

AGENDA
ACI Committee 345
Bridge Construction, Maintenance, and Repair
Spring 2014 Convention
Kansas City, MO

Sunday, April 12, 2015, 1:30 pm to 3:30 pm

Chair: Jimmy Kim at University of Colorado Denver
Secretary: Chris Carroll at University of Louisiana at Lafayette

1. Introductions
2. Approval of Fall 2014 (Washington DC) minutes
3. Membership status
The committee currently has 2 officers and 13 other voting members, 6 consulting members, and 24 associate members (45 members as shown in Appendix I)
4. Technical Sessions/Special Publication:
 - a. “Advanced Materials and Sensors towards Smart Concrete Bridges: Concept, Performance, Evaluation, and Repair” edited by Jimmy Kim (14 papers: published in 2014)
 - b. “Sustainable Performance of Concrete Bridges and Elements Subject to Aggressive Environments: Monitoring, Evaluation, and Rehabilitation” moderated by Jimmy Kim, Baolin Wan, and Isamu Yoshitake (3 sessions for F2014 in Washington, D.C.): sponsored by ACI-201 (durability), 343 (bridge design), and 345 (to be published in 2015)
 - c. “Design and Performance of Concrete Bridges and Buildings When Interacting with Soils and Foundations” in Denver, CO (F2015) moderated by Jimmy Kim and N.Y. Chang (final approval submitted in Dec. 2014), co-sponsored by ACI-343
5. Liaison reports from other committees (TAC, 342, 343, others)
6. Status of Documents
 - a. 345.1R-XX – Maintenance of Concrete Bridge Elements, Present Document Status – Staff edit (done Feb. 7, 2014), TAC review (done Aug 30, 2014), ballot 1 (done Sept 10, 2014), and ballot 2 (done Mar 14, 2015). Ballot 2 will be reviewed and a draft version will be completed
 - b. 345.XR – Guide for Concrete Bridge Deck Repair and Rehabilitation (Appendix II)—progress will be checked if time is permitted (Weyers recently updated his chapter)
7. New business
8. Adjournment

Appendix I

Membership as of Mar. 2015: **45 members**

Officers: 2

Kim, Yail Jimmy (Chair); Carroll, Chris (Secretary)

TAC Contact

French, Catherine E

Voting members: 13

Beaver, Jesse; Brown, Michael C; Estenssoro, Luis Fernando; Foden, Andrew J; Gepreags, Oliver K; Oglesby, Rita K; Sandberg, Harold R; Silfwerbrand, Johan L; Sprinkel, Michael M; St John, Paul J; Vaughn, Ronald E; Weyers, Richard E; Williams, Mark Erik

Consulting members: 6

Anderson, James C; Danley, Byron; Fouad, Fouad H; Harwood, Allan; Virmani, Yash; Wouters, Jeffrey

Associate members: 26

Al Wakeel Shahlaa A; Bartlett, F Michael; Branson, Tobias J W; Carrato, John L; Carter, Paul D; Castrodale, Reid W; Cumming, Neil A; Guth, Dena L; Haque, Mohammed E; Harris, Devin K; Hughes, Mark E; Klein, Gary J; Lee, Yoon-si; Morcous, George; Nash, William R; Pulido, Claudia P; Seo, Junwon; Simpson, John M; Smith, Jeffrey L; Soubra, Khaled S; Suh, Kwangsuk; Takhtovich, Eugene; Watts, Ralph D

Appendix II

Chapter 1 – Introduction (*Brown*)

1.1 Purpose and Scope

Includes activities normally considered as requiring repair and rehabilitation. Excluded are maintenance activities such as deck cleaning and concrete sealer applications.

Includes:

- a) crack repair
- b) pothole repair
- c) restoration of skid resistance
- d) overlays
- e) demolition and deck removal are beyond scope of document

Chapter 2 – Notations and Definitions (*Brown*)

Chapter 3 – Condition Evaluation (*Paul St. John & Jeff Smith*)

3.1 Overview

- 3.1.1 Deterioration Processes and Mechanisms
- 3.1.2 Repair vs Rehabilitation

3.2 Documentation Review

3.3 Field Survey Techniques

- 3.3.1 Visual Examination of Bridge Deck
- 3.3.2 Conventional Delamination Detection
 - 3.3.2.1 Chain Drag
 - 3.3.2.2 Hammer Sounding
- 3.3.3 Electrochemical Testing
 - 3.3.3.1 Electrical Half-Cell Potential Survey (ASTM C 876)
 - 3.3.3.2 Corrosion Rate Evaluation
 - 3.3.3.2.1 Linear Polarization
 - a) Unguarded electrode
 - b) Guarded electrode
 - 3.3.3.2.2 Potentiostatic Electrochemical Impedance Spectroscopy
- 3.3.4 Resistance and Resistivity
 - 3.3.4.1 2-point Direct-Path Resistance
 - 3.3.4.2 2-point Probe Resistivity
 - 3.3.4.3 4-point Wenner Array
- 3.3.5 Physical Sampling
 - 3.3.5.1 Coring
 - 3.3.5.1.1 Compressive and Tensile Strength & Modulus
 - 3.3.5.1.2 Petrographic Evaluation
 - a) Aggregate Type/Condition
 - b) Cement Paste Quality
 - c) Air Entrainment
 - d) Deleterious Reactions (ASR, Carbonation, DEF, Sulfate Attack)
 - e) Construction quality (freezing/thawing damage, over-finishing, honeycombing, cold joints)

- f) Presence of pozzolans or mineral admixtures
 - g) Presence of surface treatments/penetrating sealers
 - 3.3.5.2 Drilling/Concrete Powder Sampling
- 3.3.6 Chloride Concentration Testing
 - 3.3.6.1 Acid-soluble Chloride Titration
 - 3.3.6.2 Water-soluble Chloride Titration
 - 3.3.6.3 Rapid Chloride Test using Calibrated Ion-Selective Electrode
 - 3.3.6.4 X-ray Defraction technique
 - 3.3.6.5 Chloride Profiling and Diffusion Modeling
- 3.3.7 Non-Destructive Evaluation Methods
 - 3.3.7.1 Infrared Thermography
 - 3.3.7.2 Ground Penetrating Radar
 - 3.3.7.3 Sonic Methods - Impact Echo
 - 3.3.7.4 Ultrasonic Methods and Surface Wave Methods

Chapter 4 – Material and Method Selection (**Weyers & St. John**) Weyers drafted in March 2015

4.1 Overview

4.2 Materials

- 4.2.1 Crack repair
 - 4.2.1.1 Gravity systems – MMA
 - 4.2.1.2 Pressurized systems – epoxy
- 4.2.2 Pothole Repair
 - 4.2.2.1 Types of Rapid Systems
 - 4.2.2.1.1 Temporary
 - 4.2.2.1.2 Permanent
 - 4.2.2.2 Polymer Systems
 - 4.2.2.2.1 Pre-packaged systems
 - 4.2.2.2.2 Proportioned systems
 - 4.2.2.3 Asphalt Concrete
 - 4.2.2.4 Rapid Strength Gain Systems – concrete
- 4.2.3 Skid Resistance
 - 4.2.3.1 Polymer concrete overlays
 - 4.2.3.2 Grooving
- 4.2.4 Overlays
 - 4.2.4.1 Polymer Concrete Overlays
 - 4.2.4.2 Asphalt Overlays
 - 4.2.4.2.1 Without Membrane
 - 4.2.4.2.2 With Membrane
 - 4.2.4.3 Concrete Overlays
 - 4.2.4.3.1 Rapid Strength Gain Concrete
 - 4.2.4.3.2 Latex Modified Concrete
 - 4.2.4.3.3 Low-slump Dense Concrete
 - 4.2.4.3.4 Microsilica Concrete

4.3 Methods

- 4.3.1 Criteria
 - Remaining service life required:
 - a) Time of repair to rehabilitation
 - b) Rehabilitation to replacement

- 4.3.2 Performance Aspects
 - 4.3.2.1 Service Life
 - 4.3.2.2 Costs
 - 4.3.2.3 Traffic Conditions
 - 4.3.2.4 Weather Conditions
- 4.3.3 Specifications and Testing of Systems

Chapter 5 – Removal Methods and Surface Preparation (Williams)

5.1 Overview

In addition to project-specific requirements, method selection must also be guided by the following principles of sound practice:

- 1) The structure to be coated should not be damaged.
- 2) Reinforcing steel should not be damaged nor its bond with the concrete loosened.
- 3) Vibration, impact, or thermal loads applied should not weaken the concrete.

5.2 Method Overview (Present in order from least to most aggressive)

- 5.2.1 Low-Pressure Water Cleaning (Cleaning Method)
- 5.2.2 Grinding (Erosion Method)
- 5.2.3 Abrasive Blasting (Pulverizing Method)
- 5.2.4 Steel Shotblasting (Pulverizing Method)
- 5.2.5 Scarifying (Impact Method)
- 5.2.6 Needle Scaling (Impact Method)
- 5.2.7 High and Ultra High Pressure Water Jetting (Erosion Method)
- 5.2.8 Scabbling (Impact Method) – too much risk of micro-cracking?
- 5.2.9 Flame Blasting (Expansion Method)
- 5.2.10 Milling (Impact Method) – too much risk of micro-cracking?
- 5.2.11 Full Depth Removal – Saw cut, chipping hammers

5.3 Method Selection Process – Reduce risk of micro-cracking

5.4 Summary/Conclusions

Chapter 6 – Repair Methods (St. John/Kim/Williams)

6.1 Overview Complete (Williams)

6.2 Standard Repairs

- 6.2.1 Patching
 - 6.2.2.1 Partial Depth
 - 6.2.2.2 Full-Depth
- 6.2.2 Crack Repair
 - 6.2.2.1 Gravity Fill Methods
 - a) Rout and Seal
 - b) Flood coat
 - 6.2.2.2 Pressure Methods
 - a) Epoxy Injection

6.3 Repairs with Advanced Composites Complete (Kim)

Chapter 7 – Overlays (Sprinkel & Silfwerbrand)

7.1 Scope

7.2 Need for Overlays

- 7.2.1 Restored or Strengthened Load-Carrying Capacity **Complete (Silfwerbrand)**

- 7.2.2 Waterproof Barrier
- 7.2.3 Skid Resistance
- 7.2.4 Wearing Course
- 7.2.5 Reduction of Wheel Load Effect

7.3 Required Properties of Overlays

- 7.3.1 Properties required of all overlays
 - 7.3.1.1 Adhesion to concrete
 - 7.3.1.2 Cohesion
 - 7.3.1.3 Skid Resistance
 - 7.3.1.4 Durability
- 7.3.2 Properties required of waterproof barriers
 - 7.3.2.1 Impermeability
 - 7.3.2.2 Crack Resistance
 - 7.3.2.3 Temperature Compatibility

7.4 Types of Overlays

- 7.4.1 Plain Concrete Overlays **Complete (Silfwerbrand)**
- 7.4.2 Reinforced Concrete Overlays **Complete (Silfwerbrand)**
- 7.4.3 Fiber Concrete Overlays **Complete (Silfwerbrand)**
- 7.4.4 Latex Modified Concrete Overlays
- 7.4.5 Hydraulic Cement Concrete Overlays
- 7.4.6 Polymer Overlays
- 7.4.7 Membrane and AC Overlays

7.5 Design Considerations

7.6 Construction Considerations

- 7.6.1 Scarification and Removal of Unsound Concrete
- 7.6.2 Cleaning
- 7.6.3 Substrate Preparation
- 7.6.4 Placement and Consolidation
- 7.6.5 Curing
- 7.6.6 Skid Resistance
- 7.6.7 Traffic Vibrations **Complete (Silfwerbrand)**

7.7 Other Considerations

- 7.7.1 Material Performance Specifications
 - 7.7.1.1 Cement Type
 - 7.7.1.2 w/cm
 - 7.7.1.3 Aggregate Size
 - 7.7.1.4 Air Content
 - 7.7.1.5 Slump
 - 7.7.1.6 Compressive Strength
 - 7.7.1.7 Shrinkage
 - 7.7.1.8 Ductility **Complete (Silfwerbrand)**
- 7.7.2 Environmental Considerations
 - 7.7.2.1 Climate **Complete (Silfwerbrand)**
 - 7.7.2.2 Traffic **Complete (Silfwerbrand)**

Chapter 8 – Electrochemical Methods (Brown)

8.1 Overview of reinforcement corrosion causes and processes (ACI 222R?)

- 8.1.1 Influence of OH⁻ and pH

- 8.1.2 Influence of chloride
- 8.1.3 Other factors
- 8.2 Electrochemical testing for corrosion**
 - 8.2.1 Corrosion potential
 - 8.2.1.1 Methods
 - 8.2.1.2 Limitations and constraints
 - 8.2.2 Corrosion rate
 - 8.2.2.1 Methods
 - a) Linear Polarization
 - b) Electrochemical Impedance Spectroscopy
 - 8.2.2.2 Limitations and constraints
 - 8.2.3 Resistivity
- 8.3 Electrochemical Treatment Processes**
 - 8.3.1 Impressed Current Applications
 - 8.3.1.1 Cathodic Protection and Prevention (NACE RP0290-2000)
 - 8.3.1.1.1 Methods
 - a) Overlays containing Strip or Mesh Anodes
 - b) Conductive Coatings
 - 8.3.1.1.2 Limitations and Constraints
 - 8.3.1.2 Electrochemical Chloride Extraction (NACE 01101)
 - 8.3.1.3 Re-alkalization
 - 8.3.2 Galvanic Applications
 - 8.3.2.1 Cathodic Protection and Prevention
 - 8.3.2.1.1 Methods
 - a) Galvanic Coatings
 - b) Bulk Anodes and Distributed Anodes
 - 8.3.2.1.2 Limitations and Constraints

Chapter 9 – Appurtenances, Joints, Parapets and Approach Slabs

9.1 Sidewalks (Foden)

- 9.1.1 Introduction to Concrete Sidewalks
- 9.1.2 Types of Loads/Stresses Acting on Sidewalks
- 9.1.3 Possible Damages of Concrete Sidewalks
 - 9.1.3.1 Concrete Problems (Deterioration, Cracking, Abrasion, Corrosion, Water Leakage, Delamination, Surface Smoothing, Freeze-Thaw, Disintegration, etc.)
 - 9.1.3.2 Damage Due to Moving/Static Loads of Heavy Vehicles
 - 9.1.3.3 Fracture or Settlements in Sidewalks with Hollow Like Section
 - 9.1.3.4 Load Effects to Cantilevered Sidewalks
 - 9.1.3.5 Other Damages
- 9.1.4 Repair, Rehabilitation or Strengthening Techniques
- 9.1.5 Stress Reduction Techniques
- 9.1.6 Reinforcement Requirements
- 9.1.7 Surface Preparation
- 9.1.8 Overlays and Coatings
- 9.1.9 Placements Methods

9.2 Parapets (Foden)

- 9.2.1 Introduction to Concrete/Steel Parapets

- 9.2.2 Types of Loads/Stresses Acting on Parapets
- 9.2.3 Possible Damages of Parapets
 - 9.2.3.1 Concrete Problems (Deterioration, Cracking, Corrosion, Water Leakage, Delamination, Freeze-Thaw, Disintegration, etc.)
 - 9.2.3.2 Damage Due to Impact Effects of Moving Vehicles
 - 9.2.3.3 Steel-Concrete Connections
 - 9.2.3.4 Other Damages
- 9.2.4 Reinforcement Requirements
- 9.2.5 Repair, Rehabilitation or Strengthening Techniques

9.3 Joints

- 9.3.1 Bridge Deck Joints Classification **Complete (Carroll)**
- 9.3.2 Expansion/Non-Expansion Joint Functions **Complete (Carroll)**
- 9.3.3 Traffic Bearing Expansion Joints **Complete (Carroll)**
 - 9.3.4 Other Types and Features (Carroll: may be deleted?)
- 9.3.5 Review of Current Practice **Complete (Carroll)**
 - 9.3.5.1 Design Procedures **Complete (Carroll)**
 - 9.3.5.2 Construction Practice **Complete (Carroll)**
 - 9.3.5.3 Selection Guidelines **Complete (Carroll)**
 - 9.3.6 Possible Problems with Bridge Deck Joints
 - 9.3.7 Deck Joints Maintenance, Repair and Rehabilitation Practice (address below)
 - 6.1.2.c
 - 6.2.3 Joint Repairs
 - 6.2.3.1 Joint Types
 - 6.2.3.2 Surface Preparation
 - 6.2.3.3 Joint anchorage repair or replacement
 - 9.3.8 Deck Joints Waterproofing and Sealing
 - 9.3.9 Lessons for Maximizing Joint Service Life

9.4 Approach Slabs **(Williams/Harris)**

- 9.4.1 Introduction to Approach Slabs
- 9.4.2 Types and Features
- 9.4.3 Reinforcement Requirements
- 9.4.4 Seismic Effects to Approach Slabs
- 9.4.5 Possible Damages for Approach Slabs
- 9.4.6 Settlement in Approach Slabs and Abutment Backfill
- 9.4.7 Repair and Rehabilitation of Approach Slabs

TAC Review Date: March 23, 2014

Document Title: 345.1R—Guide to Maintenance of Concrete Bridge Members

No.	Page No.	Line No.	G/E/P/S	Comment	Committee Response
1.			G	This is a great document with lots of practical information on bridge maintenance and repairs. There is some missing information on the causes of cracking that needs to be included – specifically the role of the concrete mix design. Specific locations in the document that should include this information are noted below.	- The Committee appreciates TAC for its detailed review and valuable suggestions that will enhance the quality of the document. All editorial and technical concerns were addressed as shown below.
2.	1		G	through page 6 Note: Chapters 1 and 2 reorganized/reworded to follow the <i>ACI 2013 Technical Committee Manual</i> (TCM) style for chapter organization (Section 8.1.3).	- Chapter 1 has 1.1—Introduction and 1.2—Scope, conforming to Sec. 8.1.3 of TCM. Chapter 2 Definitions is also in conformance with Sec. 8.1.3 of TCM (there is no notation in this document)
3.	1	38	E	Revise to read “Maintenance is crucial to a bridge’s lifespan . . .”	- Revised as recommended
4.	1	42	E	“the concrete element” may be revised as “a concrete element”	- Revised as recommended
5.	2	1	E	“the bridge element” may be revised as “bridge elements”	- Revised as recommended
6.	2	3	P	Through 6. First sentence in this paragraph indicates that the guide does not cover repair. Yet the following sentence indicates that detailed methods of repair are referenced throughout the guide. Does this mean the other documents are referenced? Please clarify	- The sentence was revised to avoid confusion: “ <i>This guide does not cover major rehabilitation, reconstruction, or bridge inspection, and therefore, excludes repair with shotcrete and deck overlays. Detailed methods of repairing and inspecting bridges are referenced wherever necessary throughout the guide relative to the subject matter.</i> ”
7.	2	4	E	“excludes cathodic protection” may be contradictory to Sect. 10.3	- The word ‘cathodic protection’ was deleted as per comment No. 8.
8.	2	4	P	Delete cathodic protection because galvanic cathodic protection is included in 10.3	- Deleted as recommended

Primary (P) comments identify technical issues that the committee must address before publication of the document; **General (G)** comments identify issues general to the entire document that the committee must address before publication of the document; **Editorial (E)** comments identify editorial issues that the committee must address before publication of the document; and **Secondary (S)** comments identify technical or editorial issues that should be addressed either in this document or the next revision of the document.

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No.	Page No.	Line No.	G/E/P/S	Comment	Committee Response
9.	2	8	P	Either change “bridge decks” to “bridges” or add keywords for the other bridge elements covered by the guide.	- ‘ <i>bridge decks</i> ’ was replaced by ‘ <i>bridges</i> ’ as recommended
10.	2	16	E	Recommend changing article title since this is title for newly created Chapter 3 (copy that was moved out of Chapters 1 and 2).	The title was revised to read ‘ <i>3.1—Bridge maintenance</i> ’
11.	2	16	E	Is the word “Concrete” necessary here?	- ‘Concrete’ was deleted as recommended
12.	2	20	E	Is the word “Concrete” necessary here?	- ‘Concrete’ was deleted as recommended: ‘ <i>Deterioration of bridges</i> ’
13.	4	14	P	Introduction delves immediately into the details of environment and deterioration with no mention of maintenance until the last sentence. Consider reworking introduction to give a bigger picture.	- Introduction was re-written “ <i>Bridges represent a substantial investment of public funds, and are expected to provide satisfactory performance and remain in service for many years. The longevity of constructed concrete bridges can be expected to be 75 to 100 years if proper maintenance action is executed in a timely manner, while structural concrete members start to deteriorate overtime and eventually lose functionality, which could become life-threatening to the public. Aggressive environmental conditions for existing bridges involve cycles of freezing and thawing and wetting and drying, with or without the presence of chloride. Corrosion of reinforcing steel will spall the cover concrete, reducing the cross-sectional area of the reinforcing steel, and therefore, its strength. The time required for deterioration to occur varies</i> ”

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					<i>considerably, depending on severity of the exposure conditions and characteristics of the structural concrete. Traffic fatigue loading may be more dominant over time. It is believed that continuous and systematic maintenance of a bridge will extend its service life and reduce its overall operating cost. This committee report presents various technical aspects related to bridge maintenance, including the sources of deterioration and technical action that can improve the performance of existing bridge members."</i>
14.	4	15	P	through line 22 Traffic fatigue loading may be more dominant over time, and it should have such one sentence within this introduction. Also the later content has such topics related to cracks due to live load impact.	- A sentence was added as recommended: <i>"Traffic fatigue loading may be more dominant over time."</i>
15.	4	15	P	and line 16 This opening sentence is very negative and implies that concrete will never last forever. A more positive statement would be "When properly maintained, concrete bridges can be expected to last 75 to 100 years even when exposed to aggressive environmental conditions."	- The sentence was replaced: <i>"The longevity of constructed concrete bridges can be expected to be 75 to 100 years if proper maintenance action is executed in a timely manner, while structural concrete members start to deteriorate overtime and eventually lose functionality."</i>
16.	4	16	P	Deterioration should be a progressive process, and "lost strength" is not whole story. So that it may be better : "structural concrete members start to deteriorate over time and eventually lose functionality"	- The sentence was added as recommended, please see comment 15.

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No.	Page No.	Line No.	G/E/P/S	Comment	Committee Response
17.	4	17	G	<p>“...cycles of freezing and thawing and wetting and drying...” – the process of cycles should be rephrased. Later in the text was used “freezing-and-thawing” which probably better expresses the process. The other option can be to use “cycles of freezing-thawing and wetting-drying”.</p> <p>Please use “freezing-thawing” or “wetting-drying”, where ever it is appropriate throughout the document.</p>	<p>- Sec. 1.1 Introduction was re-written and the phrase TAC mentioned was deleted accordingly.</p> <p>- The following terms are typically used in practice: ‘freezing-and-thawing’ or ‘freeze-thaw’, and ‘wet-dry’. ‘freezing-thawing’ and ‘wetting-drying’ sound awkward. ‘freezing and thawing’ was revised to read ‘freeze-thaw’ and ‘wetting and drying’ to ‘wet-dry’ throughout the document.</p>
18.	4	18	E	Spalling the concrete cover will not reduce the cross sectional area of the steel. I think “reducing” should be changed to “reduce”.	<p>- The sentence was revised as per Comment No. 19.</p> <p>-‘reducing’ is grammatically correct: ‘which reduces’</p>
19.	4	18	E	“Corrosion of reinforcing steel will <u>usually result in concrete cover spalling</u> spall the concrete cover , reducing...” Corrosion of reinforcement can occur without spalling.	- Revised as recommended
20.	4	21	E	Add “and reinforcing steel” at the end of the sentence.	- Revised as recommended
21.	4	21	E	“the structural concrete” may be revised as “structural concrete”	- Revised as recommended
22.	4	21	E	“It is believed”? Could this be reworded to reflect more assuredness?	- The expression was revised to read ‘It is stated that...’
23.	5	1	P	Scope currently reads like an introduction. Rather it should clearly define the scope of the document. This would be a good place to expand on what	- The scope was re-written “ <i>The contents discussed in this report are classified into</i> ”

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No.	Page No.	Line No.	G/E/P/S	Comment	Committee Response
				is covered (maintenance) and what is not covered (structural repairs or rehabilitation). The reader could be directed to other ACI documents at this point if they are looking for structural repair techniques.	<i>two categories: i) deterioration of constructed bridges and ii) maintenance activities to address potential problems associated with such bridges. The first category is dedicated to various distressful attributes influencing the performance of existing bridge members and their consequences, while the second category is concerned about technical action with an emphasis on drainage, sealing, patching, joint repair, and other relevant topics. The following is outside the scope of the present report: major rehabilitation, reconstruction, inspection, and condition rating and evaluation."</i>
24.	5	3	E	Prefer "certain" to "many" years. Also "Design specifications" at the same line should include the citation of sources.	- Sec. 1.2 was re-written so the words TAC mentioned were deleted.
25.	5	6	E	through line 8 Deterioration being a consequence as already being implied in the preceding sentence. I think this sentence meant to stress the safety-related consequence that could threaten the public. What about: "Another consequence of maintenance delay and neglect is bridge deterioration possible bridge collapse, which could eventually become be life-threatening to the public."	- Sec. 1.2 was re-written so the words TAC mentioned were deleted.
26.	5	7	E	and line 8 It may be better to " Another consequence of maintenance delay and	- Sec. 1.2 was re-written so the words TAC mentioned were deleted.

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TAC Review Date: March 23, 2014

Document Title: 345.1R—Guide to Maintenance of Concrete Bridge Members

No.	Page No.	Line No.	G/E/P/S	Comment	Committee Response
				neglect will trigger bridge deterioration and may eventually ...”	
27.	5	10	P	All of these items are defined in the online resource and do not need to be repeated. If anything needs to be defined, it should be consistent with the bridge terminology of the AASHTO LRFD Bridge Design Specifications (e.g. superstructure and substructure).	- It is common practice in ACI documents showing definitions according to TCM10.1.4, supported by the Document for TAC review-submittal checklist.
28.	5	15	P	The definition of “damage” is inappropriate. The word “damage” is used in the document in general term, however, it has been given a specific definition which sounds like cavitation. Please see Page8, Line 10, where “Damage” is defined differently.	- The definition of damage in line 15 of page 5 was taken from the ACI Concrete Terminology manual (page 24). Information was added for consistency with line 10 of page 8: <i>“Other types of damage include reinforcing steel corrosion or concrete spalling.”</i>
29.	5	19	E	deck—the structural concrete slab or other structure that is supported on the bridge superstructure and serves as the road way or other traveled surface. Please change definition to “bridge deck”. Ensure consistent use of the term “bridge deck” throughout the document.	- Revised as recommended
30.	5	20	E	Roadway is one word	- Revised as recommended
31.	5	20	P	Change superstructure to beams or substructure. The deck is part of the superstructure.	- This definition was taken from the ACI Concrete Terminology manual (page 24). The TAC should contact ACI for changing the definition of the manual.
32.	5	22	P	Can grout also include chemical admixtures? “also a mixture of other composition but of similar consistency” basically allows any material to be considered grout. Is this the intent?	- This definition was taken from the ACI Concrete Terminology manual (page 34). The TAC should contact ACI for changing the definition of the manual.

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33.	5	23	E	Missing objective at “produce a pourable consistency”, maybe using “produce a pourable material having consistency...”	- Revised as recommended
34.	6	1	E	Add hydraulic cement before concrete.	- Revised as recommended
35.	6	1	P	Overlay should include “asphalt” as well, which also occurs a couple of times through this guide.	- The word ‘ <i>asphalt</i> ’ was added as recommended.
36.	6	3	E	Prefer using “ functionality” to “ function”	- Revised as recommended
37.	6	3	E	Should “polymeric concrete” be changed to “a layer of polymeric concrete”?	- Revised as recommended
38.	6	5	E	rehabilitation —the process of repairing or modifying a structure to a desired useful condition. Suggest deleting as it is in CT.	- Deleted as recommended
39.	6	7	E	span —distance between the support reactions of members carrying transverse loads. Suggest deleting as it is in CT.	- Deleted as recommended
40.	6	7	E	Suggest deleting “ carrying transverse loads”	- ‘span’ was deleted as per Comment No. 39
41.	6	7	E	Between is not specific enough	- ‘span’ was deleted as per Comment No. 39
42.	6	7	E	What does “transverse loads” mean?	- ‘span’ was deleted as per Comment No. 39
43.	6	9	E	Change grade to substructure	- it was revised as per Comment 44.
44.	6	9	P	ACI CT defines superstructure as everything above grade and the substructure is everything below grade, which is incorrect. The AASHTO	- This definition was taken from the ACI Concrete Terminology manual (page 73).

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				LRFD Bridge Design Specifications define superstructure as parts of the bridge that provide the horizontal span and substructure as parts of the bridge that support the horizontal span. This guide uses superstructure and substructure per the AASHTO definition. See Sections 5.4.1 and 5.5.1. Please adjust accordingly. Your definition will be considered for CT revised definition.	However, the committee agrees to the TAC's comment. The definition was revised: "superstructure—part of a bridge providing the horizontal span."
45.	6	13	E	Should "Bridge deterioration initially" be changed to "Initial bridge deterioration"?	- Revised as recommended
46.	6	18	E	"the structural" may be revised as "structural", same in the next line	- Revised as recommended
47.	6	18	E	Delete with minor repairs	- Revised as recommended
48.	6	20	E	"...categories—preventive and responsive." – Please consider using colon: "...categories: preventive and responsive."	- Revised as recommended
49.	6	20	S	good "excellent to fair condition." New bridges are rated by inspectors as in excellent condition based on FHWA NBI Ratings. The report generally uses good condition as the best condition to apply maintenance. May need to add/recognize excellent, new condition of bridges.	- Revised as recommended
50.	6	23	E	The first sentence of this section is a clause, and not a full sentence. Suggest "Procedures performed before deterioration is visible and the structural concrete member is still in good condition are called preventive maintenance."	- 'are called preventive maintenance' was added as recommended
51.	6	23	P	What is "good condition"? Provide some relativity.	- Information was added: " <i>...is still in good to fair condition according to the 9-scale evaluation criteria of the National Bridge Inventory (FHWA 1995).</i> " Federal Highway Administration (FHWA), 1995. Recording and coding guide for the

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					structure inventory and appraisal of the nation's bridges, Report No. FHWA-PD-96-001, Federal Highway Administration, Washington, D.C.
52.	6	23	P	and page 7 line 1 Is it really the case that preventative maintenance issues are "usually planned in the design stage"? Consider adding first sentence from 3.2.1 to this definition.	- The sentence was revised to read " <i>which may be planned at a design stage</i> "
53.	7	1	E	"...minor crack repair." Preventive maintenance is defined on previous page as being done before deterioration is visible.	- 'minor' was added as recommended
54.	7	1	E	through line 3 Last sentence of the first paragraph ("One procedure...") is not clear. Should it be rewritten?	- The sentence was deleted to avoid confusion: " <i>One procedure intentionally excluded from the planning stage is installation of retrofit drains; owning agencies are responsible for all maintenance procedures of this type.</i> "
55.	7	1	P	How can you caulk and repair a crack that is invisible, as the section promised on page 6, line 22?	- The first sentence of Sec. 3.1.1 was revised " <i>Procedures performed before significant deterioration is noticed and the structural concrete member is still in good condition.</i> "
56.	7	4	E	Suggest re-writing this section into two sentences: "Procedures performed in the early stages of the visible deterioration cycle, which are usually more extensive in nature, are called responsive maintenance. These may include small repairs, ..."	- Revised as recommended
57.	7	4	P	What is "responsive" maintenance as opposed to "preventive" maintenance? Do you mean "Reactive maintenance?"	- The word ' <i>responsive</i> ' was replaced by ' <i>Reactive</i> ' as suggested.

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58.	7	5	E	Revise to read: “. . . more extensive than preventative maintenance . . . “	- Revised as recommended
59.	7	5	P	The term “small repairs” and “minor repair” is used occasionally and appears to be within the scope of the document. Yet, structural repairs are not. Can the committee provide a definition for small repairs that are covered by this document? This is something that could be done in the scope. Perhaps some anecdotal examples of small and not small?	- The word ‘ <i>small repair</i> ’ was replaced by ‘ <i>minor repair</i> ’. -Information was added to clarify the level of ‘minor repair’: “ <i>...extend the service of the structural concrete members with minor repairs (i.e., condition appraisal rating of 5, FHWA 1995, including minor section loss, cracking, spalling, or scour).</i> ”
60.	7	6	E	What is “functionality of deck joint maintenance”? Use maintenance of deck joint.	- Revised to read ‘maintenance of deck joints’
61.	7	7	E	Why wouldn’t Responsive Maintenance apply to non-structural members if there are any?	- A sentence was added ‘Responsive maintenance can also apply to non-structural members’
62.	7	9	S	Suggest Section 3.2 be merged into Section 3.1.	- Sections 3.1 and 3.2 were merged as recommended.
63.	7	10	E	and line 11 Again, brief sentence here to provide indicators of “relatively good condition.”	- Information was added: “(for example, structural members are sound with minor cracking or spalling).”
64.	7	18	E	This section deserves one more sentence to parallel the style of 3.2.1. Suggest adding: “These are treatments to existing deck problems.”	- Added as recommended

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65.	7	21	E	and line 22 Maintenance is not an effective substitute for improper design and construction because it will not produce desirable results when applied to improperly designed and constructed concrete...”	- Revised as recommended
66.	7	21	P	through line 22 and page 8 lines 1-2 Excessive service cracking does not only occur due to improper design.	- The word ‘excessive service cracking’ was deleted as recommended.
67.	7	22	E	“applied” may be revised as “applies”	- Revised as recommended
68.	8	1	E	Add shallow before concrete cover	- The sentence was revised as per Comment Nos. 68 and 69: ‘Examples of improper design include inadequate or shallow concrete cover depths,’
69.	8	1	E	and line 2 “Examples of improper design include inadequate concrete cover depths, excessive surface...”	- The sentence was revised as per Comment Nos. 68 and 69: ‘Examples of improper design include inadequate or shallow concrete cover depths,’
70.	8	1	P	Extensive surface cracking is not an improper design example. It may be the result but not the cause.	- The word ‘excessive service cracking’ was deleted as shown in the Response to Comment No. 66.
71.	8	4	P	This section raises the question regarding when maintenance should occur, but does not really answer the question or tell the reader that the question will be answered in subsequent chapters. “Foresight involves the ability to identify the signs and symptoms that precede the development of damage.” Can the committee provide any guidance on the signs and	- The section was written “While maintenance activities performed in a timely manner can be extremely cost-effective, the same activities conducted after noticeable damage has occurred

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				symptoms that precede damage?	<p><i>could become a poor investment. The objective of maintenance is to extend the service life of constructed concrete structures by controlling the extent of damage nucleation and propagation. Knowledge of concrete deterioration mechanisms is crucial to foresee structural damage before it actually takes place, at a time when the concrete is still repairable prior to observing significant reinforcing steel corrosion or concrete spalling. Foresight involves the ability to identify the signs and symptoms that precede the development of damage. For example, an early signal of deterioration is the presence of leakage stains. Leakage stains usually precede frozen bearings and rust stains, delamination, and spalling of reinforced concrete bridge superstructure and substructure elements. The following chapter elaborates on the causes of bridge deterioration and contributing factors, which will be useful for making a timely maintenance decision."</i></p> <p>The signs and symptoms that precede damage are discussed in the following chapter (i.e., Ch. 4 Concrete bridge deterioration, in particular Ch. 4.1 Deterioration indicators).</p>

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72.	8	5	E	through line 7 The statement using “proper time”... and “ wrong time” may be “ timely” based on the example at line 6-7	- Revised as recommended
73.	8	12	S	Leakage stains is one example of an early signal of deterioration. Cracking in concrete is perhaps the most common early signal of deterioration.	- Information was added as recommended: <i>“For example, an early signal of deterioration is the presence of leakage stains and cracking in concrete.”</i>
74.	8	13	E	Please add a statement, or expand the current sentence, to explain what the leakage is from.	- Information was added: <i>“Leakage stains induced by water leaking from deck slabs usually precede frozen bearings and rust stains, delamination, and spalling of reinforced concrete bridge superstructure and substructure elements.”</i>
75.	8	18	E	Where are Figure 4.1 and 4.2 referenced in text?	- Figures 4.1 and 4.2 are cited in Sec. 4.1 (4.1—Deterioration indicators).
76.	8	21	E	“The following present some of the conditions relative to concrete bridges.” – Please consider to use “the following list presents...”	- Revised as recommended
77.	8	23	E	Change 4.3 to 4.1	- Revised as recommended
78.	8	23	P	and lines 1-6 on page 9 Water ponding and cracked asphalt pavement may be contributing factors, but they are not an indication of deterioration in the same way that cracking, spalling and corrosion staining are indications of deterioration.	- It seems the TAC misinterpreted the meaning of ‘ <i>Water ponding because of improper deck drainage</i> ’. Previous sentence says ‘ <i>Deterioration may be</i>

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					<i>hastened by the synergistics of environmental conditions and mechanical loading forces'</i> which means that water ponding can accelerate the deterioration of a bridge deck (e.g., deicing salt or any harmful chemicals dissolved in water).
79.	9	4	P	Figure 4.7 doesn't really show a damage indicator – more a source of damage.	- Figure 4.7 is associated with ' <i>e</i> Accumulation of deicing chemicals (Fig. 4.7)' supporting ' <i>Deterioration may be hastened by the synergistics of environmental conditions and mechanical loading forces'</i> . Figure 4.7 was not intended to show a damage indicator.
80.	9	8	E	Section 4.2 name is "Causes", but the first sentence begins with " <u>Factors contributing...</u> " Likewise, Section 4.3 name is Contributing Factors but the first sentence begins with "In general, the <u>causes...</u> "	- Revised as recommended
81.	9	9	E	Add "s" to "chloride".	- Added as recommended
82.	9	10	P	Should also mention the effects of carbonation as a potential problem.	- The sentence was revised to read: " <i>Factors contributing to concrete bridge deterioration are moisture, chloride, carbonation, acids and other aggressive chemicals</i> ". Detailed consequences of carbonation were not explained for consistency with other contributing factors. The readers will be aware that carbonation is one of the causes deteriorating bridge structures.

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83.	9	11	P	and line 12 Early-age concrete cracking due to drying shrinkage, plastic shrinkage, and plastic settlement can be main reasons for initial deterioration because moisture and chloride ions penetrate the concrete through those channels (initial cracking), it should be addressed.	- Information was added as suggested " <i>It is also worthwhile to mention that early-age concrete cracking due to drying shrinkage, plastic shrinkage, and plastic settlement can be main reasons for initial deterioration because moisture and chloride ions penetrate the concrete through those channels (initial cracking)</i> "
84.	9	16	E	Please provide approximately how much strength could be reduced for general loading	- It is case-by-case and hard to generalize because the degradation of concrete strength due to cyclic load is a function of several factors such as stress ranges, fatigue cycles, initial strength, and the like. The qualitative expression provided is believed to be sufficient to indicate the significance of fatigue loading.
85.	9	18	E	"facilitates" may be revised as "facilitating"	- Revised as recommended
86.	9	22	E	and line 23 It should follow the citation of sources, such as CEB, 1994 and ACI 201.1R	-The sentence is general and may not need specific reference: "In general, the causes and rates of deterioration depend on the relationship between design, construction, material selection, and exposure condition." Detailed information with appropriate references is provided in subsequent sections (4.3.1 Design, 4.3.2 Construction,

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					4.3.3 Materials, and 4.3.4 Climate-related exposure conditions).
87.	10	1	P	and line 2 Please explain “protection systems”?	- The word ‘ <i>other protection systems</i> ’ was deleted to avoid confusion. It basically indicates deck overlays.
88.	10	5	E	- focusing on [low] initial construction costs	- The sentence was revised as per Comment No. 89.
89.	10	5	E	Need to clean up this sentence – perhaps: “Some examples of problems that have occurred by addressing initial construction costs without considering the impact on long-term maintenance include constructing bridges that are too flat, do not have deck drains, have inadequate cover over the reinforcing steel, or have poor-quality concrete. Simple-span bridges have been commonly used for grade separations in heavily deiced urban locations since the 1950s and 60s.”	- The paragraph was revised to read ‘ <i>Some examples of problems that have occurred by addressing initial construction costs without considering the impact on long-term maintenance include constructing bridges that are too flat, do not have deck drains, have inadequate cover over the reinforcing steel, or have poor-quality concrete. The structural system widely used the 1950s and 1960s was simple-span bridges with grade separations in heavily deiced urban locations.</i> ’
90.	10	6	E	What is meant by “flat bridge”? Is this a deck with no superelevation or slope? Please check wording	- The expression was deleted as per Comment No. 89.
91.	10	7	E	Tense error. Please rewrite. Suggested: “Simple-span bridges were commonly used in 1950s and 60s for grade separations in heavily deiced urban locations.”	- It was revised to read ‘ <i>The structural system widely used the 1950s and 1960s was simple-span bridges with</i>

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TAC Review Date: March 23, 2014

Document Title: 345.1R—Guide to Maintenance of Concrete Bridge Members

No.	Page No.	Line No.	G/E/P/S	Comment	Committee Response
					<i>grade separations in heavily deiced urban locations.'</i>
92.	10	7	E	"poor-quality concrete" defined as what?	
93.	10	8	E	"60s" should be changed to "1960s"	- Revised as recommended
94.	10	12	P	Statement references a 24-year old document. What are practice guidelines now?	<p>- The sentence was superseded by "<i>Jointless integral bridges are erected thesedays to address potential problems induced by deck joints (Kim and Laman 2012; Lewis et al. 2014).</i>"</p> <p>Kim, W. and Laman, J.A., 2012, "Seven-year field monitoring of four integral abutment bridges, Journal of Performance of Constructed Facilities, 26(1), 54-64.</p> <p>Lewis, J., McGormley, J.C., and Ladson, R.D., 2014, "Joint elimination using accelerated bridge construction practices on the Indiana toll road", TRB 93rd Annual Meeting Compendium of Papers, 14 pp.</p>
95.	10	13	E	It should follow the citation of sources at "bridge design codes"	- The sentence was revised ' <i>Compared with earlier designs, current practice typically requires increased concrete cover,...'</i>
96.	10	13	E	Please consider: "Compared with earlier designs, bridge design codes <u>now</u> typically..."	- The sentence was revised ' <i>Compared with earlier designs, current practice typically requires increased concrete</i>

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					<i>cover,...'</i>
97.	10	13	P	through line 16 Design codes do not eliminate simple spans and deck joints. Engineers make these decisions.	- The expression ' <i>and eliminated simple spans and deck joints</i> ' was deleted.
98.	10	14	P	"use of air-entrained concrete "is not new, which traces back to 1940s by Power and others	- It is old but air-entrained concrete is durable in aggressive freeze-thaw environment. The information is still valid.
99.	10	15	E	"and eliminated simple spans .." inconsistency with the first part of sentence	- The phrase was deleted as per Comment 97.
100.	10	17	E	" <u>Conditions</u> Construction techniques that contribute..."	- Revised as recommended
101.	10	19	E	Change compaction to consolidation	- Compaction sounds better for concrete application. Consolidation is typically used in soils.
102.	10	20	E	Item b should be within Design section 4.3.1	- Item b) was deleted from Sec. 4.3.2- similar information exists in Sec. 4.3.1 so it was not moved. "... <i>have inadequate cover over the reinforcing steel,</i> "
103.	10	22	E	Rewrite entry	- It was replaced with " <i>Improper surface finishing</i> "
104.	10	22	P	The real problem is adding water to the concrete at the site.	- The phrase reads " <i>d) Increased concrete's w/cm during placement</i> ", which is exactly what the TAC commented.

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105.	11	1	E	Could also add g) Concrete segregation due to poor casting or improper vibration	- Added as recommended
106.	11	2	E	Please rewrite as “an increase in span length”	- This information does not exist in page 11 and line 2
107.	11	2	P	Can include higher cementitious material content as a reason for cracking	- The comment is stated in the next line “ <i>high w/cm concrete</i> ” whose phrase was superseded by “ <i>high paste-content concrete</i> ” according to Comment No. 108.
108.	11	3	P	The materials can be one of the most problematic design issues that greatly affect long-term concrete performance – especially in the concrete deck . This section deserves more attention. In particular, it is the paste content of the mix that will have the most volume changes, and therefore be a key to more rapid deterioration. Sometimes too low w/cm is also problematic, leading to autogenous shrinkage and concrete strength that is unnecessarily high (and stiff). Suggest change “high w/cm concrete” to “high paste-content concrete.”	- Ch. 4.3.3 (Materials) was revised “ <i>Material factors that contribute to deterioration include incompatibility between air-entraining and other admixtures, high paste-content concrete, temperature differentials between deck concrete and supporting girders, and nondurable aggregates vulnerable to aggregate-alkali reactions and cycles of freezing and thawing. The amount of cement paste influences volumetric changes in a concrete and the degree of shrinkage as well as compressive strength and stiffness of the concrete. In the deck, high-slump concrete can be extremely detrimental, leading to more settlement over the top reinforcing bars that induces a plane of weakness and is the first section to crack (Darwin et al. 2012).</i> ”

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No.	Page No.	Line No.	G/E/P/S	Comment	Committee Response
109.	11	3	s	“high w/cm concrete” may not be direct reason for deterioration, but improper selection of concrete types will be.	- It is a direct reason since the amount of moisture can influence deterioration (e.g., freeze-thaw, shrinkage, and the like)
110.	11	4	P	Also include temperature differentials (between deck concrete and supporting girders).	- Information was added as suggested <i>“temperature differentials between deck concrete and supporting girders,”</i>
111.	11	4	P	In the deck, high-slump concrete can be extremely detrimental, leading to more settlement over the top reinforcing bars that induces a plane of weakness and is the first section to crack. More information can be found here: Darwin, D., Browning, J., McLeod, H. A. K., Lindquist, W., Yuan, J., “Implementing Lessons Learned From Twenty Years of Bridge-Deck Crack Surveys,” Andy Scanlon Symposium on Serviceability and Safety of Concrete Structures: From Research to Practice, SP-284, American Concrete Institute, Farmington Hills, MI, 2012, pp. 8-1–8-17.	- Information was added as suggested <i>“In the deck, high-slump concrete can be extremely detrimental, leading to more settlement over the top reinforcing bars that induces a plane of weakness and is the first section to crack (Darwin et al. 2012).”</i> Darwin, D., Browning, J., McLeod, H. A. K., Lindquist, W., Yuan, J., 2012, “Implementing Lessons Learned From Twenty Years of Bridge-Deck Crack Surveys”, ACI-SP284 (Serviceability and Safety of Concrete Structures: From Research to Practice), American Concrete Institute, Farmington Hills, MI, paper number 8.
112.	11	8	E	- freezing and thawing [Fig. 4.10], deicing chemicals (Fig. 4.[7])	- The sentence was revised <i>‘deicing chemicals (Fig. 4.7), and cycles of freeze-thaw (Fig. 4.10)’</i>

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113.	11	11	E	through line 14 This comment on maintenance materials and placement conditions seems out of place in this chapter.	- The contents belong to weather issues so they are relevant to Sec. 4.3.4 Climate-related exposure conditions; the subtitle was revised to <i>'Environmental exposure conditions'</i> to avoid confusion
114.	11	12	S	Provide few examples of these many products?	- Information was added <i>'Many products such as cementitious patches require...'</i>
115.	12	3	E	In Section 5.2.2 also need to add that curbs are also exposed to vehicular impact that accelerate damages due to environmental conditions.	- Information was added <i>'Vehicle impact is another attribute degrading the performance of constructed curbs.'</i>
116.	12	5	P	Change "lacking" to read "not used". Some states do not use overlays or membranes intentionally. They adopt other protection strategies.	- The word was revised as recommended <i>"...protective systems, such as overlays or membranes, are not used."</i>
117.	12	6	E	Clogged deck drainage systems are shown in [Fig. 4.1 and Fig. 6.1]	- The sentence was revised to read <i>'They also stay wet when deck drainage systems become clogged (Fig. 4.1 and Fig. 6.1)'</i>
118.	12	6	E	(4.2) meaning what? Figure, section...	- Revised as per Comment No. 117
119.	12	6	E	Move "(Fig. 5.1)" to after word "debris" in Line 5.	- Moved as recommended
120.	12	9	E	Deck-maintenance costs vary significantly..." Remove hyphen.	- Removed as recommended
121.	12	12	E	and line 13	- Revised as recommended

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				Instead of “Code”, use the word “Policy”. Agencies may have a policy requiring an asphalt wearing surface, but not a code.	
122.	12	13	E	Delete “often”. Many states do not use asphalt overlays for the reasons stated later in the paragraph.	- Deleted as recommended
123.	12	13	E	Provide citation for “code”	- The word ‘code’ was replaced by ‘policy’ as per Comment 121.
124.	12	15	E	“surface-covering” – what else can you cover?	- The sentence was revised ‘ <i>Asphalt concrete overlays are used on bridge decks because they provide smooth ride quality and protect wearing surfaces.</i> ’
125.	12	16	E	Alternative wording: “As the asphalt deteriorates by oxidation and shrinkage cracking, and increased permeability will increase, which over time, they traps chloride-laden water, thereby promoting and accelerating concrete deterioration (Skeet and Kriviak 1994).”	- Revised as recommended
126.	12	17	E	Suggest “...over time, chloride-laden water becomes trapped, thereby...”	- The sentence was revised as per Comment No. 125.
127.	12	19	E	Add a reference to NCHRP Synthesis 425—Waterproofing Membranes for Concrete Bridge Decks.	- Information was added: ‘...as stated in NCHRP 425- Waterproofing membranes for concrete bridge decks (TRB 2012).’ <i>Transportation Research Board (TRB). 2012, “NCHRP Synthesis 425: Waterproofing membranes for concrete bridge decks”, Transportation Research Board, Washington, D.C.</i>

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128.	12	20	P	One other design item to consider with concrete decks – using larger-size aggregate will enhance the workability (in terms of optimized gradation) and durability of a concrete mix. In order to accommodate such mixes, sometimes the cover over the bottom mat of reinforcing steel must be increased slightly.	- Information was added <i>“It should also be mentioned that use of larger-size aggregate can enhance the workability (in terms of optimized gradation) and durability of a concrete mix. In order to accommodate such mixes, sometimes the cover over the bottom mat of reinforcing steel must be increased slightly.”</i>
129.	12	21	E	<i>“..rehabilitation cost.; therefore,..”</i> Remove period after cost.	- Removed as recommended
130.	12	22	S	and line 23 AASHTO LRFD Bridge Design Specifications, Six Edition with 2013 Interim Revisions – “Section 5.11.1.2.3 – Negative Moment Reinforcement” – This section specifies the requirements for embedment length beyond the point of inflection for negative moment reinforcement at supports. “Section 6.10.1.7 – Minimum Negative Flexure Concrete Deck Reinforcement” - This section specifies the design requirements for desk reinforcement in negative flexure regions of continuous spans.	- Information was added <i>“AASHTO LRFD (AASHTO 2013) specifies the requirements for embedment length beyond the point of inflection for negative moment reinforcement at supports and for desk reinforcement in negative flexure regions of continuous spans.”</i>
131.	12	23	E	<i>“There is also a direct correlation between severity of cracking and increase in transverse beam spacing (Buckler et al. 2000) and an increase span in length (Alampalli 2001). Krauss and Rogalla (1996) recommended using stiffer girders and a simply supported design to control bridge deck cracking, which conflicts with present design trends.”</i>	- The sentence mentioned in Comment No. 131 is shown in the document.
132.	13	1	E	Change transverse beam spacing to beam spacing in the transverse direction	- Revised as recommended
133.	13	2	E	<i>“increase span in length”</i> should be revised as <i>“increase in span length”</i>	- Revised as recommended

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No.	Page No.	Line No.	G/E/P/S	Comment	Committee Response
134.	13	3	E	“conflicts” may be revised as “conflict”	- Revised as recommended
135.	13	5	E	Through line 10. This paragraph should be placed in 5.2.3 Recommendations since it is discussing solutions and not problems.	- The paragraph was moved to Sec. 5.2.3 as recommended
136.	13	8	E	Before the word “flow” add the phrase “be allowed to”	- Revised as recommended
137.	13	11	E	Should “Bridge design” be changed to “Bridge designer” or “Bridge design should consider” be changed to “Bridge should be designed considering”?	- ‘It was revised to read ‘ <i>Bridge designer</i> ’
138.	13	11	P	through line 19 NCHRP Synthesis 333—Concrete Bridge Deck Performance summarizes design and construction practices that have been used to improve the performance of concrete bridge decks and should be referenced.	- Information was added as recommended <i>“NCHRP Synthesis 333 (Concrete Bridge Deck Performance, TRB 2004) summarizes design and construction practices that have been used to improve the performance of concrete bridge decks and should be referenced.”</i> Transportation Research Board (TRB). 2004, “NCHRP Synthesis 333: concrete Bridge Deck Performance”, Transportation Research Board, Washington, D.C.
139.	13	12	P	Define or describe the elements of a proper drainage system to provide guidance on this important aspect.	- Information was added <i>“Specific information on drainage systems is available in Ch. 6 (Drainage and Washing).”</i>
140.	13	13	P	Life-cycle costs can be tailored to provide any desired outcome. Is there a	- The sentence was deleted as

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				more rational approach that could be used to determine the best alternative? Is there really a wide spectrum of design choices with respect to maintenance? Perhaps this statement could be deleted.	recommended.
141.	13	15	E	Alternative wording: " <u>that are resistant to the fulfilling environmental exposure conditions</u> "	- Revised as recommended
142.	13	16	E	Suggest: "...concrete, clear concrete cover depths over reinforcement of at least 2 in. (51mm)..."	- Revised as recommended
143.	13	17	E	through line 19 Last two sentences in paragraph do not pertain to bridge decks and curbs; appear to be out of place. Section 5.2.3: Bridges should be designed to provide safe access for future inspection and maintenance. Provisions should be made for replacing individual components, such as bearings and deck joints."	- The two sentences were deleted.
144.	14	1	E	Change commas to semi-colons.	- Use of commas is grammatically correct since semi-colons are used for sentences.
145.	14	4	P	If the run-off is not chloride laden, then does that mean that there is no need to protect underlying structural elements? If not, then please reword.	- The sentence was revised " <i>Joints should protect underlying structural elements from the leakage of water or distressful chemicals such as chloride.</i> "
146.	14	10	E	Change 3.2 to 5.2	- Revised as recommended
147.	14	10	S	What is "section loss of steel girders", is it due to corrosion?	- It was revised to read ' <i>Section loss of steel girders induced by corrosion damage</i> '
148.	15	17	E	Suggest using "a potential risk" to "an annoyance or possible harm"	- Revised as recommended

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149.	15	17	E	and line 18 Please use “traveler” instead of “traveling public”	- Revised as recommended
150.	15	21	p	Please include photo of “cover plates or other protection should be used..”, or cite references for readers	- Michael Brown to submit a picture
151.	15	22	P	Why is there only a design recommendations subsection for decks? Consider adding design recommendations for 5.4 superstructure and 5.5 substructures	- Deck joints are a small item from a bridge design perspective so that design recommendations are reasonably available (this is also valid for 5.2 <i>Decks and curbs</i> having design recommendations in 5.2.3). However, super and substructures are rather broad topics that cannot include specific design recommendations within one subsection. The entire document can be considered as recommendations for super and substructures.
152.	15	23	E	This sentence states the obvious. The use of continuous spans reduces the number of joints.	- The sentence was deleted as recommended
153.	16	1	P	Explain how an abutment can be “semi-integral”	- A semi-integral abutment includes bearing pads at a construction joint where some dowel bars are placed for an integral abutment. Information was added “ <i>The difference between integral and semi-integral abutments is that the former has</i>

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					<i>dowel bars connecting the upper portion of the abutment at a construction joint, while the latter uses elastomer bearing pads at the same location in lieu of dowel bars."</i>
154.	16	4	p	The title of 5.4 is confusing. In general, the superstructure includes deck (section 5.2), floor system and other girders above bearing, as stated in <i>Bridge maintenance and evaluation</i> by Kenneth White, 1992. However, the new definition of superstructure appears here and also bearings are included.	- The term ' <i>bearing</i> ' and related sentences were deleted from Ch. 5.4.
155.	16	6	E	And lines 9 and 11. Use "deck" or "bridge deck" rather than "floor" as is included in the definitions.	- Revised as recommended
156.	16	7	E	Fig. 5.5. and 5.6 were not really needed in this document	- Figures 5.5 and 5.6 support the following sentences: <i>"Its components include main structural members, deck system, and secondary members (Fig. 5.5 and 5.6)."</i> <i>"Secondary members add stiffness to the main members. Failure of the floor system members would usually only have local effects."</i>
157.	16	17	E	Again, only chloride laden water is mentioned – should water be included?	- The sentence was revised: <i>"They should not be exposed to water, including chlorides."</i>
158.	16	17	E	Add period after water	- Revised as recommended

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No.	Page No.	Line No.	G/E/P/S	Comment	Committee Response
159.	16	18	E	It is noted that the most prominent maintenance issue is cracks – is this really the case?	- The sentence was revised to read <i>“One of the most prominent maintenance issues with concrete superstructure members is control of cracking.”</i>
160.	16	21	P	Cracking potential is greatly influenced by the concrete mix design and placement procedures. More discussion is warranted here. Darwin, D., Browning, J., Lindquist, W., McLeod, H.A.K., Yuan, J., Toledo, M., Reynolds, D. “Low-Cracking High-Performance Concrete (LC-HPC) Bridge Decks – Case Studies over the First Six Years,” <i>Journal of Transportation Research Board, No. 2022</i> , Transportation Research Record, vol. 3, p. 61-69.	- A sentence was added as recommended <i>“The potential of cracking is also influenced by a concrete mix design and placement procedures (Darwin et al. 2010).”</i> Darwin, D., Browning, J., Lindquist, W., McLeod, H.A.K., Yuan, J., Toledo, M., Reynolds, D., 2010, “Low-Cracking High-Performance Concrete (LC-HPC) Bridge Decks – Case Studies over the First Six Years”, <i>Journal of Transportation Research Board, No. 2022</i> , Transportation Research Record, 3, 61-69.
161.	17	18	E	Low permeability concrete.	- Revised as recommended
162.	17	21	S	and line 22 Consider adding references on bridge scouring here.	- Reference was added: Arneson, L.A., Zevenbergen, L.W., Lagasse, P.F., and Clopper, P.E. 2012. “Evaluating scour at bridges, 5 th edition”, Federal Highway Administration, Report No. FHWA-HIF-12-003 HEC-18, Springfield, VA.

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163.	18	3	P	Consider including maintenance of fender systems in navigable waterways which can be severely damaged by pack ice during winter.	- It is a good suggestion, whereas such a content for navigable waterways is outside the scope of the document as stated in the synopsis <i>"This guide addresses typical problems and cost-effective maintenance techniques for highway bridges and their elements..."</i>
164.	18	6	E	"bearing" is not a concrete element. Text may be revised as "bearing, and other elements accelerate concrete deterioration"	- Revised as recommended
165.	18	6	E	Change "bearing" to "bearings".	- Revised as recommended
166.	18	7	E	Alternative wording: "Drainage should be designed such that run-off will remove dirt. Drainage systems, however, can still become blocked by accumulation of material such that regular inspection and maintenance is required to ensure that the drainage system is operable."	- Revised as recommended
167.	18	10	P	Describe when it is necessary to seal the concrete. Is it when road salts are used? Should the concrete be sealed in other conditions?	- The sentence was revised to read <i>"...salt-exposed substructure areas should be cleaned and, if necessary, the concrete sealed to protect against deicing chemicals when detrimental cracks (e.g., crack width greater than 0.3 mm [0.01 in], ASCC 2003) are observed."</i> ASCC., 2003, "Specifications for crack repair-ASCC position statement #5", American Society of Concrete Contractors, St. Louis, MO.

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					Sealing can address most problems related to chemical ingress either with deicing agents or other ones. So the sentence proposed above can be general.
168.	18	11	P	Reference to a 1994 document – is there anything newer?	- The FHWA (1994) was deleted. Given the content is general, specific reference may not be necessary. A new reference (ASCC 2003) was added to the sentence according to Comment No. 167.
169.	18	14	E	through line 16 The statement is a little bit hard to follow.	- The sentence was revised ‘ <i>A bridge drainage system typically includes deck drains, scuppers, pipe, downspouts, and drain troughs—transports rainwater, ice, and snow meltwater away from the structural elements of the bridge.</i> ’
170.	18	19	P	What is a proper slope? Include suggested values or a reference.	- Information was added “ <i>...prevent ponding of water on properly sloped decks (e.g., a minimum cross slope of 2% may be used, GDOT 2014).</i> ” GDOT, 2014, LRFD bridge and structure design manual, Georgia Department of Transportation, Atlanta, GA.
171.	19	2	E	and line 3 The mention of long-term creep seems out of place. Maybe more	- The sentence was revised: “ <i>These include the long-term deformation of girders, settlement of substructure</i>

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				explanation is needed as this sentence is not clear.	<i>footings, and repaving of decks.”</i>
172.	19	2	E	Change 4.1 to 6.1 (Duplicate 344)	- Revised as recommended
173.	19	5	P	1979... most materials, design standards and construction methods have been updated.	- The 1979 reference was deleted because the contents mentioned were general.
174.	19	20	E	Suggest deleting “paper”	- The sentence was revised ‘ <i>Debris and other clogging products can plug...</i> ’
175.	19	20	E	Should a preposition be added after “even”?	- The sentence was alright.
176.	19	20	P	You note paper products plug drains. Does this preclude plastic products from plugging drains? For that matter, any other product type? Also, remove reference to specific products (plastic cups, bottles, cans...) as it could be a much wider range of things.	- The sentence was revised ‘ <i>Debris and other clogging products such as litter can plug even properly designed deck drainage systems (Fig. 6.1).</i> ’
177.	19	21	E	Alternative wording: “...and <u>reduced skid resistance</u> skid-resistance reductions. ”	- Revised as recommended
178.	20	5	E	Prefer using “from” instead of “to” following “prevent”	- The sentence is grammatically correct
179.	20	8	E	through line 10 Consider combining this section with section 6.4.4 retrofitting drains	- They were combined as recommended.
180.	20	9	E	Insert “steel” after “corroded”.	- Revised as recommended
181.	20	9	P	If portion of the corroded black reinforcements is repaired with corrosion resistant reinforcement, wouldn’t the mismatch possibly cause galvanic corrosion?	- The sentence was revised ‘ <i>Corroded steel members should be replaced with corrosion-resistant materials, such as 316LN stainless steel.</i> ’

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182.	20	9	P	and line 10 You note that corroded members should be repaired with corrosion resistant alloys and specifically note that 316LN should be used. This is very focused. What about plastic or other non-corroding products. This has to be more general. Also, remove reference to 316LN as there are other corrosion resistant steels.	- The sentence was revised ' <i>Corroded steel members should be replaced with corrosion-resistant materials, such as 316LN stainless steel.</i> '
183.	20	10	E	Change repaired to replaced	- Revised as recommended
184.	20	13	P	Can a methodology or reference be suggested for sizing the retrofitted drainage piping?	- It is case-by-case and is too specific to include in this document.
185.	20	16	E	Drilling through concrete deck for drains is not practical – maybe coring	- Revised as recommended
186.	20	17	E	Change “should be avoided” to “should not be allowed”.	- Revised as recommended
187.	20	19	E	through line 21 Clarify sentence	- To be discussed in S2015
188.	21		E	Should weep holes, riprap, and gabion be defined? Consider this – it will make this easier to read.	- Defined as recommended: <i>'... weep holes (a small opening allowing water flow) is...'</i> <i>'Riprap (rocks armoring shorelines) or gabions (steel wire cages) can be placed...'</i>
189.	21	10	E	Suggest: “Drainage systems through abutments and wingwalls can	- Revised as recommended

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				become impaired and lead to settlement problems at ends of the bridge structure where these elements are located.”	
190.	21	18	P	Is riprap only placed upstream? I thought it was placed downstream also? I believe there have been reported failures on the downstream side?	- The sentence was revised ‘ <i>Riprap (rocks armoring shorelines) or gabions (steel wire cages) can be placed along stream locations to prevent continued bank erosion.</i> ’
191.	21	20	E	“...or fire damage should debris under the bridge catch fire.” – This sentence is unclear, please consider rephrasing.	- The phrase was deleted so that the sentence reads ‘ <i>Debris should be removed from stream and river channels to prevent excessive lateral forces of the structure during high flow occurrences.</i> ’
192.	22	1	E	May want to mention someplace in this chapter that the concrete surface coatings are being used quite often for the aesthetic value they add to the visible concrete members.	- Information was added as recommended: ‘ <i>Concrete surface coatings are often used to enhance aesthetics of concrete members</i> ’
193.	22	13	S	Does the section “7.3.1.1 Types—Coatings include acrylics, epoxies, and urethanes.” mean to indicate examples or types (categories)?	- To be discussed in S2015
194.	23	1	E	Paragraph does not address riding surface	- To be discussed in S2015
195.	23	11	E	Quantify “too much”	- ‘too much’ was replaced with ‘excessive’
196.	23	15	E	Chloride absorption is not a deterioration mechanism. Reword: “...they can prevent or slow various concrete deterioration mechanisms, such as chloride absorption, which leads... ”	- Revised as recommended

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No.	Page No.	Line No.	G/E/P/S	Comment	Committee Response
197.	23	20	E	“...salt scaling...” or “...salt-scaling...” – Use consistently one phrase through entire document.	- ‘salt-scaling’ was used
198.	23	20	P	through line 23 Again, most of these documents have been superseded a long time ago	- The outdated references were superseded by a recent review paper: Safiuddin, M. and Soudki, K.A., 2011, “Sealer and coating systems for the protection of concrete bridge structures”, International Journal of the Physical Sciences, 6(37), 8188-8199.
199.	24	7	P	Are there recommendations to determine if previous coatings have been used?	- Technical details should be available from the manufacturer. ACI515.2R-13 (<i>Guide to selecting protective treatments for concrete</i>) was added.
200.	25	8	P	And line 20. Do these sections apply only to sealers and not to coatings? Please clarify.	- It is specific to sealers (Ch.7 is specific to sealers)
201.	25	8	P	The section title is “What and when to seal”. The text only describes “what”.	- The section title was revised to read “7.4—Suggested areas for sealing”
202.	25	10	P	In bridges in a marine environment, this might mean sealing the entire bridge. Is that the intent? Perhaps add discussion that differentiates between road salts and marine environment to clarify.	- The document was developed primarily for highway bridges rather than for bridges in a marine environment. This fact was clarified in the abstract section “ <i>This guide addresses typical problems and cost-effective maintenance techniques for highway bridges and their elements</i> ”

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					<i>unless otherwise stated...</i> Additional information was provided to Sec. 7.4: “ <i>Bridges situated in a marine environment may need distinct requirements</i> ”
203.	25	17	E	Within “a month or more” doesn’t seem quite right for the context	- To be discussed in S2015
204.	25	23	E	Delete comma.	- Revised as recommended
205.	26	8	E	“Sealing not be done” should be changed to “Sealing should not be done”	- The sentence was revised to read ‘ <i>Sealing performance generally increases with concrete age, and sealing should not be done until the concrete is at least two weeks of age and after deck grooving</i> ’
206.	26	9	P	Many DOT’s require a minimum of 28 days of cure time before applying concrete sealers. Please clarify.	- The sentence was revised ‘ <i>New concrete should be allowed to cure before sealing. Sealing performance generally increases with concrete age, and sealing should not be done until concrete is at least two weeks of age or as recommended by the manufacturer after deck grooving.</i> ’
207.	26	16	P	through line 17 Add ASTM or AASHTO test designations, if available.	-Information was added “ <i>it is important to verify performance and identity of the specific product being used according to</i>

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					<i>technical standards such as ASTM C1315 (ASTM 2011)."</i> ASTM, 2011, "Standard specification for liquid membrane-forming compounds having special properties for curing and sealing concrete (ASTM C1315-11)", American Society for Testing and Materials, West Conshohocken, PA.
208.	26	20	S	Don't some manufacturers allow squeegees to be used?	- To be discussed in S2015
209.	27	5	S	General Comment – Many DOT's have approved products lists for sealers. The approved sealing products were selected based on the criteria listed in Section 7.6.	<i>- Information was added 'Provided many DOT's have approved product lists for sealer, practitioners are encouraged to select such preapproved products along with the guidelines mentioned in this section.'</i>
210.	27	16	E	through line 18 Second sentence in item d ("Consult the manufacturer...") is not clear. Should it be rewritten?	<i>- The sentence was revised 'Consult the manufacturer to verify the product performance in a specific service condition and perform independent testing if necessary.'</i>
211.	28	11	E	"deck-wearing" surface?	<i>- The sentence was revised 'When measuring sealer performance on site,...'</i>
212.	28	18	E	"are" may be revised as "is"	<i>- Revised as recommended</i>

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213.	28	22	P	Instead of live loads, authors should use the term vehicular or traffic loads	- The term ' <i>live loads</i> ' was replaced by ' <i>vehicular load</i> '
214.	29	2	E	How do you define "structural maintenance"?	- The sentence was revised: ' <i>Structural expertise should be consulted before beginning the maintenance or repair of deteriorated members.</i> '
215.	29	2	E	through line 4 Is this sentence in the right place?	- The sentence was removed
216.	29	9	E	Suggest using "risk" to "danger"	- Revised as recommended
217.	29	9	E	These figures have no correlation to temperature extremes – why include them?	- The figures show typical patching work. The sentence was revised to avoid confusion: ' <i>Patching (Fig. 8.1 and 8.2) is often done under adverse field conditions, such as temperature extremes.</i> '
218.	29	16	E	Should "subject" be changed to "subjected"?	- Revised as recommended
219.	29	17	E	Add " below " at end of the sentence	- A phrase 'in Sec.8.3' was added as per Comment No. 220.
220.	29	17	P	Where are these "typical types of patching" actually described?	- The sentence was completed " <i>several typical types of patching are described in Sec. 8.3</i> "
221.	29	22	E	Rewrite sentence	- To be discussed in S2015
222.	30	1	S	General Comment – Again many DOT's have approved mixes and products	- A sentence was added ' <i>The products</i>

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				for patching materials.	<i>approved by state DOT's are also recommended.'</i>
223.	30	12	E	"Cement-based patching materials that are similar in handling, mixing, and behavior to the hydraulic concrete being repaired are more likely to be compatible and easy to apply than special materials like polymer concrete." – This sentence is unclear, please consider rephrasing.	- The sentence was revised ' <i>Cementitious patching materials are likely to be compatible and easy to apply than special materials like polymer concrete in terms of handling and mixing.'</i>
224.	31	4	P	What about local State DOT-approved products?	- Information was added " <i>State DOT-approved products may be used without physical testing, upon approval of the technical authority.</i> "
225.	31	13	S	What are "frequent" live loads?	- The sentence was revised ' <i>These include distress due to traffic load, temperature cycling, wet-dry cycling, and exposure to chlorides.'</i>
226.	31	16	S	What are "liquid membrane curing materials"?	- It was revised to read ' <i>Membrane materials are often used'</i>
227.	31	19	P	Section is focused on patching (less than 2" deep) – so why mention fibers for such a shallow repair? Hardly practical	- Fibers can potentially be used for all cementitious materials. Synthetic fibers can be used for shallow patching. The section states " <i>Refer to the report(s) of ACI Committee 544 for information on the relative merits of both steel and synthetic fibers"</i>

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228.	31	21	E	It should be “patches”	- Revised as recommended
229.	32	1	E	ACI Committee 544 is not included in the reference section	- Information was added: ‘544.1R-96 Report on fiber reinforced concrete (reapproved 2009)’
230.	32	1	E	and line 2 Refer to specific document numbers for ACI Committee reports that have information about the relative merits of both steel and synthetic fibers?	- Information was added: ‘544.1R-96 Report on fiber reinforced concrete (reapproved 2009)’
231.	32	1	P	Add “Steel fibers should have a zinc coating to prevent corrosion of the fiber in cracks.”	- Information was added as recommended “Steel fibers may be zinc-coated to prevent corrosion of the fibers in cracks.”
232.	32	4	E	Prefer “higher” to “greater”	- Revised as recommended
233.	32	6	E	The equivalent of 20° and 40° F are -7° and +4° C.	- Revised as recommended
234.	32	6	E	Insert space after “-5”.	- Revised as recommended
235.	32	8	E	Please better define “problem.”	- The sentence was revised ‘The risk of a functional problem increases as the thickness of the patch and the ability to protect the patch decreases.’
236.	32	9	E	The alternative “of” heating the area to be patched	- Revised as recommended
237.	32	9	P	Change “to” to “of” before heating	- Revised as recommended

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238.	32	18	E	“at 3-hour ages”	- The sentence was revised ‘ <i>Materials that comply with R3 performance requirements (ASTM C928) should exhibit this strength level for at least 3 hours.</i> ’
239.	33	3	P	Should “distinct” be “different”? It is unclear why the coefficient of thermal expansion affects future maintenance activities.	- The word ‘ <i>distinct</i> ’ was replaced by ‘ <i>different</i> ’ and the sentence was revised to read “ <i>Other patch materials might not be compatible with future maintenance activities because of different thermal coefficients that can cause unnecessary interfacial stresses between the existing and the newly added patch materials.</i> ”
240.	33	7	E	Fig. 8.4 and 8.5 do not match text. Consider different figures or changing call out.	- Figures 8.4 and 8.5 show typical applications for overhead and vertical patching which is the title of the section. To avoid confusion, the sentence was revised: ‘ <i>Zero-slump, nonsagging patching materials (Fig. 8.4 and 8.5) do not generally need the freeze-thaw or salt-scaling durability of deck patches, unless they are in areas expected to become saturated or subject to heavy salt exposure.</i> ’
241.	33	22	P	The surface should be “moist” only if it is required in the manufacturer’s application guides – will depend on patching material.	- The sentence was revised as recommended “ <i>The surface should be moist only if it is required in the</i>

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					<i>manufacturer's application guides."</i>
242.	33	22	P	The cleaning, recoating, or replacement of existing reinforcement may also be required in patching areas.	- A sentence was added as suggested " <i>The cleaning, recoating, or replacement of existing reinforcement may also be required in patching areas.</i> "
243.	34	4	P	First paragraph. Reference is made to 90 degree angle in repair. This is not clear and I am not sure if this is possible. You also refer to another method that changes to a 45 degree angle. These seem to be the same but one has a 90 degree angle (which may not be possible) and one has a 45 degree angle. Either I missed something or it is not clear. Consider revising to clarify.	- As shown in Fig. 8.7, a vertical cut angle of 90 degrees is used. Information was added to clarify this issue: ' <i>In common industry practice, a minimum depth of 1 in. (25 mm) vertical cut (perpendicular to the surface) should be used and then chipped inward</i> ' 
244.	34	5	E	Add cited reference for NYDOT finding.	- To be discussed in S2015
245.	34	5	S	Only the inner angle is different in the NYDOT method. What is the advantage?	- To be discussed in S2015
246.	34	14	P	ACI's preferred term for control joint is contraction joint but it is unclear	- The title was revised to 'Joints and

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				which type of joint Section 9.5 is discussing. Consider changing the title to “Expansion Joints, Cracks, and XXX Joints”.	cracks’
247.	34	14	S	Is Chapter 9 “Joints, Cracks, And Control Joints “really needed? Most of the discussions here are repeated from earlier sections of the report.	- To be discussed in S2015
248.	34	16	E	Maybe add “when” before “ exposed to chlorides”	- Revised as recommended
249.	34	22	S	and line 23 Maintenance may focus on the possible leakage, so suggest” maintenance activities are intended to prevent joints leakage, as well as retaining their functionality”	- The sentence was revised ‘ <i>Maintenance activities are intended to prevent joint leakage, as well as retaining their functionality, and to accommodate thermal and live-load movement of the superstructure, while preventing leakage through the joint.</i> ’
250.	35	1	E	Delete “and as often as necessary”.	- Revised as recommended
251.	35	3	E	“moderating” temperatures??	- The sentence was revised without ‘moderating temperatures’: ‘ <i>At a minimum, debris should be removed after winter maintenance</i> ’
252.	35	10	E	“high-impact” forces?	- The sentence was revised ‘ <i>Non-tolerable impact forces...</i> ’
253.	35	10	E	Insert “slab” after “approach”.	- Revised as recommended
254.	35	11	p	How to “raising the joint”. Please clarify	- The sentence was revised ‘ <i>The misalignment can be corrected by adjusting the approach elevation,</i> ’
255.	35	19	E	through line 20	- The sentence was revised

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				"chemical composition" of what?	<i>'Susceptibility to corrosion is dependent on the chemical composition of the concrete or other protective measures.'</i>
256.	36	3	P	and line 17 Tensile, diagonal tensile and flexural tensile stresses? Then diagonal tension, shear, and flexural tension cracks? Clarify the distinction.	- The sentence indicates general conditions that can induce cracking in concrete: tensile (axial), diagonal tensile (shear), or flexural tensile (bending). The sentence was revised to read <i>"Cracks occur when the tensile (axial), diagonal tensile (shear), or flexural tensile (bending) stress exceed the tensile strength of the concrete."</i>
257.	36	3	P	Insert "direct" before the first "tensile".	- The sentence was revised as shown in the Response to Comment 256
258.	36	8	P	Doesn't thermal cycling also promote crack growth?	- The sentence was revised to read <i>"Once a crack has developed in a bridge member, it often propagates with time due to mechanical or environmental attributes such as fatigue loading and thermal cycling."</i>
259.	36	11	P	Add after sealed "to reduce the infiltration of water and chlorides,"	- The sentence was revised <i>"structural cracks are repaired to restore structural integrity, and nonstructural cracks are sealed to reduce the infiltration of water and distressful chemicals such as chloride,</i>

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					<i>to minimize the potential for increased cracking, and to improve aesthetics.”</i>
260.	36	12	P	Not sure where shrinkage cracks fall into these two categories, but although they may begin as surface cracks, they often will propagate through the deck to the point that leakage stains will form on the underside of the deck. The role that concrete mix design and placement procedures play in reducing this cracking should be noted.	- The sentence was revised <i>“Structural cracks may be created by stresses due to live and dead loads and temperature difference. The adequate mix design and placement of concrete can reduce the occurrence of shrinkage cracks.”</i>
261.	36	13	E	“Fig. 9.1 shows” instead of “refer to fig. 9.1, which...”	- Revised as recommended
262.	36	16	E	“...above a reinforcing bar,” – please consider using plural: “reinforcing bars”.	- Revised as recommended
263.	36	17	E	through line 19 Moving “structural cracks include....” To the back of “shrinkage strains” at line 13 may be more logical	- Moved as recommended
264.	36	18	P	and line 19 The “lack of proper reinforcing” does not cause cracks. The reinforcement’s function is to control crack widths.	- The sentence was deleted since a lack of proper reinforcing will not occur if design procedures are based on code requirements.
265.	37	4	P	Different kinds of crack repairs have different life span. Can the guidelines point out what to expect from repairing a crack and how often the repair shall be repeated? In addition, crack repair using materials with different thermal properties (epoxies) may not be appropriate in some situations. Finally, an active structural crack will continue to develop even with repair. How this situation can be better handled?	- on ‘ <i>what to expect from repairing a crack</i> ’: information was added “As stated earlier, by repairing existing cracks, the structure is expected to have a longer service life with improved functionality from structural and aesthetical perspectives.”

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					<p>- on 'how often the repair shall be repeated': it is not feasible to suggest any information related to this question because no one knows when cracking occurs during service. Information was added to address this comment "<i>Although it is not practically possible to estimate a regular crack repair period, technical authorities should perform consistent inspection activities to detect potential problems that can cause structural cracks.</i>"</p> <p>- on 'crack repair using materials with different thermal properties (epoxies) may not be appropriate in some situations.': a sentence was added "<i>Attention should be paid when thermally sensitive materials such as an epoxy are used when significant thermal distress is expected.</i>"</p> <p>- on 'an active structural crack will continue to develop even with repair': Information was added "<i>Periodic technical action is also recommended for crack repair, given that active structural cracks may continue to develop after a repair work is done.</i>"</p>
266.	37	5	E	and line 6	- Revised as recommended

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				It may be better “ chloride-induced cracks in bridge elements are a long-term maintenance concern”	
267.	37	16	P	Provide a reference for 200%	- the sentence was revised and a reference was added “ <i>The material should have a significant tensile elongation capability (ASTM D638) such as more than 200%; for instance, retail urethane materials typically show an elongation value varying from 400% to 700% at break (CUE 2014).</i> ” CUE, 2014, “Polyurethane materials technical data sheet”, CUE Inc. Cranberry Township, PA.
268.	37	19	E	through line 21 Suggest replacing “debonded” with “unbonded” in this paragraph.	- Revised as recommended
269.	37	21	P	Provide a reference for 300%	- The sentence was revised “ <i>Bonded repair is recommended to use a material with at least a 300 percent tensile elongation capability by ASTM D638, supported by typical elongation properties of commercial products showing an elongation of over 600% (Dow 2002).</i> ” Dow, 2002, “Dow Corning® 890-SL self-leveling silicone joint sealant”, Dow Corning Corp., Midland, MI.

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270.	38	1	p	through line 10 What is the durability of those sealers, which may be a major concern?	- Information on durability is not available to the knowledge of Committee 345 or Durability is beyond the scope of this document.
271.	38	6	P	through line 10 Can a reference or information be provided about the size of cracks that can be epoxy injected?	- Information was added " <i>A crack width narrower than 0.05 mm [0.002 in] may be repaired by epoxy injection, as recommended by ACI224.1R-07.</i> "
272.	38	14	E	Should it be "water"?	- To be discussed in S2015
273.	38	17	P	Readers might think that a "through full-depth crack" is also a dormant crack, Please clarify	- The sentence was revised " <i>The material may leak through full-depth cracks (which tend to be active), and arrangements need to be made to either seal the bottom of the crack or to collect the leaking material (Sprinkel 1992a).</i> "
274.	38	22	E	and line 23 It seems 9.4.2.3 is duplicate from 9.4.1.1, and should be deleted.	- Sec. 9.4.2.3 was deleted.
275.	39	2	P	through line 12 It is unclear what types of joint is discussed in this section. Is the first sentence referring to construction joints, contraction joints, or both? The second sentence mentions movement joints. Is this the same as an expansion joint?	- Information was added " <i>The purpose of caulking is to prevent the penetration of deleterious materials into joints in concrete construction or exposed joints between concrete and steel members, such as bearings. Bridges are often designed with various types of joints,</i>

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					<i>where maintenance caulking can easily be carried out. These joints have various purposes, such as to reduce restraint and allow movement to occur (expansion), to allow shrinkage to occur without cracking (contraction), or as part of the construction casting sequence (construction).'</i>
276.	39	4	E	Fig 9.5 is cited in connection with caulking of joints. Fig. 9.5 shows the caulking of a crack. The figure should be referenced in Section 9.4.	- Figure 9.5 was moved to Sec. 9.4 as recommended with the following sentence 'A typical example for crack-caulking is shown in Fig. 9.5'
277.	39	14	P	This chapter is titled "Potentially Promising . . ." Yet, the most recent reference is 1994. They may have been promising 20 years ago but if they have yet to be readily accepted, forget about them. This chapter should be deleted or updated about what has happened to these potentially promising techniques and mention any new techniques.	- The title was revised to read "Chapter 10—Notable techniques for bridge maintenance" and new information was added as shown below.
278.	39	14	P	This section has changed little since this document was last published. Perhaps change the title? Note that the references are from the early nineties. Outdated literature – promising 20-year old techniques?	- Please see the Response to Comment No. 277.
279.	39	17	E	The first maintenance could be left out	- The sentence was revised as recommended 'This chapter presents some promising techniques for the maintenance of constructed bridges.'
280.	40	2	E	and line 3 The same concern: "... is a more recent development " is not recent	- The sentence was revised 'While the use of corrosion inhibitors for the protection of metallic substances is not a

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					<i>new technique, their use as part of a maintenance program for reinforced concrete structures is promising.'</i>
281.	40	3	E	Should this be "668" instead of "666" to match Reference section?	- Revised as recommended
282.	40	4	P	It is indicated that several promising corrosion-inhibiting materials have been identified. This is now twenty years old. Are they being used or not? Adjust wording accordingly.	<p>- A sentence was added "<i>Since then, a number of techniques were developed and used on site such as use of conductive polymers and organic products (Smith and Virmani 2000; Zarras et al. 2003; Shi et al. 2014).</i>"</p> <p>Smith, J.L. and Virmani, Y.P., 2000, Materials and methods for corrosion control of reinforced and prestressed concrete structures in new construction, Report No. FHWA-RD-00-081, Federal Highway Administration, Washington, D.C.</p> <p>Zarras, P., Anderson, N., Webber, C., Irvin, D.J., Irvin, J.A., Guenther, A., and Stenger-Smith, J.D., 2003, "Progress in using conducting polymers as corrosion-inhibiting coatings", Radiation Physics and Chemistry, 68, 387-394.</p> <p>Shi, L., Ye, J., Chen, C.C., Wu, Y., and Liu, J.Z., 2014, "Analysis of the influence of organic corrosion inhibitors on corrosion of reinforcement in concrete bridge</p>

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					structure under simulated field service environment”, 4 th International Conference on the Durability of Concrete Structures, 87-93.
283.	40	16	P	and line 17 How to quantify or verify “ surface treatments involvethrough to reach the steel”	- Limitation was added <i>‘To be effective, surface treatments involve either penetration of the inhibitor through cracks or absorption and migration of the inhibitor through concrete to reach the steel. To the knowledge of the committee there is no standard method to measure the effectiveness of the inhibitor.’</i>
284.	40	20	E	Add “should be” after “also”	- The sentence was revised <i>‘Concrete permeability and ambient weather conditions are factors that should also be considered.’</i>
285.	41	8	P	What about discrete or spot anodes that are now very popular with patching concrete. They should at least be mentioned here?	- A new subsection was created (10.4— <i>Discrete or spot anodes</i>) and information was added <i>“Discrete or spot anodes may be embedded in patches for reinforced concrete members to control the occurrence of corrosion. A metal alloy having a negative electrochemical potential is typically used so that a positive current is generated by the difference of a potential between the steel and anode,</i>

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					<p><i>thereby creating the cathode (Wilson et al. 2013). Commonly used materials for this corrosion protection application are zinc, aluminum, magnesium (The Concrete Society 1989). Discrete anodes are readily installed in most cases and do not require electrical power sources nor costly structural propping; however, some technical challenges should be taken into account such that the service life of installed anodes cannot be accurately estimated (The Concrete Society 1991). Sergi (2011) reported the performance of galvanic sacrificial anodes installed in steel reinforcing bars for over 10 years. It was found that the repaired area did not reveal any noticeable corrosion, accompanied by the fact that the rest potential of steel was shifted to a positive direction and the corrosion current density was reduced. Christodoulou et al. (2014) shows that such a corrosion inhibiting technique was effective when used for parking garage structures."</i></p> <p>Christodoulou, C., Goodier, C.I., Austin, S.A., Glass, G.K., and Webb, J., 2014, "A new arrangement of galvanic anodes for the repair of reinforced concrete structures, Construction and Building Materials, 50, 300-307.</p>

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					<p>Sergi, G., 2011, "Ten-year results of galvanic sacrificial anodes in steel reinforced concrete", Materials and Corrosion, 62(2), 98-104.</p> <p>Wilson, K., Jawed, M., and Ngala, V., 2013, "The selection and use of cathodic protection systems for the repair of reinforced concrete structures", Construction and Building Materials, 39, 19-25.</p> <p>The Concrete Society, 1989, "Cathodic protection of reinforced concrete", Technical Report 36, The Concrete Society, Camberley, UK.</p> <p>The Concrete Society, 1991, "Model specification for cathodic protection of reinforced concrete", Technical Report 37, The Concrete Society, Camberley, UK.</p>
286.	41	15	P	Perhaps mention that when new concrete is placed adjacent to old concrete, the corrosion in the old concrete is accelerated. This is the result of a difference in the electrolytic potential between the old and new concrete.	- To be discussed in S2015
287.	41	21	E	and line 22	- The word 'generally' was deleted

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				<p>“Generally”? Is this accurate enough or is explanation required? “10.3.2 Recommended practice—Bond strength of coating to concrete is important, and should generally be greater than 145 psi (1 MPa).”</p>	
288.	42	17	P	Consider adding a summary or conclusion section.	<p>- A summary section was added as recommended <i>“This document has presented technical challenges and solutions related to the maintenance of constructed concrete bridges and their elements with an emphasis on highway application. The causes of bridge deterioration and their contributing factors were elaborated to understand fundamental issues with regard to bridge maintenance. Also discussed were technical considerations at a design stage to minimize the occurrence of detrimental damage in a bridge structure. Attention was paid to maintenance items frequently observed on site, namely, drainage and washing, sealing, patching, and joints. Other notable maintenance activities such as use of inhibitors were dealt with. Timely maintenance is an important factor for extending the longevity of existing concrete bridges, which will eventually save rehabilitation or reconstruction expense and will ensure the wellbeing of the general public.”</i></p>
289.	43	4	E	This document has been withdrawn. Is there another more current	- Committee 504 was eliminated. The

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				document that has replaced it?	reference was deleted.
290.	43	5	E	This document has been withdrawn. Is there another more current document that has replaced it?	- It was superseded with a new document: '515.2R-13 Guide to selecting protective treatments for concrete'
291.	43	22	E	Update to Second ed. 2007?	- Updated with a new version released in 2013.
292.	44	13	E	Cannot find this reference? Please confirm accuracy. Highway Administration, McLean, VA.	- The reference info is correct: U.S. Department of Transportation, Federal Highway Administration, Office of Implementation, Research, Development, and Technology, Turner- Fairbank Highway Research Center, McLean, VA.
293.	46	18	P	Please, note that I was not able to verify the availability of Palmer, M. (1992)	- It is readily accessible on the web: just type 'How to Seal Joints in Concrete Structures' on Google and it will be available (accessed on Sept. 9, 2014).
294.	48	11	E	Please add to body of text or delete from Reference section.	- It was added to 10.2—Corrosion inhibitors for use in maintenance
295.	50	4	E	What does the "10" indicate? Explanation required? Delete from photo? Refer to Fig. 4.3.	- It is just a field inspection number and cannot be deleted since the number was included when the picture was taken

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296.	51	2	E	Please remove copyright information from figure photo. Refer to Fig. 4.5.	- It was removed as recommended
297.	52	1	E	Fig shows a truck driving in the snow, not chloride build-up. Consider changing figure or call out.	- The truck is spreading deicing agents
298.	52	2	E	Does the application of deicing require a photo? Refer to Fig. 4.7	- Figure 4.7 support Sec. 4.1 (deterioration indicators) <i>'Accumulation of deicing chemicals (Fig. 4.7)'</i> There is no harm to provide specific information.
299.	53	4	E	Debris accumulated on a curb is important why? Explain.	- As explained in Sec. 5.2.2, debris can clog drainage <i>'Decks and curbs are generally the most exposed portions of a bridge, especially where drainage is inadequate and protective systems, such as overlays or membranes, are not used. Curbs collect debris (Fig. 5.1), snow, and salt from the riding surface, staying wet long after the riding surface has dried.'</i>
300.	54	1	E	Fig. 5.2 is not called out in the text	- Figure 5.2 was used for Sec. 5.3.3 Leakage.
301.	55	2	S	The vertical separation is not clearly visible. Can the committee provide a	- To be discussed in S2015

Primary (P) comments identify technical issues that the committee must address before publication of the document; **General (G)** comments identify issues general to the entire document that the committee must address before publication of the document; **Editorial (E)** comments identify editorial issues that the committee must address before publication of the document; and **Secondary (S)** comments identify technical or editorial issues that should be addressed either in this document or the next revision of the document.

TAC Review Date: March 23, 2014

Document Title: 345.1R—Guide to Maintenance of Concrete Bridge Members

No.	Page No.	Line No.	G/E/P/S	Comment	Committee Response
				better photograph?	
302.	59	4	E	Fig. 8.1 is blurred. Can the committee provide a clearer photograph?	- To be discussed in S2015
303.	60	4	S	Fig. 8.3 is blurred. Can the committee provide a clearer photograph?	- To be discussed in S2015
304.	60	5	E	Does not show zero slump concrete, as referenced.	- Figure 8.4 shows a problem and its solution with zero slump concrete is shown in Fig. 8.5.
305.	61	1	E	Fig does not match call out.	- It agrees with the sentence provided in Sec. 8.3.2.4 ' <i>Overhead and vertical patching—Zero-slump, nonsagging patching materials (Fig. 8.4 and 8.5)...</i> '
306.	61	2	E	The synopsis states that the guide excludes repairs with shotcrete. Fig. 8.5 shows a shotcrete repair.	- The word 'shotcrete' was deleted from the synopsis.

Primary (P) comments identify technical issues that the committee must address before publication of the document; **General (G)** comments identify issues general to the entire document that the committee must address before publication of the document; **Editorial (E)** comments identify editorial issues that the committee must address before publication of the document; and **Secondary (S)** comments identify technical or editorial issues that should be addressed either in this document or the next revision of the document.