PROFILE STABILITY and NCLS UPDATE

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THE MOST ADVANCED NAME IN DRAINAGE SYSTEMS

Profile Wall Pipe Performance

- Pipes respond to load through ring compression and resistance to bending.
- Profile wall pipe performance is dependent on loading, quality of installation, material properties, and wall geometry.

Pipe Failure Modes

- Over Deflection
- Reverse Curvature
- Global Buckling
- Local Buckling

Over Deflection and Reverse Curvature

- Dependent on:
  - Loads (Live and Dead Loads)
  - Soil Quality and Compaction
  - Pipe Stiffness
- The relationship between soil stiffness and pipe stiffness is such that a majority of the strength is dependent on soil stiffness.

Global and Local Buckling

- Dependent on:
  - Loads (Live and Dead Loads)
  - Material properties
  - Pipe wall area
  - Pipe Geometry

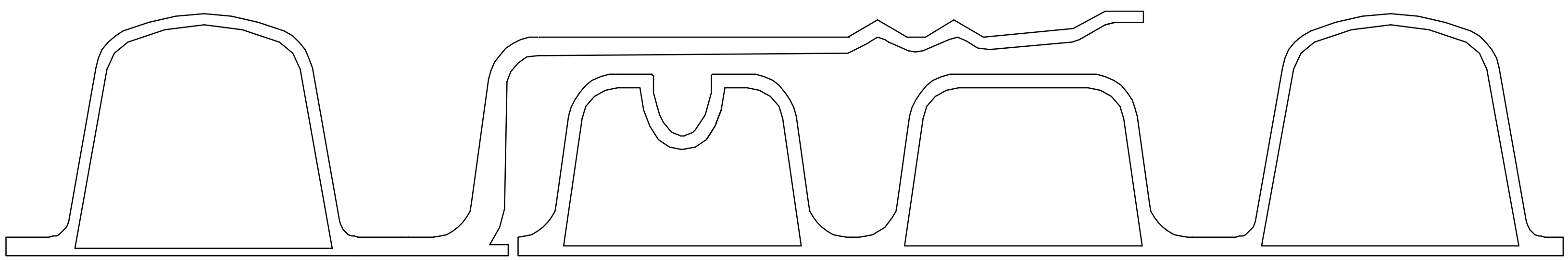
Flexural Buckling

- Characterized by over-deflection and development of a hinge.
- Crown stresses are high until material reaches yield point.
- Pipe geometry and material properties control yield point.

Compressive Buckling

- Characterized by formation of dimpling.
- Profile wall ribs deflect until compressive strain reaches material yield.
- Slenderness effects and material properties control yield point.

Profile geometry and profile stability are key to in service pipe performance



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Research

- Dimensionless Parameters, Dr. A.P.Moser, Utah State University
- Curved Beam Test, Dr. Les Gabriel, California State University - Sacramento
- LRFD Specifications for Plastic Pipe and Culverts, T.J. McGrath, Simpson Gumpertz and Heger, Inc,

Dimensionless Parameters

- Moser proposed that slenderness ratios and shape considerations appear to control the load carrying capability of profile wall pipes. As such, he developed guidelines that reflected the performance observed in a load cell.

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Moser's recommended dimensionless parameters

Dimensionless Parameter	Proposed HDPE value
t_{min}/r	≥ 0.005
t_{min}/l_{uns}	≥ 0.02
L/r^3	$\geq 4 \times 10^{-5}$
A/r	≥ 0.02
L_p/r	≤ 0.3
t_{min}= min. thickness of profile element r = radius to centroid of pipe wall l_{uns} = unsupported width of element A = area of pipe wall per unit length I = moment of inertia of pipe wall per unit length L_p = length of profile section	

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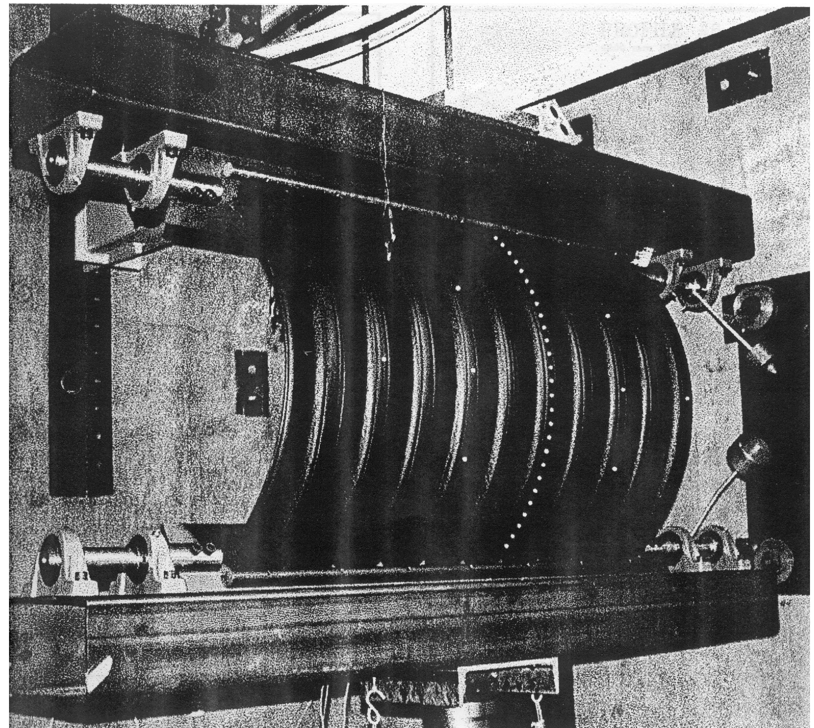
Curved Beam Test

- Curved Beam Test is a method to determine instantaneous pipe stiffness under loading.This test produces both bending and wall compression which replicates actual field loading.
- The test shows stable profiles thin less under a constant strain.
- An ASTM standard has been approved for the curved beam test, so a protocol for testing is available.



Photograph of Test Specimen in Place with Peak Targets

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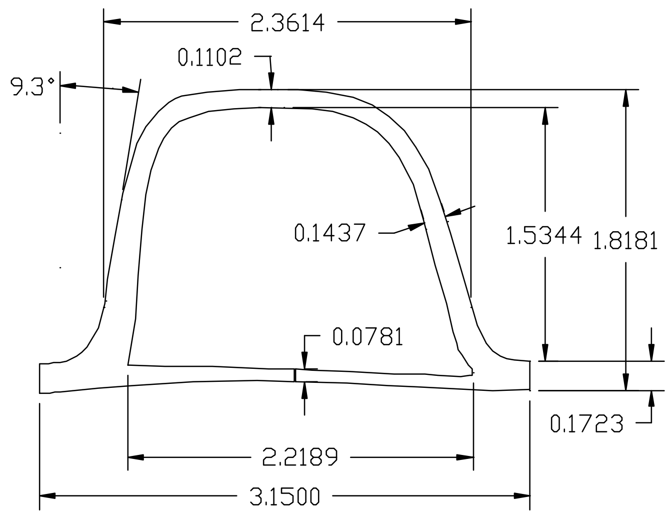
LRFD Specifications for Plastic Pipe and Culverts

- TRB Report 438 studied dimensional parameters for LRFD design calculations.
- Utilizes idealized box section to determine strain effects and stability.
- Current design practice utilizes width to thickness ratios and is subject to interpretation of cross section analysis.

Analysis of a Profile Section



Area: 1.0278
Perimeter: 15.5793
Bounding box: X: 0.0000 -- 3.1500
Y: 0.0000 -- 1.8361
Centroid: X: 1.4884
Y: 0.7491
Moments of inertia: X: 0.9977
Y: 3.2047

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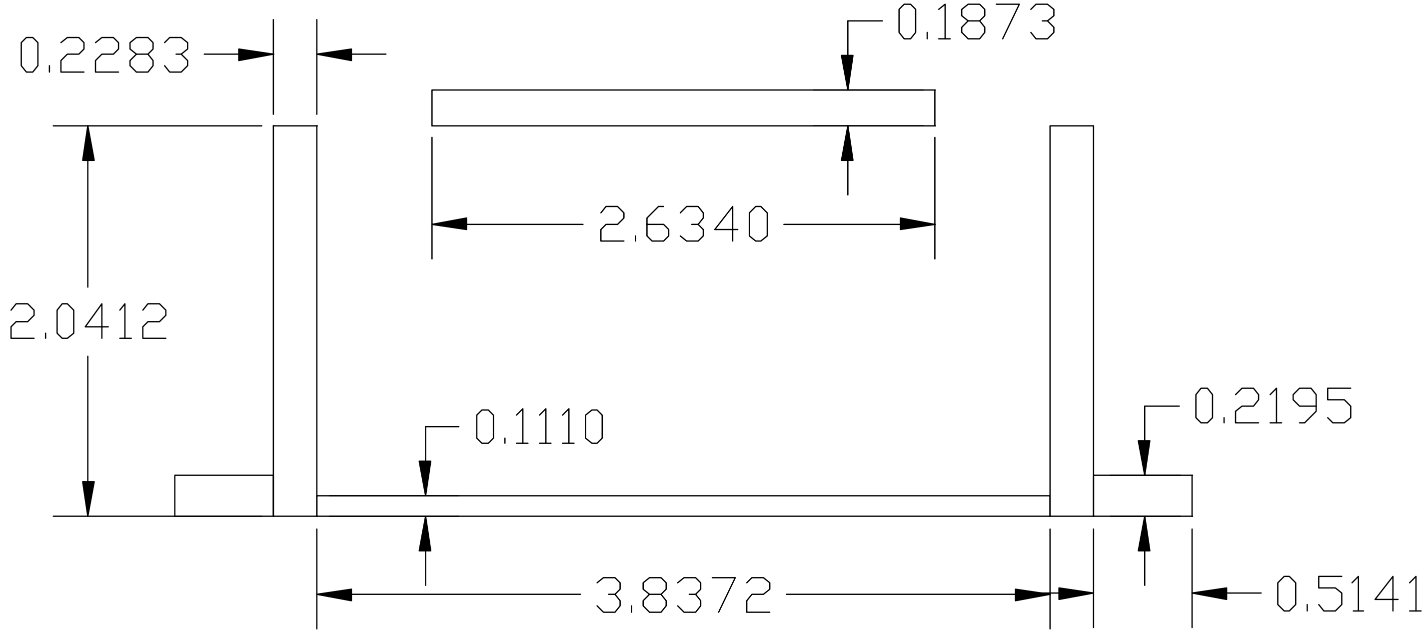
Idealized Profile Section



Design Calculations

- Idealized profile is input in LRFD design method and strengths of profiles are evaluated based on the relative strain level and slenderness ratio of the individual components.
- The material properties and effective elements determine pipe’s performance.

Limitations of Current Design Method

- Idealized profile cannot account for shape improvements in profile design.
- There is no method or standard for measuring idealized section.

Limitations of Current Design Method

- AASHTO limits or minimum dimensions are not established.
- AASHTO published material properties are overly conservative for current resins meeting SP-NCTL requirements.

What needs to be done

- Develop protocol for creating idealized profile from existing pipe profiles and field performance.
- Develop minimum dimensionless parameters that all profiles must meet.
- Update AASHTO specification for true mechanical properties.
- Develop standard QC test for realistic pipe stiffness test and profile stability.

NCLS verification

- In 2000, the AASHTO SOM revised the resin specification to require virgin resins with a SP-NCTL test at 15% stress for 24 hours.
- The finished pipe still needs to meet the ESCR requirement although it is a difficult test to perform with poor repeatability of results.

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NCLS verification

- At the 2002 SOM meeting, industry proposed replacing the finished pipe test with an NCLS test on reprocessed plaques from finished pipe.
- The motion failed due to an expressed desire to have the testing performed on samples obtained directly from finished pipe.

NCLS verification

- Industry has begun verification testing from plaques obtained from pipe wall sections with some promising results. However, problems include variability of the pipe samples, sample orientation and test repeatability.