TECHNICAL SPECIAL PROVISION

FOR

RESTORING SPALLED CONCRETE USING SHOTCRETE

SECTION T402

FINANCIAL PROJECT ID:

This TSP draft is provided as a general guideline for the designers. The engineer of record may update or append this TSP draft as he/she deems necessary for project specific needs. The engineer of record holds full responsibility for the signed and sealed TSP they furnish. The department does not accept responsibility of any mistakes or contradictions in this draft. This paragraph is intended to be deleted.

SECTION T402

T402-1 Description.

 **T402-1.1 General:** The work under this Section consists of repairing spalled or otherwise deficient concrete by shotcrete methods at locations indicated in the Plans or as directed by the Engineer. Shotcrete designates concrete or mortar conveyed through a hose and pneumatically projected at high velocity onto a surface to achieve high in-place compaction of the projected material. Shotcrete shall be applied to structure components identified in the Plans. Unless otherwise specified in the Contract Documents, it is the Contractor’s option to use either the dry process or the wet process shotcrete. However, the entire project shall be completed using the selected process. This specification does not apply to precast elements before their placement.

 Submit for Engineer’s approval the test data obtained from samples of shotcrete using the job material and equipment scheduled for production use on the actual project structure prior to the start of the shotcrete work.

 **T402-1.2 Machine Operating Requirements**: Provide equipment that supplies shotcrete material at the nozzle that is uniform and not segregated, providing a steady, constant flow of shotcrete with no detrimental surging or pulsing. Maintain the velocity and consistency of shotcrete exiting the nozzle at a uniform rate appropriate for the given job conditions to achieve satisfactory material consolidation and minimum rebound. Provide gauges at or near the dispensing guns and at or near the nozzles to check working pressures. Air for the shotcrete application shall be constant, dry, and free of oils or other contaminants.

 **T402-1.3 Corrosion Damage:** Perform repairs of corrosion-induced concrete spalls in phases for specific components where the structural integrity of the component may be affected due to the amount of required concrete removal when indicated in the Plans or as determined by the Engineer. Perform an inspection to locate and document spalled, cracked, and/or unsound concrete to be repaired prior to commencing the repair work when only estimated quantities are indicated in the Plans due to the continuous progression of damage by active corrosion.

 **T402-1.3.1 Quantities:** When the work quantities are to be determined based on the Contractor’s inspection as indicated in 402-1.3, the Department shall have the authority to increase, decrease, or delete the Plan quantities above or below the percentages allowed in Section 4-3.1 of the Standard Specifications with no adjustment to the contract unit prices. When the quantities are determined based on the Contractor’s inspection, the work will be assigned by the Engineer to a specific group of locations at a time. The Contractor shall propose the repair schedule for Engineer’s approval.

 Perform the inspection by sounding the concrete within the areas indicated in the Plans. Include in the inspection survey all areas already identified in the Plans to verify locations, dimensions, and newly identified areas. Perform the survey in the presence of the Engineer prior to commencing any repair work. The removal and replacement of damaged concrete require the previous Engineer’s approval.

 **T402-1.3.2 Tracking Repair Quantities**: Prepare a detailed report with the identified areas documented as per 402-1.3, indicating the square footage of each deficiency and the estimated total amount of repairs. Format the report to indicate the precise location of each area, estimated quantities for each repair, and calculations for each.

 When work assignments are issued, do not commence work on any new work assignment until the satisfactory completion or substantial progress (more than 40% completion) of previously issued assignments has been confirmed in writing by the Engineer.

 **T402-1.4 Work Staging:** Do not place or store equipment on the roadway unless specifically approved. Use proper equipment to execute the work and proper staging to house all the equipment considering site conditions. The Department will not allow additional time for work delays if it determines that the chosen equipment was inadequate for the existing site conditions.

 Provide special access system for sounding and repairs for spalls located at high elevations and inside pier columns and/or superstructure segments. Remove any anchors and patch any holes created to support scaffold, forms, falsework, and related holes with an appropriate approved mortar or epoxy. Do not anchor to bridge superstructure segments. Do not use permanent attachments or modify the bridge structure for staging/access.

 **T402-1.5 Shop Drawings:** Provide and submit shop drawings indicating the proposed type of access and form systems, including supports, method of shotcrete placement, and containment of shotcrete and waste materials. Assure containment systems continually function as intended daily as a minimum. Approval of the containment system will ultimately be based upon continued satisfactory performance.

 **T402-1.6 Work Plan and Work Schedule:** Submit a detailed testing and work plan and schedule to the Engineer for all the types of concrete restoration work as stated in the Contract Documents for review and written approval before beginning the concrete restoration work. Include in the work plan the anticipated repair volumes, prepackaged mix (if any), approach to spalls with concrete volumes exceeding that allowed by the manufacturer of prepacked materials, and repair methods before beginning work.

 **T402-1.7 Shotcrete Application Personnel:** Use only experienced workers under the constant direction of an experienced superintendent. The superintendent must have a minimum of 5 years of experience working with the same type of shotcrete method used and on projects of a similar type. Provide references showing satisfactory performance on at least three similar previous projects.

 Use a Nozzlemen with at least 100 hours of documented experience in using the proposed shotcrete method on other similar projects. Alternatively, when the proposed Nozzlemen do not have the required minimum experience or the Engineer deems the work critical, Nozzlemen shall possess a valid, up-to-date American Concrete Institute (ACI) Mix Process Certification for the type of shotcreting being used (dry or wet mix). Documentation for the superintendent and Nozzlemen showing compliance with the above requirements must be submitted to the Engineer for approval prior to starting the shotcrete operation.

T402-2 Materials.

 Provide a shotcrete mix design meeting the required compressive strengths shown in Table 402-1 and other requirements as specified herein. Prepare a preconstruction trial mix and a mock-up application using the proposed materials and production equipment to confirm that the mix meets the requirements with sufficient time for testing prior to commencing the production work. Furnish to the Engineer for approval a certified test report for the Portland cement shotcrete proposed for use and described in this specification, indicating that the material meets all requirements specified following the preconstruction trial mix. The shotcrete mixture shall be prepackaged material or ready mixed concrete containing at least: Portland cement, silica fume, aggregates, and, if specified in the Plans, synthetic fibers. Admixtures and Class F fly ash or slag cement will be permitted.

 The Contractor may propose the approval of slight adjustments to the mix if it results in a better placement or a denser, more uniformly completed surface if the minimum strength and other properties requirements are met. Mix all materials dry in an approved skip-operated mixer of at least one bag capacity before placing them in the shotcrete hopper.

 Test for chloride content of the preconstruction trial mix shotcrete per FM 5‑516. Test for chloride content of production shotcrete as directed by the Engineer. The chloride content of the in-place prepackaged or ready-mix shotcrete shall not exceed 0.4 pounds per cubic yard, measured per FM 5‑516.

**T402-2.1 Prepackaged Shotcrete:** Use a polymer-modified Portland cement shotcrete containing corrosion inhibitors unless otherwise allowed in the Contract Documents. The polymer-modified Portland cement shotcrete shall have a maximum water-cementitious materials (W/CM) ratio of 0.45 and meet the requirements shown in Table 402-1 at a minimum unless otherwise specified in the Contract Documents. Require the manufacturer to provide a Field Representative upon request by the Engineer.

 Mix and install the materials per the manufacturer’s written recommendations, unless otherwise specified in the Contract Documents.

|  |
| --- |
| Table 402-1Minimum Compressive Strength of Shotcrete |
| Testing Age (days) | Compressive strength (psi) |
| 1 | 3,000 |
| 7 | 4,000 |
| 28 | 5,500 |

 **T402-2.2 Ready Mix Shotcrete Materials:** Meet the requirements of FDOT Standard Specifications Division III and as follows:

 Type II Portland cement …………………… Section 921

 Coarse Aggregate\* ........................................ Section 901

 Fine Aggregate\*\* .......................................... Section 902

 Water ............................................................. Section 923

 Chemical Admixtures .................................... Section 924

 Supplementary Cementitious Materials……. Section 929

 Fibers\*\*\*....………………………………... ASTM C1116

 *Notes:*

 *\*Coarse Aggregate- No. 89 gravel stone.*

 *\*\*Fine aggregate - Silica Sand*

 *\*\*\*\* Fibers - When specified, use non-metallic fibers meeting the requirements of ASTM C1116, Type II, or Type III dosed as per manufacturer or approved design mix specifications.*

 **T402-2.3 Bonding Agent:** Use a bonding agent specifically formulated to work with shotcrete. Apply the bonding agent to the existing concrete and reinforcing steel before placing the shotcrete repair material. Ensure that such bonding agent is a solvent-free epoxy-cement-based agent. Do not use the bonding agent as a vapor barrier. Mix the bonding agent and apply it per the manufacturer’s specifications for use with shotcrete. Schedule the placement of the repair material according to the manufacturer’s allowed time and conditions when specifically used for shotcrete.

T402-3 Construction Methods.

 **T402-3.1 Surface Preparation of Repair Area:** Provide surface preparation by hydro demolition or mechanically removing all unsound concrete within the repair area to sound concrete. Chip back unsound concrete to sound concrete. Provide conditions of sound, clean, and free of any contaminants to all areas to be repaired prior to placing the spall repair material. Perform the sounding test and remove all delaminated, cracked, or otherwise deficient concrete from the areas that sound hollow. Additionally, solid sound concrete may require removal to obtain a ¾-inch to 1-inch clearance behind the existing reinforcing steel to achieve a mechanical bond. A mechanical bond is required for all spall repairs. In no case shall a spall edge exceed 4 inches without a mechanical bond to the rebar in a vertical and/or horizontal direction. Insert stainless steel dowels if no reinforcement is available to provide the mechanical bond. Use a 15-pound maximum chipping hammer for removing spalled and behind bars concrete and a 4-pound maximum scaling hammer for profiling. Remove additional 6 inches of sound concrete beyond the edge of the spall if corrosion is noted at the edge of the spall. If corrosion is still present after removing the additional 6 inches, stop the repair work and notify the Engineer.

 Chip concrete substrate to obtain a surface profile of 1/16 inch to ⅛ inch deep with a new fractured aggregate surface. Roughen profile to edge of spall, including the sawcut sides. Sandblast clean all exposed steel as per The Society for Protective Coatings (SSPC) report number 10 (SP 10). No traces of rust, mill scale, epoxy, or other contaminants shall be present after sandblasting. Ensure that the backside of the exposed reinforcement is clean. Add new rebars where reinforcement with over 25% section loss is indicated in the Plans.

 Exercise great care to prevent damage to any reinforcing steel and damage to sound concrete not intended for removal within or outside the delaminated areas. Stop work and submit to the Engineer the report of the damages to the concrete and reinforcing steel due to the Contractor’s operation. Submit a repair method for the damaged area(s) for the Engineer’s approval prior to continuing the concrete removal and restoration work.

 Saw cut the perimeter of the spalls to a minimum depth of ¾ inch or as specified by the product manufacturer if prepacked shotcrete is used. Adjust the depth of the sawcut if shallow steel is encountered as approved by the Engineer to avoid damage to the steel. No feathered edges are allowed. Provide horizontal and vertical cuts that follow the general pattern of the spall, avoiding 90-degree angles as the geometry of the spall permits. The sawcut method and equipment shall be included in the Work Plan for approval by the Engineer before commencing any work.

 Place welded wire reinforcing or supplemental reinforcing bars for shotcrete work exceeding 3 inches of cover.

 **T402-3.2 Shotcrete Placement (General).**

 **T402-3.2.1 Shotcrete Processes:**

 1. Wet Process: Mix materials for wet process shotcrete per Section 346 unless pre-packed shotcrete is used. Apply the shotcrete within 90 minutes after batching. The consistency of each batch must be uniform within each batch and uniform from batch to batch when discharged into the shotcrete placement equipment.

 2. Dry Process: Pre-dampensolid ingredients for dry-mix shotcrete as needed and mix in a batch-type or continuous-type mixer. Add the mixing water for the shotcrete at the nozzle. Accurately control the proportion of water added to the mixture to produce thorough and uniform hydration of the shotcrete. Apply dry-mix shotcrete material within 30 minutes after batching or pre-dampening. Do not use shotcrete material mix left in the hopper overnight.

 3. Mix pre-packed shotcrete as per manufacturer instructions.

 **T402-3.2.2 Shotcrete Applications Requirements:**

 Maintain the temperature of the shotcrete at least 50 degrees Fahrenheit but no more than 90 degrees Fahrenheit during application. The ambient and surface temperature of the repair component shall be at least 50 degrees Fahrenheit and rising.

 Provide shotcrete layers thickness such that no sloughing, sagging, tearing, or debonding will occur. Sandblast clean exiting concrete within 24 hours prior to the shotcrete application and damp the surface of the concrete just before application.

 Allow the initial set of the first layer to develop using the initial set time determined from the demonstration mix prior to placing the following layer. Then, remove loose, uneven, or excess material. Remove glaze and rebound by brooming, scraping, or other means.

 Whenever possible, sections shall be gunned in one layer to the full design thickness. However, for multiple layers of reinforcement, gunning of one layer of shotcrete may be required for each layer of reinforcement. Hold the shotcrete nozzle closer than normal and at a slight, upward angle when encasing reinforcement. The mixture may be wetter than normal but not so wet that sloughing behind the reinforcement will occur.

 Place shotcrete starting from the bottom on vertical surfaces. Do not incorporate rebound or previously expended material in any applied layer. Remove all such material from the surface and work area before the final set and before placing shotcrete on adjacent surfaces. Do not place shotcrete if drying or stiffening of the mixture is occurring.

 Presoak the prepared concrete surface with fresh potable water to provide a saturated, surface dry (SSD) condition or as per the bonding agent’s manufacturer published specifications.

 Apply shotcrete in layers not to exceed 1 inch thick when more than one layer is required. Decrease the thickness as necessary for overhead surfaces. Consider the thickness limit, which can be applied in each layer or lift when the material starts to sag or separate. Direct the spray into voids to avoid trapping air pockets in the voids. Troweling may be required to thoroughly work the shotcrete material into smaller voids and check for complete filling of the voids.

 Thoroughly wash down the shotcrete surface with a stream of fresh potable water and air hose excess water before continuing with the remaining shotcrete layer(s) if work stops for longer than 2 hours on any shotcrete layer before it has been built up to the required thickness. Remove any surface deposits that take a final set by abrasive blast cleaning and clean the surface with an air-water blast from the nozzle. Do not apply the curing compounds to the surfaces that will be covered by an additional layer of shotcrete.

 Use shooting strips or guide wires which do not entrap rebound sand to bring the finished work to approximate shape. Slightly round the edges to an approximate shape of a 3/4-inch radius to remove any sharp corners. Provide a positive means of checking the total thickness of the applied shotcrete by using small concrete blocks with built-in galvanized wire fasteners to allow them to be secured to the mesh or by using guide wires which can be removed prior to the final finish coat. Bring the application of shotcrete to within approximately 1/4-inch of the specified finished surface immediately preceding the final coat. Rod to line by using a flat steel-edge screed or trowel without shoving or breaking the shotcrete from its bond. Shoot the final coat in place and float or trowel as needed to give a uniform surface without sloughing or sagging.

 In-place shotcrete shall be uniform and dense, free from hollow sound areas that indicate laminations, voids, sand pockets, or debonded material. Do not square shotcrete construction joints. Slope the material at all construction joints to a thin edge. Thoroughly clean and wet all construction joints before shooting an adjacent section. Do not apply shotcrete on surfaces with standing or running water.

 **T402-3.3 Preconstruction Field Demonstration of Shotcrete Mix:**

 Ensure that the field demonstration of the proposed shotcrete mix includes the fabrication, evaluation, and testing of a mock-up product representative of the production work. The preconstruction field demonstration of the Shotcrete mix shall include the following:

 1. Prepare two 24-inch x 24-inch x 4-inch-deep test panels containing steel reinforcement representing the partial mock-up of the project.

 2. Each nozzleman shall gun two test panels with the proposed mix design to be used on the project and for each gunning orientation to be encountered on the job.

 3. Cure the panels in the field in the same manner as the structure for 1 day and then transport them to the designated testing laboratory, where curing shall be continued until the testing time.

 4. Cut one of the test panels with a trowel or a metal template before the initial set to visually check for possible voids under the reinforcement for shotcrete projects of less than 200 square feet in the presence of the Engineer.

 5. For larger-size projects where specific evidence of good encasement of reinforcing bars is needed, cut cores from the test panels after the concrete has hardened for at least 3 days. Cores shall be cut through the steel for evaluation.

  6. Use the second panels for small and large projects for compressive strength testing of the applied shotcrete. Take 2-inch to 4-inch diameter core samples from the panel at the locations between the reinforcement. The designated laboratory shall perform the compressive strength of the cores at the specified age per ASTM C42.

 7. Determine the initial and final set time for the shotcrete mix using ASTM C191 or ASTM C403 as applicable.

 8. Ensure that the in-place shotcrete demonstrates consistent quality and is free from segregation, honeycombing, sand pockets, sand lenses, sagging, dry patches, overspray, rebound, or incomplete encasement of reinforcement. Shotcrete shall also be free from delamination, cracking, or single voids with more than ¼-inch dimensions. Chlorides shall not exceed 0.4 pounds of chlorides per cubic yard of shotcrete.

 **T402-3.4 Testing of Production Shotcrete.**

 **T402-3.4.1 Quality Control Testing:** Thoroughly check for sags, bridging, and other deficiencies immediately after shotcrete surfaces are brought to final thickness. At a minimum of 3 days after completion of the placing of the shotcrete, thoroughly test again with a small hammer for any deficient sections. At this time, the shotcrete will have attained sufficient strength for all sound sections to ring sharply. Remove and replace any unsound portions of the work found during this inspection period or at any other time prior to the final inspection of the work, at no cost to the Department.

 Sample and test production shotcrete at the frequency specified in this Section. At a minimum, compressive strength, air content, and flexural strength tests shall be performed for each testing cycle. Test boiled absorption and chlorides for the in-place shotcrete when required in the Contract Documents or as directed by the Engineer. Condition and test shotcrete panels per ASTM C1140.

 Prepare one test panel for each shotcrete crew per LOT consisting of one day of production or 200 square feet, whichever occurs first for compressive strength tests. Use the same ingredients of shotcrete and gunning orientation as the shotcrete applied to the job in the testing sample preparation. Prepare the test panels at the same time as the production shotcreting. These panels shall be cured and delivered to the designated testing laboratory. Test values on such panels shall equal or exceed the required 28-day and other specified age compressive strengths.

 Obtain a minimum of three cores from the panel representative of the tested area. The average compressive strength of the cores taken from the work shall equal or exceed the specified strength for the class of shotcrete applied, and no single core shall have strength less than 85% of the specified value.

 If deemed necessary by the Engineer, the adequacy of the bond between the existing concrete and the shotcrete shall be determined by pull-off tests per ACI 503. Minimum bond strength of 250 psi will be accepted as satisfactory.

 The sampling schedule for production testing may be reduced as directed by the Engineer based on a minimum of three previous satisfactory test results and adequate Contractor quality control.

 **T402-3.4.2 Verification Testing:** The Department may verify the testing of any section and reject shotcrete that does not conform to the specification requirements regarding test values, soundings, visual examination, and chloride content. The cost of any additional testing of a suspect or disputed shotcrete that results in rejection shall be borne by the Contractor. The Contractor shall remove and replace or correct defective shotcrete to the satisfaction of the Engineer.

 **T402-3.5 Finishing:** Surfaces of all repaired areas shall be smooth and uniform and match the concrete components’ original profile unless otherwise required in the Contract Documents. Adjust shotcrete placement and finishing methods to prevent gaps between the existing concrete and the shotcrete patching material. Prior to the initial set, the shotcrete surface shall be scraped or cut with a trowel or metal template to obtain an even and aesthetically acceptable appearance. The final finishing shall be with a wet sponge unless otherwise specified. Trowel or float smoothing will not be allowed.

 **T402-3.6 Curing:** Protect the surfaces of finished shotcrete from drying or cracking after placement. Use fogging before the application of moist curing when necessary.

 Wet cure all finished shotcrete surfaces for 7 days by saturating the surface a minimum of four times daily with a fine spray of fresh potable water. The concrete may be cured by using a curing compound. The rate of curing compound application shall be less than 1 gallon of curing compound per 100 square feet of the surface. The color of the curing compound shall be approximately that of the existing concrete.

 Wet burlap curing may be necessary as directed by the Engineer. Start curing as soon as the finished shotcrete surface withstands the curing operation without damage.

 Trowel finish repair edges requiring touch-up work with the same type of shotcrete material used for the repair as directed by the Engineer.

 Do not apply curing compound to shotcrete spall repairs on components within the limits of cathodic protection.

T402-4 Durability of the Spall Repair.

 Use concrete repair materials included explicitly in the Contract Documents or previously approved by the Engineer. Perform repairs on new concrete to last as much as the native concrete. Repairs on ten-year-old or older concrete with Portland-Cement-based mixes shall have a maintenance-free service life of two years. Repairs on ten-year-old or older concrete with Polymer-Modified mixes shall have a maintenance-free service life of four years.

T402-5 Method of Measurement.

 The quantity to be paid for will be based on the volume, in cubic feet, of defective areas restored and approved by the Engineer. The method utilized in determining the volume shall be the area in square feet of spalled areas multiplied by the average depth of such areas.

T402-6 Basis of Payment.

 The quantity to be paid for shall be the volume, in cubic feet, of spalled or otherwise deficient areas restored, complete, in place, and accepted satisfactory by the Engineer.

 The quantity determined as provided in 402-1.3 shall be paid for at the contract unit price bid for restoring the defective concrete areas. Such price and payment shall be full compensation for all work specified in this Section and shall include all materials, testing, equipment, labor, concrete removal and disposal, saw-cutting, surface preparation, new reinforcement, forming, curing, and incidentals necessary to complete the work.

 Cost for restored spall areas will be paid based on the volume of actual spalls restored by the Contractor and the specified repair material. Quantities given in the Plans are estimates and may be increased, decreased, or deleted beyond the limits allowed by Section 4 of the Specifications as necessary based on actual conditions found on the structure.

 Payment will be made under the appropriate Pay Item:

401-70-7 Restore spalled or deficient Concrete - Shotcrete - per cubic foot.