Saving Time with Steel Tub Girders in St. Clair County

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CONstrict PREFABRICATED BRIDGE SYSTEM

ST CLAIR COUNTY ROAD COMMISSION SINCE 1913

St. Clair County, Michigan

226 Bridges County Wide

- 38 Load Limit Posted
- 2 Closed To Traffic

Structure Condition Summary

- Good/Fair (5 or Greater) 185
- Poor (4) 21
- Serious/Critical (3 or Less) 20

History of TEG Engineering, LLC

- Founded in 2007, Licensed Engineering Firm in 41 states.
- Prequalified for Design Services with both TxDOT and MDOT
- Headquartered in Grand Rapids, Michigan, other office in Houston
- Over 22 Employees
- Civil Structural Engineering Firm Specializing in Precast Concrete for Heavy Civil Construction.
- Member of AISC, ACI, PCI, NSBA and SSSBA

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Prefabricated Structures Specialists

- TEG selected by CBP, one of over 300 applicants

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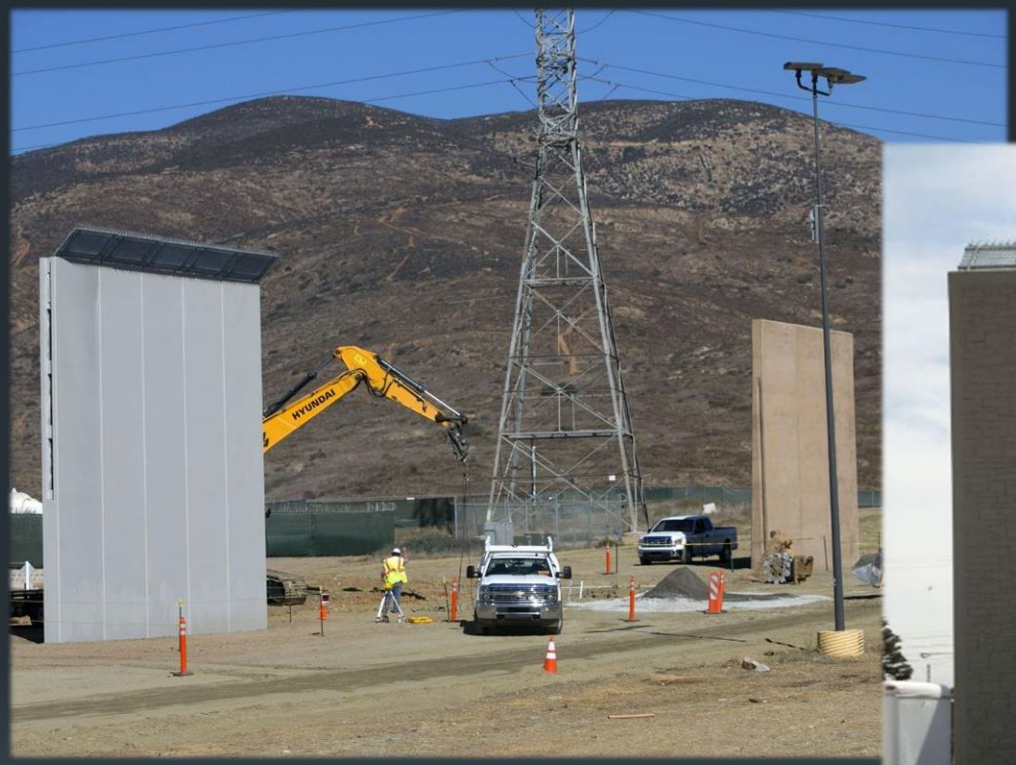

- 30’ Tall Precast Concrete Wall

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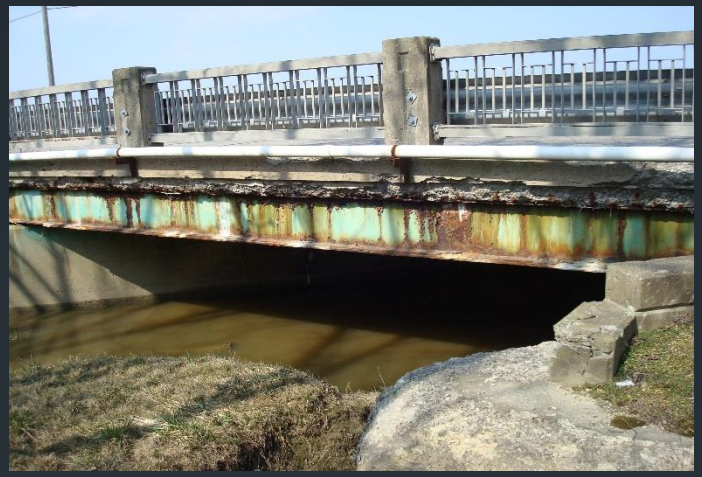
2 Posted Bridges on Marine City Hwy

- Marine City Highway over Unnamed Canal (4-08)
- Marine City Highway over Meldrum Drain (4-09)



3000 ft

2 Superstructure Replacements on a heavily trafficked local highway

Marine City Highway is a 2 lane road with more than 16,000 ADT.

Marine City Intersection at County Line Road

Goals of Superstructure Replacement

- Utilize the existing abutments
- Match the existing superstructure depth
- Maintain constructability by county maintenance crew
- Structure design per MDOT HL-93(MOD) loading
- Additional 60 year service life

Existing Marine City Hwy over Meldrum Drain (4-09)

Why Tub Girders Were Chosen

Steel Bridge

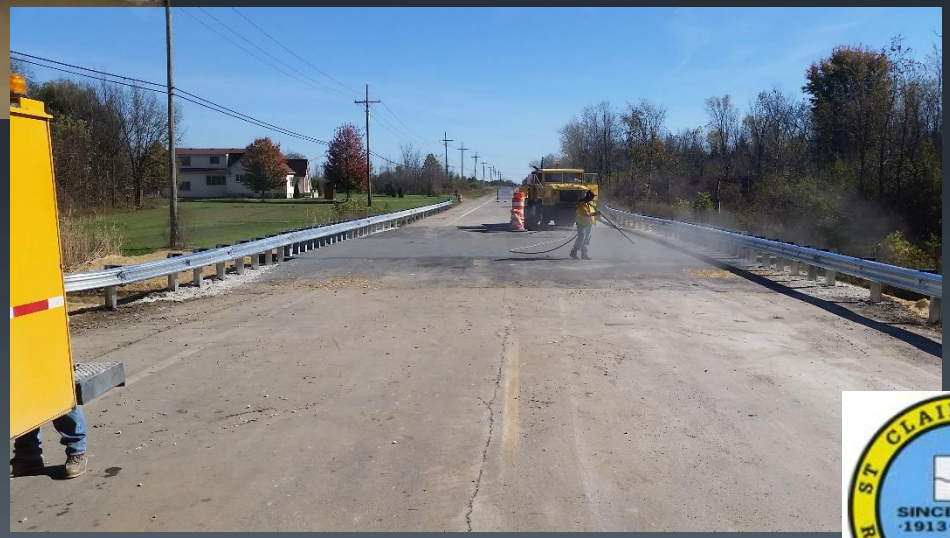
$75,000
+ HMA Overlay
+ Guardrail
+ Labor
+ Equipment

Pre-Cast Box Culvert

$63,000
+ Headwalls
+ Wing Walls
+ Crane Rental
+ Earthwork/Heavy Demo
+ HMA
+ Labor
+ Equipment

Tub Girder with Pre-Cast Deck

$57,000
+ HMA Approaches
+ Epoxy Overlay
+ Guardrail
+ Labor
+ Equipment



***Based on Engineer's Estimate, the Tub Girder system was approximately 10% cheaper in this particular application.

History of the Con-Struct System

- Con-Struct was Developed in 2003
- Con-Struct is a Press-Brake-Formed Steel Tub Girder Bridge System with a Network of Manufacturers throughout the United States.
- First Project was in Saginaw, MI 2004
- Approved for use in 5 States and Saskatchewan, Canada.
- Over 25 bridges installed with Spans ranging from 20’ to 80’
- Bridge Locations in Missouri, Michigan, Texas, Minnesota and Colfax, SK

Bridge over Brainerd Raceway
Installed in 2007.

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Con-Struct Bridge System Components

Integral Backwall

FHWA GRS-IBS
Project

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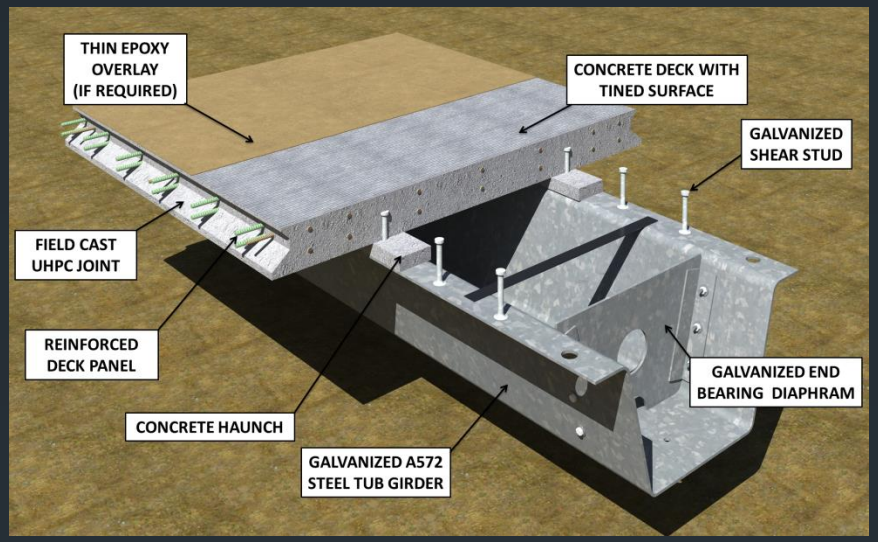
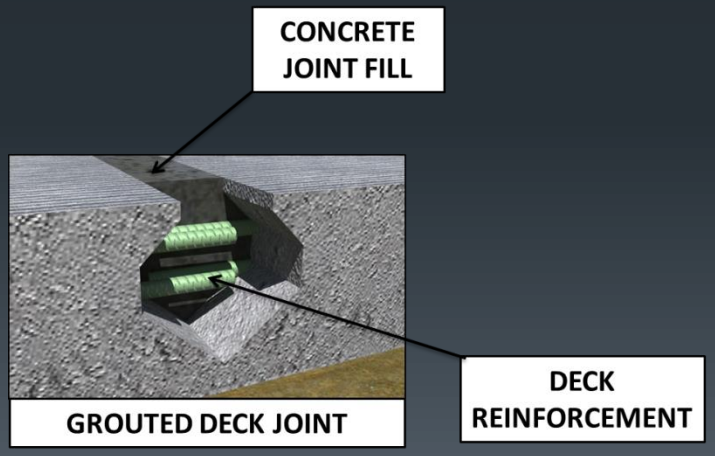
Con-Struct Prefabricated Bridge Solution

- Con-Struct Standardized and Simplified Fabrication and Details
- Industry can Produce Press Brake Formed Steel Tub Girders in 58’ Continuous Lengths
- Precast Concrete Industry Involved in Manufacturing Process
- New high-strength, non-shrink grouts provide durable solutions for deck joints
- FHWA involvement in innovative projects and funding (ABC, UHPC and GRS)





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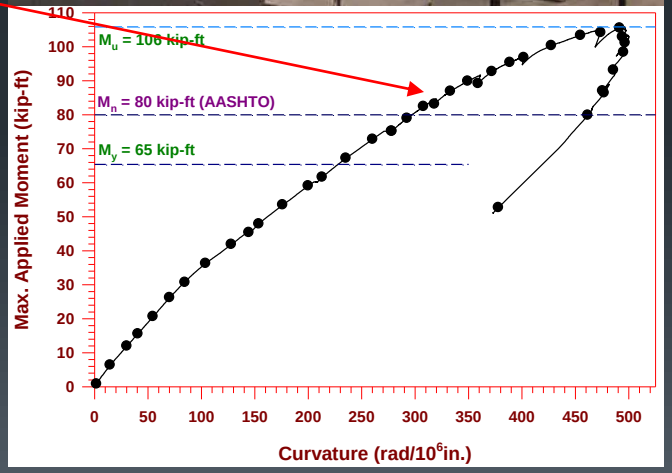
Con-Struct Prefabricated Bridge Solution

- Independently researched and tested by MDOT through Michigan State University (MDOT installed their own bridge in 2011)
- Installed and ready for traffic in a single day
- Simple and durable deck joint connection
- 75 year service life
- Delivered and installed at less cost than that of conventionally constructed concrete beam bridges

Tested Capacity Exceeds AASHTO



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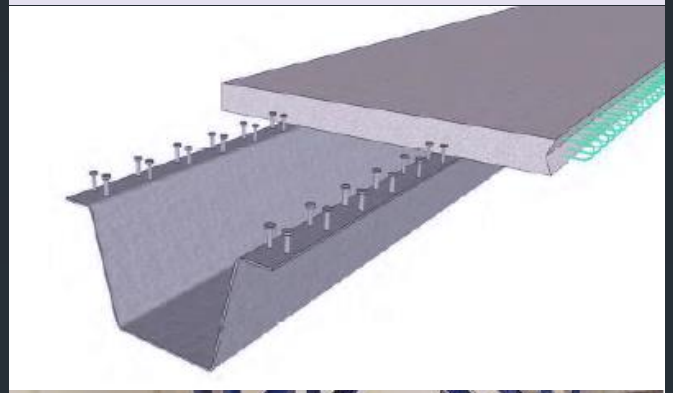
Press-Brake-Formed Steel Tub Girders

- 2016 Research Funded by SSSBA
  - IBC-16-95 *Evaluation of Modular Press-Brake-Formed Steel Tub Girders*
  - Joint effort from West Virginia University, Marshall University and University of Wyoming
- Assess Feasibility and Details
- Test Fatigue and Distribution Factors
- Determine Applicable Design Methods
  - AASHTO LRFD



Press-Brake-Formed Steel Tub Girder

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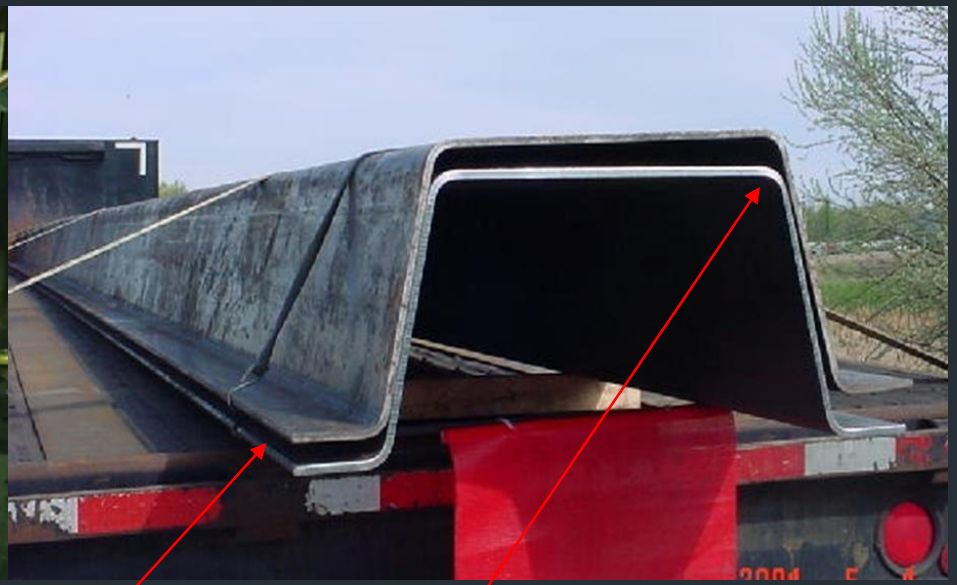
Press-Brake-Formed Steel Tub Girder



60' Long
Press Brake

ASTM A572
or A588 Steel

4t Bend
Radius

- Press-Brake-Formed Steel Tub Girders - No Flange to Web Welds, Reduced Fabrication Costs
- Per AISC Bend Radius > 4t - No Brittle Fracture, AASHTO Category B Fatigue

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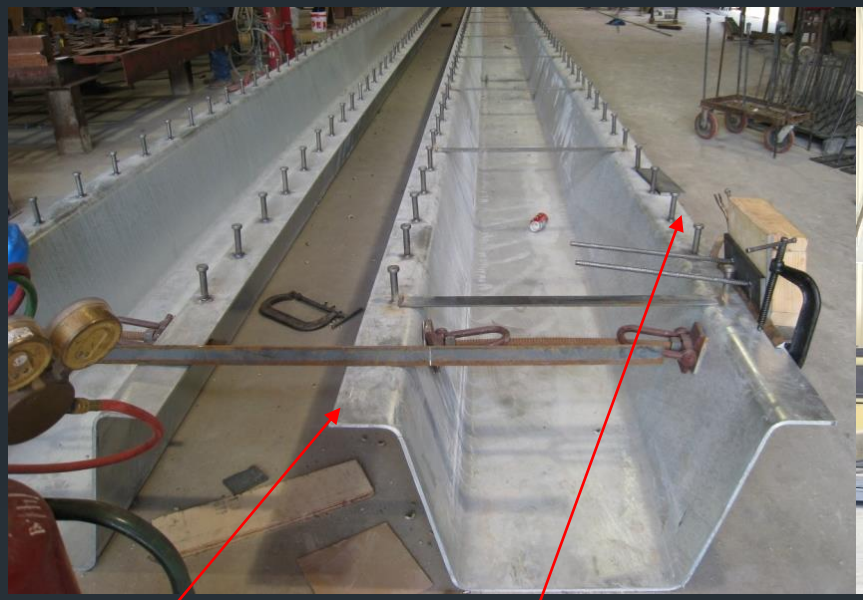
Press-Brake-Formed Steel Tub Girder - Galvanize



Hot-Dip Galvanized

Shear Studs

Double-Dip Process

- Hot-Dip Galvanized to Provide 60+ Year Protective Coating
- Stern Bayou in Ottawa County was Galvanized in 1966 with no current signs of coating deterioration

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Precast Concrete Deck Panels

- Simple Panel Installation Utilizing High Strength Grout
  - MDOT Type H-1
    - QuickCrete Precision Grout
    - Dayton Superior Conspec 100

HPC Grout Fill

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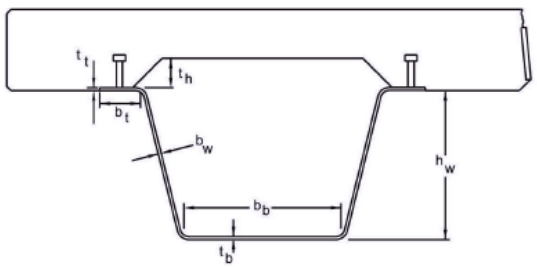
AASHTO/MDOT Design Procedures

- Standard Designs from 20’ to 80’ Spans
- Follows AASHTO LRFD and MDOT Design for HL-93(MOD) Loading
- Tested AASHTO Live Load Distribution Factors
- Easy to Follow and Check Mathcad Calculations
- Compatible with MDOT Load Rating Standard Spreadsheet

50 FT SPAN - U18X88 SECTION DESIGN

1. Con-struct Input Parameters



1.3 Slab/Girder Section Properties

1.3.1 Section Dimensions

$t_s := 8$ (In) Thickness of slab

$t_{overlay} := 0$ (In) Thickness of overlay

$t_{ws} := 0$ (In) Thickness of wearing surface

$t_t := \frac{3}{8}$ (In) Thickness of Top Flange

$b_w := t_t = 0.375$ (In) Thickness of Web

$t_b := t_t = 0.375$ (In) Thickness of Bottom Flange

$t_h := 2$ (In) Depth of Haunch

$b_s := \frac{W \cdot 12}{Beams_{Unit}} = 84$ (In) Width of slab and overlay

$b_t := 5.5$ (In) Width of Top Flange

$h_w := 17.25$ (In) Height of Web

$b_b := 18$ (In) Width of Bottom Flange

$b_h := 5.5$ (In) Width of Haunch

$\theta := 76$ Angle of Web to the Horizontal

$\theta_{rad} := \theta \cdot \frac{\pi}{180} = 1.33$ Angle of Web to the Horizontal

$\Delta := L_{span} \cdot \frac{3}{50} = 3$ (In) Camber

$r_{inner} := 4t_t = 1.5$ (In.) Inner Radius of Corner Bend

$r_{outer} := 5t_t = 1.88$ (In.) Outer Radius of Corner Bend

$r := 4 \cdot t_t + 0.5 \cdot t_t = 1.69$ (In.) Center Radius of Corner Bend

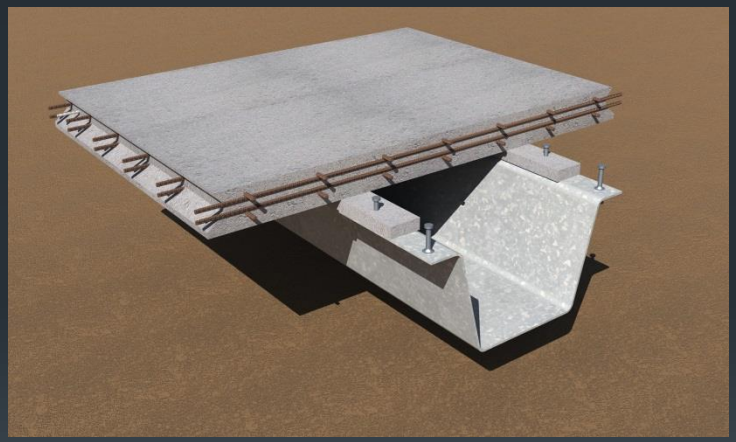
$$D := \frac{\left(h_w + t_t - 2 \cdot \sqrt{2 \cdot r^2 - 2 \cdot r^2 \cdot \cos(\theta_{rad})} \cdot \sin\left(\frac{\theta_{rad}}{2}\right)\right)}{\sin(\theta_{rad})} = 15.53$$ (In.) Depth of Web Measured Along Slope

$L_{tub} := 2 \cdot D + 2 \cdot b_t + b_b + 4 \cdot r \cdot \theta_{rad} = 69.01$ (In) Total Length of tub along section

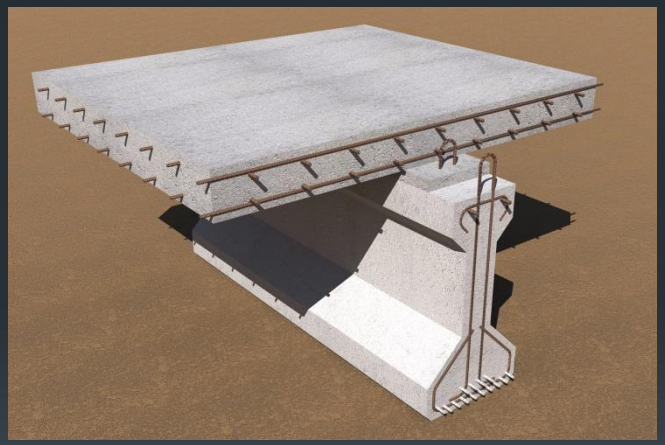
Con-Struct Prefabricated Bridge Advantages

- LEED Material Comparison
  - Prestressed Concrete Beam (PCB) vs. Con-Struct Steel Tub
  - 88% of Steel is Recycled
  - ½ the Volume = ½ the Weight

Con-Struct



Prestressed Concrete I-Beam



LEED MATERIAL COMPARISON			
Prestressed Concrete Beam (PCB) vs. Con-Struct Steel Tub Girder			
	PCB	Con-Struct	Unit
$VOLUME_{STEEL\ TOTAL}$	0.078	0.210	ft^3/ft
$VOLUME_{CONCRETE\ TOTAL}$	8.248	3.876	ft^3/ft
$VOLUME_{TOTAL}$	8.326	4.086	ft^3/ft
$VOLUME_{SAVINGS}$		**4.240**	**ft^3/ft**

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Fabrication For New Superstructures

- Fabrication of the Con-Struct superstructure began 2 months prior to bridge demolition
- Bridge units were manufactured at ADL Systems in Portland, MI
- In-plant Quality Assurance Testing Done by Consultant

Galvanized Steel Tub Girders

Fabrication of Bridge Unit

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Demolition of Existing Bridges

- On Monday Oct 9th, (Nov 6th) Marine City Highway was closed to traffic
- Monday and Tuesday county crew removed existing bridge superstructure

Existing Steel Beams

Existing Substructure to Remain

Repair of Existing Abutments

- Existing abutments were repaired with Transpo T-17 Polymer Concrete patch material
- MDOT heavy riprap was used as scour protection of existing spread footing abutment

Existing Abutments

Riprap for Scour Protection

Install New Superstructure

- On Thursday Oct 12th (Nov 9th) Con-Struct bridge units were delivered
- Bearing pads and expansion joint material were placed on abutment
- Con-Struct superstructure units arrived before 8:00a.m.

Bearing and Joint Filler

Con-Struct Bridge Units

Install New Superstructure

- County excavator was used to install 25’ span units for bridge 4-08 (crane was used for 35’ 4-09)
- All 6 Con-Struct superstructure units were all placed before noon
- Units were cast with integral backwalls

Excavator to Install 4-08

Crane to Install 4-09

Install New Superstructure

- Transpo T-17 Polymer Concrete was used for the deck joint between units
- T-17 was tested for rebar development length and the joint designed specifically for T-17 material

Forming Deck Joint

Pouring T-17 Polymer Joint Concrete

Finishing Touches

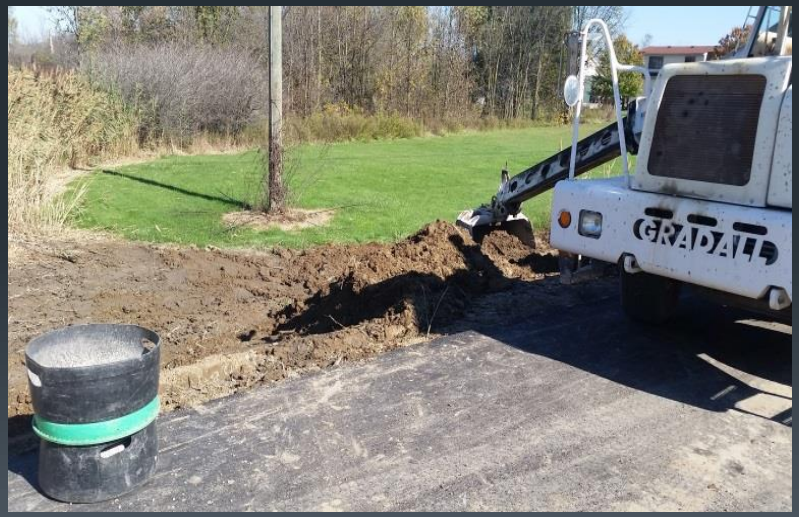
- Over the following 5 days asphalt approaches were paved,
- Guardrail posts were installed.....

Pave 20' Approach

Install Guardrail Posts

Finishing Touches

- Slopes were re-graded,
- Existing wing walls were repaired……



Re-grade Slopes at Approach

Repair Existing Wingwalls

Finishing Touches

- A thin epoxy overlay was placed on the new concrete deck surface for 4-08 bridge
- The thin epoxy overlay was not done for 4-09 bridge due to weather limitations

Place Epoxy Compound

Cover with Aggregate and Re-Epoxy

Finishing Touches

- Guardrail was installed
- Slopes were restored

Install Guardrail

Slope Restoration

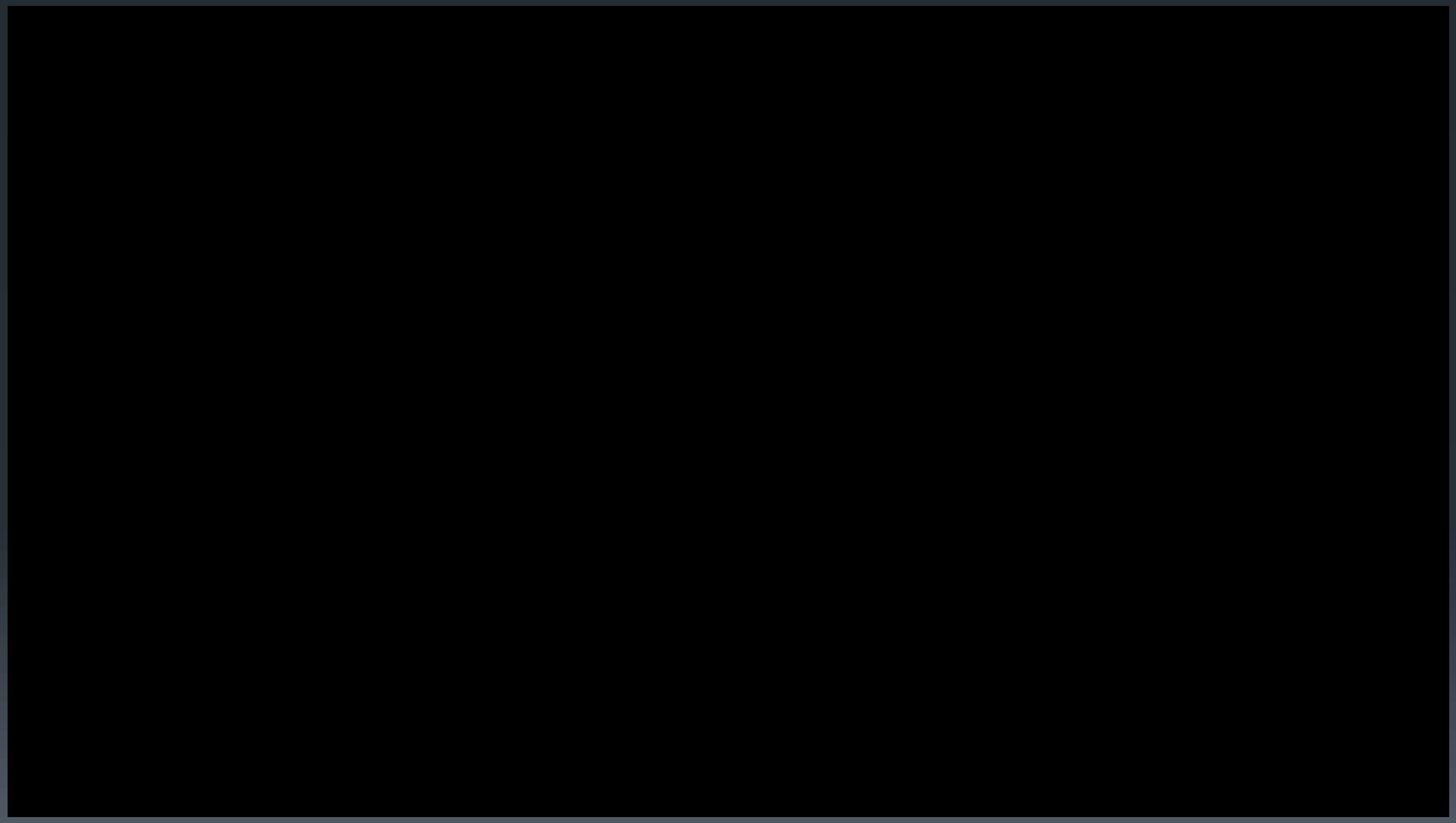
Marine City Hwy over Unnamed Canal (4-08)

- Total Completed Cost = $180,751.46
  - Includes material, labor, overhead, equipment
- Total Completion Time = 10 Working Days

Marine City Hwy over Meldrum Drain (4-09)

- Total Completed Cost = $222,843.83
  - Includes material, labor, overhead, equipment
- Total Completion Time = 10 Working Days

Installation Video



Saving Time with Steel Tub Girders in St. Clair County

In Conclusion:

- 80% Less Expensive Than Reconstruction
- 90% Less Traffic Delays

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Thank you for your time !

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