (THK=3.34 in)
- PP-test 48 CMP (THK=0.125 in)
- PP-test: 66 CMP (THK=0.138 in)
THE END