

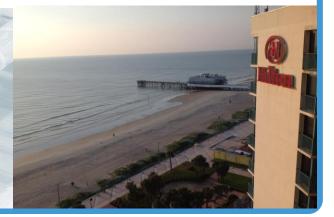
Post-Expo

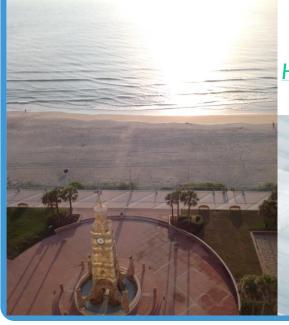
6/15/2016, 1:00pm - 4:00pm Hilton Daytona Beach Oceanfront Resort

St Johns Room

100 North Atlantic Avenue Daytona Beach, Florida 32118, USA Tel: 1-386-254-8200







INNOVATIVE EFFICIENT EXCEPTIONAL

Part 1 - Presentations

- GFRP Industry perspective
 - ACMA-TSC (John Busel)
 - ii. Owens Corning (Chris Skinner)
- 2. ACI Committee 440 perspective (Antonio Nanni)
- 3. AASHTO-T6 perspective (Will Potter FDOT rep.)
- 4. FDOT perspective
 - i. Materials (Chase C. Knight)
 - ii. Design (Steve Nolan)
 - iii. Construction (future workshops)
 - iv. Maintenance (future workshops)







I. Overview

II. Material Requirements

III. Research



State Materials Office

2016 esign Training



Overview

State Materials Office Roles:

- Material Specifications
- Sampling and Testing Requirements
- Quality Control Program Production Facility Approvals
- Conduct and Facilitate Research Durability/Service Life

GFRP Rebar Workshop
2016



Material Requirements

- Producer Quality Control
 - a) Specifications Section 105
 - b) Materials Manual Chapter 12.1
 - c) Specifications Section 932
- 2. Acceptance at the Project Level
 - a) Certification
 - b) Sampling and Testing
- 3. MAC





Material Requirements

- - Section 105 Contractor Quality Control
 - FRP producers must meet requirements of Materials Manual

http://www.dot.state.fl.us/programmanagement/Implemented/SpecBooks/default.shtm

- Materials Manual Chapter 12.1
- Specifications Section 932

Ensure the FLOURERS OF STUDINGER SHEET AND ASSESSED FOR THE PROPERTY OF STUDINGERS OF Producers of Structural Steel and Miscellaneous Metal Components shall meet the http://www.dot.state.fl.us.programmanagement/httplemented/URLinSpecs/Section/111V1-sht subsequent and the programman an Producers of Fiber Reinforced Polymer Composites shall meet the requirements of Section 12-1, Volume II of the Department's Materials Manual, which may be viewed at the http://www.dot.state.fl.us/programmanagement/Implemented/URLinSpecs/Section121V2.shtm.

limited to http://www.dot.state.fl.us/program

- 2. Acceptance at the Project
 - a) Certification
 - b) Sampling and Testing
- MAC

inspection Department will respond to the producer within 21 calendar days of receipt of the proposed Department will respond to the producer within 21 catendar days of receipt of the proposed Producer Quality Control Program. The Department may perform evaluation activities to verify

http://www.dot.state.fl us-programmanagement/Implemented/URLinSpecs/Section8

http://www.dot.state.fl.us/programmanagement/Implemented/URI inSpecs/Section83VI.shtm. Producers of Precast Prestressed Concrete Products using Self Consolidating Producers of Prescriptions of Section 8.4. Volume II of the Department's Materials

Produces of Incidental Precast/Prestressed Concrete Products shall meet the Producers of incidental Precast/Prestressed Concrete Products small meet the requirements of Section 8.2, Volume II of the Department's Materials Manual, which may be

Producers of Portland Cement Concrete shall meet the requirements of Section 9.2. Volume II of the Department's Materials Manual, which may be viewed at the following

The Producer Quality Control Program must be revised for any reason. it me rromcet Quanty Comor rrogram must be revised not any reasons, including non-compliance, submit the revision to the Department. The Department will respond to the producer within seven calendar days of receipt of the revised Producer Quality Control

105-4.6 Producer's Quality Control (QC) Plan: Submit detailed policies, methods and procedures to ensure the specified quality of all applicable materials and related production procedures to ensure the spectimes quantity or an apparature materials and the operations. Include other items in addition to these guidelines as necessary.

105.4.6.1.1 Qualifications: Submit the Training Identification Numbers (TINs) or any other information which will be traceable to the certification agency's training (11/xs) or any omer miormanon winco win oe naceause to the certification agency a training location and dates for all technicians performing sampling, testing and inspection for both field

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Material Requirements

- Producer Quality Control
 - **Specifications Section 105**
 - b) Materials Manual Chapter 12.1
 - **Production Facility Qualification Process**
 - **Producer Responsibilities**
 - Incoming raw material control
 - Manufacturing quality control
 - QC inspection
 - Handling, Storage, Shipment
 - Documentation and Record Retention
 - c) Specifications Section 932
- 2. Acceptance at the Project Level
 - a) Certification
 - b) Sampling and Testing

Materials Manual Fiber Reinforced Polymer Composites

Revised: October 27, 2014

Section 12.1 FIBER REINFORCED POLYMER COMPOSITES

12.1.1 PURPOSE

This procedure provides guidance for the development and implementation of This procedure provides guidance for the development and implementation of the quality control plan for the manufacture, storage, and transportation of the quality control plant for the manufacture, storage, and dailsportation of fiber reinforced polymer composites for Florida Department of Transportation (FDOT) projects. Fiber reinforced polymer composites, hereinafter referred to as composites, include for example: glass, carbon, aramid, or basalt reinforced polymeric materials. 12.1.2 AUTHORITY

Code of Federal Regulations (CFR), Federal-Aid Policy Guide (FAPG), Subchapter G - Engineering and Traffic Operations, Part 637 - Construction Inspection and Approval, Subpart B — Quality Assurance Procedures for

Sections 20.23(3)(a) and 334.048(3), Florida Statutes.

12.1.3 REFERENCES

Design Standards, Topic No. 625-010-003, Florida Department of

Florida Department of Transportation Standard Specifications for Road and

American Society for Testing and Materials (ASTM) Standard Test Methods and Specifications, Philadelphia, Pennsylvania

American Association of State Highway and Transportation Officials Anienam Association of State Highway and Transportation Officials (AASHTO), Part I Specifications, and Part II Tests, Washington, D.C.

Field Sampling and Testing Manual, Florida Department of Transportation US Department of Transportation Federal Aviation Administration, Advisory

Volume II: Fiber Reinforced Polymer Composites

http://www.dot.state.fl.us/programmanageme nt/Implemented/URLinSpecs/Section121V2.shtm

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Material Requirements

- Producer Quality Control
 - **Specifications Section 105**
 - Materials Manual Chapter 12.1
 - c) Specifications Section 932
 - Developmental pre July 2016
 - Standard July 2016 forward
 - Sizes and Strengths
 - Physical Property Requirements for **Producer Qualification**
 - Requirements for Acceptance at the Project Level
- 2. Acceptance at the Project Level
 - Certification
 - Sampling and Testing

NONMETALLIC ACCESSORY MATERIALS FOR CONCRETE PAVEMENT AND CONCRETE STRUCTURES 932-1 Joint Materials. 932-1 L1 Proformed Joint Filler for Payement and Structures: Preformed joint filler imperfections flush on the finished pads with a bonded vulcanized patch material compatible 932-1 Joint Materials. impertections must on the anisated page with a bonded vincounzed page material companion with the elastometric bearing pad. Repairs employing caulking type material or repairing the 932-2.6.1 Testing: Test bridge bearing pads in accordance with FM 5-598. Laminated bridge bearings must meet a minimum compressive load of 2.400 psi and non-Laminated orage oearings must meet a minimum compressive toad of 2,400 psi and non-laminated (plain) pads must meet a minimum compressive load of 1,200 psi. If any properties are lanumater (pram) page must meet a minimum compressive took or 1,200 pst. if any properties identified as non compliant with the criteria specified, the bearing shall be rejected and the Identified as non-compilant with the criteria specified, the ocating small of rejected and the confirmation sample tested. If the confirmation sample test results are also non-compilant, the pe III LOT shall be rejected 932-2.6.2 Marking: Each elastomeric bearing pad shall be permanently marked. The marking shall consist of the order number, LOT number, pad identification number. The marking snau consist of the order number, LOT number, pad menutication number, elastomer type, and shear modulus or hardness (when shear modulus is not specified). Where possible, the marking shall be on a face of the bridge bearing pad that will be visible after 932-2.6.3 Certified Test Results: For bridge bearing pads, submit complete certified test results from the independent laboratory for all tests specified, properly identified by 932-2.6.4 Certification: The Contractor shall submit to the Engineer a certification conforming to the requirements of Section 6 stating that the bearing pads, (plain, teatmenton conforming to the requirements of section to stating that the occurring parts, quantification shall the reinforced or elastomeric) meet the requirements of this Section. The certification shall aber reinforced or enstonency meet me requirements or ans section. The certification designate the bearings in each LOT and state that each of the bearings in the LOT was usasguare the occurings in each LOT and state that each of the occurings in the LOT was manufactured in a reasonably continuous manner from the same batch of elastomer and cured 932-3 Fiber Reinforced Polymer (FRP) Reinforcing Bars.

polymer (GFRP) or carbon fiber reinforced polymer (CFRP) reinforcing bars. All FRP

polymer (GFRF) or caroon more removed polymer (GFRF) removing ours. All FRF reinforcing bars shall meet the requirements of ACI 440.6 following the test methods from Femiorcing oars snan meet the requirements of AC1 440.0 following the less memoris non-ACI 440.3. Use only GFRP bars manufactured using glass fibers classified as E-CR or R that ACL 440.5. Use only OF KP bars manufactured using glass more classified as E-CK of K meet the requirements of ASTM D578. Meet the additional requirements of this Section following the sampling frequency and number of specimens required by ACI 440.6. ang me sampang nequency and manner of specimens required by ACL 440.0.

932-3.2 Additional Requirements for Bar Size and Strength: The nominal diameter of FRP bars shall be in 1/8 inch increments as described in Table 3-1.

The measured cross-sectional area of FRP bars, including deformations, lugs, and coating or any bond enhancing surface treatment shall be measured according to ASTM D7205 via the Archimedes method.

The minimum bar diameter, derived from the actual cross sectional area and alculated based on a circular cross section including any surface treatment, shall be greater than

The maximum bar diameter, derived from the actual cross sectional area and The maximum oar manneser, derived from the actual cross sectional area and calculated based on a circular cross section including any surface treatment, shall be less than or carcurated based on a circular cross section mending any surface meanings, shart or less the equal to the maximum bar diameter derived from the maximum cross section area given in

The nominal diameter and nominal cross-sectional area of an FRP bar shall be used as the bar size designation and for reinforced concrete design calculations and minimum

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http://www.dot.state.fl.us/programmanagement/OtherFDOTLinks/Developmental/Default.shtm http://www.dot.state.fl.us/programmanagement/Implemented/SpecBooks/default.shtm





Material Requirements

- 1. Producer Quality Control
 - a) Specifications Section 105
 - b) Materials Manual Chapter 12.1
 - c) Specifications Section 932
- 2. Acceptance at the Project Level
 - a) Certification
 - Notarized Statement from FRP Producer sent **prior to shipment**
 - Certificate of Analysis for each LOT sent with each shipment
 - b) Sampling and Testing

Blank Notarized Certification Statement Example "USE ON PLANT'S LETTERHEAD"

MATERIAL CERTIFICATION

FLORIDA D.O.T.

FIBER REINFORCED POLYMER PRODUCTS

Contractor:

F.D.O.T. Project Number:

F.D.O.T. Contract Number:

Project Location:

Description of Products:

We certify the described fiber reinforced polymer products will be manufactured by our plant in accordance with the requirements set forth in the Florida Department of Transportation Contract Documents and the plant's approved quality control plan. The plant's quality control manager or the inspectors under his/her direct supervision will inspect and review all QC records of the products prior to their shipment to the project site. Each shipment of the fiber reinforced polymer products to the project site will be accompanied with a signed or stamped delivery ticket. A certificate of analysis

Plant Company Officer or Designee:
Signature:
Date:

(Notarized)

MAC 3.

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Material Requirements

- 1. Producer Quality Control
 - a) Specifications Section 105
 - b) Materials Manual Chapter 12.1
 - c) Specifications Section 932
- 2. Acceptance at the Project Level
 - a) Certification
 - b) Sampling and Testing
 - Samples selected by Engineer after delivery to project
 - Contractor responsible for verification testing using independent ISO Lab
- 3. MAC





Material Requirements

- Producer Quality Control
 - a) Specifications Section 105
 - b) Materials Manual Chapter 12.
 - c) Specifications Section 932
- 2. Acceptance at the Project Lev
 - a) Certification
 - b) Sampling and Testing
- 3. MAC
 - a) Specifications
 - b) Production Facility Profiles and Listings





esign Training
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Research

- 1. Degradation mechanisms
- 2. Service life estimation
- 3. Performance of surface enhancements
- 4. Durability of bends
- 5. Field exposure

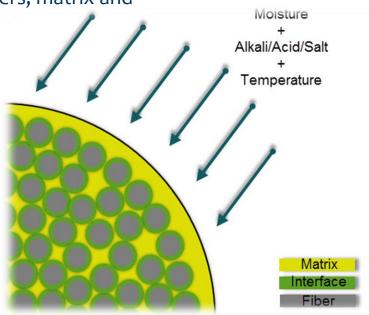
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Research

- 1. Degradation mechanisms
 - Model degradation of FRP in concrete based on synergistic effects of physical and chemical aging on fibers, matrix and interface
- 2. Service life estimation
 - Test protocol based on degradation model
- 3. Performance of surface enhancements
- 4. Durability of bends
- 5. Field Exposure



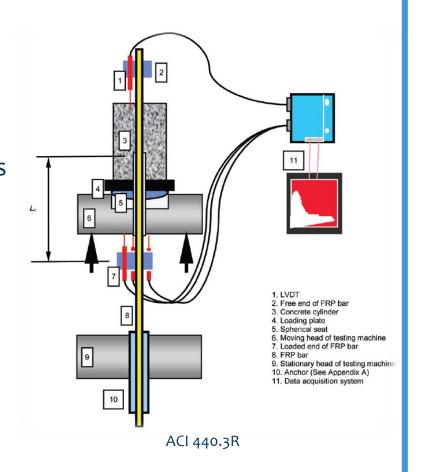
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Research

- Degradation mechanisms
- 2. Service life estimation
- 3. Performance of surface enhancements
 - Durability of rebar-concrete bond
- 4. Durability of bends
- 5. Field Exposure



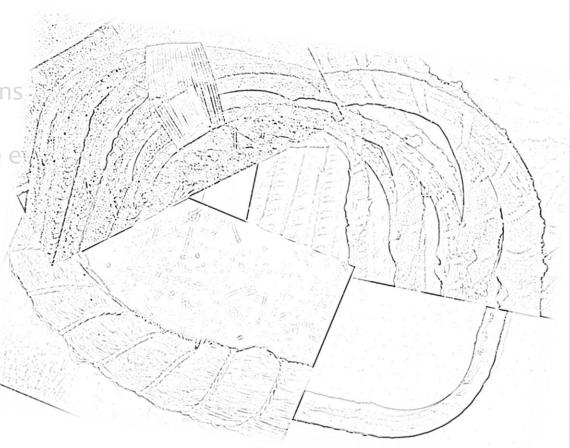






Research

- Degradation mechanisms
- 2. Service life estimation
- 3. Performance of surface e
- 4. Durability of bends
 - Effect of modified pultrusion on durability
- 5. Field Exposure



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Research

1. Degradation mechanisms

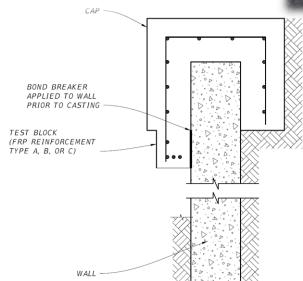
2. Service life estimation

3. Performance of surface enha

4. Durability of bends

5. Field exposure

Test blocks/beams





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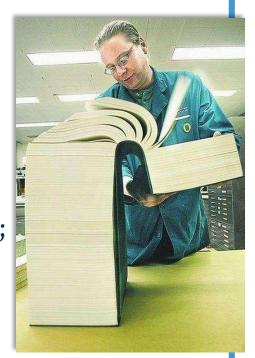
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Design Documentation

What's available from FDOT?

- 1. Design criteria
 - a) Fiber Reinforced Polymer Guidelines (FRPG)
 - b) Structures Design Guidelines (SDG);
- 2. Detailing criteria **Structures Detailing Manual (SDM)**;
- 3. Design Standards;
- 4. **Specifications** (Construction and Materials).



FDOT's Fiber-Reinforced Polymer Deployment Train

GFRP
Reinforcing
Bars

CFRP Prestressed Piles

Fender Systems





Design Documentation

- 1. Design criteria
 - a) Fiber Reinforced Polymer Guidelines (FRPG)
 - Overall commentary on FRP;
 - Specific design criteria, plan content and Specification requirements;
 - Design review requirements;
 - Approval of use process;
 - Permitted uses for each type of FRP.
 - b) Structures Design Guidelines (SDG)
 - Overall design criteria;
 - Revised and/or supplemented by Fiber Reinforced **Polymer Guidelines (FRPG)** for given applications of FRP.

http://www.dot.state.fl.us/structures/StructuresManual/CurrentRelease/ StructuresManual.shtm

FDOT's Fiber-Reinforced Polymer Deployment Train



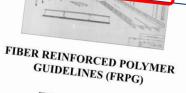
External FRP Laminate Repairs



Volume 1 - Structures Design Guidelines Volume 2 - Structures Detailing Manual

Volume 3 - Modifications to LTS-6

Volume 4 - Fiber Reinforced Polymer Guidelines



FDOT STRUCTURES MANUAL **VOLUME 4** JANUARY 2016



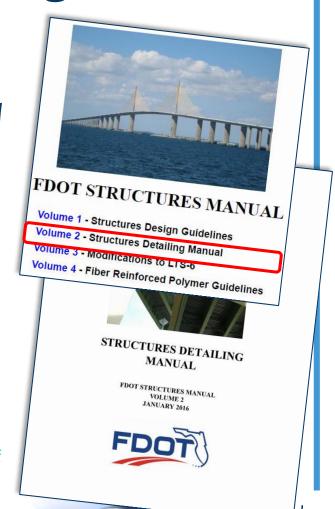
FDOT





Design Documentation

- Detailing criteria Structures Detailing Manual (SDM):
 - a) Overall detailing criteria;
 - b) Revised and/or supplemented by Fiber Reinforced Polymer Guidelines (FRPG) for given applications of FRP.



http://www.dot.state.fl.us/structures/StructuresManual/CurrentRelease/Vol4FRPG.pdf

FDOT's Fiber-Reinforced Polymer Deployment Train

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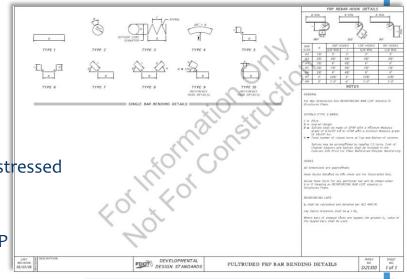


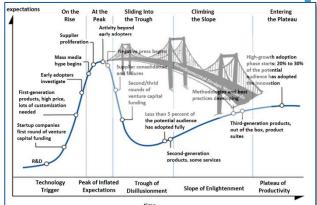


Design Documentation

Design Standards:

- a) FY2016-17 Design Standards:
 - Index 22600 series Square CFRP & SS Prestressed Concrete Piles;
- b) Developmental Design Standards:
 - Index D6011c Gravity Wall Option C (GFRP reinforced);
 - Index D21310 Pultruded FRP Bar Bending Details;
 - Index D22420 GFRP reinforced 32" F-Shape Traffic Railing;
 - Index D22440 series Precast Concrete CFRP/GFRP Sheet Pile Wall
 - Index D22900 GFRP reinforced Approach Slab;





FDOT's Fiber-Reinforced Polymer Deployment Train

GFRP
Reinforcin
Bars

CFRP Prestressed Piles

Fender Systems





Design Documentation

4. Specifications:

- a) Standard Specifications (effective July 2016):
 - Implemented previous FRP Developmental Specifications.
- b) Developmental Specifications:
 - Dev400FRP Concrete Structures Fiber Reinforced Polymer Reinforcing;
 - **Dev410FRP** Precast Concrete Box Culvert;
 - Dev415FRP Reinforcing for Concrete;
 - Dev450FRP Precast Prestressed Concrete
 Construction Fiber Reinforced Polymer (FRP);
 - Dev932FRP Nonmetallic Accessory Materials for Concrete Pavement and Concrete Structures;
 - Dev933FRP Prestressing Strand;





(Photograph) Hughes Bros. Coated tie wire.

FDOT's Fiber-Reinforced Polymer Deployment Train

GFRP Reinforcir Bars CFRP Prestressed Piles

Fender Systems





Roadmap to the safe deployment of GFRP reinforcement for concrete structures

- Barriers to expanded GFRP Implementation
- Potential Focus Areas



FDOT's Fiber-Reinforced Polymer Deployment Train

GFRP Reinforcing Bars CFRP Prestressed Piles

Fender Systems





Barriers to expanded FRP Implementation:

- 1. First cost
- 2. Lack of confidence in durability for submerged environments (FDOT seeking 75 100 year service life)
- 3. Limitations on the strength due to degradation of properties over time (currently C_E factor = 0.7 for GFRP exterior environments) [goes with item #2]
- 4. Limitations on strength due to low design resistance factors (phi factors) related to lack of ductility and strength variability in the FRP materials (currently 0.55-0.65 for tensioned-control to compression-controlled flexural failure modes)
- 5. Restrictions in bar bending capabilities, and challenges with field modifications to bar shapes
- 6. Low Elastic Modulus, resulting in greater deflections and larger crack openings
- 7. Update AASHTO Guide Specification

FDOT's Fiber-Reinforced Polymer Deployment Train

GFRP Reinforcin Bars CFRP Prestressed Piles

Fender Systems





Potential Focus Areas:

- 1. Rationalization of Resistance Factors (phi factors) used to address lack of ductility and variability in material strength properties;
- 2. Refinement of Environmental Reduction factors (CE);
- 3. Resolution of durability question in submerged environments;
- 4. Advancement in bent bar fabrication;
- **5. Mitigation of lower elastic modulus effects** as related to member deflections and concrete crack widths;
- **6. Investigate hybrid designs** using FRC and/or Carbon-steel strand with GFRP rebar:
 - Concrete Sheet Piles;
- **7. Improved FRP Industry coordination** especially between ACMA-TSC and AASHTO SCOBS-T6 (FRP) & T10 (Concrete);

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GFRP Reinforcin Bars CFRP Prestressed Piles

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Potential Focus Areas (cont.):

- 8. Continued Standardization
- 9. Accommodation of potential customization and optimization of FRP reinforcing and other products
- 10. Guidance on the use of Life Cycle Cost Analysis for FRP justification
- **11. Project Monitoring**
- 12. Outreach and Technology Transfer
- **13.** Repair Methods [added]
- **14. Bridge Inspection** [added]

FDOT's Fiber-Reinforced Polymer Deployment Train

GFRP Reinforcin Bars CFRP Prestressed Piles

Fender Systems





Questions ??



FDOT Contact Information:

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Ivan Lasa, B.S.C.E. (Corrosion Lab.) (352) 955-2901
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