SECTION III:

PROCESS CONTROL MANUAL

The primary objective of the process control manual is to ensure that bonded repair and retrofit of concrete structures using FRP composites are conducted in a manner that conforms to contractual and regulatory requirements. Conformance of the contractor's work to the requirements is verified on the basis of objective evidence of quality. This document supplements the construction specifications for bonded repair and retrofit of concrete structures using FRP composites.

The process control procedures and the systems outlined herein describe how the quality assurance (QA) program is designed to ensure that all quality and regulatory requirements are recognized and that a consistent and uniform control of these requirements is adequately established and maintained.

The success of the QA program depends on (a) thorough understanding of its aims and (b) its full implementation by the owner's representatives.

1 QA POLICY AND PROGRAM OVERVIEW

1.1 QA Policy

The QA program has been developed to ensure that the project is carried out in a planned, controlled, and correct manner. It includes procedures for scheduling and assigning work; recording, retaining and retrieving records for all construction activities; identifying and resolving deficiencies affecting the work; and verifying compliance with the requirements of the QA program.

The QA program can be modified, if necessary, to meet the needs of individual projects or to comply with any specific requirements or agreements. The program will implement those requirements and agreements by applying them to specific activities and will identify the items and services to which the program applies.

The QA procedures (QAPs) define the organizational structure within which the program is to be implemented and delineate the responsibility and authority of the various personnel involved.

The QA program will be periodically reviewed, audited and updated for improvement, as necessary.

1.2 QA—An Overview

1.2.1 Quality Definitions

- Quality Assurance (QA)—Established philosophy, programs and organization covering activities whose purpose is to ensure that the overall quality control program is being effectively implemented.
- Quality Control (QC)—A planned system of activities whose purpose is to provide a level of quality that meets the needs of users.

1.2.2 QA/QC Goals

- Develop staff understanding and acceptance of QA philosophy and procedures.
- Develop staff understanding of their particular roles in implementing QA/QC procedures.
- Meet the owner's need for a quality product.
- Ensure that appropriate procedures are followed at each step of the process from the inspection of incoming raw materials to the application of the final coating to achieve a specified performance.

1.2.3 Elements of QA Program

- Set out QA philosophy and QC procedures.
- Establish corporate and office QA staff functions.
- Host seminars on QA philosophy and QC procedures and other aspects relating to high-quality services and deliverables.
- Implement QA/QC procedures.
- Monitor adherence to policy and procedures.
- Monitor schedule adherence and check deliverables at milestones.
- Identify the type of contract to be signed and check for unrealistic responsibilities, warranties, indemnifications and ambiguous wording.

2 QA GUIDELINES FOR CONSTRUCTION ACTIVITIES

2.1 Responsibilities

2.1.1 QA Manager

The QA manager is responsible for the development and the implementation of the QA program and for ensuring adherence thereto. The QA manager monitors and audits all project activities on a systematic basis, documents the findings in project audits, and reports the findings to the unit manager, the

project manager, or technical department managers, as appropriate. The QA manager also identifies the corrective measures for all noncompliances with the QA program. The QA manager has the overall authority of initiating, redirecting or terminating activities so that they are consistent with the QA program. The QA manager may (a) initiate any activities that will ensure adherence to the QA program and (b) utilize the personnel necessary to properly administer the QA program. Specific duties of the QA manager include the following:

1. Developing, modifying, updating and implementing the QA program.
2. Assisting the unit managers in implementing the provisions of the QA program.
3. Assisting the project manager in establishing project-specific QA requirements based on the owner's special needs and the established standard procedures.
4. Instructing project personnel in using the QA procedures.
5. Monitoring adherence to the QA program.
6. Approving QA programs of contractors, subcontractors, and consultants, where required.
7. Providing input for reports, specifications, and other documents, where QA information is required.

2.1.2 Project Officer

The project officer is responsible for the preparation of letters of interest and proposals and for assisting in negotiations and finalizing the contract. Specific duties of the project officer during different phases include the following:

1. During the proposal phase:
   a. Developing the project scope in conjunction with the owner's goals and objectives.
   b. Determining QA program requirements and special QA procedures to be followed in the work process.
   c. Establishing the proposed project budget, schedule and staffing requirements.
   d. Directing the preparation of letters of interest, proposals and contracts.
   e. Participating in the negotiations.
   f. Signing the letters of interest, proposals and contracts.
2. During the selection phase:
   a. Selecting final prospective contractors, subcontractors and consultants.
   b. Establishing the work scope, schedules and budgets.
   c. Assisting in contract negotiation.
   d. Drafting and finalizing the contract terms.
   e. Disseminating all proposal and contract information to the project manager and other appropriate staff members.
   f. Establishing proposal budgets and schedules and controlling the costs during the precontract stage.
3. During the implementation phase of the project:
   a. Monitoring the project performance and the financial status.
   b. Meeting with the project parties, as needed, to assess work progress and address any possible concerns.

2.1.3 Project Manager

The project manager is responsible for maintaining liaison with different parties, as well as overall responsibility for all technical and administrative aspects of the project. The project manager reports to the project officer and the unit manager, as required. The project manager has the authority to make modifications to the requirements of the QA program in order to comply with the owner's special requirements and to suit objectives of a particular job. The project manager will also determine which QA procedures are to be followed and will modify those procedures as necessary to suit specific job requirements, all subject to the approval of the QA manager. Specific duties of the project manager include the following:

1. Review the project scope, contract plans and specifications for construction-related services.
2. Satisfy the organizational needs, equipment and staffing requirements to adequately implement required QA program activities.
3. Implement and monitor the QA program activities for the project.
4. Monitor compliance with the provisions of the contract.
5. Maintain the relation between the owner and the contractor.
6. Resolve errors and omissions on construction plans and specifications and assist in the solution of technical problems.
7. Receive all project information and properly disseminate it to the appropriate staff members.
8. Approve reports, specifications and drawings.

2.1.4 Resident Engineer

Responsibilities of the resident engineer include the following:

1. Review construction plans and specifications and review the contract for construction-related services.
2. Establish QA program activities, responsibilities, and documentation requirements.
3. Implement and administer the day-to-day QA program activities to verify conformance to the plans, specifications and the referenced quality standards. Expedite distribution of the QA program documents and information.
4. Coordinate QA program activities with the project manager, the design engineer, the contractor and its

subcontractors. Receive and review staff comments on the quality of the work and take action as required. Advise the project manager of potential or existing quality problems.

5. Review and evaluate all required inspections, nonconformances and audit reports. Ensure that reports are timely, accurate, distributed and reconciled. Address and resolve quality problems reported by the construction inspectors. Verify that the contractor's QC procedures and reporting systems are adequately established, accurate and current.
6. Assist the project manager in evaluating the staffing requirements and qualifications of project personnel. Verify individual qualifications.
7. Review technical information submitted by the contractor to ensure conformance to the submittal requirements of the plans and specifications.
8. Direct all required inspections of the procured materials for incorporation in the project work. Monitor the quality certifications, proper quantities, and required identifications. Monitor inspection for, and documentation of, any shipping and/or storage damages.
9. Review test reports of the materials to verify that the specified tests have been performed in the required number or frequency. Indicate conformance or nonconformance with the plans and specifications and referenced quality standards.
10. Instruct and train the construction inspectors in their particular duties pertaining to the current and upcoming project work.
11. Review and evaluate claims, requests for change orders and time extensions in accordance with the provisions of the plans and specifications. Make recommendations to the project manager for resolution of any contractual dispute.
12. Supervise all administrative services needed to document the construction process.
13. Report work progress, schedule, tests and contractual matters, as specified.

2.1.5 Office Engineer

Responsibilities of the office engineer include the following:

1. Develop and maintain the QA program records system and the project-filing index in cooperation with the resident engineer. Monitor the activities of recording clerks.
2. Receive, file and distribute to designated recipients the QA program all documents produced by the construction inspectors, the resident engineer, testing laboratories and the contractor.
3. Monitor and evaluate, under the direction of the resident engineer, the reporting of quality data.
4. Assist the resident engineer in monitoring the contractor's QC programs. Verify implementation of the contractor's QC documentation at all levels of inspection.
5. Verify the quality documentation of furnished materials and equipment upon arrival at the construction site.
6. Review material test reports for adequacy, completeness, and conformance to specifications and the referenced quality standards.
7. Provide accurate reporting of all QA program activities to verify compliance with the plans and specifications. Assist construction inspectors with the production of QA program records.
8. Produce, or secure and maintain for use, a set of up-to-date "as-built" or record drawings. Verify accuracy, current revisions, and reproducibility of "design" drawings and their certification. Verify the distribution of up-to-date contract documents to the field staff and the contractor.
9. Verify that materials incorporated in the work are identified by dates, bulletin numbers, change order numbers, signatures and other pertinent data requirements.
10. Act, in the absence of the resident engineer, on matters concerning the QA program for the project.
11. Maintain the QA program files to provide identifiable, retrievable and reproducible construction documents; include contract drawings, specifications and records of incorporated materials and equipment, tests and inspection data.

2.1.6 Construction Inspectors

Responsibilities of the construction inspectors include the following:

1. Maintain daily contact with the resident engineer and the office engineer, and assist in the implementation of the QA program activities.
2. Perform daily visual on-site inspections of construction quality and materials. Document project activities, payment quantities and QA program activities. Prepare daily inspector's reports (DIRs). Coordinate inspection activities with the inspections of the contractor, the materials test laboratory technicians, and the owner's representatives according to the scheduled QA program activities.
3. Witness all required field tests by the contractor. Verify that the individual performing the test signs the test documentation. Indicate witnessing the test where applicable, date the document, and indicate concurrence with the results.
4. Verify during preparatory inspection meetings with the contractor representatives that contract-required engineering and quality-related documents have been submitted and approved prior to commencing the work.

5. Advise the resident engineer of potential or existing quality problems.
6. Record tests witnessed and inspections performed on the DIR, and verify that the report is timely, accurate and signed.
7. Review material test reports to verify that the specified tests are performed in adequate number and that the results are in accordance with the contract plans, specifications, and the referenced quality standards.
8. Assist during receiving inspections of materials and equipment for proper quantity, identification of any shipping damage, and conformance with the procurement documents. Receive and file certificates of compliance, shipping documents and logs.
9. Maintain testing equipment in working order. Arrange for calibration of test equipment at required intervals. Document calibration of test equipment.
10. Verify that work in the field is performed in accordance with contract plans and specifications. Ensure that plan sets issued for construction are current.
11. Coordinate with or assist survey crews to verify correct locations, alignments and elevations of ongoing or completed work.

2.2 Preparation of a Project-Specific QA Plan

2.2.1 Project Start-Up Considerations

An important QA element before starting a construction project is becoming fully familiar with the intent and details of the plans and specifications. Identifying any apparent errors, omissions or ambiguities early in the project will help ensure quality and will limit change orders and contractual disputes. The project start-up duties for the project team include the following:

1. Review the contract for the performance of construction-related services and list those administrative, inspections, observation duties and procedures for which the contractor is responsible. A sample of duties that the contractor is solely responsible for includes the following:
   a. Contractor's means and methods for construction.
   b. Safety of contractor's work force.
   c. Contractor's adherence to schedule, etc.
2. Assisted by the chief or senior construction inspector, review the construction contract documents (plans and specifications) between the owner and the contractor. List all administrative, procedural, inspection, and field testing responsibilities to be performed. At this stage, any discrepancies and ambiguities in the duties and responsibilities should be identified and resolved prior to proceeding with the project.
3. Understand the impact of any imposed environmental, phasing or operational limitations or constraints on the construction processes.
4. Review the proposed project staff and organization for the following:
   a. Adequacy of staff positions needed to cover the contractual obligations.
   b. Required staff licensing and certification.
   c. Technical qualifications and experience of assigned personnel, contractors and its subcontractors for specialty services.
   d. Need for staff training in specific inspection procedures, safety awareness, and limitations in the authority, relations with the contractor, its subcontractors, the owner, and the public.
5. Review the physical aspects of the project work area and adequacy of the facilities provided to house construction site staff.
6. Verify the availability of measuring and testing (M&T) equipment and instruments needed to verify the quality of components to be incorporated into the finished work. Check that licenses needed to own, store, or operate M&T equipment are on file. Determine which testing will be done in-house and which will be done by an independent facility.
7. Ensure availability of all forms needed to document the quality of the constructed project and its administrative processes.

2.2.2 Considerations Related to the Verification of Quality of the Constructed Project

Review the contract agreement for the specific obligations related to the following.

2.2.2.1 Document Control

Establish procedures for issuance and transmission of design revisions and addenda to the plans and specifications, shop drawings, staging and phasing plans, traffic control plans, contractor's required submissions of work plans, schedules and general correspondence.

2.2.2.2 Constructability Review

Following are important items to consider during the constructability review:

1. Check for realistic scheduling of work activities. Identify need for overtime and double-shift work and unusually high-peak demand for machinery and construction plant.
2. Check the proposed construction schedule for compatibility with sequencing and phasing of the work, as related to natural phenomena, such as high flood periods, hurricane seasons, high tides and general inclement weather periods.
3. Check for proper sequencing of operations. Identify any operations that are on the critical path and that

could cause delays and possible loss of a construction season.

4. Check for adequate rights-of-way and access to the construction areas. Verify adequacy of areas reserved for contractor's work, lay down and storage areas.
5. Check for interference with traffic, utilities and other ongoing or sequential contract work by others.
6. Identify long-lead items and the need for unusual construction materials and equipment.
7. Check for use of appropriate materials and up-to-date designs and technology. Identify the use of unconventional or highly specialized designs or expensive materials, which could limit competition and result in high bids. Verify that new materials are being used in the manner intended by the manufacturer.
8. Check contract documents for ambiguities and inconsistencies that could lead to schedule delays, contractual disputes and possible legal actions. Verify that details shown are adequate to ensure proper erection and construction sequencing.
9. Check for community impacts such as noise, dust, and release of toxic or otherwise unsafe materials into the environment.
10. Check for conformance to all governmental regulations that safeguard the environment, the work place and the public.
11. Check that accessibility for maintenance, repair and in-service inspection has been provided. Review maintenance, repair and inspection requirements and verify that the design shown on the drawing provides adequate access for these activities.
12. Avoid duplication of data in the specifications and the drawings by ensuring the following:
    a. Dimensions are correct and consistent, and tolerances are appropriate.
    b. Drafting practices conform to the standards specified.
    c. Drawings are legible.
    d. Drawings reproduce satisfactorily.

2.2.2.3 Quality Aspects of Construction Specifications

Problems related to the specifications that may lead to change orders, claims, arbitration and litigation are broken down into the following categories in descending order of frequency.

"Or Equal" Specifications

To avoid problems with "or equal" specifications, it is best to list those physical or functional properties of the name brand product you wish to see duplicated in the "or equal" product.

Constructability

Contract documents may be defective if the work shown is not reasonably constructible. Remember the ordinary sequence of trades in the construction process, and look for bad phasing or details that require a succeeding trade to install something before the preceding trade would normally arrive on the job.

In setting the tolerances, be sure that they follow industry standards or are no more stringent than contained in standard specifications. If more stringent tolerances are required, word the specifications so that the contractor's attention is alerted to this fact so that he/she can adjust his/her normal work methods and pricing to achieve the results required.

Overly strict or literal interpretation of the specifications on tolerances beyond the normal industry standards generally results in change order decisions in favor of the contractor.

Ambiguities and Typographical Errors

Ambiguities in the specifications are usually the result of duplication, which is to be avoided. If there are two ways of reasonably interpreting documents, the courts will usually side against the preparer. The use of standard specifications will help reduce this category of problems.

Conflicts Between Plans and Specifications

Specifications usually contain a clause in the general provisions establishing an order of precedence between the various contract document components:

1. Signed contract
2. Other provisions such as special conditions
3. General provisions
4. Plans
5. Technical specifications

To minimize conflicts between plans and specifications, it is important to avoid duplication. Avoid repeating the same information in plans and specifications. If an entire specifications section is in the plans, that section should be omitted entirely from the specifications. Construction contracts frequently contain a clause that in effect says that anything mentioned in the specifications and not shown on the plans or shown on the plans and not mentioned in the specifications shall be interpreted as being shown or mentioned in both. The case of an item mentioned only in the specifications and not shown on the plans can lead to change orders on the basis that the contractor had adequate information as to quality, but was unable to assess the cost of installing the item because its physical relation to other project components was not defined or was lacking. Leaving something out of the specifications that is shown on the plans leaves open the possibility for the contractor to supply the cheapest possible alternative.

Inspection Requirements

Overly restrictive tolerances have been discussed above. Inspection or observation of the contractors' work invariably creates some interference with the performance of the work by the contractor. Frequency of tests and observations should be in line with the normal industry standards or the standard specifications. Failure to adhere to the industry norms may produce claims. Overzealous or inconsistent inspection, although not

part of this general subject, also is a frequent cause for change order claims in this category.

Safety and Health Requirements

Failure to comply with local codes can result in lawsuits, charge-backs, or awards against the design engineer.

2.2.2.4 Product Identification, Traceability and Certification

1. Establish procedures for identifying materials and products, including documentation needed to verify the quality of products and materials, such as batch plant records, laboratory tests, catalog cuts and any other documentation.
2. Comply with storage requirements to prevent deterioration of materials and products at the work site, including preventive maintenance while in storage.
3. Comply with requirements for identification, rejection, or segregation of substandard or unacceptable materials or products.
4. Comply with requirements for identification of certified materials and identification of the status of tests and inspections for incorporated materials, including specified marking, tagging, and stamping and/or physical isolation.

2.2.2.5 Process Control

Comply with requirements in regard to specified construction processes.

2.2.2.6 Inspection and Testing

The contract plans and specifications should be checked for any testing requirements, sampling frequency, acceptance criteria and tolerances. Easy checklists should be developed to assist the construction inspectors in assessing conformance to all testing requirements and to ensure proper record keeping. Examples of checklists are provided in Section 2.2.7. Following are the steps required to develop QC procedures for testing and inspection:

1. Study the plans and specifications to identify all testing and inspection requirements for the project.
2. Assemble relevant contract documents needed to determine standards to be met for each test or inspection.
3. Develop any necessary checklists and train inspection staff.
4. Monitor for compliance to specified standards to be met according to the plans and specifications for the following:
   a. In-process tests and inspections
   b. In-plant tests and inspections
   c. Receiving inspections
   d. Final testing and inspections
5. Record results of required tests, inspections and observations in a timely manner on standard forms.

2.2.2.7 Maintenance of Measuring and Testing (M&T) Equipment

1. Establish a calibration and maintenance program for all M&T equipment used at the work site under the control of the field staff. The program may include specific contractual requirements, industrial or national standards and guidelines, or M&T equipment manufacturer's recommendations.
2. Document actions taken to calibrate and maintain testing equipment used and controlled by the work site inspection staff.
3. Obtain acceptable calibration and maintenance documentation for testing the subcontractor's M&T equipment.

2.2.2.8 Certification of Trade Workers

Monitor compliance for contractual requirements relating to the qualifications of trade workers performing project work, such as specified licenses and certifications. Monitor for compliance with mandated training programs for the contractor's staff.

2.2.2.9 Identification of Nonconforming Work

1. Review for compliance with specified procedures for identification and documentation of nonconforming work.
2. Evaluate and resolve remedial actions according to the options allowed in the plans and specifications such as the following:
   a. Reworking to meet requirements.
   b. Acceptance of work with or without repair.
   c. Use of materials or products at an alternative application or location.

2.2.2.10 Implementation of Corrective Actions

Initiate and monitor corrective actions as governed by the applicable provisions of the plans and specifications:

1. Monitor corrective actions for effectiveness.
2. Proactively investigate causes for nonconformance and formulate remedial or alternative processes to prevent recurrences.
3. Implement and document process changes resulting from corrective actions.

2.2.3 Considerations Related to Performance and Administrative Services

Review the plans and specifications for specific obligations related to the following categories.

2.2.3.1 Claims and Change Orders

1. Implement specified procedures for handling and resolving claims, requests for extra compensation, time extensions and change orders.
2. Conduct a timely analysis of claims and change order requests, and formulate clear and concise recommendations for their resolution.
3. Identify early potential claims and their impact on project costs and schedule. Formulate strategies for limiting claims.

2.2.3.2 Shop Drawings

Implement specified procedures for the handling of shop drawings. Monitor and facilitate the timely review of these documents by the proper party, including documentation of the process.

2.2.3.3 As-Built or Record Plans

Monitor the performance of contractual requirements for compiling and maintaining a current and updated record set of contract drawings and specifications. The record set may be compiled and produced by the contractor or by the owner's representative field staff, as contractually specified. Identify the reason for field changes in a separate record, and document any time or cost implications.

2.2.3.4 Coordination of Construction Activities

1. Schedule and conduct progress meetings, prepare agendas for meetings, and distribute memorandums of meetings to all attending parties. Identify issues requiring follow-up action. Designate the action party, and set time limits for the requested action. Monitor coordination of activities between the primary contractor and its subcontractors.
2. Review the contractor's work schedule. Identify any schedule slippage and review remedial actions proposed by the contractor to meet the approved schedule.
3. Monitor coordination between the contractor and its subcontractors and impacted agencies, companies and jurisdictions.

2.2.4 Record-Keeping Considerations

Sufficient documentation and records shall be accumulated to provide objective evidence that the construction process was performed in accordance with accepted engineering practice and with contractual requirements. The documentation should include not only the final design documents, such as drawings and specifications, but also all construction records and any communications, instructions and directives that have a direct bearing on the project.

A record-keeping system should be established prior to starting the project. The system, at a minimum, should be able to do the following:

1. Organize project files according to a mandated file index system or one developed for the particular project. Maintain the filing system to permit the timely and accurate retrieval of documents.
2. Establish and maintain separate files for documents to indicate the compliance with the QC system for the project. Records that document adherence to the provisions of the plans and specifications include the following:
   a. Inspection logs, daily inspector's reports and diaries
   b. Test data, including mill tests and certifications
   c Qualification reports
   d. Validation and calibration reports
   e. Material review reports
   f. Batch plant records
3. Prepare correspondence on a timely basis. Log incoming and outgoing correspondence. Log general complaints from the public, and document environmental issues arising from the general public and governmental agencies. Log pending or follow-up correspondence.
4. Identify the receiving organization for project records and files at completion of project. Establish a retention time for project files.
5. Maintain at the work site's required publications, documents and other materials referred to in the plans and specifications needed to properly understand and carry out the work scope and to comply with the requirements of the owner and of those of regulatory entities and standard-setting associations.

2.2.4.1 Retention of Records

Reports and records to be retained shall be determined by the project manager and/or the department managers. Records designated for retention shall be legible, suitable for reproduction, complete and adequately identifiable to the item involved.

2.2.4.2 Subcontractor Records

Records of subcontractors shall be controlled and retained in the same manner as records of the contractor.

2.2.4.3 Permanent Storage of Records

Permanent documents designated for storage shall be stored in the project file.

2.2.4.4 QA/QC Records

A single file identified as "QA/QC Records" containing copies of all QA/QC documents shall be maintained in the project files.

2.2.5 Elements of a Project-Specific QA Plan

In the absence of an owner-directed format and content requirement, the following format and content is suggested:

Section 1 *Organizations for Quality*—Provide an organization chart and description of the quality

process, who implements it, who monitors it and who has the ultimate responsibility.

Section 2 *Quality Review*—Identify the internal unit level reviewer delegated to conduct primary QA reviews, the schedule for such reviews, and the format of the reviews.

- The suggested format of the review is a brief summary memorandum outlining the highlights of the review and any recommended corrective actions to be taken. The completed checklists are to be appended to the summary review memorandum. The recipients (distribution) of the QA reviews shall be listed.
- Define the implementations of corrective actions to be taken and the required documentation needed to close out all listed corrective actions.

Section 3 *QA Records*—Define how the Project QA reviews and documentation of any completed remedial actions shall be maintained as a permanent part of the project files. Specify that additional copies shall be filed with the unit's construction service coordinator together with the minimum retention period after project close out.

2.2.6 Preparation of Project-Specific QA Checklists

After the project-specific responsibilities and duties have been identified, they can be subdivided into the following broad categories:

1. Staffing and staff qualifications
2. Contract documents
3. Project files
4. Project start-up requirements
5. Miscellaneous contractual requirements
6. Claims and change orders
7. Schedule monitoring
8. Estimates and payments
9. Construction close-out
10. Daily inspection reports
11. Materials and materials certification: general
12. Materials and materials certification: specific

For each of the first 12 subdivisions, a pro-forma QAP checklist has been prepared listing concerns generally of relevance in assessing the quality of services that the contractor is providing.

The resident engineer and the chief or senior construction inspector in conjunction must review these draft QAP checklists with the contract documents for the construction-related services. Any additional specific responsibilities imposed on the contractor in these contract documents should be added to the draft QAP checklist items listed under the appropriate subdivision. Blank spaces have been provided in each subdivision to customize the draft QAP checklist to the demands of the specific project. Add sheets as needed.

The draft checklists for materials and materials certification, in particular, are very general and are limited to just a few of the standard technical construction specification divisions. These checklists must also be augmented with the quality requirements for those materials in the project's particular contract specifications. Additional checklists should be prepared for each of the major specification divisions that are part of the particular contract and that require staff involvement in certifying, observing, inspecting, testing or assessing results.

To allow further flexibility in the arrangement of checklists, the resident engineer may wish to reorganize the checklists in accordance with the applicable paragraphs of the general and special provisions of his/her particular job.

Some owners, mostly state DOTs, require their construction services providers to formulate their own QA plan. Such QA plans are based on specific guidelines required by the owner and are generally similar to the QAP checklists that follow.

2.2.7 QAP Checklists for FRP Construction

A comprehensive QA/QC program implemented and monitored by the FRP material suppliers and the FRP installation contractors should be maintained in order to ensure quality repair. QC is the direct responsibility of the contractor and should cover all aspects of the strengthening project depending on the size and complexity of the project at hand. QA during construction is the responsibility of the owner and can be achieved through a set of inspections, measurements, and applicable tests as specified in the construction specifications. The QAP checklists provided in this section address the most important parameters in the application of FRP systems. These checklists are offered as examples and are designed to assist the owners in developing their QA requirements. They follow the construction specifications for bonded repair and retrofit of concrete structures using FRP composites.

2.2.7.1 Project Start-Up Requirements (QAPs 1 through 6)

Prior to starting construction, all contractor shop drawings should be reviewed in light of the design plans and specifications to ensure adherence to the contract documents. Any perceived conflicts should be resolved prior to starting the work. The contractor should submit a material certification and identification of all the FRP materials to be used. The quantity, location and orientation of all FRP reinforcing materials to be used should be specified. The owner should ensure that the project is adequately staffed for the complexity of the job and the approved construction schedule. The qualification of contractor personnel should be evaluated to ensure that personnel have the skills, ability and experience necessary for FRP strengthening projects.

2.2.7.2 Material Qualification and Acceptance (QAP 7)

The FRP materials should be qualified on the basis of the plans and performance specifications requirements. The contractor should provide information demonstrating that the proposed FRP material meets all design and specifications requirements such as tensile strength and modulus, durability, bond strength, and glass transition temperature. Performance tests on the supplied materials should be performed according to the QC test plan and should meet the requirements specified in the engineer's performance specifications. These tests may include measuring parameters such as the tensile strength and modulus, glass transition temperature, gel time, pot life, and the adhesive shear strength. The results from independent tests of the FRP constituent materials and laminates fabricated with them should be submitted by the contractor for approval prior to starting the work. Material property information supplied by the manufacturer or material supplier could form the basis for acceptance of the FRP materials if no testing requirements are stated in the construction specifications.

2.2.7.3 Removal of Defective Concrete and Restoration of Concrete (QAP 8)

The work under this section consists of restoring delaminated, or otherwise deteriorated, concrete on selected elements using polymer- or latex-modified concrete. Concrete restoration shall include the removal of all delaminated concrete from the area to be restored and an additional 1 to 2 in. from behind the reinforcement in delaminated areas. Any loose concrete remaining in the damaged region must be removed, leaving the member with sound concrete. Surfaces where the carbon FRP (CFRP) system is to be applied must be sound. Concrete spalls and delaminations must be repaired according to the procedure identified in the plans and specifications.

2.2.7.4 Inspection of Concrete Substrate (QAP 9)

The concrete surface should be inspected before the application of the FRP material. The surface should be prepared in accordance with the engineer's specifications. The concrete surface should be examined for surface smoothness or roughness, holes, cracks, corners, and other imperfections.

2.2.7.5 Application Conditions (QAP 10)

The ambient temperature, concrete surface, and surface dryness should conform to the engineer's specifications. FRP application should be halted if rain appears to be imminent. If rain is threatening after starting the application process, the contractor should be instructed to protect the installed areas against contact with surface moisture.

2.2.7.6 FRP Application Process (QAPs 11 through 13)

Special care shall be taken to keep all records on the quantity of mixed resin during a 1-day period, the date and time of mixing, the mixture proportions and identification of all components, the ambient temperature, the humidity, and other factors affecting the resin properties. These records shall also identify the FRP sheet used each day, its location on the structure, the ply count and direction of application, and all other useful information. Sample FRP plate specimens shall be fabricated according to a predetermined sampling plan under the same ambient conditions and procedures used to apply the FRP material to the concrete surfaces. Performance tests on these FRP specimens may be conducted as needed. The evaluation of the relative cure of FRP materials can be performed (1) at the laboratory by testing sample plate specimens or resin samples using ASTM Standard D3418 or (2) at the construction site by physically observing resin tackiness and hardness of work surfaces or retained resin samples. Visual inspection of fiber orientation and waviness may be required for specific FRP material systems, since poor orientation infers misalignment of the entire system from the angles specified in the drawings. Fiber misalignments of more than 5° from the specified angle ($^{1}/_{12}$ slope) may adversely affect the provisional performance of the FRP reinforcement and should be reported to the engineer. Noncompaction of fiber sheets when multiple plies are applied can result in significant voids, sagging, and local areas of debonding, all of which will substantially affect the overall performance of the FRP system and should be reported to the engineer. Additional information is provided for precured and near surface mounted FRP systems.

2.2.7.7 Identification of Defective Work (QAP 14)

The inspection program should cover such aspects as the presence and extent of delaminations, the cure of the installed system, adhesion, laminate thickness, fiber alignment and material properties.

2.2.7.8 Postapplication—QC Tests (QAP 15)

An inspection of the FRP repair system should be conducted after the full cure. Delaminations if detected should be evaluated considering their size and number relative to the overall application area, as well as their location with respect to structural load transfer. The inspection methods may include visual assessment, acoustic sounding (i.e., hammer sounding), ultrasonics, and thermography. Tension adhesion testing of cored samples should be conducted using known methods such as those described in ACI 503R or ASTM D4541. The sampling frequency should conform to the engineer's specifications. Cored samples required for adhesion testing can also be used to determine the laminate thickness or the number of plies. Approved methods to repair FRP materials having some delaminations may be used depending upon the size, number, and location of delaminations. These repairs should be performed in accordance with the engineer's specifications. The laminate should then be reinspected following delamination repairs, and the resulting delamination maps or scan should be compared with that of the initial inspection to verify whether the repair was properly accomplished. All inspection

records and test results related to the FRP material should be retained. It should include delamination repair, on-site bond tests, anomalies and correction reports, and all physical test results from the designated laboratories.

2.2.7.9 General Job Administration (QAPs 16 through 20)

QAPs 16 through 18 address general job administration conditions such us claims and change, orders, schedule monitoring, estimates and payments, and DIRs.

The checklists at the end of this section are pro-forma and must be modified to the particular project. The attached diskette provides Word files for the checklists so that users can modify the checklists.

3 IMPLEMENTING AND MONITORING THE QA PROGRAM

3.1 Implementing the QA Program

The unit manager or his/her representative shall be responsible for implementing the QA program. This may be done by way of regularly scheduled project status meetings, QC reviews, spot checks and interviews with staff, or other means as determined by the unit manager. Any deficiencies, errors or nonconformances detected shall be addressed and corrective measures instituted.

The procedure for implementing the QA program is as follows:

1. The unit manager shall review the work in progress, design documents, records and project files for conformance to established procedures and generally accepted engineering practice. He/she may question staff regarding their knowledge and implementation of the QA program and shall provide instruction and assistance in its proper applications.
2. Any deficiencies, errors or nonconformances that may affect the quality of the work shall be immediately brought to the attention of the project manager and/or department managers. Deficiencies, errors, or nonconformances of a minor nature shall be brought to the attention of the individual involved for corrective action.
3. Deficiencies in staff or facilities shall be addressed by the unit manager or referred to the corporate staff for assistance, as required.

3.2 Monitoring the QA Program

The QA manager shall be responsible for monitoring the implementation of the QA program. This may be done by way of periodic project audits, spot checks, interviews with staff, or other means as determined by the QA manager. Any deficiencies, errors or nonconformances detected shall be reported and corrective measures instituted by the project manager under the direction of the unit manager. Nonconformances should be reaudited to ensure compliance.

The procedure for monitoring the implementation of the QA program is as follows:

1. The QA manager shall periodically review projects in progress or recently completed. He/she shall review design documents, records and project files for conformance to the established procedures and general good engineering practice. He/she may question staff regarding their knowledge and implementation of the QA program and shall provide instruction and assistance in the program's proper applications.
2. Any deficiencies, errors or nonconformances that may affect the quality of the work shall be immediately brought to the attention of the unit manager, project manager and/or department managers. Deficiencies, errors or nonconformances of a minor nature shall be brought to the attention of the individual involved for corrective action.
3. The QA manager shall review any corrective actions that have been taken and shall report instances of inadequate action or unresponsiveness to the president for appropriate action.

FORM NO. QAP 1
Project Start-Up Requirements

Project No: _____ Project Name: _____

YES	NO	N/A	
_____	_____	_____	1. Have the construction contract documents been preliminarily reviewed for their overall completeness, obvious errors and omissions, constructability, etc.?
_____	_____	_____	a. Have the provisions been reviewed with the field staff?
_____	_____	_____	b. Have the design engineer and the owner been advised of findings?
_____	_____	_____	2. Have the contract documents for construction-related services between the consultant and the owner been reviewed against the construction contract documents to identify possible conflicts in imposed duties and responsibilities?
_____	_____	_____	a. Have all perceived conflicts been resolved?
_____	_____	_____	3. Has a preconstruction meeting been held?
_____	_____	_____	a. Is the agenda for the preconstruction meeting in accordance with the owner's requirements?
_____	_____	_____	b. Are minutes of the meeting in the files?
_____	_____	_____	4. Has contractor submitted all required documents on time:
_____	_____	_____	a. Insurance certificates?
_____	_____	_____	b. Bonds?
_____	_____	_____	c. Construction inspector qualifications?
_____	_____	_____	d. Permits?
_____	_____	_____	e. Equipment calibration?
_____	_____	_____	f. Quality control plans?
_____	_____	_____	g. Material safety data sheets?
_____	_____	_____	h. Schedules?
_____	_____	_____	i. Certificate(s)?
_____	_____	_____	5. Have accident and emergency reporting procedures and documentation been established and reviewed with the field staff?
_____	_____	_____	6. Are all forms needed to document the construction processes and quality of the work on hand at the start of the project?
_____	_____	_____	7. Is the project fully equipped with necessary field measuring and testing equipment?
_____	_____	_____	8. Is the measuring and testing equipment periodically re-calibrated according to the manufacturer's recommendation?
_____	_____	_____	9. Are calibration documents on file?

Remarks:

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Reviewer/Date: _____

Resident Engineer/Date: _____

FORM NO. QAP 2
Contract Documents

Project No: _____ Project Name: _____

YES	NO	N/A	
_____	_____	_____	1. Is a complete set of contract documents available?
_____	_____	_____	a. Plans?
_____	_____	_____	b. Specifications?
_____	_____	_____	c. Other?
_____	_____	_____	2. Are all design changes and amendments incorporated in these documents?
_____	_____	_____	3. Are all field changes incorporated in the documents?
_____	_____	_____	4. Are “as-built” plans being updated to reflect field revisions?
_____	_____	_____	5. Have all design and field changes been signed and sealed by the design engineer?
_____	_____	_____	6. Have all design and field changes been included and approved in the change orders?
_____	_____	_____	7. Are shop drawings being logged and tracked?
_____	_____	_____	8. Are all support documents required or referenced in the construction engineering and inspection contract available on site?

Remarks:

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Reviewer/Date: _____

Resident Engineer/Date: _____

FORM NO. QAP 3
Specifications Review Checklist

Project No: _____ Project Name: _____

YES	NO	N/A		
_____	_____	_____	1.	Are the specifications complete and clear to the extent necessary to properly specify construction and performance requirements?
_____	_____	_____	2.	Have duplications or inconsistencies between contract drawings and the specifications been eliminated?
_____	_____	_____	3.	Are proper codes, standards, processes, etc., referenced?
_____	_____	_____	4.	Are requirements for shop drawings properly specified, as to both content and timely submission?
_____	_____	_____	5.	Are new materials employed and installed in the manner approved by the manufacturer?
_____	_____	_____	6.	Is proper test and inspection documentation specified?
_____	_____	_____	7.	Are the acceptance criteria tests (tolerances, etc.) specified, and are they adequate, realistic, and in line with the ordinary construction practice?
_____	_____	_____	8.	Are provisions made for the qualification and approval of special construction processes and for the personnel performing these processes?
_____	_____	_____	9.	Are measuring and testing equipment calibration requirements and cleaning, storage and handling requirements properly specified?
_____	_____	_____	10.	Are the measurement units and the basis of payment properly specified?
_____	_____	_____	11.	Is nomenclature used in the specifications exactly as it is used on the contract drawings?

Remarks:

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Reviewer/Date: _____

Resident Engineer/Date: _____

FORM NO. QAP 4
Drawing Review Checklist

Project No: _____ Project Name: _____

YES	NO	N/A		
_____	_____	_____	1.	Is the scope of the set of contract drawings satisfactory?
_____	_____	_____	2.	Do the structures, equipment or components satisfactorily meet the functional needs and requirements?
_____	_____	_____	3.	Has accessibility for maintenance, repair and in-service inspection been provided?
_____	_____	_____	4.	Are materials properly identified on the contract drawings?
_____	_____	_____	5.	Are the items constructible as shown? Has the normal sequencing of construction trades been followed?
_____	_____	_____	6.	Is construction phasing or staging clearly shown?
_____	_____	_____	7.	Are dimensions and tolerances correct and consistent?
_____	_____	_____	8.	Have duplications and redundancy of information, data and dimensioning been eliminated?
_____	_____	_____	9.	Are the plans signed and sealed by a professional engineer?
_____	_____	_____	10.	Are the drawings legible and reproducible?
_____	_____	_____	11.	Do the titles and drawing numbers agree with the cover sheet list of the drawings?

Remarks:

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Reviewer/Date: _____

Resident Engineer/Date: _____

FORM NO. QAP 5
Staffing and Staff Qualification

Project No: _____ Project Name: _____

YES	NO	N/A	
_____	_____	_____	1. Is the project adequately staffed based on its complexity and the approved construction schedule?
_____	_____	_____	2. Are project personnel on the job site during contractor's operations?
_____	_____	_____	3. Are the staff members properly trained and informed regarding:
_____	_____	_____	a. Authority, responsibilities and duties of the construction inspector?
_____	_____	_____	b. General rules of project safety?
_____	_____	_____	c. Hazard communication employee training program?
_____	_____	_____	d. Specific technical inspection and testing requirements?
_____	_____	_____	e. Emergency and accident procedures?
_____	_____	_____	4. Are the names and qualifications of the contractor staff on file?
_____	_____	_____	5. Do contractor staff members have required professional or technical accreditation?
_____	_____	_____	a. Has this been verified?
_____	_____	_____	6. Does the contractor's staff include a qualified provider of first aid services?

Remarks:

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Reviewer/Date: _____

Resident Engineer/Date: _____

FORM NO. QAP 6
Miscellaneous Contractual Provisions

Project No: _____ Project Name: _____

YES	NO	N/A		
_____	_____	_____	1.	Is a copy of the fully executed bid blank in the prime contractor's file?
_____	_____	_____	2.	Is there an equal employment opportunity (EEO) compliance checklist on file?
_____	_____	_____	3.	Have the contractor's EEO policy, affirmative action and disadvantaged business enterprise (DBE) affirmative action plans been submitted?
_____	_____	_____	4.	Have the monthly EEO reports been filed?
_____	_____	_____	5.	Have all needed permits been applied for by the owner?
_____	_____	_____		a. By the contractor?
_____	_____	_____		b. Are copies of all required permits in the files?
_____	_____	_____		c. Are the conditions of each permit being adhered to?
_____	_____	_____	6.	Are environmental permits or environmental control plans required? If yes, are they included in the submittal package?
_____	_____	_____	7.	Has a traffic control plan been specified for this project?
_____	_____	_____	8.	Have local law enforcement agencies been notified by the contractor of the provisions of the traffic control plan?
_____	_____	_____	9.	Has the contractor submitted names and telephone numbers of the emergency contact personnel to all agencies involved?
_____	_____	_____	10.	Has the contractor submitted evidence of required bonding and insurance?
_____	_____	_____	11.	Are meetings with the owner on a scheduled basis?

Remarks:

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Reviewer/Date: _____

Resident Engineer/Date: _____

FORM NO. QAP 7
Material Qualification and Acceptance

Project No: _____ Project Name: _____

YES	NO	N/A		
_____	_____	_____	1.	Have all required samples been collected and submitted?
_____	_____	_____	2.	Are all certified mill analyses and third-party test results on file?
_____	_____	_____	3.	Are all material acceptance requirements being met?
_____	_____	_____	4.	Are the materials that have failed testing requirements disposed of according to the contract requirements?
_____	_____	_____	5.	Are “or equal” materials and equipment submitted by the contractor approved by the design engineer?
_____	_____	_____	6.	Are all certified materials properly identified according to the contract requirements?
_____	_____	_____	7.	Have all relevant documents that are needed to determine if the standards are met provided to the inspection staff?

Remarks:

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Reviewer/Date: _____

Resident Engineer/Date: _____

FORM NO. QAP 8
Removal of Defective Concrete and Restoration of Section

Project No: _____ Project Name: _____

YES	NO	N/A	
_____	_____	_____	1. Have the perimeters of existing spalls been identified and sawcut to a minimum depth of 3/4 of an inch to prevent feathered edges?
_____	_____	_____	2. Are the limits of concrete removal for each member identified in the plans?
_____	_____	_____	a. If yes, did the contractor remove any concrete beyond the identified areas?
_____	_____	_____	b. Did the contractor obtain the engineer's approval to remove concrete beyond the identified areas?
_____	_____	_____	3. Have cracks within solid concrete greater than 0.25 mm (0.01 in.) been epoxy injected?
_____	_____	_____	4. After removal of all defective areas, did the contractor inspect and clean the substrate from any dust, laitance, grease, oil, curing compounds, wax, impregnations, foreign particles and other bond-inhibiting materials?
_____	_____	_____	5. Has all exposed steel been sandblasted clean to a near white appearance prior to concrete placement?
_____	_____	_____	6. Was mechanical anchorage of the repair material with the substrate specified?
_____	_____	_____	a. If yes, was the anchorage installed according to specifications?
_____	_____	_____	7. Did the contractor apply a bonding and reinforcement protection to all exposed reinforcement and concrete surface prior to concrete placement?
_____	_____	_____	8. Did the contractor use the approved material and method of application including manufacturer's technical specifications and formulation if applicable?

Remarks:

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Reviewer/Date: _____

Resident Engineer/Date: _____

FORM NO. QAP 9
Inspection - Surface Preparation

Project No: _____ Project Name: _____

YES	NO	N/A	
_____	_____	_____	1. Is the restored concrete surface smooth, uniform and matching the concrete component's original profile?
_____	_____	_____	a. If no, were the deviations less than 0.8 mm (1/32 in.)?
_____	_____	_____	2. Did the contractor remove form lines and sharp edges by grinding or filling with putty?
_____	_____	_____	3. Have all inside and outside corners and sharp edges been rounded or chamfered to a minimum radius of 25 mm (1 in.)?
_____	_____	_____	4. Are there any voids or depressions with diameters larger than 12.7 mm (1/2 in.) or depths greater than 3.2 mm (1/8 in.), when measured from a 305-mm (12-in.) straight edge placed on the surface?
_____	_____	_____	a. If yes, have surface depressions and voids been filled and cured according to specifications?
_____	_____	_____	5. Have all cracks in the surface of concrete or the substrate wider than 0.25 mm (1/100 in.) been filled using pressure injection of epoxy in accordance with the procedures outlined in the specifications?
_____	_____	_____	a. Was any surface roughness resulting from crack injection alleviated according to specifications?
_____	_____	_____	6. Was the surface checked and cleaned of any dust, laitance, grease, oil, curing compounds, wax, impregnations, surface lubricants, paint coatings, stains, foreign particles, weathered layers and any other bond-inhibiting materials?
_____	_____	_____	7. Was the final preparation of all surfaces receiving FRP performed according to the specifications?

Remarks:

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Reviewer/Date: _____

Resident Engineer/Date: _____

FORM NO. QAP 10
Application Conditions

Project No: _____ Project Name: _____

YES	NO	N/A	
_____	_____	_____	1. Is the ambient temperature and temperature of concrete surface within the range of 50–95°F, or as specified by the manufacturer?
_____	_____	_____	2. Are the contact surfaces completely dry at the time of installation of FRP system?
_____	_____	_____	a. Was the moisture level measured using a mortar moisture meter?
_____	_____	_____	b. Was the moisture level less than 10% or the specified limit?
_____	_____	_____	3. Does rain appear to be imminent?
_____	_____	_____	a. If yes, stop application of the material until dry conditions are ensured.
_____	_____	_____	4. If rain is threatening after starting the application process, instruct the contractor to protect the installed areas against contact with surface moisture.

Remarks:

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Reviewer/Date: _____

Resident Engineer/Date: _____

FORM NO. QAP 11
FRP Application Process (Wet Lay-Up Systems)

Project No: _____ Project Name: _____

YES	NO	N/A	
			1. *Resin Mix*
_____	_____	_____	– Is the resin prepared according to the mix ratio and procedures recommended by the manufacturer until thorough mixing with uniform color and consistency is achieved?
_____	_____	_____	– Is the resin diluted with organic solvents? (NOT allowed)
_____	_____	_____	– Is the resin mixed in quantities sufficiently small to ensure its use within the manufacturer-recommended pot life?
_____	_____	_____	– Is the excess resin disposed of when it exceeds its pot life or begins to generate heat or show signs of increased viscosity?
			2. *Primer and Putty*
_____	_____	_____	– Is the primer applied uniformly to penetrate all surface pores of concrete substrate where the FRP system is to be installed?
_____	_____	_____	– Does the rate of application of primer follow the manufacturer's recommendations?
_____	_____	_____	– Are the ambient and concrete surface temperatures as specified in the contract drawings and recommended by the manufacturer?
_____	_____	_____	– Is the excess primer disposed of when it exceeds its pot life?
_____	_____	_____	– Is the putty, if necessary, applied as soon as the primer becomes tack-free or until non-sticky to the fingers?
_____	_____	_____	– In case of delays longer than 7 days, is the surface of primer cleaned and prepared for the putty, if necessary?
_____	_____	_____	– Does the applied putty meet the surface profile according to the contract drawings?
_____	_____	_____	– Is the excess putty, if used, disposed of when it has exceeded its pot life?
_____	_____	_____	– Are the surfaces of primer and putty protected from dust, moisture and other contaminants before applying the FRP system?
			3. *Fabric Saturation and Placement*
_____	_____	_____	– Is the saturant applied uniformly on all surface areas of concrete where the FRP system is to be installed?
_____	_____	_____	– Is the viscosity of the saturant sufficiently low, according to the manufacturer's recommendations, to fully impregnate the fiber sheets?
_____	_____	_____	– Does the rate of application of saturant follow the manufacturer's recommendations?
_____	_____	_____	– Are the ambient and concrete surface temperatures as specified in the contract drawings and recommended by the manufacturer?
_____	_____	_____	– Is the excess saturant disposed of when it exceeds its pot life?
_____	_____	_____	– Is the fiber sheet cut to the length specified in the contract drawings (typically in segments shorter than 4.6 to 6.1 m [15 to 20 ft])?
_____	_____	_____	– Is the fiber sheet placed properly and pressed gently onto the wet saturant within its pot life?
_____	_____	_____	– Is any entrapped air between fiber sheet and concrete released?
_____	_____	_____	– Is rolling done in the fiber direction for unidirectional fiber sheets?

_____ _____ _____ – Is rolling done in the fill direction end to end, and then the warp direction, for bidirectional fiber sheets?

_____ _____ _____ – Is there excessive force or sharp metal rollers involved that could damage the fibers? (NOT allowed)

_____ _____ _____ – Is sufficient saturant applied on top of the fiber sheet as overcoat to fully saturate the fibers?

_____ _____ _____ – Is there any interruption in the application of undercoat, fiber sheets, and overcoat?

_____ _____ _____ – Is the above sequence repeated properly for each additional fiber sheet, with an overcoat resin 15–20% greater than a single ply?

_____ _____ _____ – Is each new fiber sheet applied before the onset of complete gelation of the previous layer?

_____ _____ _____ – Does the number of plies applied in a single day follow the contract drawings and the manufacturer recommendations?

_____ _____ _____ – In case of several days of delay between plies, is the surface of previously cured layers of the FRP system prepared properly before applying new fiber sheets?

4. *Splice and Overlap*

_____ _____ _____ – Are lap joints constructed when there is an interruption in the direction of the fibers?

_____ _____ _____ – Are lap splice lengths as specified in the contract drawings, but at least 152 mm (6 in.)?

_____ _____ _____ – Are lap splices staggered on multiple plies and adjacent strips, unless permitted in the contract drawings?

_____ _____ _____ – Are all lap joints in the fiber directions made in a single day?

_____ _____ _____ – Is there any lap joint in the transverse direction, if specified in the contract drawings?

5. *Fiber Orientation*

_____ _____ _____ – Are the fibers aligned on the structural member according to the contract drawings?

_____ _____ _____ – Is there any deviation in fiber alignment more than 5°? (NOT allowed)

_____ _____ _____ – Are fibers free of kinks, folds and waviness?

6. *Anchoring of FRP Sheets*

_____ _____ _____ – Is anchorage for the FRP sheets installed according to the contract drawings, and in such a way to avoid damage to fibers or concrete?

7. *Stressing Applications*

_____ _____ _____ – Are stressing hardware and procedures according to the contract drawings and the manufacturer's recommendations?

_____ _____ _____ – Is the grouting pressure according to the contract drawings?

8. *Curing and Final Coating*

_____ _____ _____ – Is the FRP system allowed to cure according to contract drawings and the manufacturer's recommendations?

_____ _____ _____ – Is the resin chemistry field modified for rapid curing? (NOT allowed)

_____ _____ _____ – Does the elevated temperature that is used for curing follow the contract drawings and manufacturer's recommendations?

_____ _____ _____ – Is the FRP system protected until it is fully cured?

_____ _____ _____ – Is the FRP system under full load before it is fully cured?

_____ _____ _____ – Is continuous pressure applied, if necessary, for the cure of FRP system?

_____	_____	_____	– Is the surface of FRP system prepared according to the contract drawings and the manufacturer's recommendation to receive coating?
_____	_____	_____	– Are solvent wipes used for surface cleaning? (NOT allowed)
_____	_____	_____	– If abrasive cleaning is necessary, is the air pressure at the nozzle limited to avoid any damage to fibers?
_____	_____	_____	– Is the thickness of protective coating for the FRP system as specified in the contract drawings and specifications?
_____	_____	_____	– Does the final appearance match the color and texture of the adjacent concrete?

Remarks:

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Reviewer/Date: _____

Resident Engineer/Date: _____

FORM NO. QAP 12
FRP Application Process (Precured Systems)

Project No: _____ Project Name: _____

YES	NO	N/A	
			1. *Application of Adhesives*
_____	_____	_____	– Is the adhesive prepared according to the mix ratio and procedures recommended by the manufacturer until thorough mixing with uniform color and consistency is achieved?
_____	_____	_____	– Is the adhesive applied uniformly on all surface areas of concrete substrate where the precured FRP system is to be applied?
_____	_____	_____	– Does the rate of application of adhesive follow the manufacturer's recommendations?
_____	_____	_____	– Are thickness and viscosity of the adhesive layer according to the manufacturer's recommendations?
_____	_____	_____	– Are the ambient and concrete surface temperatures as specified in the contract drawings and recommended by the manufacturer?
_____	_____	_____	– Is excess resin that has exceeded its pot life disposed of?
			2. *Placement of Precured System*
_____	_____	_____	– Is the precured FRP system clean?
_____	_____	_____	– Is the precured FRP system cut to the length specified in the contract drawings?
_____	_____	_____	– Are manufacturer's recommendations on the timing and sequence of stacking, overlap and banding, horizontal and vertical joints, staggering of splices and overlap and butt joints followed?
_____	_____	_____	– Is the precured FRP system placed in the wet adhesive within its pot life?
_____	_____	_____	– Is entrapped air between laminate and concrete released?
_____	_____	_____	– Is excess adhesive between laminate and concrete removed?
_____	_____	_____	– Is the FRP system left undisturbed until the adhesive fully cures?
			3. *Anchoring of Precured System*
_____	_____	_____	– Is permanent anchorage for the FRP system properly installed according to the contract drawings?
_____	_____	_____	– Are temporary clamping and shoring for the FRP system properly installed according to the contract drawings?
			4. *Grouting of Precured Shells*
_____	_____	_____	– Is the precured FRP shell around the concrete column grouted at least 24 hours after installation?
_____	_____	_____	– Does pressure grouting follow the contract drawings and the manufacturer's recommendations?
_____	_____	_____	– Does the grout have a shrinkage strain of less than 0.0005 and a compressive strength greater than 27.6 MPa (4,000 psi)?
			5. *Stressing Applications*
_____	_____	_____	– Is stressing hardware according to the contract drawings and the manufacturer's recommendations?
_____	_____	_____	– Are the stressing procedures followed according to the contract drawings and the manufacturer's recommendations?

6. *Curing and Final Coating*

_____	_____	_____	– Is the FRP system allowed to cure according to contract drawings and the manufacturer's recommendations?
_____	_____	_____	– Is the resin chemistry field modified for rapid curing? (NOT allowed)
_____	_____	_____	– Does the elevated temperature that is used for curing follow the contract drawings and manufacturer's recommendations?
_____	_____	_____	– Is the FRP system protected until it is fully cured?
_____	_____	_____	– Is the FRP system under full load before it is fully cured?
_____	_____	_____	– Is continuous pressure applied, if necessary, for the cure of the FRP system?
_____	_____	_____	– Is the surface of FRP system prepared according to the contract drawings and the manufacturer's recommendation to receive coating?
_____	_____	_____	– Are solvent wipes used for surface cleaning? (NOT allowed)
_____	_____	_____	– If abrasive cleaning is necessary, is the air pressure at the nozzle limited to avoid any damage to fibers?
_____	_____	_____	– Is the thickness of protective coating for the FRP system as specified in the contract drawings and specifications?
_____	_____	_____	– Does the final appearance match the color and texture of the adjacent concrete?

Remarks:

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Reviewer/Date: _____

Resident Engineer/Date: _____

FORM NO. QAP 13
FRP Application Process (Near Surface Mounted Systems)

Project No: _____ Project Name: _____

YES	NO	N/A	
			1. *Application of Embedding Paste*
_____	_____	_____	– Is the embedding paste prepared according to the mix ratio and procedures recommended by the manufacturer until thorough mixing with uniform color and consistency is achieved?
_____	_____	_____	– Are all grooves, where the FRP system is to be placed, half filled with the paste?
_____	_____	_____	– Are voids between concrete substrate and the embedding paste removed?
_____	_____	_____	– Are the ambient and concrete surface temperatures as specified in the contract drawings and recommended by the manufacturer?
_____	_____	_____	– Is the excess paste disposed of when it exceeds its pot life?
			2. *Placing FRP Reinforcement*
_____	_____	_____	– Is the FRP bar or strip clean?
_____	_____	_____	– Is the FRP bar or strip cut to the length specified by contract drawings?
_____	_____	_____	– Is there any shearing of FRP bar or strip? (NOT allowed)
_____	_____	_____	– Is the FRP bar or strip placed at mid-depth of the groove and lightly pressed to force the paste to flow around it?
_____	_____	_____	– Is the grove fully filled with additional paste and then leveled?

Remarks:

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Reviewer/Date: _____

Resident Engineer/Date: _____

FORM NO. QAP 14
Identification of Defective Work

Project No: _____ Project Name: _____

YES	NO	N/A		
_____	_____	_____	1.	Did you find any voids and air encapsulation between the concrete and the layers of primer, resin and/or adhesive, and within the composite itself?
_____	_____	_____	2.	Are there any delaminations between layers of composite fabric?
_____	_____	_____	3.	Are there any broken or damaged edges of the composite?
_____	_____	_____	4.	Is there any wrinkling and buckling of fiber and fiber tows?
_____	_____	_____	5.	Are there any discontinuities due to fracture of fibers, breaks in the fabric, or cracks in prefabricated material?
_____	_____	_____	6.	Are there any cracks, blisters or peeling of the surface coating?
_____	_____	_____	7.	Are there any resin-starved areas or areas with nonuniform impregnation/wet-out?
_____	_____	_____	8.	Is there any undercured or incompletely cured polymer?
_____	_____	_____	9.	Are there any incorrectly placed reinforcement configurations?

Remarks:

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Reviewer/Date: _____

Resident Engineer/Date: _____

FORM NO. QAP 15
Postapplication - Quality Control Tests

Project No: _____ Project Name: _____

YES	NO	N/A	
_____	_____	_____	**1. Inspection for Debonding** Perform surface inspection for any swelling, bubbles, voids or delaminations after at least 24 hours for initial resin cure.
_____	_____	_____	Is the presence of voids and air pockets suspected?
			If yes,
_____	_____	_____	– Perform an acoustic tap test with a hard object to identify delaminated areas by sound.
_____	_____	_____	– Mark all voids and assess them in terms of size.
_____	_____	_____	– Repair voids in accordance with the procedures established in the contract drawings and specifications.
_____	_____	_____	**2. Inspection for Adhesion** Perform direct pull-off test according to ASTM D4541 or ACI 503R-93 after at least 24 hours for initial resin cure.
_____	_____	_____	Are test locations representative and on flat surfaces?
_____	_____	_____	Is the number of tests performed in accordance with the number established in the contract drawings and specifications?
_____	_____	_____	Is the observed failure mode of the core specimen cohesive within concrete? Failure at the bond line at tensile stress below 1.38 MPa (200 psi) is unacceptable.
_____	_____	_____	Repair concrete area after bonding test according to the procedures established in the contract drawings and specifications.

Remarks:

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Reviewer/Date: _____

Resident Engineer/Date: _____

FORM NO. QAP 16
Claims and Change Orders

Project No: _____ Project Name: _____

YES	NO	N/A		
_____	_____	_____	1.	Have any claims been made to date?
_____	_____	_____	2.	Has the contractor provided written notification of all claims?
_____	_____	_____	3.	Did the notifications include specifics of the claims?
_____	_____	_____	4.	Did the resident engineer acknowledge each claim?
_____	_____	_____	5.	Is a separate file maintained for each claim?
_____	_____	_____	6.	Is each claim being processed and tracked according to the requirements of the specifications?
_____	_____	_____	7.	Has the resident engineer reviewed each claim, documented findings, and made a recommendation for resolution?
_____	_____	_____	8.	Have change orders been issued for satisfactorily resolved claims? Number_____ Est. Value: $_____
_____	_____	_____	9.	Does any resolved change order affect the scope of work or lengthen the contract time?
_____	_____	_____	10.	Are there any currently unresolved claims? Number_____ Est. Value: $_____
_____	_____	_____	11.	Are there any anticipated claims?
_____	_____	_____	12.	Are there any resolved change orders as a result of field conditions? Number_____ Est. Value: $_____
_____	_____	_____	13.	Are there any pending change orders as a result of field conditions? Number_____ Est. Value: $_____
_____	_____	_____	14.	Are there any change orders related to the extra work authorized by the owner? Number_____ Est. Value: $_____

Remarks:

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Reviewer/Date:_____

Resident Engineer/Date: _____

FORM NO. QAP 17
Schedule Monitoring

Project No: _____ Project Name: _____

YES	NO	N/A		
_____	_____	_____	1.	Has the contractor's work schedule been approved?
_____	_____	_____	2.	Does the contractor's work plan match the established schedule?
_____	_____	_____	3.	Is the resident engineer meeting with the contractor on a regular basis to verify and update the work plan and schedule?
_____	_____	_____	4.	What is the current status of the contract? Contract Time Used: _____%, as of Date: _____ Work Completed: _____%.
_____	_____	_____	5.	Was the "Notice to Proceed" issued in accordance with stipulations of the specifications?
_____	_____	_____	6.	Has the contractor asked for time extensions to the contract?
_____	_____	_____		a. Are time extensions anticipated?
_____	_____	_____	7.	Are time extension requests being processed according to the provisions of the specifications?
_____	_____	_____	8.	Are time extension requests based on weather delays in accordance with documented weather conditions in the daily inspector's reports?
_____	_____	_____	9.	Is there a schedule slippage?
_____	_____	_____		a. Has the owner been advised?
_____	_____	_____		b. Is there an impact on the schedule and cost?
_____	_____	_____		c. Has the contractor formulated a "back-on-schedule" plan?
_____	_____	_____		d. Have time extensions been granted? Number _____ Total time _____days

Remarks:

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Reviewer/Date: _____

Resident Engineer/Date: _____

FORM NO. QAP 18
Estimates and Payments

Project No: _____ Project Name: _____

YES	NO	N/A	
_____	_____	_____	1. Is there back-up documentation for all pay items?
_____	_____	_____	2. Are monthly payments for quantities in agreement with the engineer's estimate of quantities for that month?
_____	_____	_____	3. Are items being paid for according to the method of measurement and basis for payment called for in the specifications?
_____	_____	_____	4. Is the mobilization item being paid according to the provisions of the specifications?
_____	_____	_____	5. Is there a separate payment item for stockpiled materials?
_____	_____	_____	6. Are stockpiled materials reverified in the following month to reconcile quantities with materials incorporated into the work?
_____	_____	_____	7. Do the records indicate when the stockpiled materials are incorporated into the work?
_____	_____	_____	a. Was a deduction made for any partial payment amount previously issued?
_____	_____	_____	b. Are equipment and material storage conditions noted on daily inspector's reports?

Remarks:

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Reviewer/Date: _____

Resident Engineer/Date: _____

FORM NO. QAP 19
Daily Inspectors Reports (DIR)

Project No: _____ Project Name: _____

YES	NO	N/A		
_____	_____	_____	1.	Are daily inspector's reports (DIRs) current?
_____	_____	_____		a. Are contractor's equipment and labor force clearly documented on DIRs?
_____	_____	_____		b. Are contractor's hours of work logged?
_____	_____	_____	2.	Is the contract day/date correctly listed on the DIRs?
_____	_____	_____	3.	Is the owner's project number listed correctly?
_____	_____	_____	4.	Is there a DIR for each construction inspector on site?
_____	_____	_____	5.	Is the particular operation or location of work clearly identified?
_____	_____	_____	6.	Are all work quantities shown for the work performed each day?
_____	_____	_____	7.	Are the subcontractor's activities clearly documented on respective DIRs?
_____	_____	_____	8.	Is there a separate DIR for each utility, force account crew, or disadvantaged business enterprise (DBE) working on the project?
_____	_____	_____	9.	Is the DBE contractor identified as DBE on the DIR?
_____	_____	_____	10.	Are weather conditions and delays adequately noted?
_____	_____	_____	11.	Is the DIR signed and dated by the responsible supervisor?
_____	_____	_____	12.	Are DIRs written in a concise, understandable and legible manner?
_____	_____	_____	13.	Are delays on the project being specifically accounted for?
_____	_____	_____	14.	Are accidents, injuries and damages described on the DIRs?
_____	_____	_____	15.	Are unusual conditions noted (high water, lane closures, icing, etc.)?
_____	_____	_____	16.	Are disputed items of work listed on the DIR?

Remarks:

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Reviewer/Date: _____

Resident Engineer/Date: _____

FORM NO. QAP 20
Construction Close-Out

Project No: _____ Project Name: _____

YES	NO	N/A		
_____	_____	_____	1.	Have items on the final "punch list" been accepted and closed out?
_____	_____	_____	2.	Has the final estimate been prepared, including pending change orders?
_____	_____	_____	3.	Have all pay item quantities on the final estimate been cross-referenced from source documents?
_____	_____	_____	4.	Have the final record plans been completed in accordance with contractual requirements?
_____	_____	_____	5.	Are all incorporated materials and equipment tested and certified according to the requirements of the contract?
_____	_____	_____	6.	Have all contractual incentive/disincentive provisions been correctly applied and administered?
_____	_____	_____	7.	Has the resident engineer followed all contractual requirements in accepting the project?
_____	_____	_____	8.	Has the owner's staff completed any required inspections prior to final acceptance?
_____	_____	_____	9.	Are all project files reviewed before transfer to the required receiver?

Remarks:

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Reviewer/Date: _____

Resident Engineer/Date: _____