2013 ABCD

PennDOT's Bridge Initiatives

Presentation to the

Susquehanna Chapter of ABCD

By Tom Macioce, P.E.

September 5, 2013

Overview

- PennDOT Next Generation Initiatives
- SCC for Drilled Shafts
- Mass Concrete
- BRADD
- Deck Cracking Research Program
- Fracture Critical Members
- Risk Based Postings

PennDOT Next Generation

- Change how we do business
- Within PennDOT and across agencies
- Teams evaluating 6 key components:
  - Resource Sharing
  - Policy
  - Procedures
  - Technology
  - Equipment
  - Other

PennDOT Next Generation

- 38 Active Teams
- Project Delivery and Bridge Related:
  - Bridge Inspection – 1 of 3 pilots
  - Geotechnical PNG
  - Survey
  - CADD
  - Highway and Bridge Design
  - Highway Design and Technology
  - Bridge Design and Technology

50 ksi Piles

- CAPWAP Data from Districts 2-0, 3-0, 8-0, 10-0 and 11-0 evaluated; a total of 41 data sets
- Pile lengths ranging from 30’-100’
- H-Pile types: 10x57, 12x74, 12x84 and 14x117
- Hammers: Pileco D19-42 (E=42,506 ft-lbs), ICE I-19 (E=43,242ft-lbs), Berminghammer B-21 (E=53,245 ft-lbs), ICE I-30 (E=71,543 ft-lbs) and ICE I-46 (E=107,740 ft-lbs)

50 ksi Piles

- CAPWAP data supports the increased capacity from 36 ksi to 50 ksi by showing that at a maximum driving stress of 40 ksi the 50 ksi capacities are achieved
- Maximum allowable driving stress will increase to 45 ksi for H-piles
- BC-757 revised to match PTC splice criteria

District	11-0	8-0	2-0	3-0	8-0	10-0
State Route Section	2040 A18	4014 005	0080 B36	0973 026	2078 002	0356 06M
S #	30424	28375	30736	32256	27764	29745
H-Pile Type	12x74	10x57	12x74	14x117	12x74	14x117
H-Pile Area (in^2)	21.8	16.8	21.8	34.4	21.8	34.4
Hammer and Energy (ft-lbs)	Pileco D19-42 42,500	Pileco D19-42 42,500	ICE I-19 43,200	ICE I-30 71,450	Pileco D19-42 42,500	Pileco D19-42 42,500
Pile Length (ft)	30.3	40.0	40.3	65.30	70	100.6
Bearing Stratum	Shale	Limestone	Shale	Siltstone/ Sandstone	Silty Sand with Gravel/Schist	Sandstone
Required Resistance based on 36 ksi (kips)	331	304	430	557	436	615
Required Resistance based on 50 ksi (kips)	554	426	554	873	554	873
CAPWAP Capacity (kips)	436	629	447	1024	509	696
Maximum Compressive Driving Stress (ksi)	25.3	39.0	24.4	29.8	24.0	24.9
Ultimate Capacity Stress (ksi)	20.0	37.4	20.5	25.5	23.3	20.2

	PUB 15A 1989 Data Sets					
Test Number	0012	0013	0014	0018	0022	0023
H-Pile Type	10x57	12x74	10x42	12x74	12x74	10x57
H-Pile Area (in^2)	16.8	21.8	12.4	21.8	21.8	16.7
Hammer Energy (ft-lbs)	26,300	26,300	26,300	40,000	26,300	26,300
Pile Length (ft)	60	60	60	70	30	30
Bearing Stratum	Shale with Sandy Laminae	Shale with Sandy Laminae	Shale with Sandy Laminae	Soft Shale	Soft Shale	Soft Shale
Driving Criterion	20 bpi	20 bpi	20 bpi	20 bpi	Not driven to refusal	Not driven to refusal
Safety Factor	2.0	2.0	2.0	2.0	-	2.2
Failure Criteria (in)	0.60	0.78	0.72	0.88	0.43	0.42
Ultimate Capacity (kips)	290	512	288	524	312	336
Design Capacity (kips)	200	256	144	262	196	150
Ultimate Capacity Stress (ksi)	17.26	23.49	23.33	24.03	14.31	20.0

50 ksi Piles

- AASHTO Axial Pile Capacity
- A6.9.2, A6.9.4, and A6.5.4.2

  $P_r = \varphi_c P_n$, where $P_n = 0.66 A_s F_y$

  $\Phi_c = 0.50$ w/tip (0.60 w/o tip)

  $P_r = 0.33 A_s F_y$ ($F_y = 50$ ksi for H-piles)

- Keep redundancy for soluble rock, D6.15.2

  "For piles bearing on soluble bedrock (limestone, etc.), the ϕ factor of 0.273 shall be applied to the axial capacity of the pile to provide pile group redundancy and limit the design stress to 9 ksi."

  (0.66)(0.273)(50)=9 ksi (same as current design criteria)

50 ksi Piles

- Geotechnical Capacity

Revision for Piles in Soft Rock

- *10.7.3.2.2 Piles Driven to Soft Rock*

  The following shall supplement A10.7.3.2.2.

  If bearing in weak rock, the unit bearing resistance shall be estimated by treating the soft rock as soil in accordance with D10.7.3.8.

- *10.7.3.8 Determination of Nominal Bearing Resistance for Piles*

  In general, the Department prefers the use of the semi-empirical methods (α-method, β-Method, λ-Method, Nordlund/Thurman Method) in A10.7.3.8.6 to estimate the axial resistance of piles in soil.

PNG Initiatives

- Elastomeric Bearing Pad Testing Requirements
  - Issued SOL 483-13-08 June 14, 2013
- Revising BD613M Pot Bearing standards to BC
  - Reduction in 3-6 drawings per bridge plan
- Revise BD609M Structure Mounted Guiderail
  - Reduction in 1-2 drawings per bridge plan
- Elimination of Shear and Moment Diagrams for conventions bridges using PennDOT software
  - Reduction in 3-6 drawings per bridge plan

PNG Initiatives

- DM4 appendix for Sample Streamlined TSL report
- DM4 appendix for Sample Streamlined Foundation report

SCC Drilled Shafts

- Standard Special Provision to Pub 408 Section 1006 – Drilled Caissons and Sockets
  - SCC typically consists of a mixture of Portland cement, pozzolan, fine aggregate, coarse aggregate, water, air-entraining admixture with high range water reducing admixture and other ASTM C-494, Type S admixtures.
  - Mix Design Criteria
    - Appropriate ASTM, ACI, PCI Standards
    - Class A only
    - Cementitious Material
    - Additives
    - Ground Granulated Blast Furnace Slag
    - Class C Fly Ash

SCC Drilled Shafts

- Initial CT (Cont.)
  - Testing Procedures
    - Plant
      - J-Ring
      - VSI
      - Slump Flow
      - Hardened Entrained Air
    - Field
      - J-Ring
      - VSI
      - Slump Flow
      - Cross-Hole Sonic Logging (CSL)
  - Post-Construction
    - Payment and Schedule adjustments for false positives associated with CSL testing and evaluation

Mass Concrete

- Produce a structure free of shrinkage cracks that would be a result of heat of hydration during the curing of large concrete cross-sections
- Structural Definition of Mass Concrete
  - Minimum Dimension of ≥6’
  - Drilled Shaft Diameters ≥ 6’
  - (Mix design but no Thermal Cont. Plan)
  - Heat Signature Analysis
  - Use best practices
- Thermal Control Plan Required if
  - Minimum Dimension of > 9’

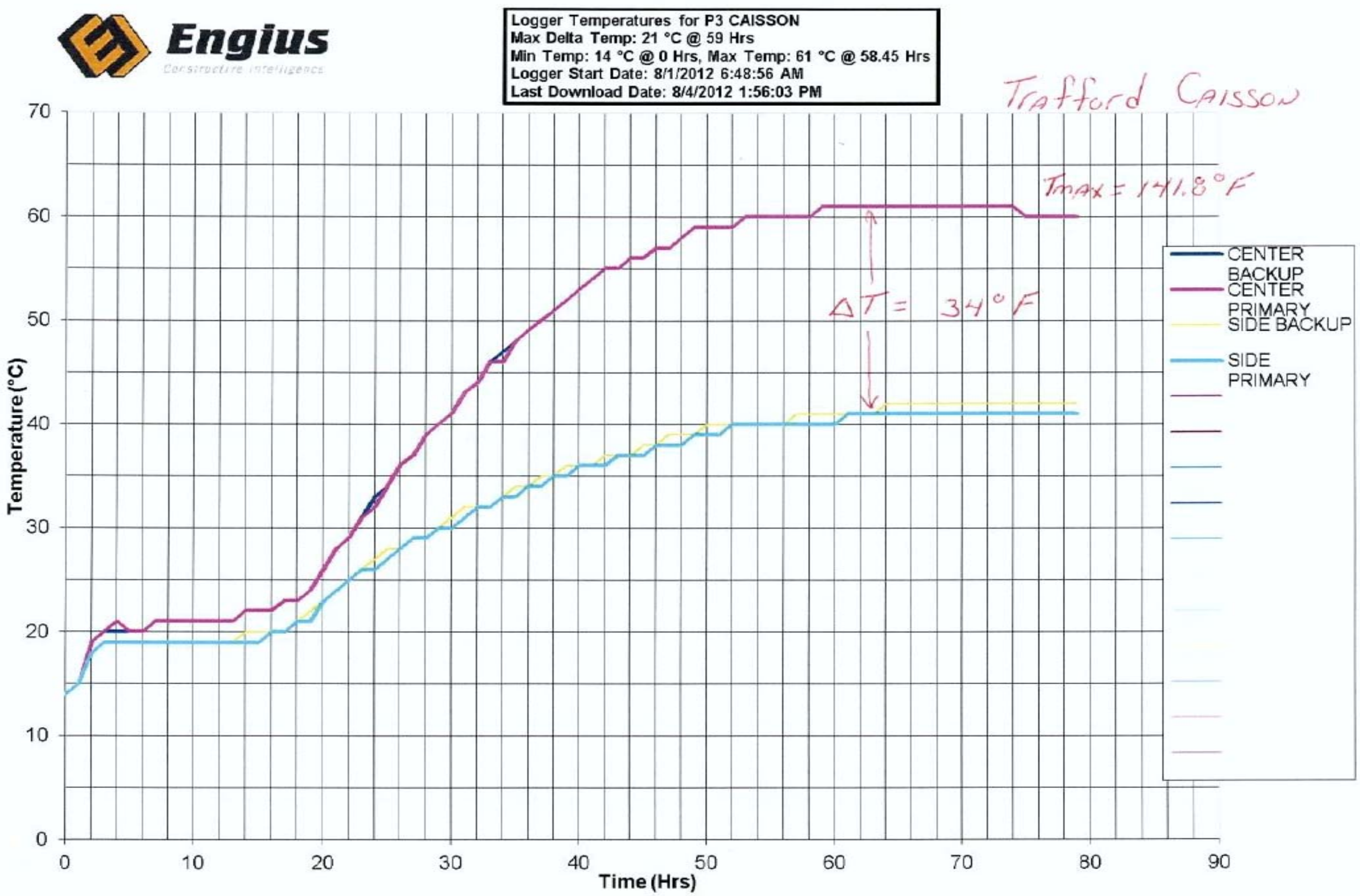
Mass Concrete

- Mix Design Criteria, Pub-408, Sect-704
  - Minimum Cementious Content 564 pcy
  - Max temp (initial + rise) <160 F
  - Lower Cement Content
    - Fly Ash 15% to 25%
    - GGBFS 25% to 45%
    - Total Substitution of Portland cement ≤60%
  - Larger Aggregate Size, #3, #476
  - Aggregate must be non-reactive
  - Reduce Initial Concrete Temperature

Mass Concrete

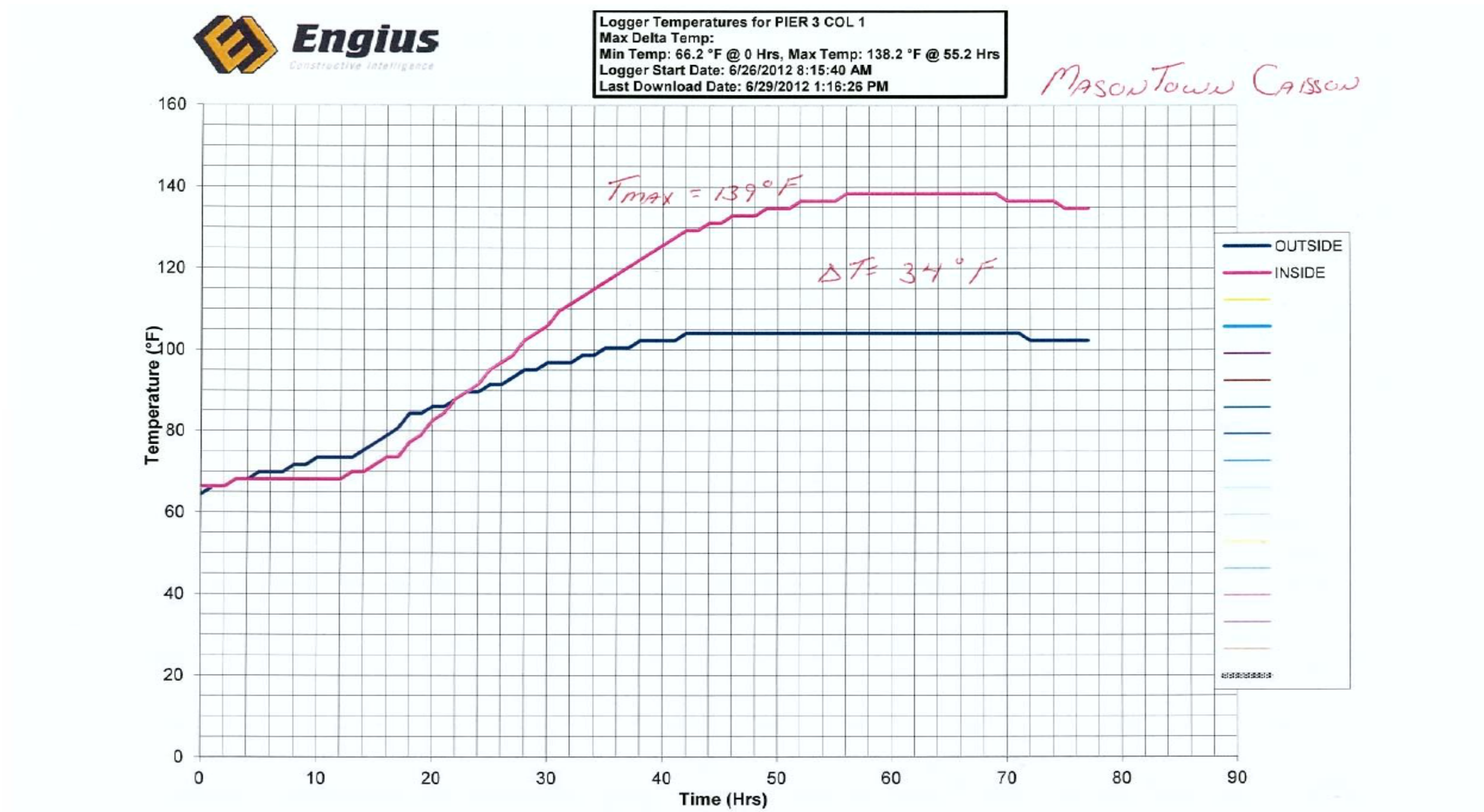
- Thermal Control Plan (Dim >9’)
  - Based on approved mix design
  - Temperature Control Plan
    - Methods to control max temperature <160 F
      - Determine heat signature of mix by cert. lab
      - Mixing (cool with ice and/or nitrogen)
      - Placement (consider effect of ambient temp)
    - Temperature Recording Devices
    - Temperature Monitoring Plan During Cure
      - Measures to control temperature differential
      - Keep differential gradient <36 F
      - Design cooling system if required

Mass Concrete



8'-0" Diameter Caisson Socket

Mass Concrete



9’-0” Diameter Caisson

BRADD

- BRADD Version 3.2.0.0
  - Anticipated release November 2013
  - ***New Functionality – Integral Abutment Substructure detailing and drafting (pile cap, piles, and attached wings)***

BRADD (continued)

- BRADD Version 3.2.0.0
  - LRFD Programs to be included:
    - PSLRFD Version 2.6.0.1
    - STLRFD Version 2.1.0.0
    - BPLRFD Version 1.6.0.0
    - ABLRFD Version 1.12.0.0

BRADD (continued)

- BRADD Version 3.2.0.0
  - DM-4 – May 2012 Edition
  - Change No. 1 to BD-600M Series (Pub. 218M – September 2010 Edition)
  - Change No. 1 to BD-700M Series (Pub. 219M – October 2010 Edition)

BRADD (continued)

- BRADD Version 3.2.0.0
  - Approximately 175 problem reports addressed, including:
    - completely new pile layout method for traditional abutments with pile footings
    - User Defined Barrier for Superstructure Only Jobs

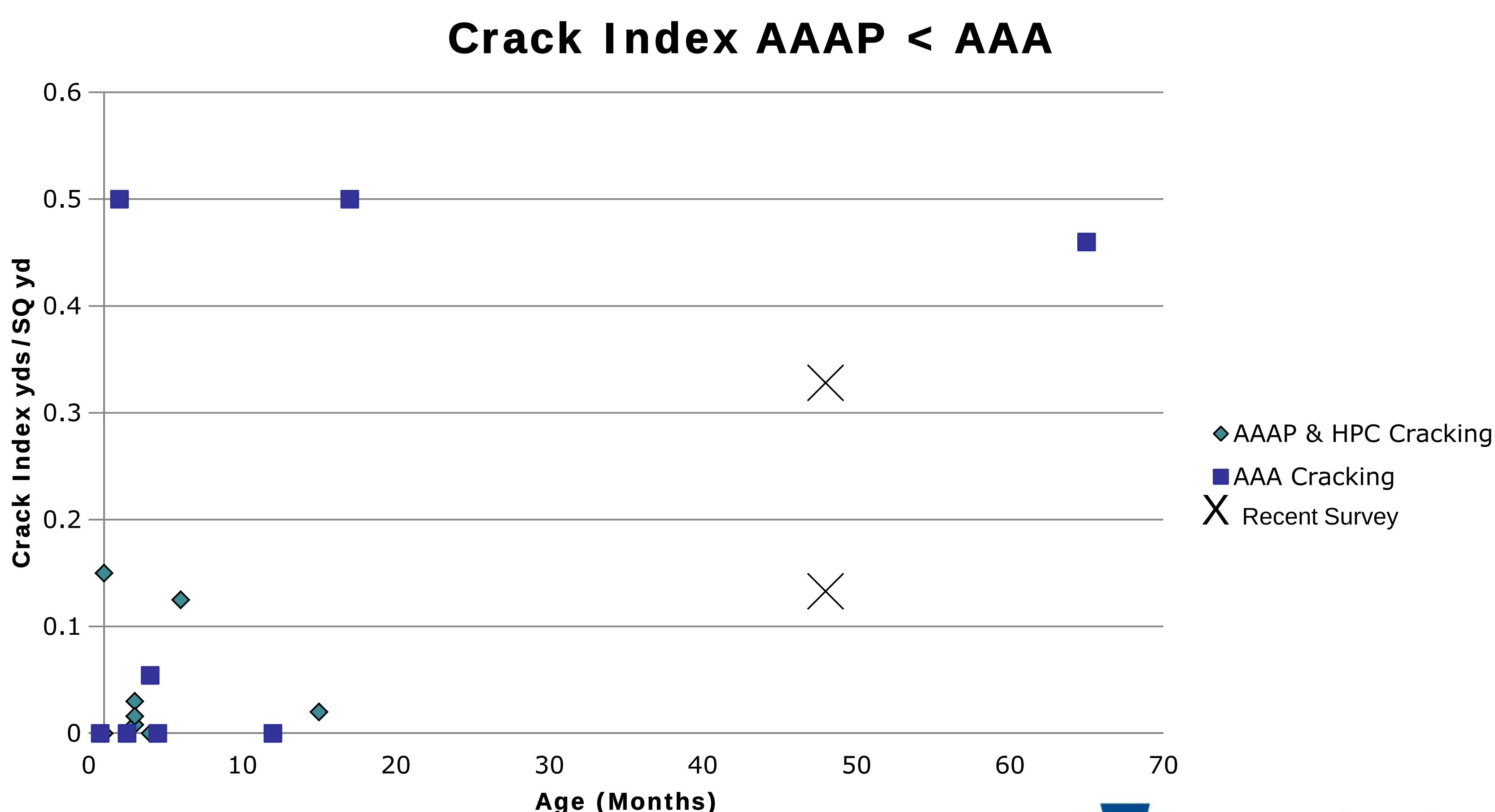
BRADD (continued)

- BRADD Road Shows
  - Fall 2013; Winter and Spring 2014
  - Dinner meeting presentation to in-state ABCD, ASHE, and ASCE groups to review and discuss Integral Abutment functionality in BRADD Version 3.2.0.0

Deck Cracking

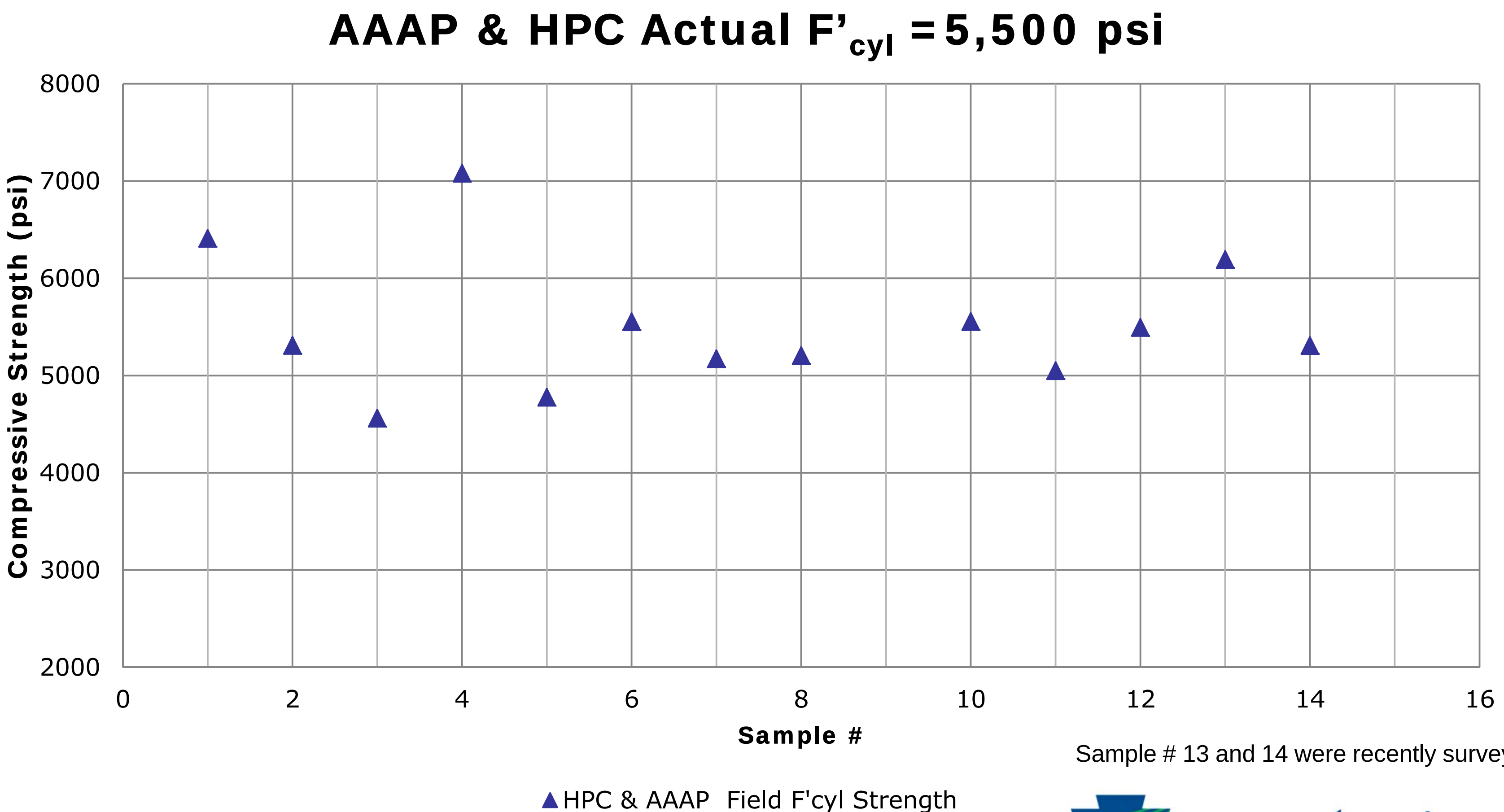
- Basic Questions
  - Is deck cracking detrimental to long term performance of bridges?
  - What is acceptable threshold for deck cracking?
  - What is the appropriate treatment for extensive deck cracking?
  - When to apply treatment

Deck Cracking



pennsylvania
DEPARTMENT OF TRANSPORTATION
www.dot.state.pa.us

Deck Cracking

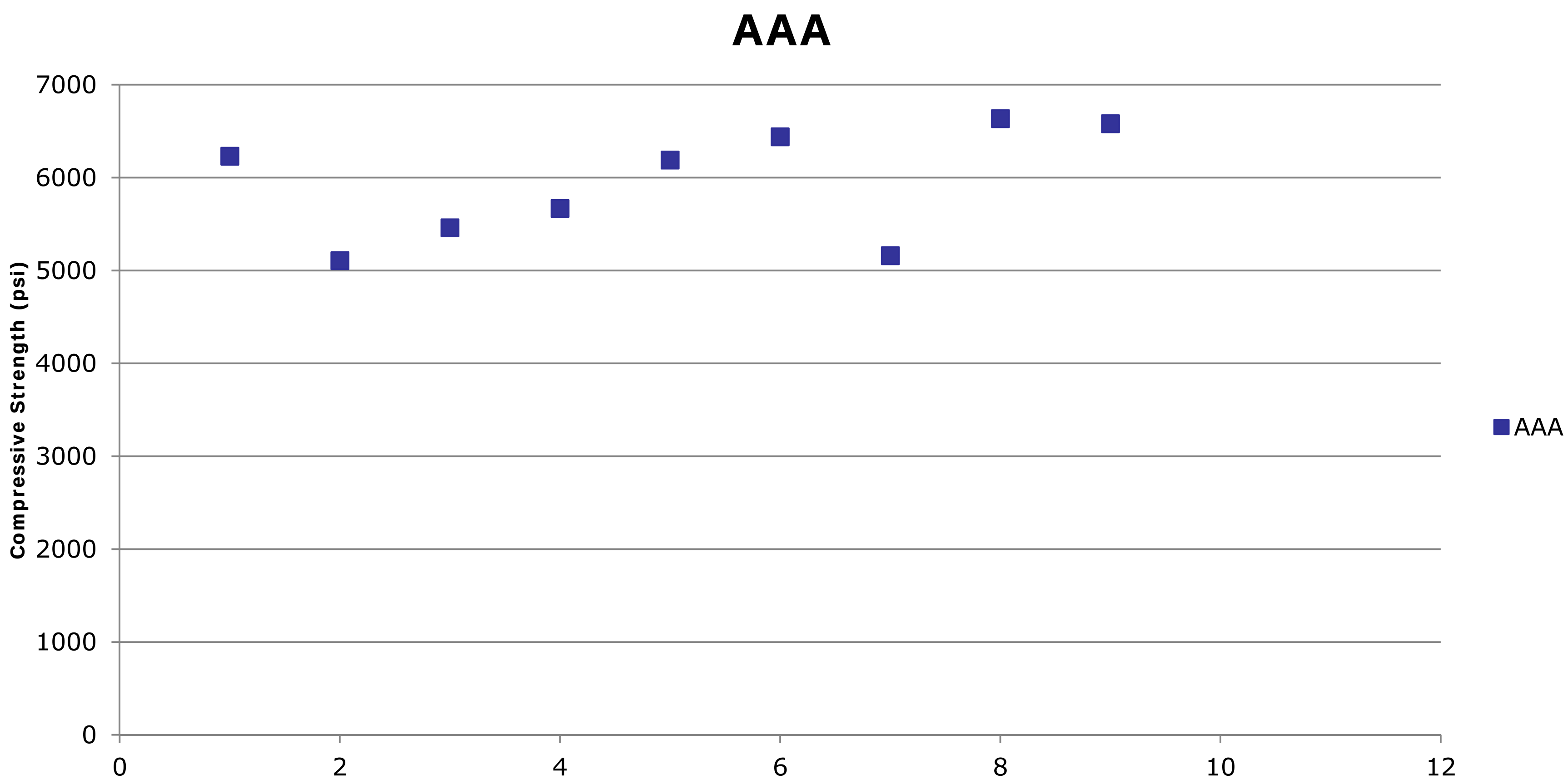


Sample # 13 and 14 were recently surveyed

pennsylvania DEPARTMENT OF TRANSPORTATION

www.dot.state.pa.us

Deck Cracking



Deck Cracking

- Penn State selected contractor to study bridges investigated in the mid 80s
- Develop database to capture deck properties and cracking
- The “Bridge Condition Analysis Matrix” will be created to include the following items:

- Data elements compatible with BMS2-Pontis
- Develop a bridge deck deterioration model to be included in Pontis. (i.e. loss of rating/yr, etc.)
- Include fields to populate future Bridge Management System based on AASHTO Bridge Element Inspection Manual.

Deck Cracking

- Track causes and trends of deck cracking
- Track long-term performance of decks
- Track performance of remediation methods
- 18 month study

Fracture Critical Members

- FHWA memo of June 20, 2012

Overall Requirements	FCM – main members that do not have load path redundancy (internal member redundancy and structural redundancy do not count) Examples – Steel Cross Girder Pier Cap, trusses, girder floorbeam system, etc.	SRM (System Redundant Member) – FCM that by detailed 3d analysis gains redundancy by system behavior (must consider FCM as fully fractured incl. non-tension elements, i.e. internal redundancy does not apply) Potential Examples –small prefab truss; large truss bridge, twin box girder, mid spans of 2 girder continuous structure, etc.
Design	FCM	FCM
Fabrication and Material	FCM	FCM
In Service Inspection	FCM	Non FCM

Fracture Critical Members

U.S. Department of Transportation
Federal Highway Administration

Memorandum

Subject: **ACTION:** Clarification of Requirements for Fracture Critical Members

Date: June 20, 2012

/s/ original Signed by

From: M. Myint Lwin, P.E., S.E.
Director, Office of Bridge Technology

In Reply Refer To: HIBT-10

To: Directors of Field Services
Federal Lands Highway Division Engineers
Division Administrators

The purpose of this memo is to provide clarification of the FHWA policy for the classification of Fracture Critical Members. For design and fabrication, only Load Path Redundancy may be considered. For in-service inspection protocol, Structural Redundancy demonstrated by refined analysis is now formally recognized and may also be considered. Internal member redundancy is currently not recognized in the classification of Fracture Critical Members for either design and fabrication or in-service inspection. Finally, this memo introduces a new member classification, a System Redundant Member (SRM), which is a non-load-path-redundant member that gains its redundancy by system behavior.

Fracture Critical Members

The NBIS and MBE definitions are substantially the same. FHWA agrees with either of the FCM definitions maintained by AASHTO but also recognizes the inconsistency in the language between the MBE and LRFD. FHWA interprets LRFD's use of ***"component in tension"*** to be a steel member in tension, or sub-element within a built-up member that is in tension. Also, FHWA interprets the phrase from LRFD "***inability of the bridge to perform its function"*** to mean the inability of the bridge to safely carry some level of traffic (Live Load) in its damaged condition. This live load may be less than the full design live load for the strength limit state load combination. The Load Factors and Combinations used to evaluate the damaged condition must be agreed upon between the Owner and Engineer and reviewed by FHWA.

Redundancy

FCMs by all definitions are an essential part of a non-redundant bridge system. LRFD defines Redundancy as "the quality of a bridge that enables it to perform its design function in a damaged state" and Redundant Member as "a member whose failure does not cause failure of the bridge." Redundancy can be provided in one or more of the following ways:

1) Load Path Redundancy
2) Structural Redundancy
3) Internal Member Redundancy

Load path redundancy is based on the number of main supporting members between points of support, usually parallel, such as girders or trusses. Structural redundancy can be provided by continuity in main members over interior supports or other 3-dimensional mechanisms. Internal member redundancy can be provided by built-up member detailing that provides mechanical separation of elements in an effort to limit fracture propagation across the entire member cross section.

Fracture Critical Members

inspection and more strict shop certification is required to meet the AWS D1.5 Bridge Welding Code requirements for fracture critical fabrication. Collectively, these requirements are referred to as the Fracture Control Plan (FCP).

The FHWA expects that all members identified as FCMs **according to load path redundancy** be fabricated to meet the fracture critical requirements for quality. FHWA emphasizes that when identifying FCMs during design it is not the failure of only the element in tension that needs to be considered with regard to the performance of the damaged bridge, but rather the failure of the entire member containing that tension element. For example, a bridge girder in bending has two elements in tension, a flange and a portion of the web. For the purpose of the load path redundancy assessment, all three elements of the girder cross-section, tension flange, web and compression flange should be considered fractured.

With regard to the identification of FCMs for design purposes, the provisions of Section 6.6.2 of the LRFD state ***"The Engineer shall have the responsibility for determining which, if any, component is a FCM. Unless a rigorous analysis with assumed hypothetical cracked components confirms the strength and stability of the hypothetically damaged structure, the location of all FCMs shall be clearly delineated on the contract plans."***

Fracture Critical Members

The interpretation of definitions and recognition of refined analysis provided herein has created a new member classification: a member that requires fabrication according to the AWS FCP, but need not be considered a FCM for in-service inspection. This memo defines this new member as a "System Redundant Member (SRM)." SRMs should be designated on the design plans with note to fabricate them in according with AWS Chapter 12. The criteria, assumptions, and the refined analysis used to determine the system redundancy condition must be retained and included in the inspection records or permanent bridge file. Changes in conditions of bridge elements or loading on the bridge could result in SRMs becoming FCMs in the future and requiring fracture critical inspection; therefore, it is vitally important to retain the refined analysis records and revise them as needed to account for these changes over the life of the structure. FHWA Divisions should work with their state partners to assure that their engineering practices align with the requirements given in this memo.

High Performance Steel (HPS) and use of internally redundant detailing both have the potential to further improve the fracture propagation resistance of FCMs and should be implemented where practical. The implications of such measures are the subject of ongoing research efforts.

Risk Based Postings

- Year long study
- Reviewed 15+ DOT posting policies
- 1997 last funding increase
- Next funding increase?
- System is aging
- Need to extend life of bridges

Risk Based Postings

- Basic Criteria
- Superstructure or Substructure Condition 4
  - ADTT <500 -Safe Load Capacity 0.9 OR
  - ADTT =>500 -Safe Load Capacity 0.8 OR

- Superstructure or Substructure Condition 3 or less
  - Safe Load Capacity 0.8 OR

pennsylvania DEPARTMENT OF TRANSPORTATION
www.dot.state.pa.us

Risk Based Postings

- Applies to State and Local Bridges
- Will affect other SD bridges – implication to overweight vehicle permit analysis

- Any questions?