Sample Guide Specifications for Construction of Geosynthetic Reinforced Soil-Integrated Bridge System (GRS-IBS)

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PREFACE

This guide was issued to provide guidelines for construction of the geosynthetic reinforced soil-integrated bridge system (GRS-IBS). Refer to *Geosynthetic Reinforced Soil Integrated Bridge System Interim Implementation Guide* for GRS-IBS design and construction guidelines.[1]

This guide serves as the technical basis for agency-developed standard specifications. Local experience and practice shall be incorporated as applicable.

SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
	NOTE: volumes greater than 1000 L shall be shown in m^3			
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERATURE (exact degrees)		
°F	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	°C
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	$candela/m^2$	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
		TEMPERATURE (exact degrees)		
°C	Celsius	1.8C+32	Fahrenheit	°F
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	$candela/m^2$	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380.
(Revised March 2003)

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SECTION 1. GENERAL REQUIREMENTS

1.1. GUIDELINES FOR USING THIS DOCUMENT

The following notes shall be considered when using this document:

- This guide serves as a technical basis for agency-developed standard specifications. Therefore, it may be subject to modifications for agencies in order to complement and integrate with their current practices and construction and material specifications.

- This is a basic quality assurance (QA) specification wherein the contractor is responsible for controlling the quality of materials and workmanship, and the agency is responsible for accepting the completed work based on the measured quality.

- Local experience and practice shall be incorporated as applicable.

- Items in this document that may require further input, modifications, or edits by the agency are underlined. Additionally, "XXX" indicates missing information that needs to be filled in by the agency.

- The guidance outlined here applies specifically to geosynthetic reinforced soil (GRS) abutments built with concrete masonry unit (CMU) blocks facing element. However, this guide can be adapted to other GRS structures built with different facing systems.

- If a different facing element other than CMU (e.g., concrete, timber, metal, gabion baskets, etc.) is used, special design considerations shall apply.

- Refer to the *Geosynthetic Reinforced Soil Integrated Bridge System Interim Implementation Guide* for terminology used in this document.[1]

1.2. QA RESPONSIBILITIES

- QA is defined by the American Association of State Highway and Transportation Officials (AASHTO) R10-06.[2] It is an umbrella term, wherein the responsibility for assuring quality is shared by both the contractor and the agency. The six core elements of an agency's QA program include contractor quality control (QC), agency acceptance, agency independent assurance, dispute resolution, qualified laboratories, and qualified personnel.

- The contractor is responsible for providing an appropriate QC system that includes QC inspection, sampling, and testing in accordance with these specifications and the contractor's QC plan.

- The XXX Department of Transportation will monitor the adequacy of the contractor's QC activities and will perform acceptance inspection, sampling, and testing. The agency's acceptance information will be utilized in the final acceptance determination for each lot of material produced and placed.

1.3. STANDARD REFERENCE DOCUMENTS

Standard reference documents include the following:

- *Geosynthetic Reinforced Soil Integrated Bridge System Interim Implementation Guide*.[1]
- XXX Department of Transportation standard material and construction specifications for roads and bridges.
- Any contract special provisions for the specific project.

1.4. DESCRIPTION OF WORK

This work consists of furnishing materials and constructing geosynthetic reinforced soil-integrated bridge systems (GRS-IBSs) to the lines and grades designated in the plan drawings and approved shop drawings.

SECTION 2. MATERIAL REQUIREMENTS

2.1. CMU FACING ELEMENT

2.1.1. Physical Requirements

1. Furnish-facing elements consisting of split-face CMU should meet ASTM C90-11b requirements, with a minimum required compressive strength of 4,000 psi and a maximum water absorption rate of 5 percent after 24 h.(3)

2. In areas where repeated freezing and thawing occur, CMU block units shall be tested for freeze-thaw durability in accordance with ASTM C1262-10.(4)

3. Specimens used for absorption testing shall not subsequently be used for freeze-thaw testing.

4. CMU blocks shall be furnished within the following tolerances:

    - The height of each individual block shall be within $^{1}/_{16}$ inches of the specified dimension.

    - The length and width of each individual block shall be within $^{1}/_{8}$ inches of the specified dimension.

    - Hollow CMU units shall have a minimum face shell thickness of 1.25 inches and a web thickness of $^{3}/_{4}$ inches.

5. The CMU units shall be randomly sampled and tested in accordance with ASTM C140-12.(5) Contractor QC testing shall be conducted at a qualified agency or AASHTO accredited laboratory as described in section 4.4 of this guide.

6. Agency acceptance testing of the CMU blocks will be performed on a lot basis.

2.2. BACKFILL MATERIAL

Furnish sound, crushed durable particles, fragments of stone gravel free from organic matter or other deleterious material for the abutment, reinforced soil foundations (RSFs), and integrated approach conform to the following:

2.2.1. Abutment Backfill

Backfill material shall meet the following requirements:

- Quality requirements.
    - Gradation (see table 1).
    - Angle of internal friction with a minimum of 38 degrees.

- Plasticity Index (PI) with a maximum of 6 (AASHTO T 89-10 and AASHTO T 90-00).[6,7]

Table 1. GRS abutment backfill gradation requirements.

Description	Value	
	Well-Graded Material	Open-Graded Material
Maximum grain size (inches)	0.5–2	0.5–2
Percent passing the No. 200 sieve (percent) (AASHTO T 11-05)[8]	≤ 12	≤ 5

- Soundness.
  - The backfill material shall be substantially free of shale or any other poor durability particles.
  - The backfill material shall have a magnesium sulfate loss of less than 30 percent after four cycles or a sodium sulfate soundness loss of less than 15 percent after five cycles (AASHTO T 104-99).[9]
  - Well-graded aggregates and open-graded aggregates shall be used as respectively defined in sections 3.3.1.1 and 3.3.1.2 of FHWA-HRT-11-026.[1]
  - Open-graded aggregates shall be used if the abutment will be submerged at any point.

2.2.2. RSF Backfill

The backfill for the RSF shall be well-graded material as described in section 2.2.1 of this guide.

2.2.3. Integrated Approach Backfill

Well-graded backfill material shall be furnished as described in section 2.2.1 of this guide for the integrated approach.

2.3. GEOSYNTHETICS

1. Geosynthetics consisting of geogrid or geotextile for the GRS abutment should be furnished. Furnish geotextile for the RSF and integrated approach.
2. Geosynthetics material may be manufactured from polypropylene, high-density polyethylene, or polyester.
3. Geosynthetics can be either uniaxial or biaxial. When a uniaxial type is used, higher-strength axis must be placed perpendicular to the wall face.
4. Geosynthetics composed of a minimum ultimate tensile strength of 4,800 lb/ft according to ASTM D 4595-11 for geotextile or ASTM D 6637-11 for geogrid should be furnished.[10,11] The design requirements may call for a geosynthetic with higher strength.

5. Geosynthetic reinforcement strength at 2 percent strain shall be greater than the unfactored required reinforcement strength.

6. The geosynthetic shall be evaluated in accordance with XXX Department of Transportation standard procedures (refer to section 3.4 of FHWA-HRT-11-026).[1]

2.4. MISCELLANEOUS MATERIALS

- **Concrete block wall fill**—Furnish AASHTO class A concrete with a minimum compressive strength of 4,000 psi.[12] Furnishing, placing, finishing, and curing of concrete shall be done according to XXX Department of Transportation specifications.

- **Flashing**—Flashing, such as 4-inch by 1.5-inch aluminum fascia or equivalent, may be used to serve as a drip edge under the superstructure within the clear space to shed potentially corrosive fluids off of the dry cast block and to prevent animals from burrowing into the abutment.

- **Foam board**—A durable foam board, such as expanded polystyrene filler or equivalent, having a compressive strength greater than or equal to 10 psi may be used to provide a setback and create a bearing buffer between the superstructure and the wall face.

- **Reinforcing steel bar**—Deformed #4 (0.5-inch diameter) bars that conform to AASHTO M31M/M31-10 or ASTM A615/A615M-12 shall be furnished.[13,14] The bars shall be epoxy coated conforming to AASHTO M 284M/M 284-09.[15]

- **Asphaltic coating**—An asphaltic coating shall be shop installed on the concrete beam when embedded between the GRS abutment and the wing wall to seal the embedded concrete.

SECTION 3. CONSTRUCTION REQUIREMENTS

3.1. LABOR AND EQUIPMENT

Section 7.2 of the *Geosynthetic Reinforced Soil Integrated Bridge System Interim Implementation Guide* may be consulted for information regarding typical labor, tools, equipment requirements proven to efficiently construct the GRS-IBS, and suggestions on how to improve productivity.[(1)] However, it is the responsibility of the contractor to choose the construction method, labor, and equipment that is most efficient for the specific site.

3.2. SITE LAYOUT

Conduct a survey according to XXX Department of Transportation specifications.

3.3. EXCAVATION

1. All excavation shall comply with the Occupational Safety and Health Administration as well as State and local requirements.

2. Excavation shall include provisions for drainage with a sloped cut to facilitate the movement of water downstream and away from the wall.

3. Any over-excavation that forms a pit shall be backfilled with suitable free draining material and compacted.

3.4. RSF

In the absence of specific ground improvement requirements in the plans and special provisions, the following shall apply:

1. Excavation for the RSF shall be in accordance with section 3.3 of this guide.

2. The base of the RSF shall be cut smooth and excavated to uniform depth, and all loose, soft, wet, frozen, organic, and unsuitable material shall be removed from the base and sides of the excavation.

3. The base of the RSF shall be graded level for the entire area of the base of such backfill plus additional 1 ft on all sides or to the limits shown in the plans.

4. Excavation shall be backfilled as soon as possible to avoid adverse weather delays. If this cannot be achieved, the excavation shall be graded to one end to facilitate the removal of any water. If excavation is flooded, all water shall be removed along with soft saturated soils.

5. The RSF shall be constructed with well-graded backfill material placed from the face to the back to roll folds or wrinkle to the free end of the reinforcement layer. It shall be compacted in 6-inch-thick lifts according to section 3.5 of this guide.

6. The fill material shall be graded, leveled, and compacted before encapsulating the RSF.

7. The RSF shall be encapsulated in the geotextile reinforcement and placed perpendicular to the abutment face to protect it from possible erosion. The geotextile shall be sized to fully enclose the RSF on the face and the wing walls sides.

8. The first layer of the reinforcement shall be placed on the upstream side of the abutment with subsequent layers, if needed, overlapped a minimum of 3 ft on the top of the preceding layer.

9. If the GRS abutment is adjacent to water, the reinforcement sheet shall overlap a minimum of 3 ft. All overlap sections in the area of the RSF shall be oriented to prevent running water from penetrating layers of reinforcement.

10. The wrapped corners of the RSF need to be tight and without exposed soil within the RSF to complete the encapsulation.

11. Reinforcement shall be in accordance to section 3.6 of this guide.

3.5. PLACEMENT OF BACKFILL AND COMPACTION

1. For well-graded fills, the backfill material shall be compacted to at least 95 percent maximum dry density according to AASHTO T-99-10.[16]

2. For well-graded fills, adjust the moisture content of the compacted backfill materials to within 2 percent of the optimum moisture content.

3. The GRS mass shall be constructed using compacted lifts of 8 inches, which are equal to the facing block size.

4. Compaction shall be performed using vibratory roller compaction equipment or other similar methods approved by XXX Department of Transportation.

5. For open-graded fills, compact each layer using a suitable compactor capable of compacting 8 inches of fill until there is no visible evidence of further compression. A minimum of four passes shall be applied per lift.

6. Hand-operated compaction equipment, such as lightweight mechanical tampers, plates, or rollers, approved by XXX Department of Transportation is required within 3 ft of the front of the wall face so as not to damage or dislocate the facing blocks.

7. The top 5 ft of the abutment shall be compacted to 100 percent of the maximum dry density in accordance with AASHTO T-99-10.[16]

8. Compaction equipment shall be selected to achieve the required fill material density.

3.6. PLACEMENT OF GEOSYNTHETIC REINFORCEMENT

1. Geosynthetic reinforcement shall be installed in accordance with the manufacturer's site-specific wall erection instruction.

2. The geosynthetic reinforcement shall be placed so that the strongest direction (i.e., cross machine direction) is perpendicular to the abutment facing.

3. Reinforcement coverage shall be 100 percent of the embedment area unless otherwise shown in the working drawings.

4. Adjacent sections of the geosynthetic reinforcement do not need to be overlapped except when exposed in the wrap-around face system, at which time, the reinforcements rolls shall be overlapped or mechanically connected per the manufacturer's requirements.

5. Geosynthetic reinforcement shall be laid so that it is taut and free of wrinkles prior to backfilling.

6. Geosynthetic reinforcement shall be placed directly on the compacted horizontal fill surface. The reinforcement shall bear uniformly on the compacted reinforced soil from the connection to the wall to the free end of the reinforcing elements.

7. The geosynthetic reinforcement shall extend between the layers of the CMU block.

8. The geosynthetic reinforcement shall cover a minimum of 85 percent of the top surface of the CMU block. Any excess reinforcement material showing through the face shall be removed in accordance with the manufacturer's directions.

9. A minimum backfill layer of 6 inches shall be placed on the geosynthetic prior to operating any vehicle over it.

10. Bearing reinforcement beds shall be placed behind the CMU block at 4-inch spacings in the top five layers of the GRS abutment or as determined by the design.

11. In the superelevation case, the reinforcement layers become stair-stepped in the upper wall layers as the superelevation of the abutment is constructed. In such situations, the reinforcement shall terminate along the angle surface of the superelevation. The GRS wall reinforcement schedule shall show the termination of each layer of the reinforcement across the abutment wall from low to high elevations.

3.7. WALL FACING

1. CMU, as specified in section 2.1, shall be used for the GRS wall facing.

2. The CMU block construction shall begin at the lowest portion of the excavation with each layer placed horizontally.

3. Each CMU block shall be placed tightly against the adjoining block without any gaps.

4. Each CMU layer shall be completely constructed and cleaned of any debris and fill material prior to placing the next layer of geosynthetic reinforcement and CMU.

5. A stretcher or running bond shall be maintained between courses of blocks to ensure that the joints between the blocks are offset with each row.

6. If a scour countermeasure, such as riprap, is used, a geotextile filter fabric shall be placed under the countermeasure and anchored between the first and second course of the CMU block.

7. CMU blocks displaced out of required alignment during construction shall be carefully moved back into position by methods that will not cause damage to the CMU blocks or other work.

8. Any damaged CMU blocks shall be replaced to retain the new wall integrity.

9. Battered wall alignment shall be maintained following the same procedures as for vertical walls.

10. Detail facing to account for wall batter and corners.

11. All cuts shall be performed to maintain the standard running or stretcher bond between the rows of the dry-stacked blocks, with the vertical joints of each course midway between those of adjoining courses.

12. In superelevations, the top course of CMU beneath the superstructure shall be trimmed to match the elevation difference and clear space across the abutment.

13. Facing wall and wing wall courses shall be staggered to form a tight interlocking stable corner.

14. Corner details shall be submitted to accommodate corners other than right angles.

15. The top three courses of CMU blocks shall be filled with concrete wall fill, pinned with No. 4 steel bar, and embedded with a minimum of 2-inch cover (see specifications in section 2.4).

3.8. LEVELING COURSE

1. The first course of the facing block shall be set level and to grade.

2. A thin leveling layer of fine aggregate, which shall not exceed 0.5 inches, may be used on the top of the RSF to facilitate construction of the first course of the facing block. If the leveling layer required exceeds 0.5 inches, a mortar or grout shall be placed in the gap between the RSF and the first CMU block course.

3.9. BEAM SEAT

Refer to section 7.8 of FHWA-HRT-11-026 at http://www.fhwa.dot.gov/publications/research/infrastructure/structures/11026/007.cfm#beam.[(1)]

3.10. PLACEMENT OF SUPERSTRUCTURE

Refer to section 7.9 of FHWA-HRT-11-026 at http://www.fhwa.dot.gov/publications/research/infrastructure/structures/11026/007.cfm#placement2.[1]

3.11. APPROACH INTEGRATION

Refer to section 7.10 of FHWA-HRT-11-026 at http://www.fhwa.dot.gov/publications/research/infrastructure/structures/11026/007.cfm#approach.[1]

3.12. SITE DRAINAGE

Refer to section 7.11 of FHWA-HRT-11-026 at http://www.fhwa.dot.gov/publications/research/infrastructure/structures/11026/007.cfm#drainage.[1]

SECTION 4. CONTRACTOR QC

4.1. DESCRIPTION

The contractor shall provide a QC system to ensure that all materials and workmanship meet the required quality levels specified. The contractor shall provide qualified QC personnel and laboratory facilities and perform QC sampling, testing, inspection, data analysis, corrective action (when necessary), and documentation as outlined below.

4.2. CONTRACTOR QC PLAN

Before the start of the work, the contractor shall submit a written QC plan for approval by the agency. The QC plan is not intended to be a generic document, but rather, it must be project specific. The plan should sufficiently document the QC processes of all contractor parties (i.e., prime contractor, subcontractors, and producers) performing work required under this specification.

4.2.1. QC Plan Submittal Requirements

The contractor shall be prepared to discuss the QC plan at the pre-construction conference, including the proposed submittal date, QC organization, and sources of materials.

The contractor shall submit one hard copy and one electronic copy of the QC plan for agency approval no less than 45 days prior to the start of any work activities related to GRS-IBS construction, including excavation. The contractor shall not start work on the subject work items without an approved QC plan.

4.2.2. QC Plan Format and Contents

The QC plan shall be structured to follow the format and section headings outlined below. The pages of the QC plan shall be sequentially numbered. The plan shall address, in sufficient detail, the specific information requested under each section and subsection.

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4.2.3. QC Plan Approval and Modifications

- Approval of the QC plan will be based on the inclusion of the information required in section 4.2.2 of this guide. Revisions to the QC plan may be required for any part of the plan that is determined to be insufficient by the agency.

- Approval of the QC plan does not imply any warranty by the agency that the QC plan will result in completed work that complies with the specifications. It remains the responsibility of the contractor to demonstrate such compliance.

- The contractor may modify the QC plan as work progresses when circumstances necessitate changes in QC personnel, laboratories, or procedures. In such case, the contractor shall submit for agency approval an amended QC plan identifying changes at least 3 calendar days prior to the proposed changes being implemented.

4.3. QC PERSONNEL REQUIREMENTS

- The contractor's QC system and QC plan shall be administered by a qualified QC manager. The manager shall have full authority to institute any actions necessary for the successful implementation of the QC plan. Principal responsibilities of the QC manager shall include preparation and submittal of the QC plan, managing the activities of all QC personnel, communicating on quality issues, and ensuring that all requirements in the approved QC plan are met. The QC manager shall have relevant QC experience and qualifications acceptable to the agency.

- All QC sampling, testing, and inspecting conducted at the construction site shall be performed by qualified field QC technicians (QCTs). A minimum of one field QCT shall be present during construction of the GRS-IBS. Work will not be accepted by the agency unless the field QCT is present at the site during construction operations and performs the required QC inspection, testing and documentation. All Field QCTs shall be qualified as required by the agency's QA program.

- Any QC testing that is performed at QC laboratories shall be performed by qualified laboratory QCTs. The contractor shall ensure a sufficient number of laboratory QCTs to adequately implement the minimum QC requirements contained in this specification and as outlined in the approved QC plan. All laboratory QCTs shall be qualified as required by the agency's QA program.

4.4. QC LABORATORY FACILITY REQUIREMENTS

- All QC testing shall be performed in laboratories qualified through the agency's Laboratory Qualification program (LQP) or accredited through the AASHTO Accreditation program (AAP).

- Laboratory facilities shall be kept clean, and all equipment shall be maintained in proper working condition. The QC manager shall have overall responsibility for ensuring that all laboratories utilized for QC are in compliance with the requirements of the LQP or AAP. This includes providing required AASHTO, ASTM, and agency reference documents and ensuring that all required testing equipment and tools are properly functioning and calibrated.

- The agency shall be permitted unrestricted access to inspect and review the contractor's QC laboratory facilities. The agency will advise the contractor in writing of any noted deficiencies concerning the laboratory facility, equipment, supplies, testing personnel, and procedures. Deficiencies shall be grounds for the agency to order an immediate stop to incorporating materials into the work until they are corrected.

4.5. QC OF STANDARD MANUFACTURED ITEMS

- All manufacturers of standard manufactured items shall have a QC system in place that meets the requirements established in AASHTO R38-10.[17] Each manufacturer shall maintain a Quality System Manual (QSM) that addresses the format and content of AASHTO R38-10.[17] The manufacturer shall perform QC inspection and testing in accordance with their QSM.

- All standard manufactured items delivered to the project site shall be accompanied by a manufacturer's certificate of compliance (COC), which includes the QC inspection and testing results for the corresponding manufacturer's lot.

- The contractor shall be responsible for reviewing the manufacturer's COC and accompanying QC results for all standard manufactured items delivered to the project, including, but not limited to, the following:
    - CMU blocks.
    - Geosynthetic reinforcement.
    - Flashing.
    - Foam board.
    - Reinforcing steel bar.
    - Asphaltic coating.
- The contractor shall provide copies of each manufacturer COC to the engineer. The contractor's QC personnel will assist the agency in obtaining acceptance samples for any standard manufactured items, as required by the agency.
- The contractor will perform QC inspection of all standard manufactured items upon delivery to the project site and during storage. Contractor QC personnel will also provide inspection of all standard manufactured items throughout field installation of the GRS-IBS system.

4.6. QC INSPECTION

The contractor shall perform QC inspection of all work items addressed under this specification. Inspection activities during production and placement may be performed by qualified production personnel (e.g., skilled laborers, foremen, and superintendents). However, the contractor's QC personnel shall have overall responsibility for QC inspection.

QC inspection activities must address the following primary components: equipment, environmental conditions, materials, and workmanship. The minimum frequency of QC inspection activity shall be in accordance with the requirements below and as outlined in the approved QC plan.

4.6.1. QC Inspection of CMU Facing Element, Backfill, and Geosynthetics

The contractor's personnel will perform QC inspection during installation of the CMU facing element, backfill material, and geosynthetics in accordance with the requirements of this specification. The minimum attributes to be inspected are outlined in table 2 and table 3. The contractor shall identify in the QC plan the specific inspection activities necessary to ensure the quality of the work, including any additional QC inspection attributes not specifically listed in table 2 and table 3.

Table 2. Minimum QC inspection of CMU facing element.

Inspection Component	Attributes Inspected	Minimum Inspection Frequency	Point of Inspection	Inspection Method
Equipment	As specified in QC plan	Per QC plan	Per QC pan	Per QC plan
Environmental conditions	Underlying surface soundness and moisture	Per QC plan	Underlying surface	Visual check
	Temperature of air and underlying surface	One per day	At placement location	Check measurement
Materials	CMU blocks (correct type)	Per QC plan	Stockpile on site	Visual check and manufacturer COC
	CMU block dimensions	Per QC plan	Stockpile on site	Check measurement
	Reinforcing steel bar (correct type)	Per QC plan	Stockpile on site	Visual check and manufacturer COC
	Concrete wall fill (correct type)	Per QC plan	At placement location	Check concrete batch ticket
Workmanship	CMU block course (free of debris)	One per CMU course	Each CMU course	Visual check
	CMU block fit (free of gaps)	One per CMU course	Each CMU course	Check measurement or visual check
	CMU block horizontal alignment	One per CMU course	Each CMU course	Check measurement or visual check
	CMU block vertical alignment	One per two CMU courses	Each two CMU courses	Check measurement
	Reinforcing steel bar alignment/cover	One per top of wall or wall parapet	At placement location	Check measurement or visual check
	Concrete wall fill finishing/curing	One per top of wall or wall parapet	At placement location	Visual check
	Concrete coping wall fill finishing/curing	One per top of wall or wall parapet	At placement location	Visual check

Table 3. Minimum QC inspection of backfill material and geosynthetic reinforcement.

Inspection Component	Attributes Inspected	Minimum Inspection Frequency	Point of Inspection	Inspection Method
Equipment	As specified in QC plan	Per QC plan	Per QC plan	Per QC plan
Environmental Conditions	Underlying surface soundness and moisture	Per QC plan	Underlying surface	Visual check
	Temperature of air and underlying surface	One per day	At placement location	Check measurement
Materials	Abutment backfill (correct type and free of organics)	One per backfill layer	At placement location	Visual check
	RSF backfill (correct type and free of organics)	One per backfill layer	At placement location	Visual check
	Integrated approach backfill (correct type and free of organics)	One per backfill layer	At placement location	Visual check
	Geosynthetics (correct type and free of tears)	One per backfill layer	At placement location	Visual check and manufacturer COC
Workmanship	Abutment backfill (lift thickness)	One per backfill layer	Post-compaction of each lift	Check measurement
	RSF backfill (lift thickness)	One per backfill layer	Post-compaction of each lift	Check measurement
	Integrated approach backfill (lift thickness)	One per backfill layer	Post-compaction of each lift	Check measurement
	Level of backfill behind CMU facing block	One per backfill layer	Post-compaction of each lift	Visual check
	Geosynthetics (embedment area coverage = 100 percent)	One per backfill layer	Each geosynthetic layer	Visual check
	Geosynthetics (coverage of top surface of CMU blocks > 85 percent)	One per backfill layer	Each geosynthetic layer	Visual check
	Geosynthetics (no excessive construction damage)	One per backfill layer	Each geosynthetic layer	Visual check
	Geosynthetics (splice seams staggered)	Per reinforcement schedule	Each geosynthetic layer	Visual check

4.7. QC SAMPLING AND TESTING

The contractor's QC personnel will perform QC sampling at the site of GRS field placement. QC testing will be performed at the field placement site or at the contractor's QC laboratory depending on the quality characteristic being tested. The contractor shall furnish approved containers for all material samples. The engineer shall be provided the opportunity to monitor and witness all QC sampling and testing.

4.7.1. GRS Lot and Sublot Sizes

Each lot of GRS backfill material will represent material from the same source, be produced or obtained under the same controlled process, and will possess normally distributed specification properties. Each lot will be divided into sublots of equal size to assess the quality characteristics of the lot. The lot size and corresponding sublot size for each GRS backfill material item is listed in table 4.

Table 4. GRS backfill material lot and sublot sizes.

Backfill Item	Material Type(s)	Lot Size	Sublot Size
Abutment backfill	Well-graded aggregate	Total quantity (cubic yard) of backfill material type/ same source/abutment	See table 5
	Open-graded aggregate		
RSF backfill	Well-graded aggregate	Total quantity (cubic yard) of backfill material type/ same source/RSF	See table 5
Integrated approach backfill	Well-graded aggregate	Total quantity (cubic yard) of backfill material type/ same source/integrated approach	See table 5

4.7.2. Random QC Sampling

The contractor's QC system shall utilize stratified random sampling of each lot produced and placed. The contractor's qualified QC personnel shall obtain random QC samples at the minimum frequencies specified in table 5. In all cases, the QC sampling frequencies shall result in a minimum of one random sample per sublot.

Random sample locations shall be determined using the random number tables and procedures contained in ASTM D 3665-07 or an electronic random number generator.[(18)] The determination of all random sample locations shall be documented on standard test report forms (TRFs). The contractor will provide the engineer with the random QC sampling locations for each sublot prior to production and placement of the relevant sublots.

4.7.3. Selective Sampling

The contractor's QC system will also utilize selective sampling (i.e., non-random samples) as needed to provide supplemental information to assist in maintaining all production and placement processes in control. The contractor's qualified QC personnel shall obtain selective

QC samples from any sublot as determined necessary and in accordance with the guidelines established in the approved QC plan.

4.7.4. QC Sample Identification System

The contractor shall establish a reliable system for the identification of all QC samples obtained. All samples shall be correctly labeled with the following minimum information:

- Contract number.
- Date of sample.
- Material type.
- Lot and sublot number.
- Sample number.
- Sample type (i.e., random or selective).
- Sample location (e.g., station and offset).

4.7.5. Retention of Split Samples

The contractor will retain split samples from each QC material sample and provide a split sample to the engineer if requested. All split samples shall be properly labeled and stored for a period of 30 days or until tested. These split samples will be utilized, if necessary, in the dispute resolution process. The retained split samples may be discarded prior to the required 30 days if mutually agreed on by the contractor and the agency.

4.7.6. QC Testing of GRS Lots

The contractor's QC personnel will perform QC testing during production and field placement of the backfill material to ensure that the production and placement processes are providing work conforming to the contract requirements. All QC testing shall be in accordance with AASHTO, ASTM, or agency procedures specified in table 5. The engineer shall be provided the opportunity to monitor and witness all QC testing.

- Laboratory testing shall follow section 9.3.1 of FHWA-HRT-11-026 at http://www.fhwa.dot.gov/publications/research/infrastructure/structures/11026/009.cfm#lab.[(1)]
- Field testing shall follow section 9.3.2 of FHWA-HRT-11-026 at http://www.fhwa.dot.gov/publications/research/infrastructure/structures/11026/009.cfm#field.[(1)]
- Testing shall also follow any supplements by XXX Department of Transportation.

Table 5. Minimum QC sampling and testing of backfill material.

Quality Characteristic	Test Method	Sublot Size	Minimum Test Frequency	Point of Sampling	Sampling Method
Gradation	AASHTO T 11-05(6) and AASHTO T 27-05[19]	—	One per lot	Source of material (before use)	Random; AASHTO T 2-91[20] and AASHTO T 248-11[21]
PI	AASHTO T 89-10(7) and AASHTO T 90-00[8]	—	One per lot	Source of material (before use)	Random; AASHTO T 2-91[20] and AASHTO T 248-11[21]
Maximum dry density and optimum moisture content	AASHTO T 99-10[16] (method C) and AASHTO T 180-10[22] (method D)	—	One per lot	Source of material (before use)	Random; AASHTO T 2-91[20] and AASHTO T 248-11[21]
In-place density and moisture content (per targets)*	AASHTO T 310-11[23] (method B) and other approved procedures	Minimum two per lift per day	One per sublot	In-place compacted backfill (before placing subsequent layer)	Random; AASHTO T 310-11[23]

— Indicate that the there is no sublot size.

*If density requirements cannot be achieved due to material incapable of being compacted or tested to maximum values as determined by AASHTO T 99-10, compact each layer a minimum of four passes using vibratory compactor until there is no visible evidence of further consolidation.[16]

4.8. QC DOCUMENTATION AND DATA EVALUATION

4.8.1. QC Inspection Documentation & Evaluation

The contractor shall document all QC inspection activity for each GRS lot produced and placed. All inspection results shall be recorded within 24 h of inspection on current standard inspection report forms (IRFs). The QC manager shall evaluate inspection results in a timely manner to confirm that production and placement processes are in control. The contractor shall submit hard copies of all IRFs to the engineer at the completion of each lot.

4.8.2. QC Sampling and Testing Documentation and Data Analysis

The contractor shall document all QC sampling and testing data for each GRS lot produced and placed. All sampling and testing data shall be recorded within 24 h of sampling and testing on current standard TRFs. The QC manager shall evaluate sampling and testing results in a timely manner to confirm that production and placement processes are in control. The contractor shall submit hard copies of all TRFs to the engineer at the completion of each lot.

4.9. QC RECORDS SYSTEM

4.9.1. QC Daily Diary

The QC manager should maintain a QC daily diary to document all major activities or actions related to the contractor's QC system. The QC daily diary serves as a summary record of key actions taken by QC personnel each day. Recommended information that should be recorded in the QC daily diary includes the following:

- The day's weather or environmental conditions.
- A summary of production or placement activities completed.
- Any non-conforming material or workmanship identified.
- Any corrective actions recommended or taken by QC personnel.
- Discussions held with other contractor personnel or agency personnel.
- Visitors to the production facility or field placement operation.

4.9.2. QC Record Books

The contractor shall maintain one or more ringed binders referred to as "QC record books" to store all required QC documents. Separate QC record books shall be kept at each GRS backfill material production facility and at the project field site. QC data for each pay item number shall be organized into separate sections by quality characteristic and by lot number. QC documents to be stored in the QC record book(s) include the following:

- A signed copy of the current approved QC plan.
- The original signed copies of all completed IRFs.
- The original signed copies of all completed random sampling location forms.
- The original signed copies of all completed TRFs.
- A current copy or printout of all control charts.
- A current copy or printout of all running QLA performed.
- Current summaries of all individual QC test results to date (by lot and sublot).
- Summary sheets of material quantities produced or placed (by lot and sublot).

Each required record shall be inserted into the corresponding QC record book within 24 h after the document has been completed. All QC record books shall be maintained in a suitable

location. The engineer shall be provided access to all QC record books as part of the agency's monitoring of contractor QC activity.

4.9.3. QC Records Retention

All contractor QC records identified above shall be retained for a minimum of 3 years. The records shall be protected from damage or alteration. When requested by any State or Federal agency for audit or similar purposes, the contractor shall provide complete access to all QC records.

SECTION 5. AGENCY ACCEPTANCE, MEASUREMENT, AND PAYMENT

5.1. ACCEPTANCE

The agency is responsible for performing all acceptance activities and making the final acceptance determination for each GRS-IBS lot produced and placed. The agency's acceptance system will include monitoring the contractor's QC activity, performing acceptance inspection, sampling and testing, and determining the quality and corresponding payment for each lot. These activities will be performed for each GRS-IBS lot. The agency should use *Acceptance of Non-Structural Precast Elements* in developing their acceptance procedures.[24]

Materials for GRS-IBS shall be pre-approved materials evaluated under XXX Department of Transportation guides. Construction of the GRS-IBS and services will be evaluated according to section(s) from XXX of XXX Department of Transportation standard specifications.

5.2. MEASUREMENT

Measure the GRS-IBS items listed in the bid schedule according to section XXX of XXX Department of Transportation standard specifications and the following as applicable:

1. Measure the GRS-IBS by the square foot of the front wall face. This will include all elements.

2. Measure the GRS abutment backfill and the RSF backfill by the cubic yard.

3. Measure excavation by the cubic yard.

5.3. PAYMENT

The accepted quantities will be paid at the contract price per unit of measurement for the GRS-IBS pay item listed in the bid schedule. Payment will be full compensation for the work prescribed in the aforementioned sections.

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