RESEARCH SYNTHESIS
LOAD RATING REINFORCED CONCRETE BOX CULVERTS

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RESEARCH SYNTHESIS
LOAD RATING REINFORCED CONCRETE BOXED CULVERTS
FIRST PROJECT: TXDOT 0-5849
EVALUATING EXISTING CULVERTS FOR LOAD CAPACITY
ALLOWING FOR SOIL STRUCTURE INTERACTION
2007-2009
The Research Problem

• When rights-of-way crossing existing culverts have to be raised and/or widened, the culverts have to be reanalyzed.

• Current analysis methods (direct stiffness) and AASHTO loading protocols often result in such culverts being judged deficient.

• The direct-stiffness method is too conservative in that it does not account for (beneficial) soil-structure interaction effects.
Modification

- **New Problem**: TxDOT’s “current” rating procedure was not clear, repeatable
- **Solution**: articulate a clear, repeatable procedure in the *Culvert Rating Guide*
- **Quality Assurance**: conduct a series of quality checks to demonstrate that the *Culvert Rating Guide* is clear, repeatable, and valid for TxDOT culverts
Culvert load rating is about going from here...
RF = \frac{C - A_1D}{A_2L (1 + I)}
Load Rating Flow Chart

Culvert Rating Guide

Load Rating Culverts
so you can check here.
Field Instrumentation and Load Testing

• Live Load and Operating Rating Case Studies
  – Case 1: Shallowater
    • 2’ Fill
    • 4’ Fill
  – Case 2: Plainview
  – Case 3: Tulia

• Dead Load Concerns

• Conclusions

• Recommendations
Culvert Selection:
Shallowater, Plainview, Tulia
Case 1: Shallowater Instrumentation Plan
Lay Out the Gage Line
First Pass: One Truck Straddles Gage Line
Third Pass: Two Trucks Straddle Gage Line
Case 1: Shallowater: 2’ Fill
Live Load Moment Predicted and Measured
Validation of the TxDOT Culvert Rating Guide

Load Rating Culverts

STGEC: 4 DEC 2013
Subject: Section 7.4.1, AASHTO Manual for Condition Evaluation of Bridges (2003)

From:

Date:

In Reply Refer To:

“A concrete [culvert] need not be posted for restricted loading when it has been carrying normal traffic for an appreciable amount of time and shows no distress.”
SECOND PROJECT: TXDOT 5-5849-01
SOFTWARE DEVELOPMENT TO IMPLEMENT THE TXDOT CULVERT RATING GUIDE
2012-2013
CULVLR 1.0.2
CULVLR Input
CULVLR Critical Section Details

Load Rating Culverts

STGEC: 4 DEC 2013
CULVLR Capacity Calculations

Load Rating Culverts

STGEC: 4 DEC 2013
CULVLR Demand Modeling
CULVLR Load Rating Calculations

Load Rating Culverts

STGEC: 4 DEC 2013
### General Information
- **Design Sheet:** MC10-3
- **Design Year:** 1958
- **Steel Grade:** Gr. 40 (Fy = 40ksi)
- **Concrete Class:** Class A (f'c = 3000psi)
- **Number of Spans:** 3
- **Clear Span:** 10.0ft
- **Clear Height:** 7.0ft
- **Roadway Width:** 7.0ft
- **Design Soil Depth Range:** 4.0-6.0ft

### Soil Properties
- **Soil Unit Weight:** AASHTO Policy
- **Demand Model:** Culvert Rating Guide (2009) Level 1: CULV5 2.2.2

### Controlling Load Rating
- **Cover Soil Depth:** 6.0ft
- **Inventory Rating:** HS13
- **Mode:** moment
- **Operating Rating:** HS23
- **Load Case:** reduced lateral maximum
  - **Capacity:** 11,422k-ft
  - **Dead Load:** 6,260k-ft
  - **Live Load:** 2,243k-ft

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**Critical Section Sketch**

Refer to report 5-5849-03 narrative for key to interpreting critical section colors.

- Load rating calculations.
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THIRD PROJECT: TXDOT 5-5849-03
LOAD RATING TXDOT CULVERT DESIGN STANDARDS
2012-2013
Completed Load Rating Work

- **Digitization** of TxDOT’s Design Standards for CULVLR (1855 Designs)
- **Level 1/AASHTO Policy** Load Ratings of Designs (~60,000 Load Ratings)
  - CULV5 (60/30pcf Equivalent Fluid Weights)
  - Range of Depths of Fill
- **Level 3/AASHTO Policy** Load Ratings of Designs (~2,500 Load Ratings)
  - RISA-3D (High, Medium and Low soil stiffnesses)
  - Critical Depth of Fill from Level 1/AASHTO Load Ratings
- **Level 1/TxDOT Practice** Load Ratings of Designs (~60,000 Load Ratings)
  - CULV5 (40/20pcf equivalent fluid weights; ignore bottom slab)
  - Range of Depths of Fill
5-5849-03 Load Rating
Standard Designs
5-5849-03 Volume 1
All Analyses – Level 1/AASHTO

- OR < 3
- IR<3, OR>3
- IR>3, OR<10
- IR<20, 10<OR<20
- IR>20, OR>20

- 587, 32%
- 694, 37%
- 215, 12%
- 145, 8%
- 18, 1%
- 196, 10%
5-5849-03 Volume 2
All Analyses – Level 3/AASHTO

Percentage of Total Load Ratings

Level 1 AASHTO
Level 3 High
Level 3 Medium
Level 3 Low

Case D - NG
Case C - NG
OR < 3
IR<3, OR>3
IR>3, OR<10
IR<20, 10<OR<20
IR>20, OR>20
Case B - OK
Case A - OK

Load Rating Culverts
STGEC: 4 DEC 2013

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Culvert Load Rating Lessons Learned

1. Culvert load rating is highly complex.
2. Production load rating tools achieve efficiency in effort at the expense of analytical simplification, the result being excess conservatism (non-uniform).
3. Increased analytical sophistication reduces excess conservatism.
4. TxDOT’s culvert designs are generally good relative to the policy for which they were designed; that is, TxDOT culvert design standards have not been heavily over-designed.
5. Load rating applies to a physical culvert structure where all key parameters are identified.
Much remains to be done...
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THANK YOU!!!