An Assessment of Corrugated HDPE Pipe Performance Under Railroads

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Corrugated Polyethylene Pipe Testing under 315,000-Pound Cars at FAST

Letter Report No. P-09-052

Prepared for Plastic Pipe Institute

by Joseph A. LoPresti

Transportation Technology Center, Inc.

…a subsidiary of the Association of American Railroads

P. O. Box 11130, Pueblo, Colorado 81001 USA,

December 28, 2009

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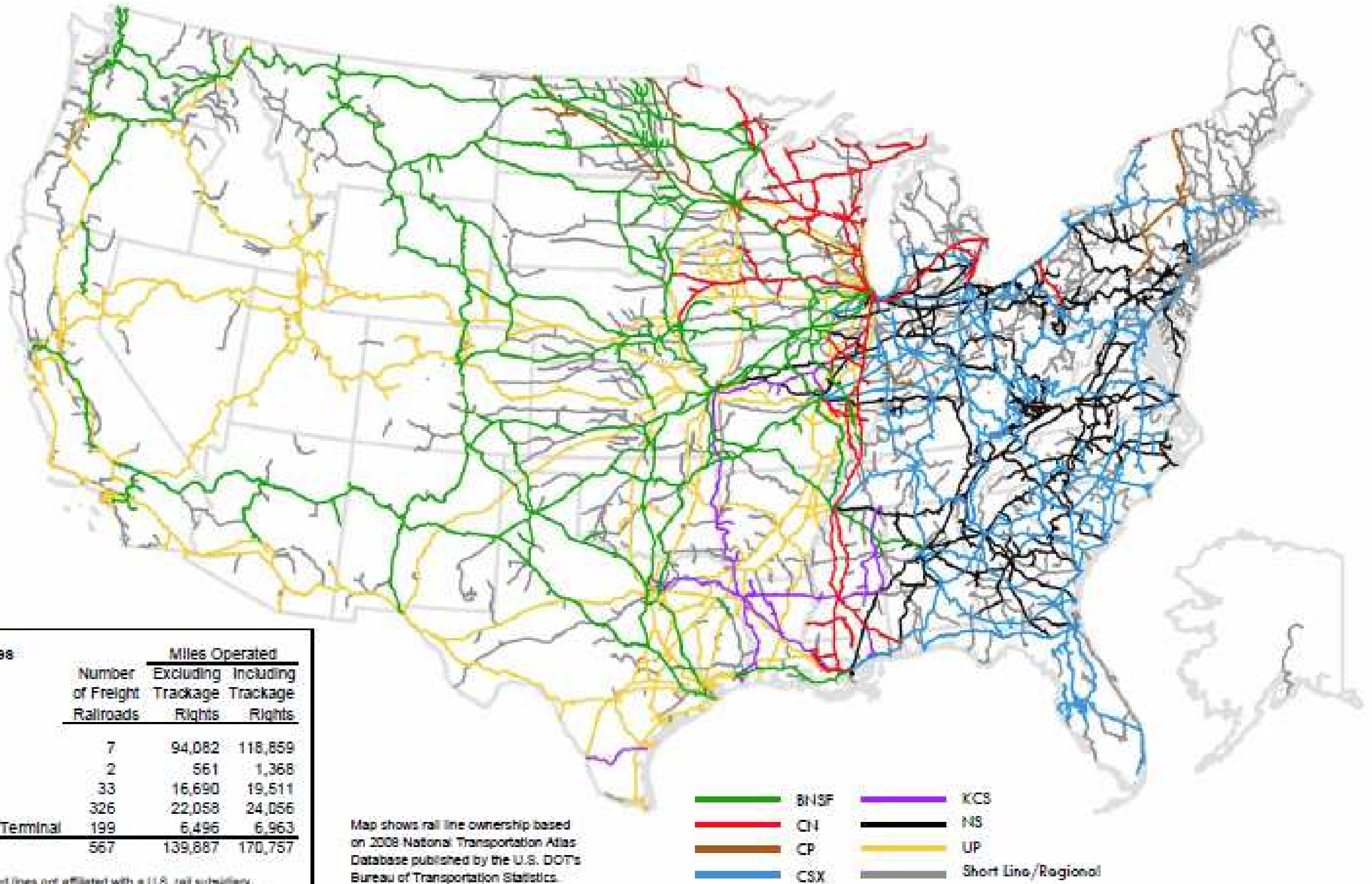
Railroad Network of the

UNITED STATES 2008



United States Totals	Number of Freight Railroads	Miles Operated: Excluding Trackage Rights	Miles Operated: Including Trackage Rights
Class I	7	94,082	118,859
Canadian*	2	561	1,368
Regional	33	16,690	19,511
Local	326	22,058	24,056
Switching & Terminal	199	6,496	6,963
Total	567	139,887	170,757

*Canadian-owned lines not affiliated with a U.S. rail subsidiary.
**Excludes 743 miles owned by Amtrak. All or some of these miles might be operated by freight railroads under trackage rights.

Map shows rail line ownership based on 2008 National Transportation Atlas Database published by the U.S. DOT's Bureau of Transportation Statistics.

February 2010

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- Currently 7 major railroads (Class I) and hundreds of Class II and III railroads comprising 140,000 miles of track in U.S.

- Revenues in the freight rail industry were $63B in 2009

- 1.4 million freight cars operating in 2009 (450,000 Class I)

- Freight Rail Infrastructure Expansion Act of 2009 proposes increased funding and tax incentives for freight rail

- FRA recently announced $25M funding for high speed rail

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ENVIRONMENTAL ADVANTAGES OF RAIL

- Railroad fuel efficiency is up 94% since 1980
- A freight train moves a ton of freight an average of 480 miles on a gallon of fuel (0.6 liters of fuel per 100 km)
- According to Federal Railroad Administration, railroads are 2 – 5 times more fuel-efficient than trucks

- A single freight train can take the load of 280 trucks
- If 10% of current long distance highway freight switched to rail, national fuel savings would exceed 1B gallons/year (3.8 B Liters/year)

$4.00

JANUARY/FEBRUARY 2012

Land and Water

THE MAGAZINE OF NATURAL RESOURCE MANAGEMENT AND RESTORATION

Storm Water Culvert Repair

Stands Up To Weight Of Railroad Trains And Contaminated Soil

A 20-foot section of SaniTite® HP pipe being nudged into the culvert. It took the crew just hours to slipline the entire 200 feet of the culvert.

Contractor easily assembles the field joint together with ratchet straps.

This required the repair to be able to seal out any contamination from above, not inhibit the creek's water flow rate and still be able to withstand the weight of 17 feet of earth and the multi-ton Amtrak passenger and freight railcars frequently passing overhead every day.

The final headwall and the 60-inch diameter pipe blends in with the surrounding area.

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- TTCI – Transportation Technology Center, Inc., Pueblo, CO
- FAST – Facility for Accelerated Service Testing
- Typical train consist = 80 315,000 lb (156 ton) cars and 4 GP-40 locomotives

- Static Wheel Loads
  - (Wheel Load)(# of wheels) = Gross Weight of Car

Axle Load	Gross Weight of Cars	
Axle load (tons)	Gross weight of cars (lbs)	Type
10	80,000	Light rail transit
15	120,000	Heavy rail transit
25	200,000	Passenger Cars
25	200,000	Common European freight limit
27.5	220,000	U.K. and Select European limit
33	263,000	North American free interchange limit
36	286,000	Current Heavy Axle load weight for North American Class 1
39	315,000	Very limited use; research phase

- **We Used 39 Ton Axle Load Cars (315,000 lb) for the test; TTCI started using these loads in 1988**

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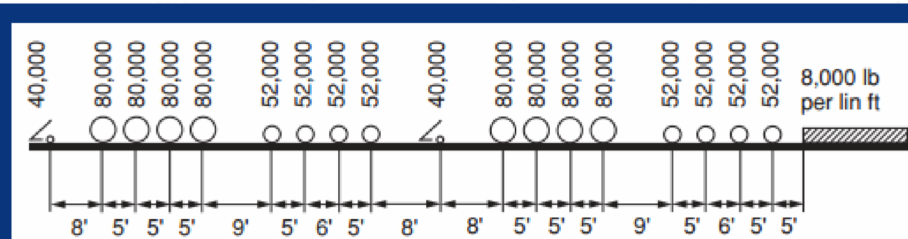
Live Load Transferred to Pipe

Cover, ft. (m)	AASHTO H-25 or HS-25(1) Live Load Transferred to Pipe, P_L, psi (N/mm²)	AASHTO H-25 or HS-25(1) Live Load Distribution Width, L_W in (mm)	Cooper E-80(1) Live Load Transferred to Pipe, P_L, psi (N/mm²)	Cover, ft. (m)	AASHTO H-25 or HS-25(1) Live Load Transferred to Pipe, P_L, psi (N/mm²)	AASHTO H-25 or HS-25(1) Live Load Distribution Width, L_W in (mm)	Cooper E-80(1) Live Load Transferred to Pipe, P_L, psi (N/mm²)
1 (0.3)	15.63 (0.108)	31 (787)	N/R	14 (4.3)	negligible	N/A	4.17 (0.0288)
2 (0.6)	6.95 (0.048)	52 (1321)	26.39 (0.1824)	16 (4.9)	negligible	N/A	3.47 (0.0240)
3 (0.9)	5.21 (0.036)	73 (1854)	23.61 (0.1632)	18 (5.5)	negligible	N/A	2.78 (0.0192)
4 (1.2)	3.48 (0.024)	94 (2388)	18.40 (0.1272)	20 (6.1)	negligible	N/A	2.08 (0.0144)
5 (1.5)	2.18 (0.015)	115 (2921)	16.67 (0.1152)	22 (6.7)	negligible	N/A	1.91 (0.0132)
6 (1.8)	1.74 (0.012)	136 (3454)	15.63 (0.1080)	24 (7.3)	negligible	N/A	1.74 (0.0120)
7 (2.1)	1.53 (0.011)	157 (3988)	12.15 (0.0840)	26 (7.9)	negligible	N/A	1.39 (0.0096)
8 (2.4)	0.86 (0.006)	178 (4521)	11.11 (0.0768)	28 (8.5)	negligible	N/A	1.04 (0.0072)
10 (3.0)	negligible	N/A	7.64 (0.0528)	30 (9.1)	negligible	N/A	0.69 (0.0048)
12 (3.7)	negligible	N/A	5.56 (0.0384)	35 (10.7)	negligible	N/A	negligible

Cooper E-80 Load



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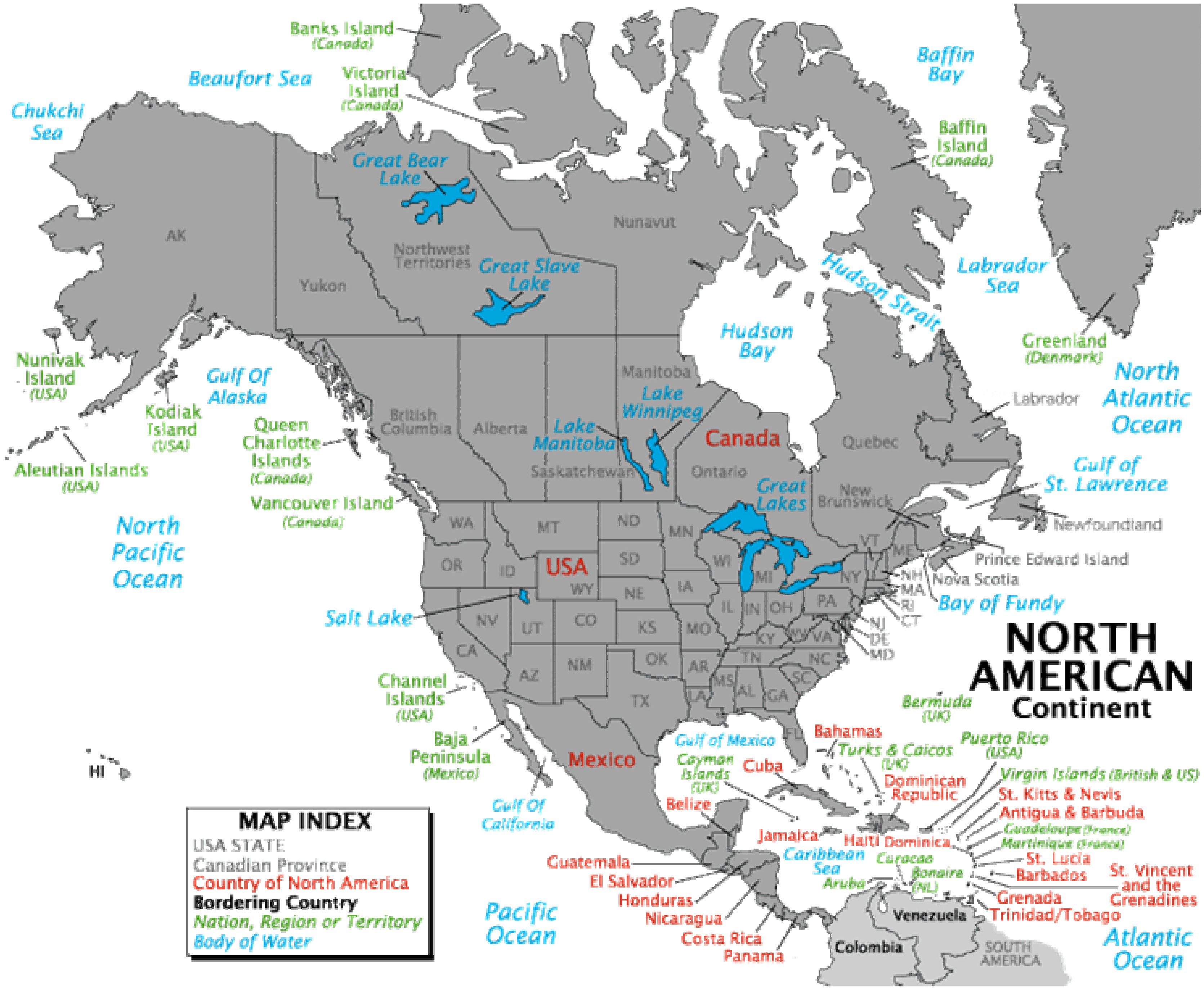
TTCI

- Headquartered in Pueblo, CO at the U.S. Federal Railroad Administration's Transportation Technology Center
- Includes 50 miles of test track for specialized full scale rail tests
- TTCI capable of accumulating 1 million gross ton-miles / day on high tonnage loop


NORTH AMERICAN Continent
MAP INDEX
USA STATE
Canadian Province
Country of North America
Bordering Country
Nation, Region or Territory
Body of Water
Banks Island (Canada)
Beaufort Sea
Victoria Island (Canada)
Chukchi Sea
Baffin Bay
Baffin Island (Canada)
Great Bear Lake
Nunavut
AK
Yukon
Northwest Territories
Great Slave Lake
Hudson Strait
Labrador Sea
Hudson Bay
Greenland (Denmark)
North Atlantic Ocean
Labrador
Nunivak Island (USA)
Gulf Of Alaska
Kodiak Island (USA)
Manitoba
Lake Winnipeg
Queen Charlotte Islands (Canada)
British Columbia
Alberta
Lake Manitoba
Canada
Quebec
Aleutian Islands (USA)
Saskatchewan
Ontario
Gulf of St. Lawrence
Great Lakes
New Brunswick
Newfoundland
Vancouver Island (Canada)
North Pacific Ocean
WA
MT
ND
MN
VT
ME
Prince Edward Island
OR
ID
USA
SD
WI
NY
NH
MA
RI
CT
Nova Scotia
WY
NE
IA
MI
PA
Bay of Fundy
Salt Lake
NV
UT
CO
IL
IN
OH
NJ
DE
MD
KS
MO
KY
WV
VA
CA
OK
TN
NC
AZ
NM
AR
SC
Channel Islands (USA)
MS
AL
GA
TX
LA
Bermuda (UK)
Baja Peninsula (Mexico)
FL
Gulf of Mexico
Bahamas
Turks & Caicos (UK)
Puerto Rico (USA)
Mexico
Cayman Islands (UK)
Cuba
Dominican Republic
Virgin Islands (British & US)
HI
St. Kitts & Nevis
Gulf Of California
Belize
Antigua & Barbuda
Guadeloupe (France)
Jamaica
Haiti
Dominica
Martinique (France)
Guatemala
Caribbean Sea
Curacao
St. Lucia
El Salvador
Bonaire (NL)
Barbados
St. Vincent and the Grenadines
Honduras
Aruba
Grenada
Nicaragua
Venezuela
Trinidad/Tobago
Pacific Ocean
Costa Rica
Colombia
SOUTH AMERICA
Atlantic Ocean
Panama

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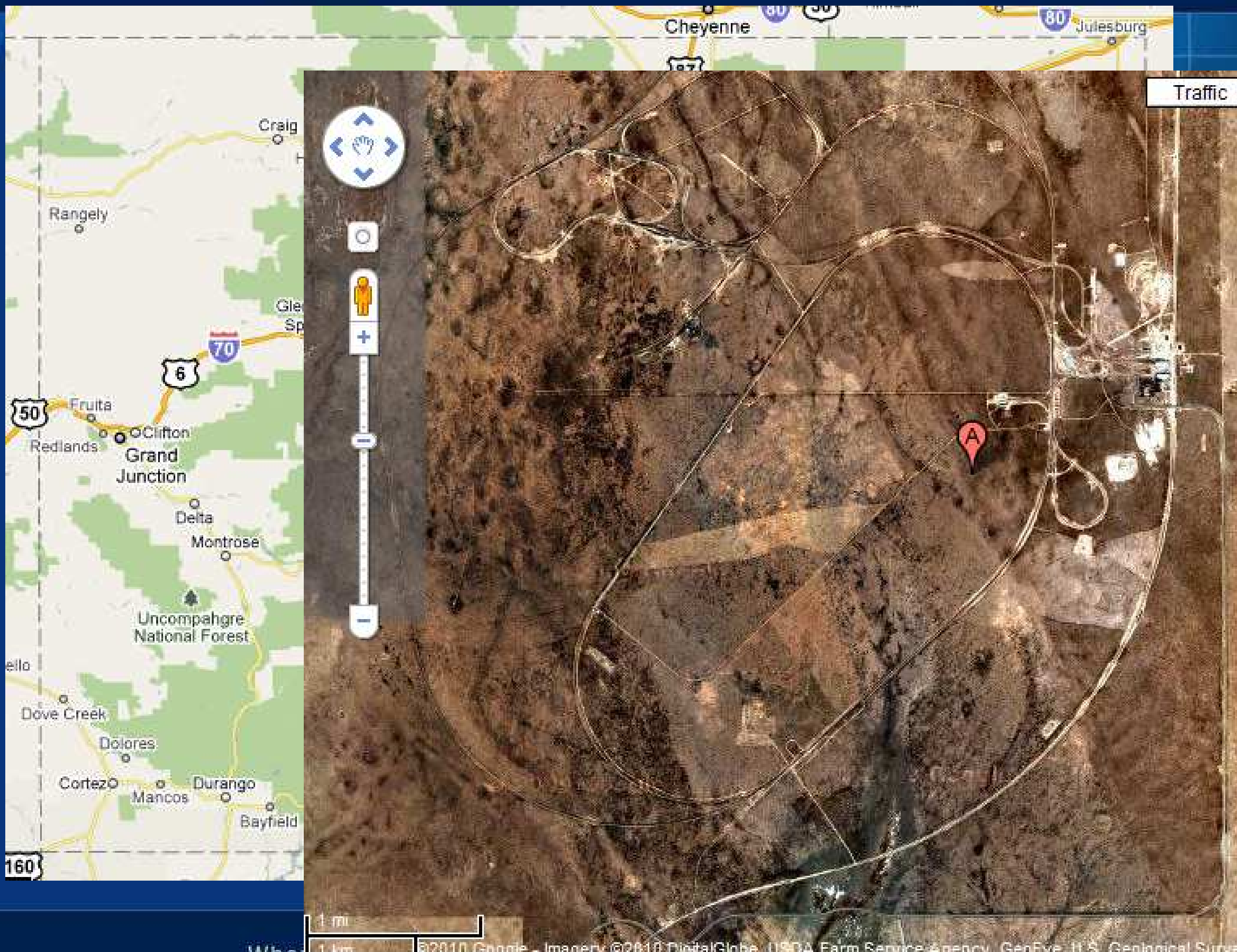

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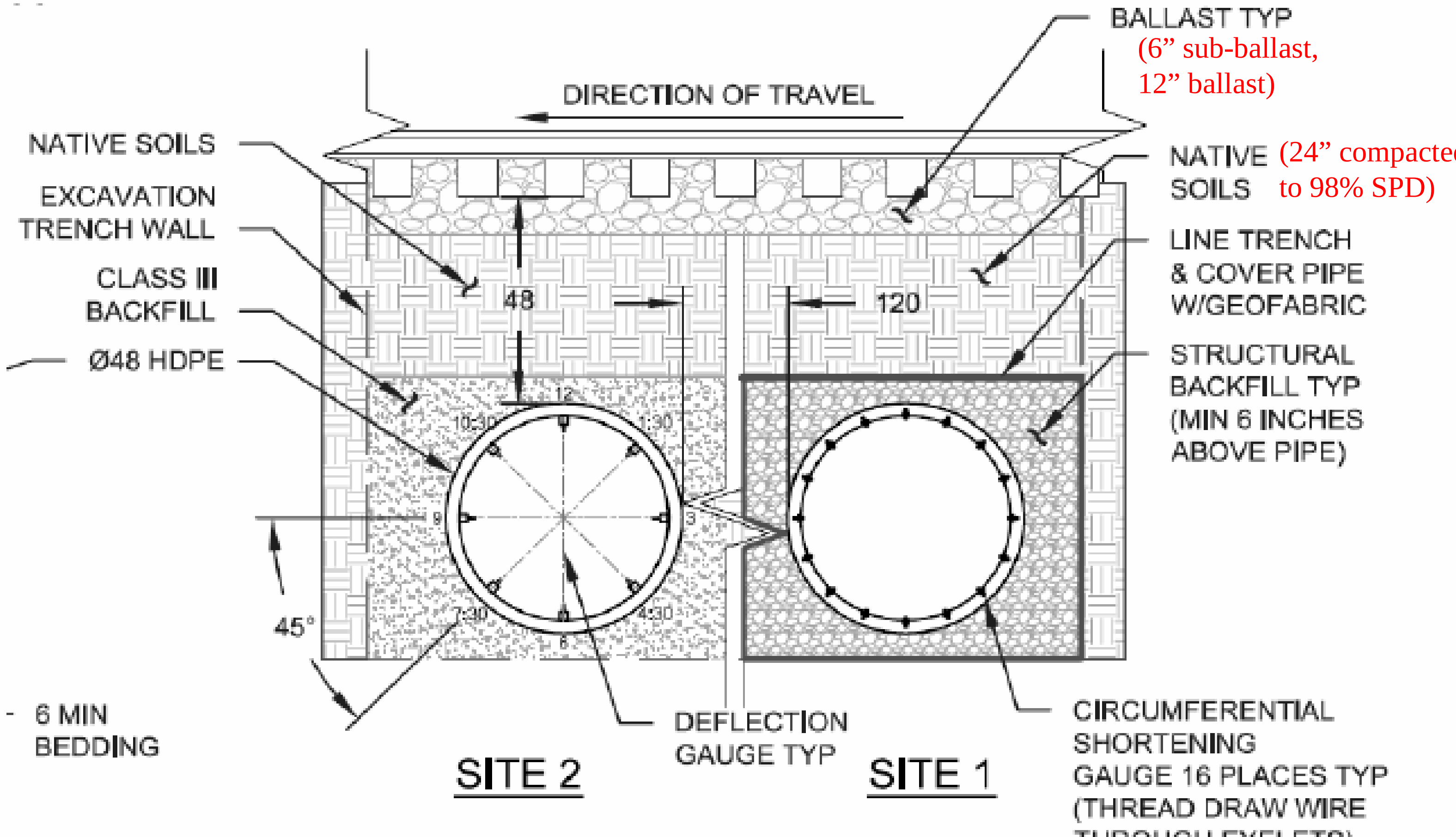


CROSS SECTION A-A

SCALE: NTS

When what's inside has to stay inside, it's polyethylene pipe. **Count on it.**

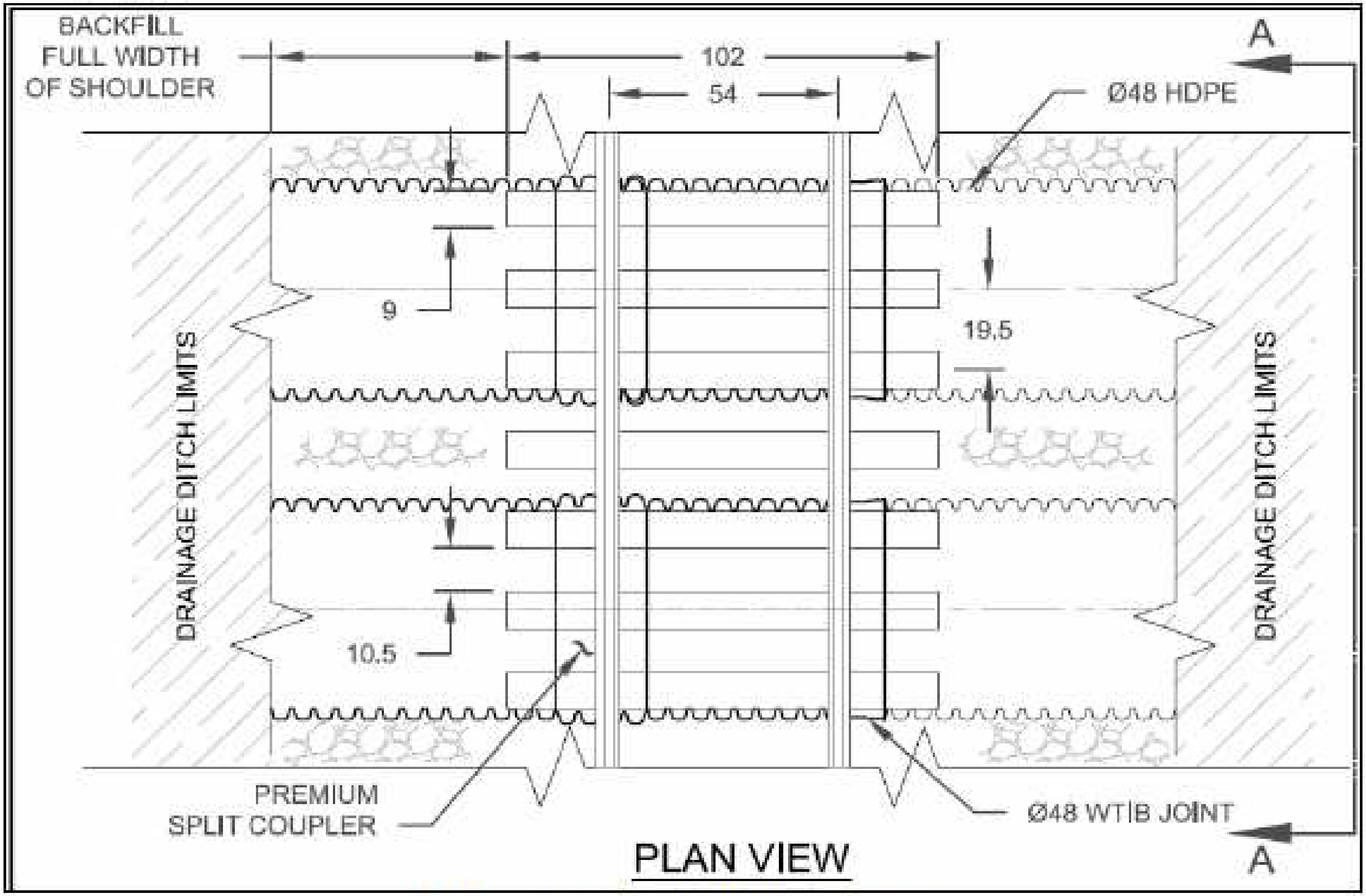
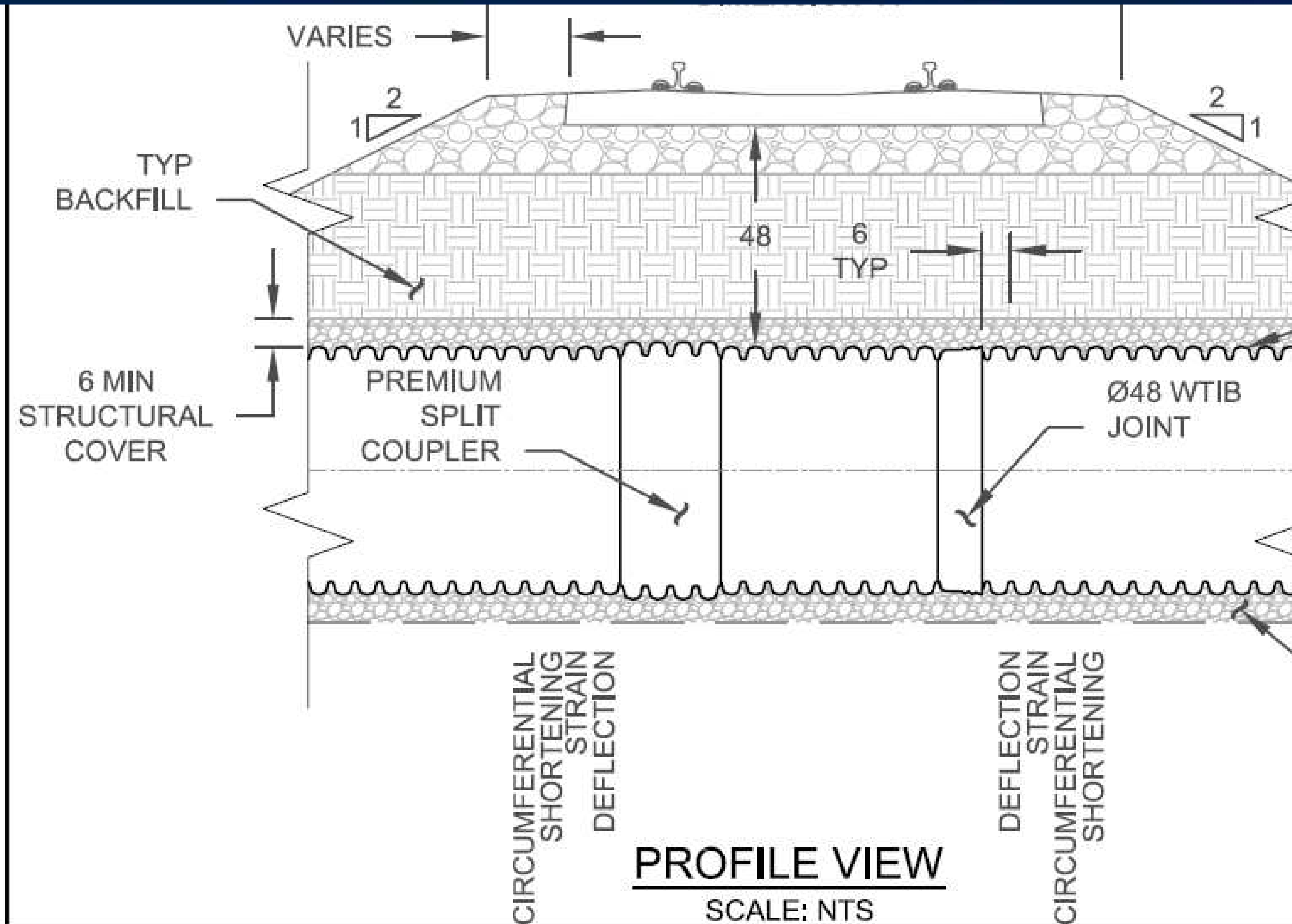


Figure 5. Installation Plan View



PROFILE VIEW

SCALE: NTS

-Instrumented 2 58” pipes (1 for each backfill type)

- 16 strain gages, 10 string pots on each pipe

- One end of pipe had an inline bell WT coupler; the other end a fabric wrapped split coupler

-Track loads directly over joints

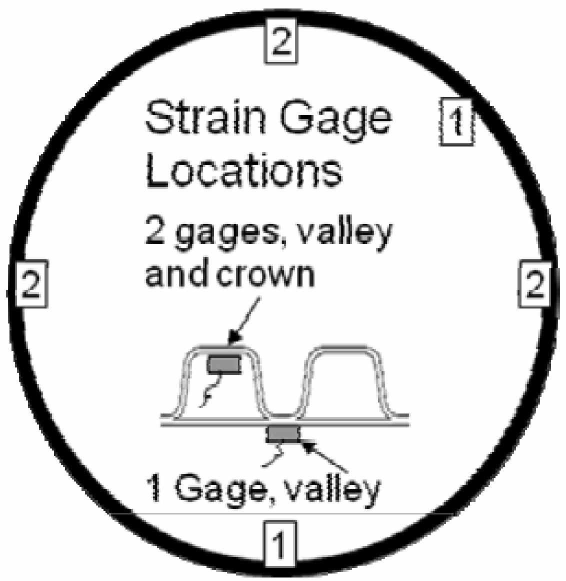
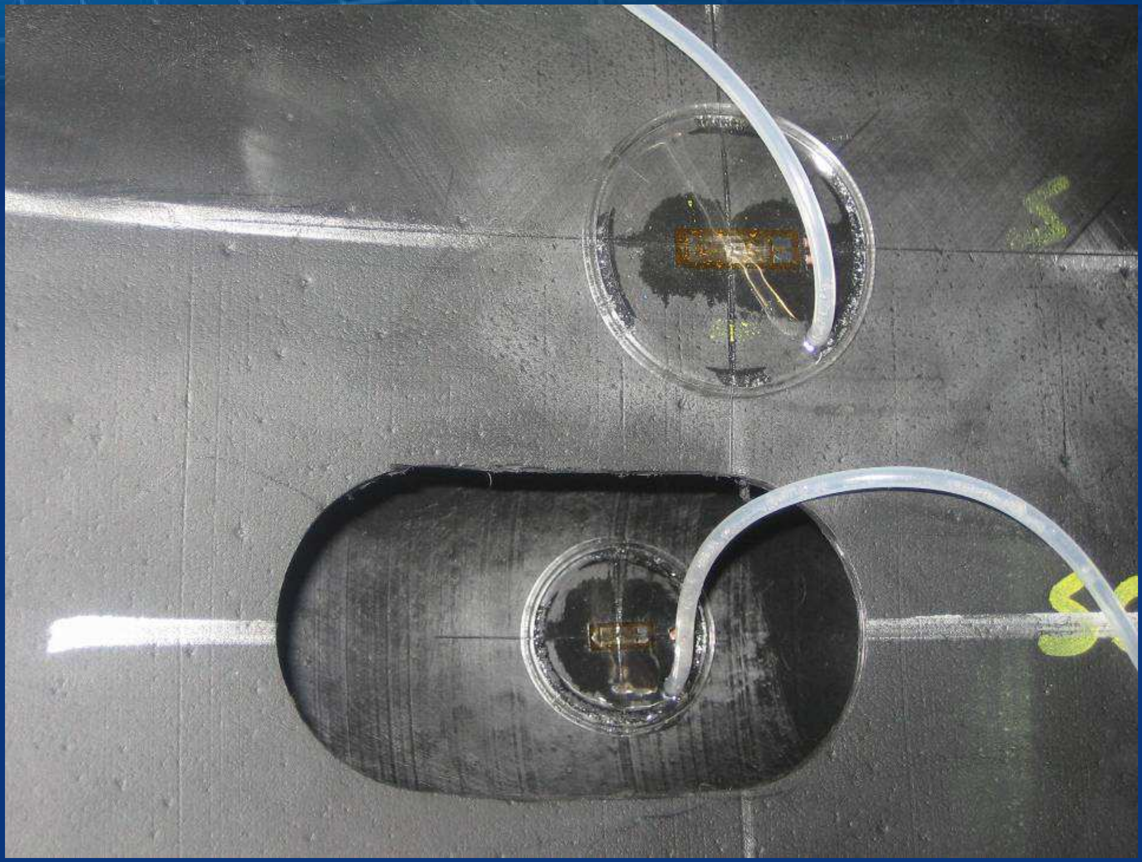


Figure 2. Strain Gage Locations



EXCAVATION FOR THE PIPES

Excavating trench
for the pipe


DEERE
SECTION
5


214

Installing the instrumented pipe sections

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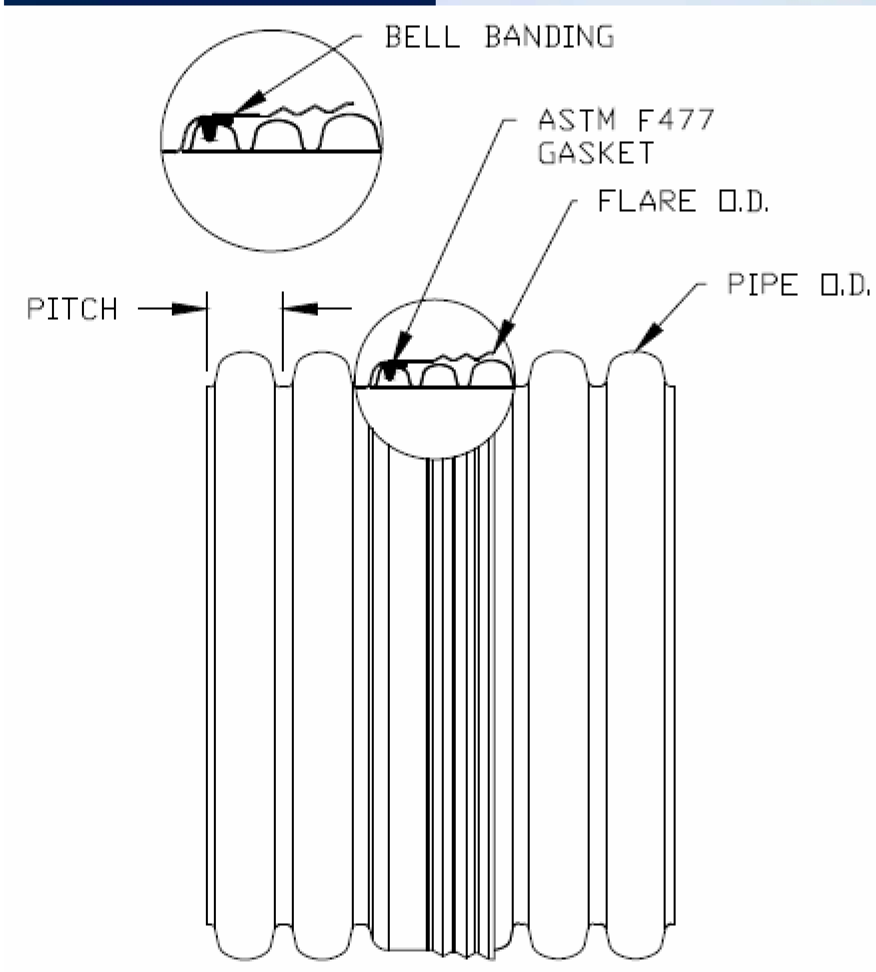

When what's inside has to stay inside, it's polyethylene pipe. **Count on it.**


Bell and spigot
WT joint
Split coupler
Joint


Placing crushed stone backfill around pipe

SITE 1 – Crushed stone #57 Backfill, vibrated with jumping jack

SITE 2 – Native soil backfill (ASTM Class III), vibrated with jumping jack


Pipe #2
Soil Backfill
First foot over pipe - Compacted to 94% SPD with small vibratory roller.
Second foot over pipe – Compacted to 98% SPD with loader and large vibratory larger roller.
Pipe #1
Stone Backfill
CAT

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Initial compaction of the native cover soil

Final Compaction

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When what's inside has to stay inside, it's polyethylene pipe. **Count on it.**

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When what's inside has to stay inside, it's polyethylene pipe. **Count on it.**

Strains and Deflections were Measured:

- Statically, when backfill and track construction was complete
- Statically, after accumulating 1 MGT of Heavy Axle Load (HAL) traffic
- Dynamically, during 10 laps of train operations after completing 1 MGT of HAL traffic
- Statically, prior to train operations after accumulating 96 MGT of HAL traffic
- Dynamically, during 10 laps of train operations after completing 96 MGT of HAL traffic


Data Collection
(See Video)

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When what's inside has to stay inside, it's polyethylene pipe. **Count on it.**

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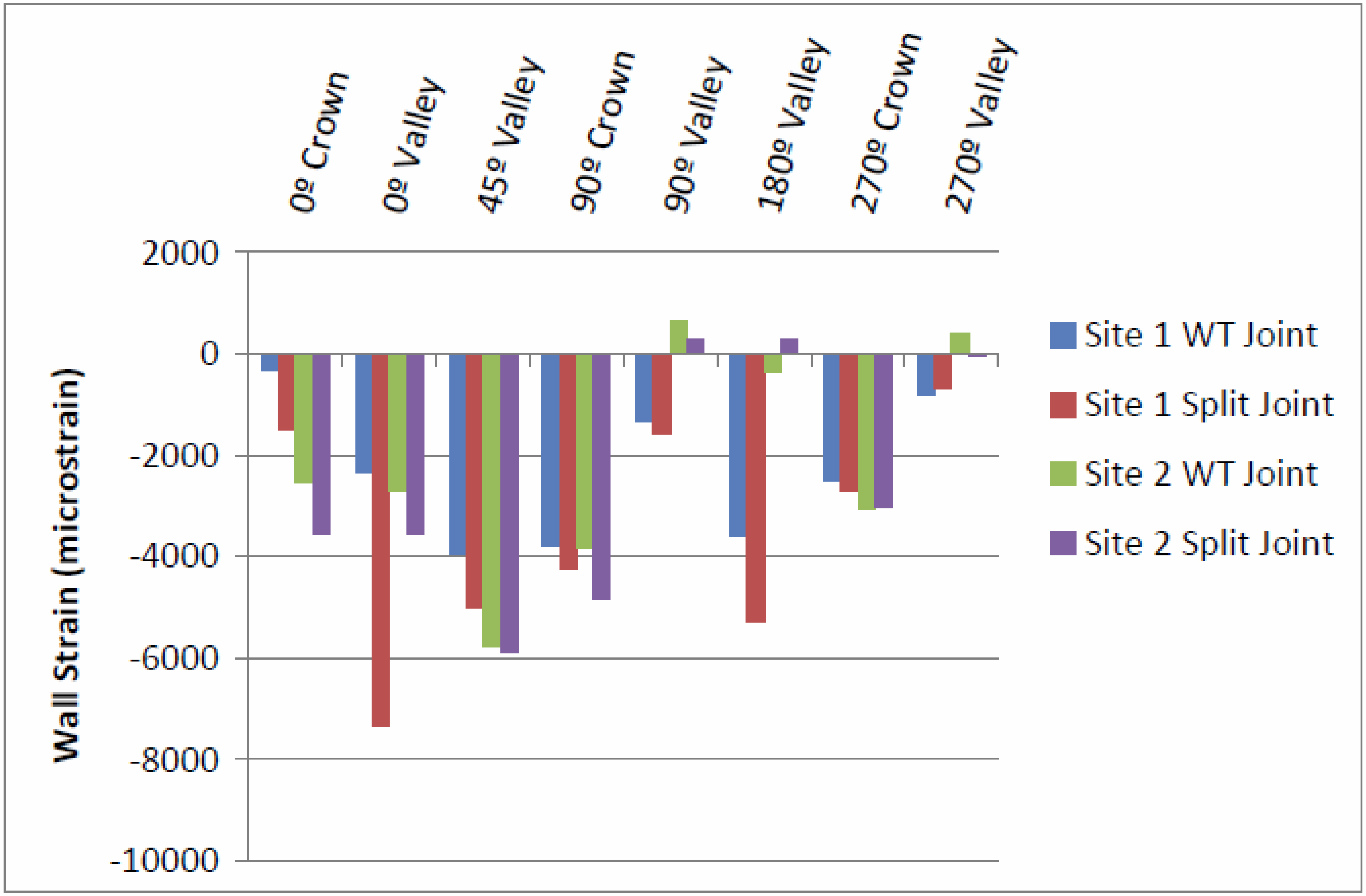
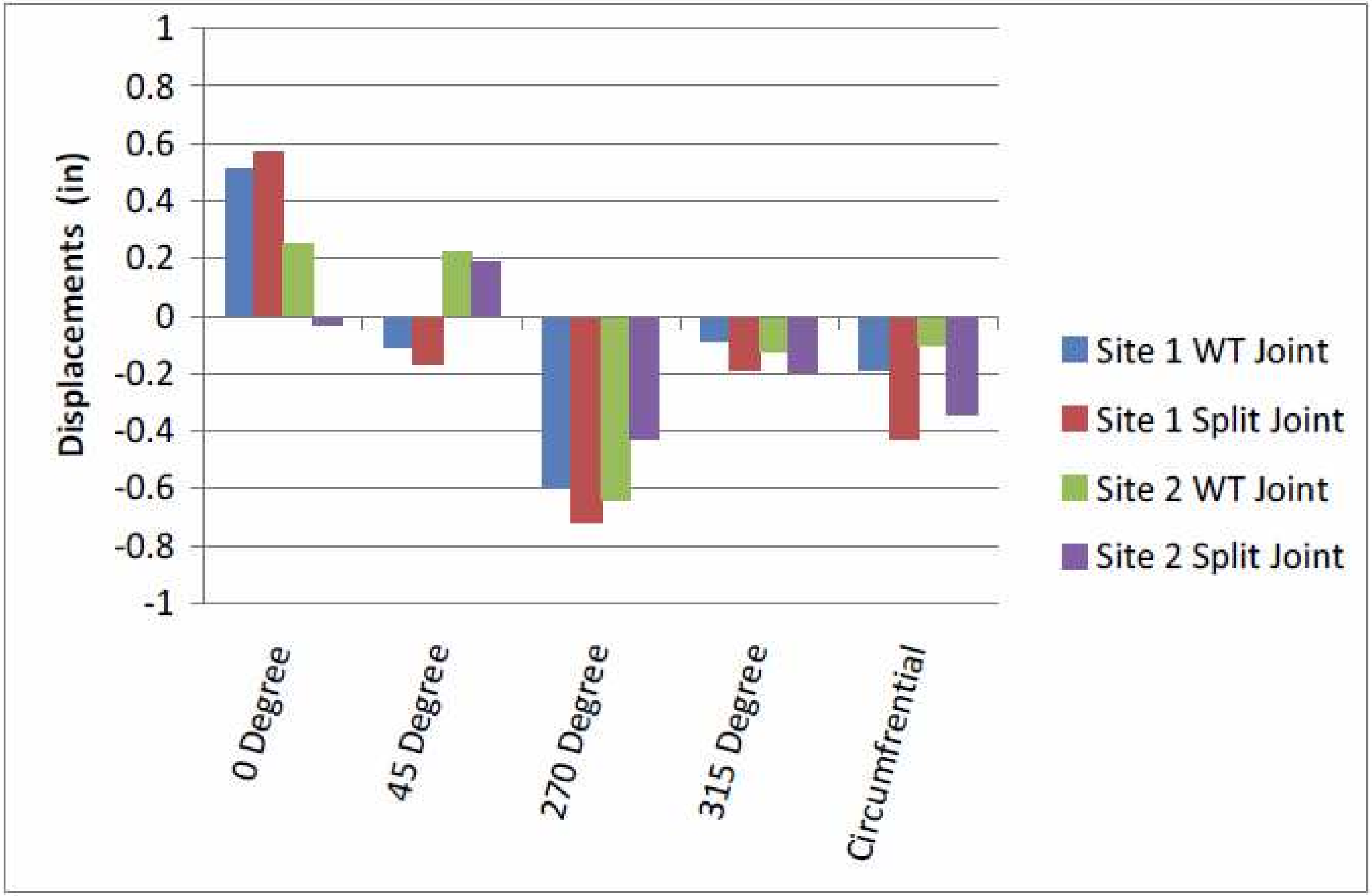


Pipe Wall Strains from Construction and Backfill



Pipe Deflections from Construction and Backfill

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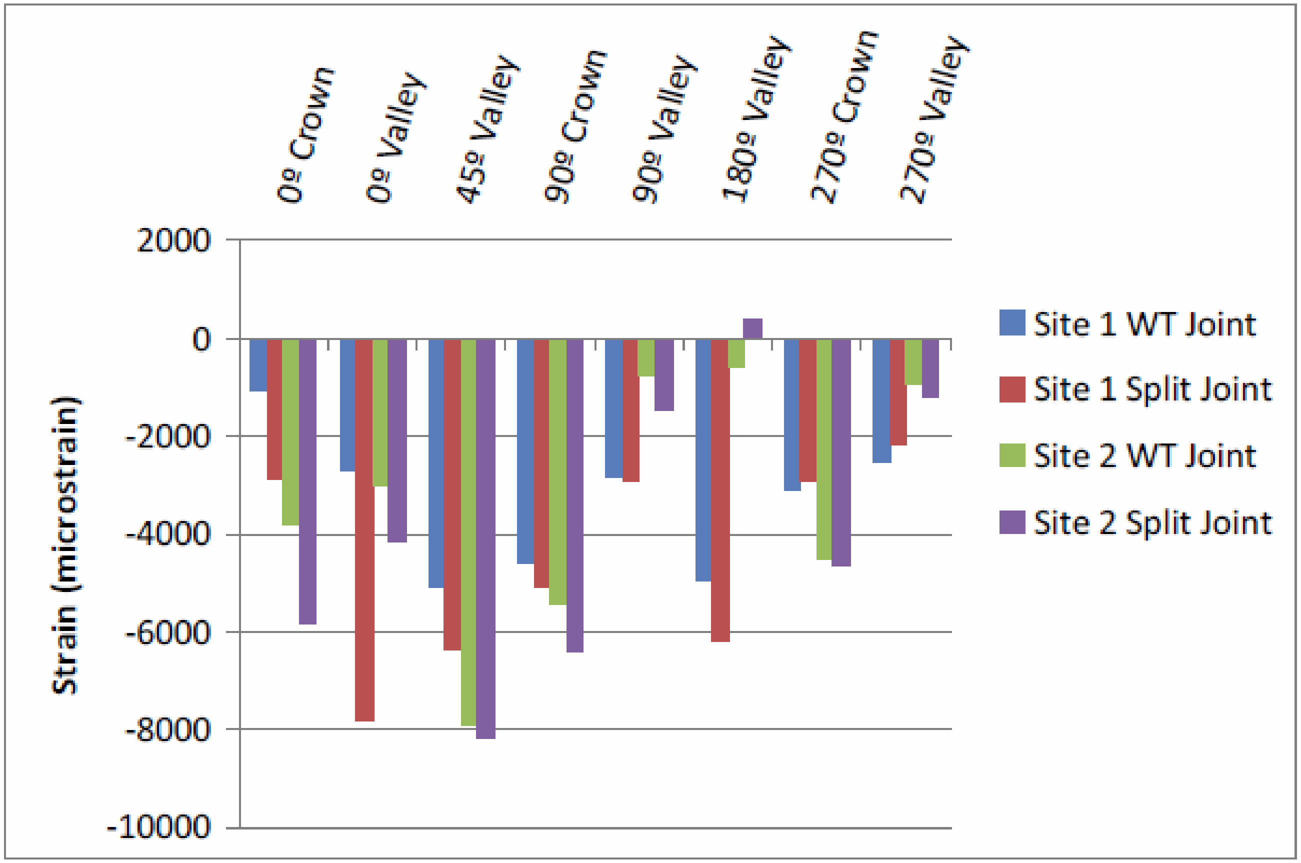

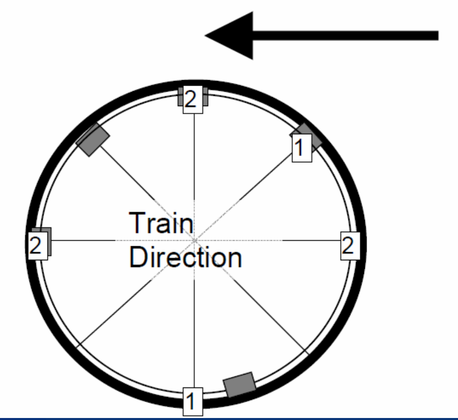

Maximum dynamic wall strains from 40 mph train after 1 MGT

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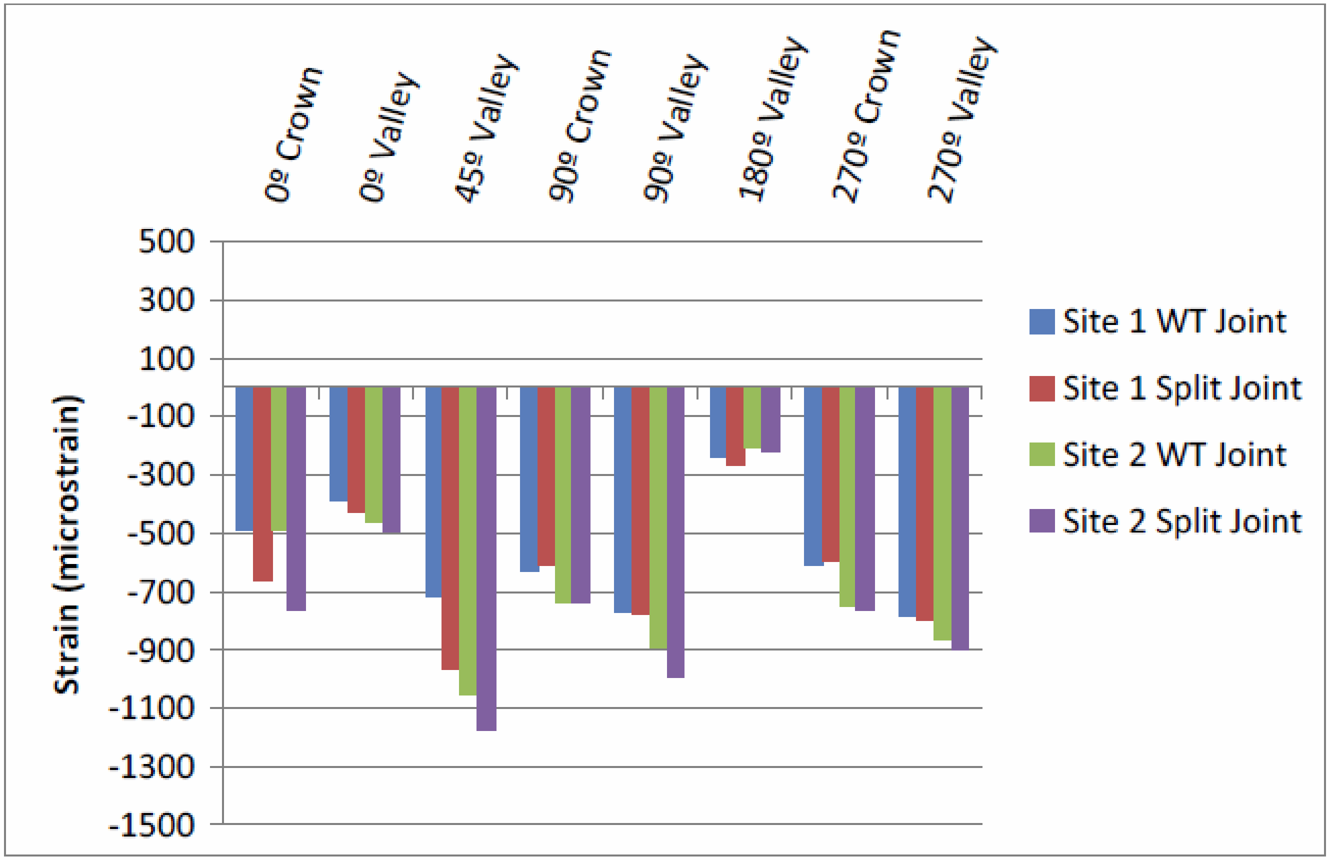

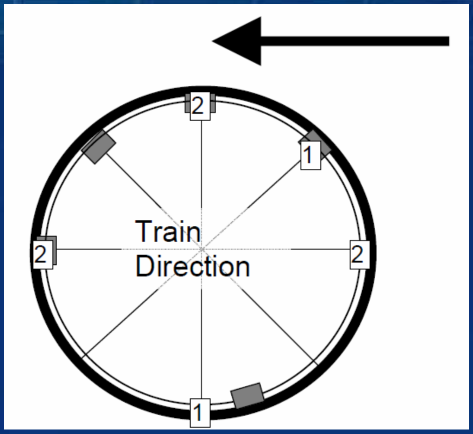

Maximum peak-peak dynamic wall strains from 40 mph train after 1 MGT

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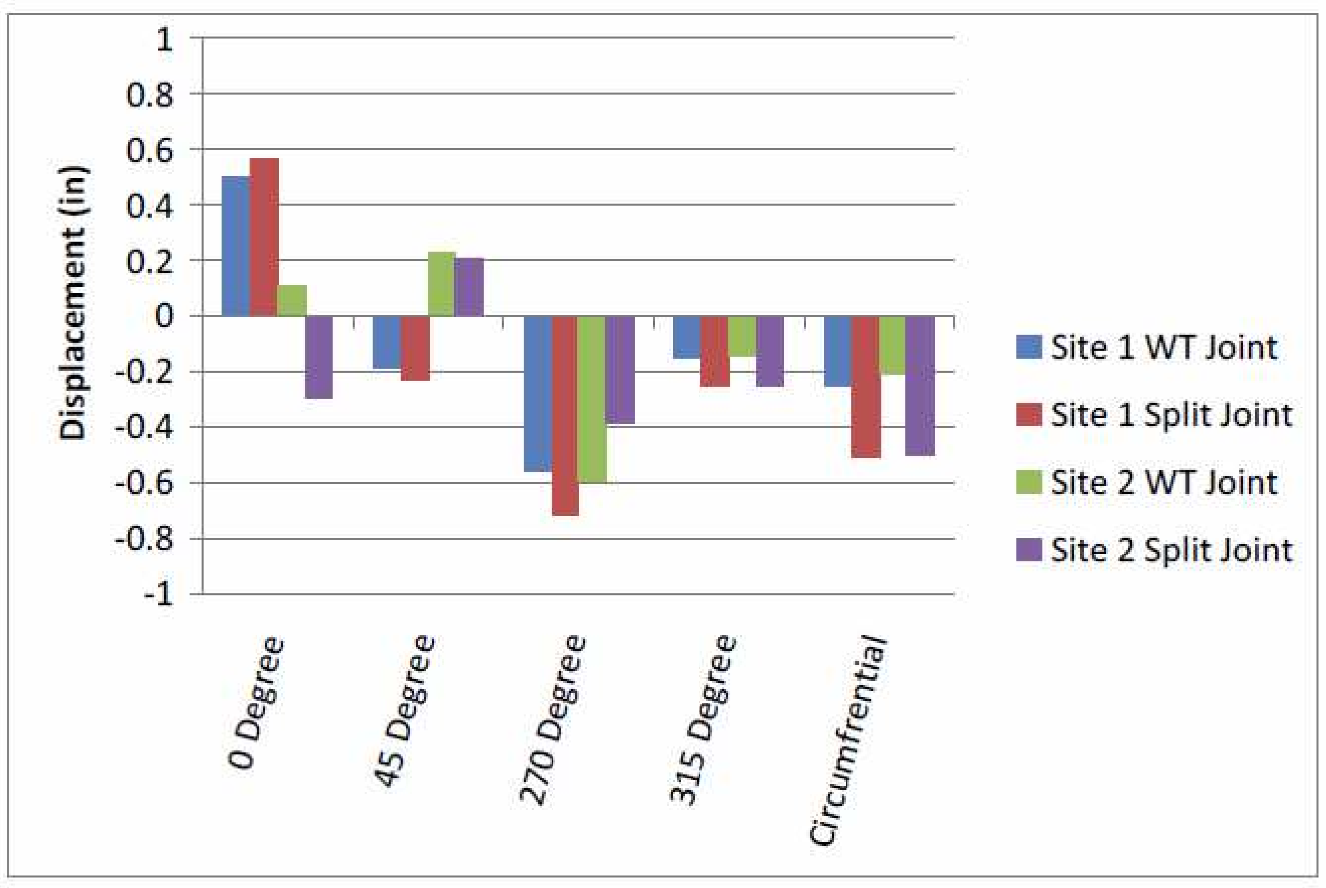

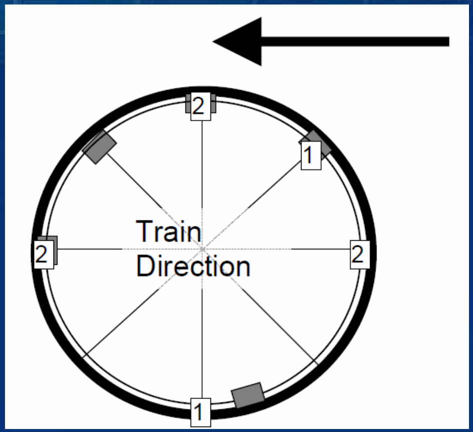

Maximum deflections from 40 mph train

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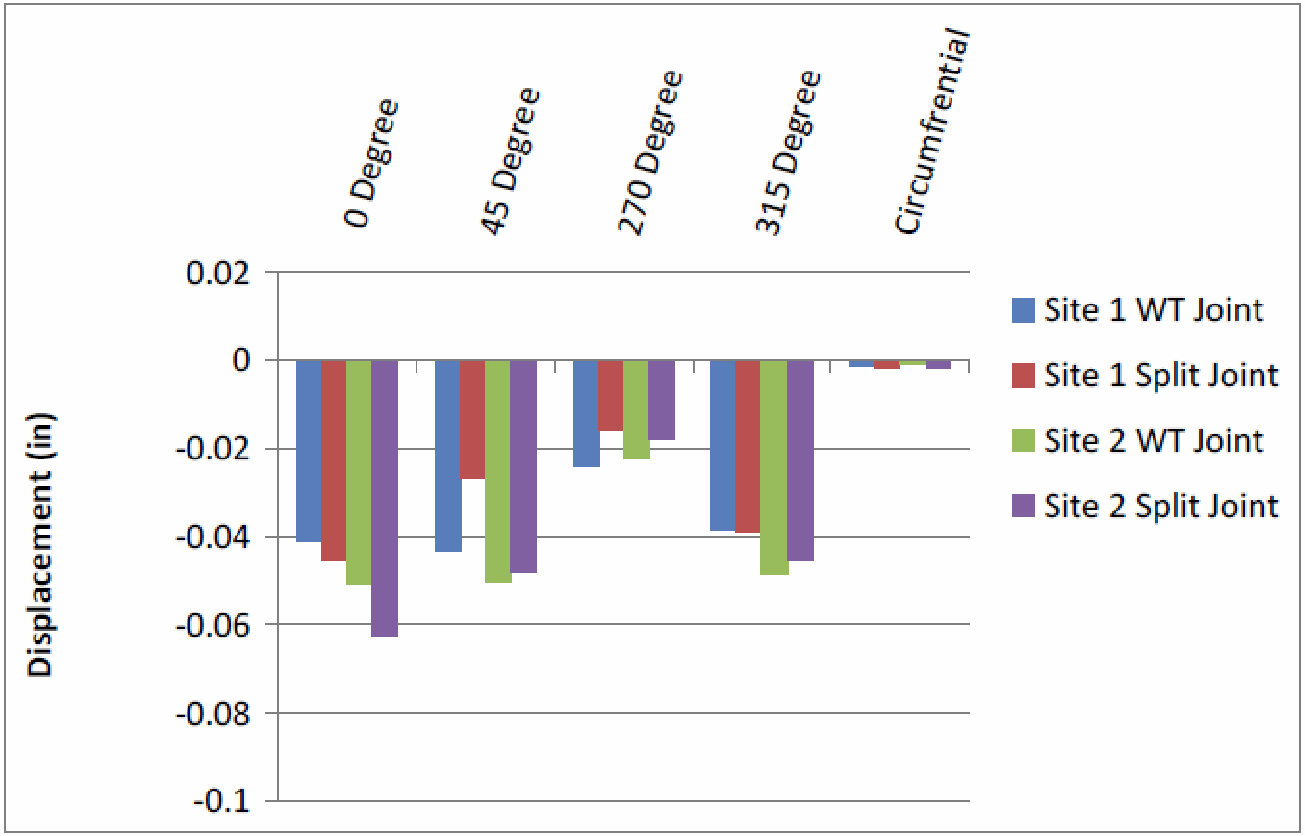

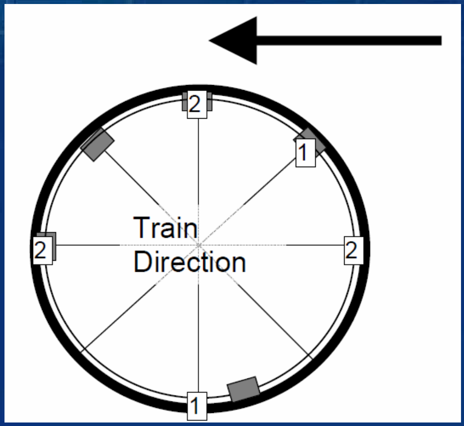

Maximum peak-peak changes in deflection due to dynamic load from 40 mph train

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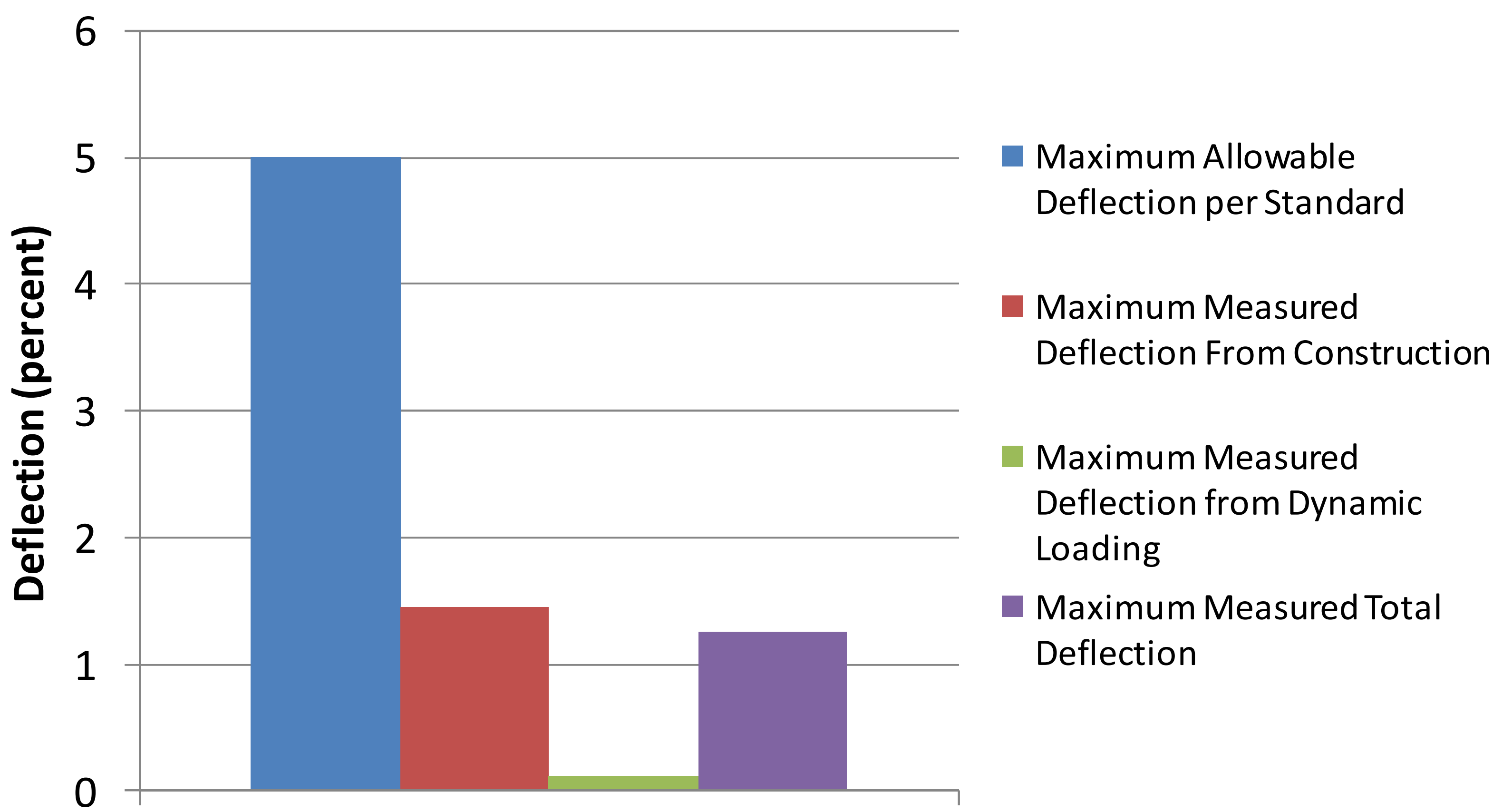
Measured vs. Allowable Deflections



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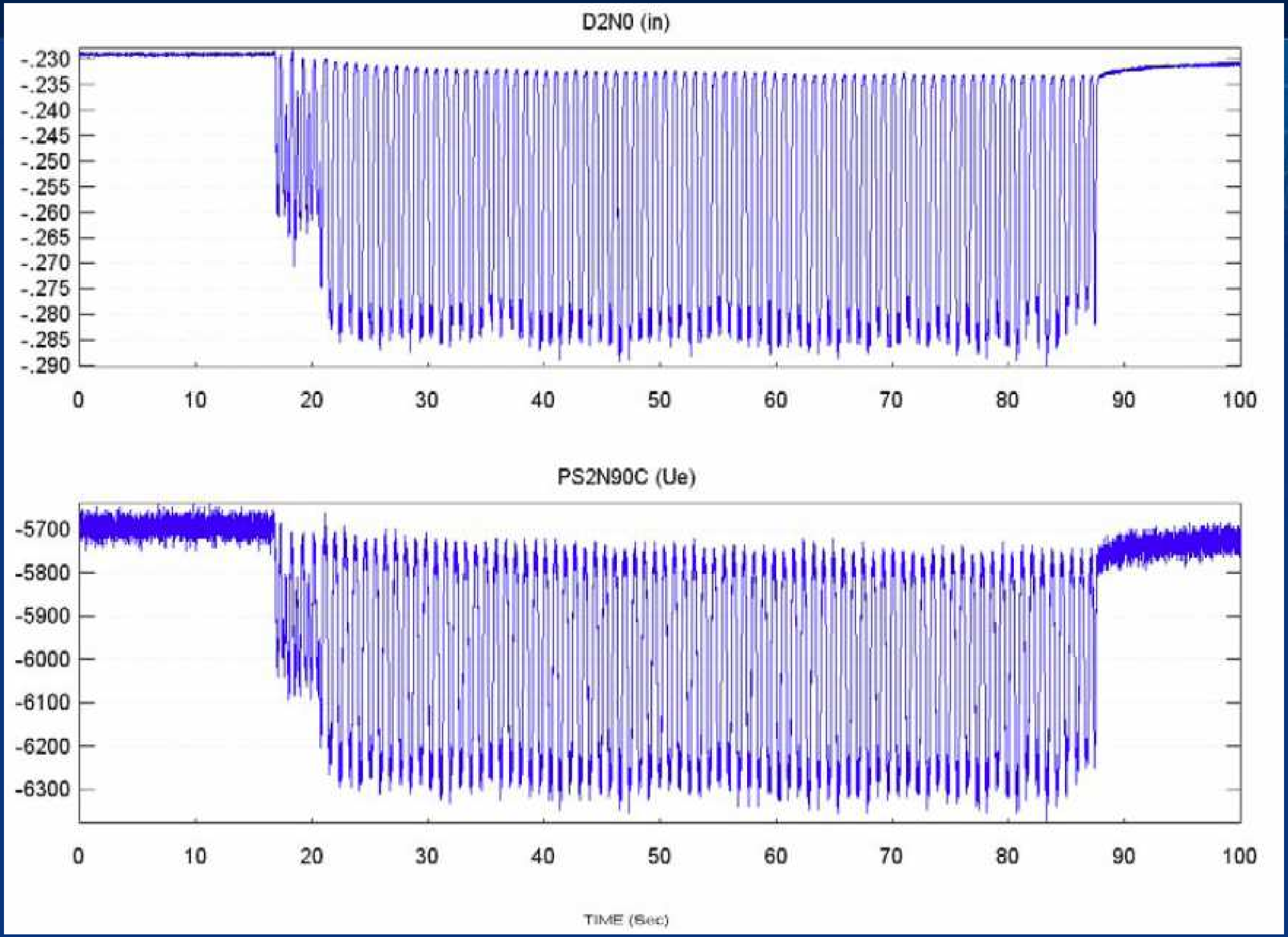

Sample dynamic strain and deflection data for train pass

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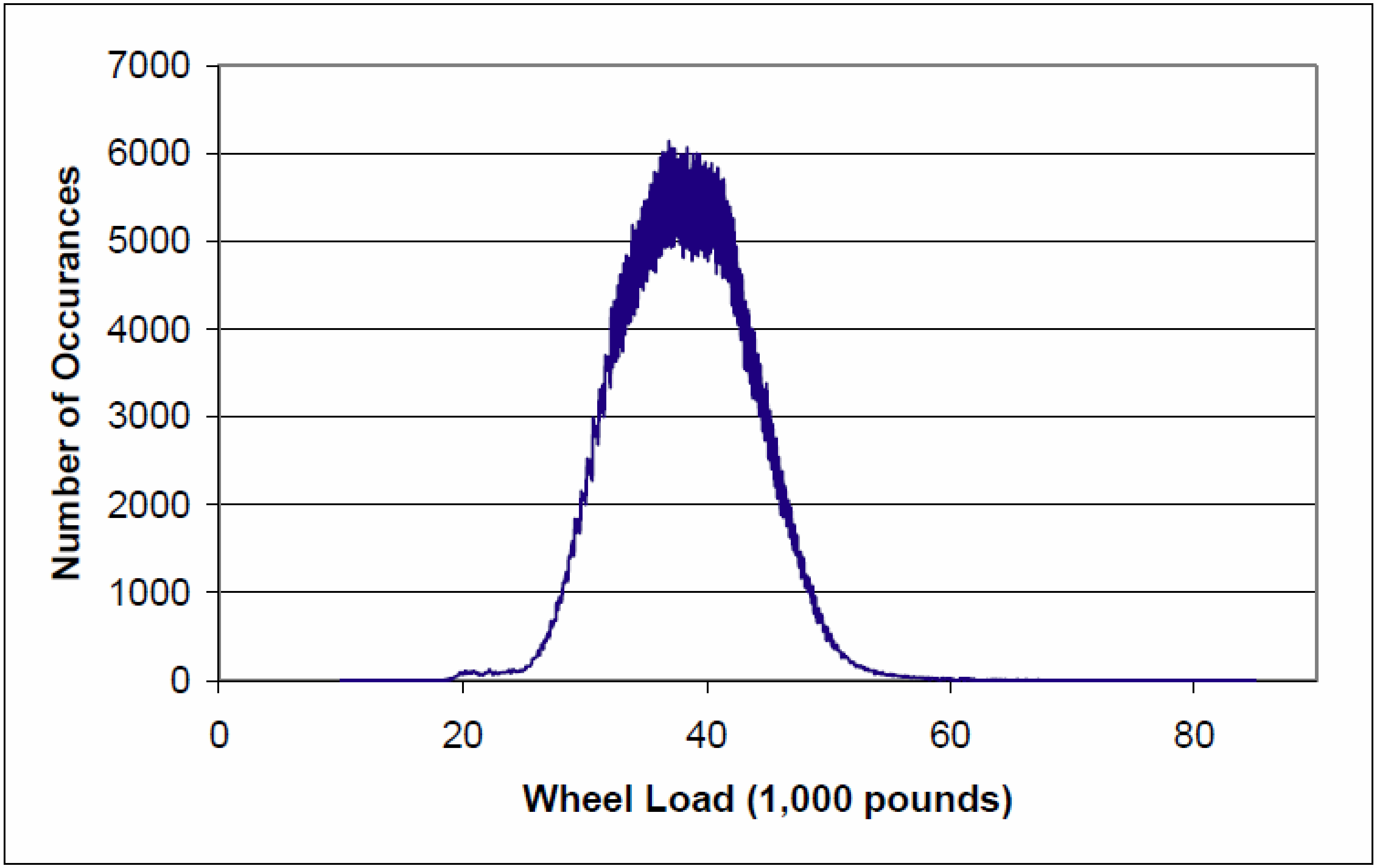


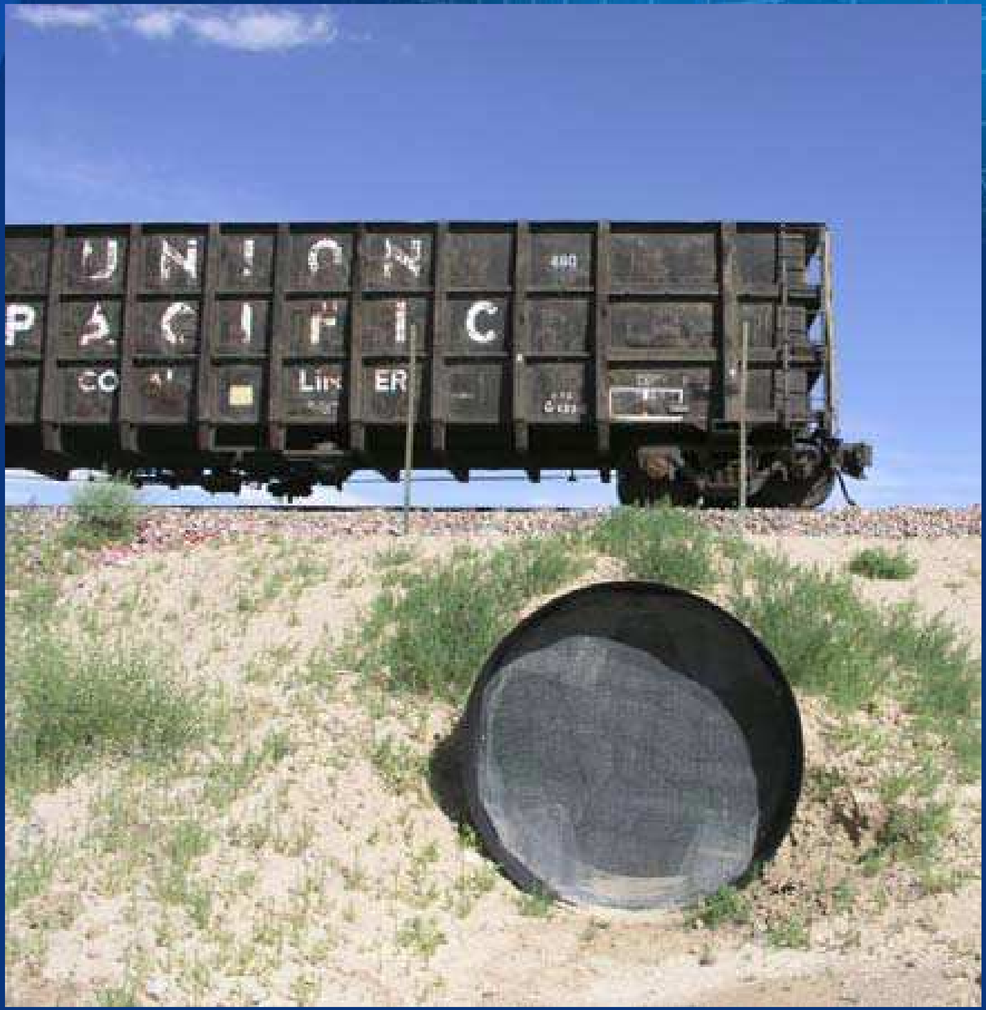
Dynamic distribution of wheel loads over track

Data was collected after 96 MGT as well:

- Strains were slightly higher than after 1 MGT test (max strain increased by 600 microstrain, or 0.06%)

- Deflections were slightly higher than after 1 MGT (max deflection increased by 0.2", or 0.4%)

- Maximum circumferential shortening increased from 0.5" to 0.8"



After 6 Weeks Static Load:

- One set of wheels parked over each pipe continuously for 6 weeks

- Negligible track deflection at the end of 6 weeks; rebounded completely when train was removed

-No track geometry maintenance needed after the test due to soil settlement or pipe deflection

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KEY SUMMARY POINTS

- Maximum strain due to construction loads was **-7300 microstrain (0.73%)** compressive

- **Tensile** strains were **negligible**

- Maximum peak-peak strain due to dynamic loads was **1173 microstrain (0.12%)** compressive

- Maximum deflection due to construction loads was **1.46%**

- Maximum deflection due to dynamic loads was **0.12%**

KEY CONCLUSIONS FROM TTCI

-Pipes performed acceptably through 96 MGT

- No track geometry maintenance was required at test site due to pipe deflection or fill settlement

- Ride quality over the pipes was satisfactory

- The maximum deflection caused by dynamic loads was 0.06” (0.12%)

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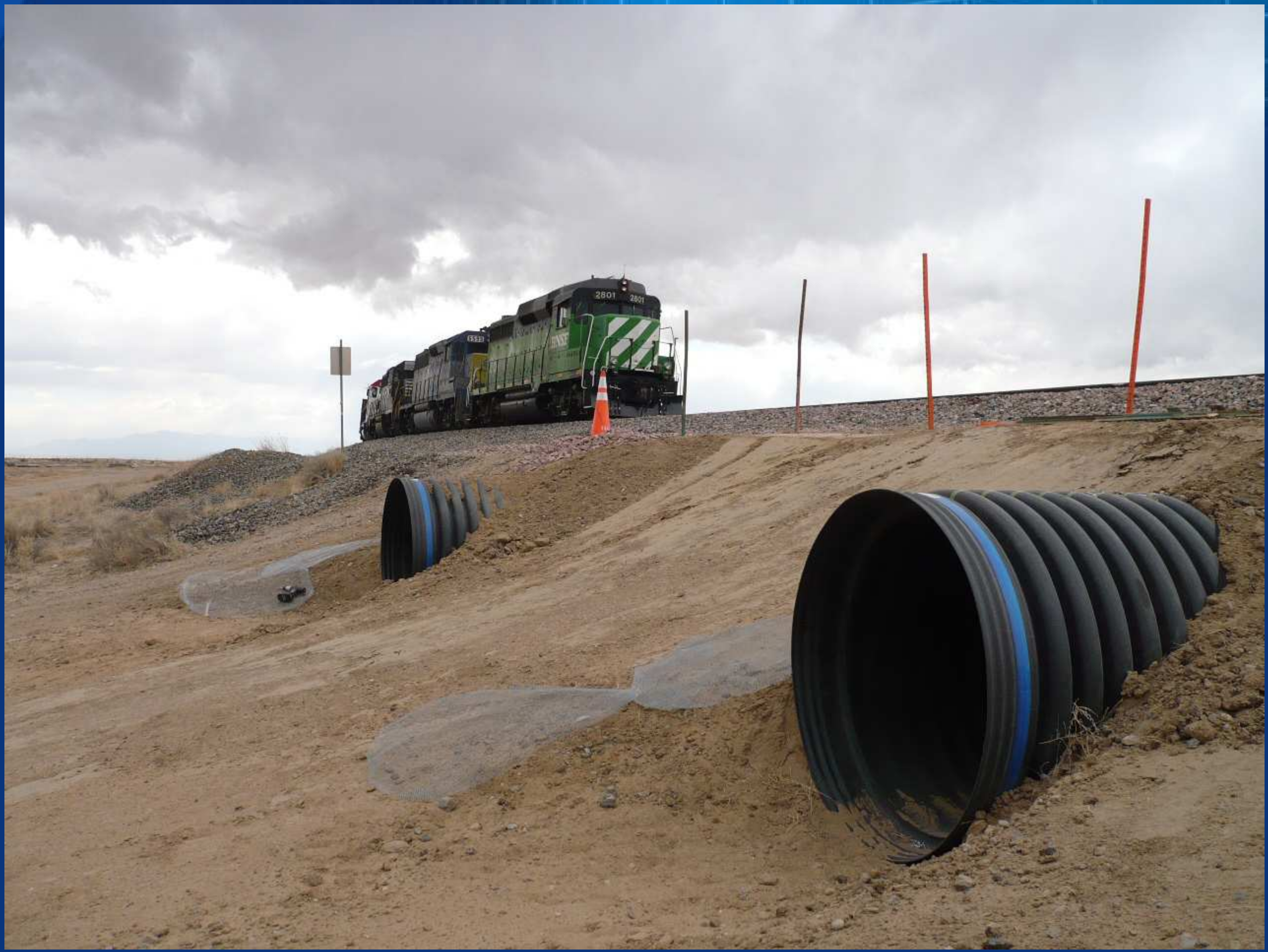
CONCLUSION



- **Large diameter corrugated HDPE pipe is recommended for railroad applications, including shallow fills, when properly installed**

- **Large Diameter corrugated HDPE pipe was included in the 2012 AREMA Specifications as a result of this study**

QUESTIONS?