Tech Brief

GUIDE SPECIFICATION FOR JOINTED PRECAST CONCRETE PAVEMENT

INTRODUCTION

Jointed precast concrete pavement (JPrCP) technology has gained wide acceptance in the United States (US) for rapid repair and rehabilitation of concrete pavements, and for reconstruction of heavily trafficked asphalt intersections and ramps. This widespread use in the US is fairly recent, with most projects in service fewer than 10 years. JPrCP technology is used most frequently where maintenance of traffic limits work zones to overnight durations and where long-life pavement performance is needed. The service life of intermittent JPrCP repairs is expected to be at least 20 years. Longer-length applications of JPrCP are expected to serve for 40 years or more without a need for corrective treatment except griding to restore desired surface characteristics.

Panel fabrication, storage, delivery and installation are unique steps leading to a satisfactory JPrCP experience. This guide specification for JPrCP has been developed based on knowledge of the best practices from thirty-one highway agencies throughout the US that have constructed at least one JPrCP project up to ten or more such projects. It may be used by these and other highway agencies to create state-of-the-art guidance, with modifications needed to incorporate individual highway agency format and standards.

This guide specification presents considerations for the use of JPrCP based on the best practices observed from experiences of numerous highway agencies. This document provides best practices for the use of JPrCP. It does not create any Federal requirements other than those stipulated in statute or regulation.

U.S. Department of Transportation
Federal Highway Administration

GUIDE SPECIFICATION FOR JOINTED PRECAST CONCRETE PAVEMENT

1.0 SCOPE

1.1 General

A jointed precast concrete pavement (JPrCP) incorporates precast concrete panels installed over a prepared new or existing base. The precast concrete panels are fabricated and installed in accordance with the contract plans. This guide specification details recommendations, resulting from highway agency experiences, for materials and processes for fabrication of the panels and construction of JPrCP to be used for rehabilitation or reconstruction of existing asphalt and concrete pavements.

The work includes, but is not necessarily limited to, the following:

1. Sawcutting and removing existing pavement.
2. Existing or new base preparation.
3. Installation of approved bedding material, if required.
4. Installation of load transfer devices at transverse joints.
5. Installation of tie bars along the longitudinal joints, if required.
6. Placement of precast panels.
7. Application of bedding grout or panel undersealing, as required.
8. Grouting or patching of dowel bar and tie bar slots, as required, and other designated ports.
9. Joint sawing, if applicable, and joint sealing.
10. Diamond grinding, if applicable.

In this guide specification, the term "Engineer" refers to the representative of the highway agency and the term "Contractor" refers to the general contractor who is contracted to perform the work. The following standard-making organizations are referred to in this specification:

- ASTM – American Society for Testing and Materials
- NPCA – National Precast Concrete Association
- PCI – Precast/Prestressed Concrete Institute

1.2 End Product

The end product for the work is the JPrCP constructed using materials, equipment and processes referenced in this guide specification. The end product is accepted or is considered defective on the basis of the following acceptance testing:

1. Fabricated Precast Panels
    a. Highway agency requirements for concrete. See Para. 3.1.
    b. Panel dimensional tolerances. See Para. 5.8.
2. Installed Precast Panels
    a. Vertical elevation difference at transverse joints. See Para. 7.1.
    b. Joint width at transverse and longitudinal joints. See Para. 7.2.
    c. Damaged or defective concrete. See Para. 7.3.

d. Deflection testing. See Para. 7.4.
e. Smoothness testing. See Para. 7.5.

Defective panels and defective panel installation are mitigated in accordance with Para. 8.0.

1.3 End Product Responsibility

The Contractor is responsible for the materials and processes that produce the end product. It is the Contractor's responsibility to ensure that the processes for fabricating and installing the precast panels can be satisfactorily performed.

The Engineer will determine if the Contractor's materials and processes produce an end product that is in conformity with the plans and specifications. Tolerances to determine conformity for measurable components of the materials, processes, and end product are provided in this guide specification.

When the Engineer determines that a panel delivered to the project site, the panel installation process, or the installed panel is not in conformity with the plans and specifications and results in an unacceptable product, the affected panel(s) must be removed and replaced or otherwise corrected at the Contractor's expense in accordance with Para. 8.0 – Defective Panels and Defective Panel Installation.

1.4 Preconstruction Conference

At least 7 days, but not more than 30 days, prior to panel fabrication, the Contractor and his team members will meet with the Engineer to review the highway agency's project plans and specification, and related issues concerning panel fabrication, delivery and installation. The following are minimum agenda items for the Preconstruction Conference:

1. Submittals and status of submittals.
2. Critical material availability issues.
3. Highway agency requirements for concrete.
4. Fabrication and installation schedule.
5. Panel fabrication process control.
6. Panel surface texture to be applied.
7. Test section requirements.
8. Weather limitations for panel installation.
9. Contractor's process control (quality control (QC)) and testing.
10. Agency acceptance (quality assurance (QA)) and testing.
11. Construction maintenance of traffic (MOT).
12. On-site safety and emergency management plan (SEMP).
13. Work stoppage before and during special local events and holidays.
14. Who on Contractor's staff has stop-work authority?
15. Who on Engineer's staff has stop-work authority?
16. On-site issues and disputes resolution hierarchy.

Additional preconstruction meetings may be held at the request of the Engineer or the Contractor.

1.5 Precast Panels

Typical considerations for precast concrete panels are, as follows:

1. Precast panel dimensions conform to the dimensions shown on the project plans.
2. Precast panels may be reinforced or prestressed.
3. Precast panels typically have provisions to accommodate load transfer at transverse joints using round epoxy-coated dowel bars [INSERT REFERENCE TO HIGHWAY AGENCY SPECIFICATION].
    a. Dowel bar diameter and length will be as shown on the plans developed by the highway agency.
    b. The number of dowel bars to be used per panel and location will be as shown on the plans. The longitudinal axis of the dowel bar typically will be located at the panel mid-depth plus or minus 1/4 in. vertically.
    c. The panel load-transfer mechanism using dowel bars may include use of slots at the panel surface or slots at the panel bottom. The depth of the slots typically will not exceed half the panel thickness plus 1-1/4 inch.
        i. For top slots, the width at the top surface typically will not exceed 1-1/2 in. and the width at the location of the dowel bars typically will be at least 2-1/2 in. and not more than 3-1/2 in.
        ii. For bottom slots, the width at the bottom surface typically will be no more than 2-1/2 in. and the width at the location of the dowel bars typically will be at least 3 in. and not more than 3-1/2 in.
        iii. For both top slots and bottom slots, the slot length typically will not exceed the length of the dowel bar plus 1 in.
        iv. The grout or patching material typically used to fill the slots is described in Para. 3.3.
        v. The load transfer effectiveness at transverse joints of the installed precast pavement typically is demonstrated at a test section, which is described in Para. 7.4.
    d. Panels incorporating other load-transfer mechanisms will require approval by the highway agency prior to the pre-bid meeting for any specific project/contract.
4. Panel support is a bedding layer between the base and the panel. The bedding layer is placed either before or after a panel is installed. The bedding layer thickness typically will be a maximum of 1/2 in. The bedding layer may be one of the following, as designated in the plans:
    a. For grade-placed panels: Panels will be supported by a graded and compacted sand-cement layer.
        i. A sand-cement material is described in Para. 3.6.
        ii. Grade-placed panels will require subsequent application of an undersealing cementitious grout to ensure full contact underneath the panel. An undersealing cementitious grout is described in Para. 3.4.
    b. For grout-supported panels: Panels will be supported by a cementitious bedding grout. This method requires use of adjustable leveling lifts, fabricated at four

locations integrally with the panel, to support and adjust the desired elevation of the panel. The use of shims to support the panels is not permitted. The bedding grout is injected through ports to completely fill the gap under each panel after the panel has been raised to the desired elevation using the leveling lifts.

i. The plate at the base of the leveling lift must be dimensioned to minimize plate penetration into the base layer.
ii. A bedding grout used to support the panels is described in Para. 3.7.

c. Other bedding layers may be approved by the highway agency.

2.0 SUBMITTALS

The Contractor will provide, as a minimum, the submittals listed in the following sections. The personnel and laboratories conducting the aggregate and concrete related testing for the project will meet the requirements of ASTM C 1077 for concrete testing personnel and concrete testing laboratory requirements.

2.1 Pre-construction Submittals

Pre-construction submittals will be submitted to the Engineer before the pre-paving meeting. Submittals include, but are not limited to, the following:

1. Panel Fabrication Related
    a. Concrete plant certification (from AGENCY, NPCA, or PCI).
    b. Concrete testing laboratory certification (as per ASTM C 1077).
    c. Concrete testing personnel certification (as per ASTM C 1077).
    d. PCI certification if panels are to be pre-tensioned.
    e. PCI or NPCA certification if panels are to be reinforced using steel bars.
    f. Reinforcing steel mill certificate.
    g. Prestressing steel mill certificate, if applicable.
    h. Lifting/leveling lift system anchor test certificate or test report indicating suitability of the system for the designated use.
    i. Dowel bar and tie bar certificate.
    j. Cement mill certificates.
    k. Supplementary cementing material mill certificates.
    l. Aggregate certificate or test report.
    m. Admixture certificate or test report.
    n. Water certificate, test report or a statement that municipal drinking water source will be used.
    o. For each concrete mixture to be used:
        i. Maximum aggregate size and target air content.
        ii. Concrete mixture proportions.
        iii. Concrete compressive strength data.
    p. Panel fabrication process control plan.
    q. Panel texture to be provided.
    r. Final set of panel shop drawings.

2. Panel Installation Related
    a. On-site test section plan.
    b. Panel installation plan detailing:
        i. On-site equipment list, as a minimum:
            1. Existing pavement removal equipment.
            2. Base preparation equipment.
            3. Panel lifting and handling equipment.
            4. Grout mixture equipment.
        ii. On-site crew list and responsibilities.
        iii. Daily work activity plan.
        iv. Existing pavement removal plan.
        v. Base preparation, including grading and compaction, as applicable.
        vi. Panel-related preparatory work before installing panels.
        vii. Crane positioning and panel lifting from trucks.
        viii. Bedding grout application sequence for grout-supported panels.
        ix. Undersealing grout application sequence for grade-placed panels.
        x. Dowel bar slot patching or grouting sequence.
        xi. Joint sawing and sealing timing.
    c. Dowel bar slot patching material or grout certification.
    d. Panel undersealing grout certification for grade-placed panels.
    e. Bedding grout certification for grout-supported panels.
    f. Epoxy material certification for use with dowel bar and tie bar installation in existing concrete pavement. Epoxy materials are described in ASTM C 881, two component Type IV, Grade 3.
    g. Maintenance of traffic (MOT) plan.
    h. Contractor quality control (CQC) program.
    i. Safety and emergency management plan.
    j. Inclement weather plan.
    k. Diamond grinding plan detailing equipment, process and timing.
3. Just-in-Time-Training (JITT)
    a. The JITT agenda covers key details related to the project-specific plans and specifications, as well as best practices for panel installation that ensure quality panel installation.
    b. JITT instructor name and qualifications related to precast concrete pavement construction.
    c. JITT date, time and location.
    d. List of Contractor crew, including all supervisory personnel, that will attend the JITT.
    e. JITT typically is conducted within 2 to 4 weeks of the start of construction.
    f. The JITT will be scheduled following approval by the highway agency.

2.2 Contractor Process Control Testing Submittals

Submittals related to Contractor process control or quality control typically are submitted to the Engineer in writing within 24 hours of completion of the tests. These submittals include the following process control tests:

1. Panel fabrication related:
    a. Concrete air content.
    b. Concrete compressive strength at time of panel form stripping.
    c. Concrete compressive strength at the specified age or at time of panel shipment to the project site.
    d. Embedded dowel bar alignment, if out of tolerance.
    e. Panel dimensions for panels out of specified dimensional tolerances.
2. Panel installation related:
    a. Sand-cement mixture design for the bedding layer including compressive strength at the specified age, if applicable.
    b. Undersealing grout compressive strength at the specified age, as per ASTM C109, if applicable.
    c. Bedding grout compressive strength at the specified age, as per ASTM C 109, as applicable.
    d. Bedding grout efflux time, as per ASTM C 939, as applicable.
    e. Slot patching material compressive strength at specified ages, as per ASTM C 109 or ASTM C 39.
    f. Vertical elevation difference at transverse joint corners before and after diamond grinding, if applicable.
    g. Width of transverse joints at each corner.
    h. Width of longitudinal gap at corners of each panel.
    i. Transverse joint deflection test data, if applicable.

3.0 MATERIALS

3.1 Concrete

Use concrete meeting the requirements of [INSERT REFERENCE TO HIGHWAY AGENCY SPECIFICATIONS] unless noted otherwise in the contract documents or fabricator shop drawings.

Note to Specifiers: The following concrete properties typically are used for precast panel concrete:

1. Design concrete flexural strength at 14 or 28 days as per highway agency practice, typically a minimum: 650 psi.
2. Alternatively, design concrete compressive strength at 14 or 28 days as per highway agency practice, typically a minimum: 4,000 psi.
3. Concrete compressive strength at time of panel form stripping, typically a minimum: 2,500 psi.
4. Concrete compressive strength at time of panel shipment to the project site, typically a minimum: 4,000 psi.
5. Concrete compressive strength at the specified age, 14 or 28 days as per highway agency practice, typically a minimum: 4,000 psi.
6. Concrete aggregate: Based on highway agency practice.
7. Concrete air content: Based on highway agency practice.
8. Concrete durability requirements: Based on highway agency practice.
9. Concrete aggregate quality and gradation: Based on highway agency practice.

10. Cementitious materials: Based on agency practice.
11. Concrete admixtures: Based on agency practice.

3.2 Reinforcement

Use reinforcing bars meeting [INSERT REFERENCE TO HIGHWAY AGENCY SPECIFICATIONS]. Provide a minimum concrete cover of 2 in. (OR AS PER HIGHWAY AGENCY PRACTICE) between any reinforcement and exposed concrete surfaces. Show cover details in the fabricator shop drawings.

For non-prestressed panels, provide a double mat of reinforcement with a size and spacing of steel in both directions that result in a ratio of steel area to concrete area of at least 0.0018 (0.18%) and a maximum center-to-center bar spacing in both directions of 12 in.

For prestressed panels that are pretensioned during fabrication, provide a double mat of steel reinforcement in the non-prestressed direction that results in a ratio of steel area to concrete area of at least 0.0018 (0.18%) and a maximum center-to-center bar spacing of 12 in.

For prestressed panels, use prestressing steel that meets the requirements of [INSERT REFERENCE TO HIGHWAY AGENCY SPECIFICATIONS]. Prestressing tendons typically will be high-strength (ASTM A416/A416 M, Grade 270 or better) low-relaxation strand.

The panels may include additional reinforcement based either on job-site loading conditions, (e.g., when slabs must be loaded before bedding grout is applied beneath the panels), or on irregular shape of panels, and at locations of lifting inserts and block-outs, to be shown in the fabricator shop drawings.

3.3 Grout or Patching Materials for Dowel Bar and Tie Bar Slots and for Grout and Lifting Insert Ports

Grout or patching materials typically will be the material designated on the shop drawings or an equivalent material approved by the highway agency. The compressive strength of grout or patching material at the time of opening to traffic typically will be at least 2,500 psi. Typical grout and patching material requirements are shown in Table 1.

TABLE 1 – TYPICAL GROUT AND PATCHING MATERIAL REQUIREMENTS

Property	Minimum	Maximum
Compressive Strength, Opening to Traffic	2,500 psi	-
Compressive Strength, 28-day	4,000 psi	-
Expansion (ASTM C 940)	-	0.40 %
Contraction	-	0.05%
Freeze-Thaw Loss (25 cycles at 10% NaCl)	-	1.0%
Bond Strength (to dry PCC), 28-day	300 psi	-
Initial Set Time	15 minutes	-
Chloride Content	-	0.05%
Sulfate Content	-	5.0%

3.4 Panel Undersealing Grout (for Grade-Placed Panels)

For grade-placed panels, the undersealing grout typically will be the material designated on the fabricator shop drawings or an alternate prepackaged material approved by the highway agency for this purpose. The Efflux Time (ASTM C 939) at the time of grout pumping into the grout ports typically will be 15 to 20 seconds. The compressive strength of the undersealing grout at time of opening to traffic typically will be 500 psi.

3.5 Fine-grained Granular Bedding (for Grade-Placed Panels)

Use of fine-grained granular bedding for grade-placed panels is not allowed.

3.6 Sand-Cement Bedding (for Grade-Placed Panels)

For grade-placed panels, use a mixture of sand and cement that typically will develop a minimum compressive strength of 500 psi at the time of opening to traffic. The bedding thickness typically will not exceed 1/2 in.

3.7 Bedding Grout (for Grout-Supported Panels)

For grout-supported panels, the bedding grout material will be the material designated on the shop drawings or an equivalent material approved by the highway agency. The compressive strength of the bedding grout material at time of opening to traffic typically will be at least 500 psi. Typical bedding grout material requirements are shown in Table 2. The minimum thickness of the bedding grout typically will be ¼ in.

TABLE 2 – TYPICAL BEDDING GROUT MATERIAL REQUIREMENTS

Property	Minimum	Maximum
Compressive Strength at Removal of Leveling Lift Bolts	100 psi	
Compressive Strength at Opening to Traffic	500 psi	-
Compressive Strength at 28-days	2,500 psi	-
Expansion (ASTM C 940)	0	3.0 %
Efflux Time (ASTM C 939), just before introducing grout into the grout ports	15 seconds	30 seconds

4.0 PANEL LAYOUT AND FABRICATOR SHOP DRAWINGS

The Contractor typically will provide project-specific panel layout drawings and fabricator shop drawings from the panel fabricator for each contract. The fabricator shop drawings for manufacture of the precast concrete panels typically will meet the requirements of Para. 1.5 of this guide specification. The fabricator shop drawings typically will include, as a minimum, details related to concrete materials, grouts, slot patching materials, epoxy materials, reinforcement, pretensioning strand, panel lift and leveling inserts, panel surface texturing, and panel handling and shipping.

All Contractor-submitted fabricator shop drawings will be signed by a Registered Professional Engineer on the Contractor's team licensed to practice in [STATE]. Copies of the approved fabricator shop drawings will be returned to the Contractor.

4.1 Panels Adjacent to Existing Concrete Pavement

The fabricator shop drawings typically will include details related to the load transfer provision at joints that include an existing concrete pavement. These details include:

1. Design of panel to be placed next to the existing concrete pavement, indicating how the panel will be installed and how the joint load transfer provision will be provided for.
2. Drilling of holes in the existing concrete pavement to insert dowel bars at the specified depth, spacing, and alignment.
3. Diameter and length of the holes to be drilled.
4. Epoxy material details.
5. Injection of epoxy and installation of dowel bars into drilled holes.

5.0 PANEL FABRICATION

The panels will be supplied by a precast concrete fabricator whose plant is certified by PCI, NPCA, or [HIGHWAY AGENCY NAME].

5.1 General Panel Fabrication Considerations

The following considerations are for fabrication of the panels:

1. Fabricate the panels in accordance with the fabricator shop drawings. Install the reinforcement, the lifting inserts, and grout ports, in the amounts and at locations designated in the fabricator shop drawings.
2. Dowel bars and tie bars will be installed in the amount, at the alignment and at locations designated in the fabricator shop drawings.
3. Dowel bar and tie bar slots will be installed in the amount, at the alignment and at locations designated in the fabricator shop drawings.
4. Tendons for pre-tensioning will be installed in the amount and at locations designated in the fabricator shop drawings.
5. Use rigid metal side forms and a metal bed to fabricate the panels. Use of non-metallic forms and bed is not permitted.

5.2 Panel Hardware Installation

Panel hardware will be embedded in the panel as shown in the fabricator shop drawings. The panel hardware may include the following:

1. Reinforcement placed in a single or both directions and in two layers.
2. Prestressing strands for pretensioning, placed mid-depth to 1/2 inch below mid-depth.
3. Block-outs for dowel bars, tie bars and any other load-transfer devices.
4. Grout tubes for the following:
    a. Dowel bar slots.
    b. Undersealing or bedding grout.
5. Lifting/leveling lift hardware; plates at bottom of leveling lifts must be able to carry panel loading without settlement into the underlying layer.

5.3 Concrete Mixture and Concrete Placement

Concrete will be produced in accordance with the requirements of ASTM C94 [OR INSERT REFERENCE TO AGENCY SPECIFICATION]. Concrete plants supplying the concrete will be certified by the [AGENCY NAME] or in accordance with the requirements of National Ready Mixed Concrete Association's QC3 checklist.

Slump concrete or self-consolidating concrete may be used. The concrete mixture to be used will be the concrete mixture submitted by the Contractor to the [AGENCY NAME]. Any changes to the cementitious content, the aggregate source, the aggregate gradation, and the water to cementitious materials ratio will require submission of a new mixture design for approval by the highway agency before the new concrete mixture can be used for panel fabrication.

Concrete will be placed and consolidated, as necessary, to ensure that the concrete quality is uniform throughout the panel and the concrete aggregates do not segregate.

5.4 Surface Texture

Apply one of the following textures, in accordance with [INSERT REFERENCE TO AGENCY SPECIFICATION], to the top surface of the panel:

1. Longitudinal or transverse tining.
2. Astro-turf drag.

The texture will be applied while the concrete is still in a plastic state, but without damaging the surface of the concrete and before application of membrane curing compound.

5.5 Concrete Curing

5.5.1 Conventional Curing of the Panels

Once the panel finishing details are taken care of, the panel surfaces and sides will be sprayed with an approved concrete-curing compound. The curing compound will be applied within four hours of panel stripping.

The curing compound used will be a white pigmented membrane curing compound from [THE AGENCY]'s approved list.

5.5.2 Steam Curing of the Panels

Steam curing, at atmospheric pressure, will be the done as a precaster option. When steam curing is used, it will be done in accordance with industry accepted standards.

For steam-cured pre-tensioned panels, de-tensioning and flame-cutting of the tendons will be done at the end of steam curing.

The conventional curing of the panel, in accordance with Para. 5.5.1, will be applied within 60 minutes of exposure to ambient conditions.

5.6 Pre-tensioning of Panels

If pre-tensioned panels are to be used, the panel design and the fabricator shop drawings typically include the details for pretensioning of the panels, including the minimum concrete compressive strength at the time of prestressing strand detensioning. Unless otherwise noted in the fabricator shop drawings, pretensioning will be achieved using 0.5 in.-diameter strands. The strands will be positioned at locations designated in the fabricator shop drawings.

At about 15 to 20 hours, just before the formwork is stripped and after the concrete has attained the desired strength, the strands will be released from the anchorage at the bulkheads. The strands may be released earlier from the anchorage if steam curing is used and desired compressive strength is met. The strands will be flame-cut after the formwork is stripped.

5.7 Formwork Stripping and Panel Finishing

The panels typically will be stripped of formwork after the concrete has attained a minimum compressive strength of 2,500 psi to ensure that the concrete will not be damaged during the stripping process and to allow for the lifting of the panels. The stripped panels may be moved to other areas within the plant to complete finishing details, as follows:

1. Clean-up of the slot block-outs. Sand-blasting of dowel-bar and tie-bar slots.
2. Applying project- and panel-specific marking on each panel.
3. Cutting of pre-tensioning tendons, if applicable.
4. Checking for any damage to the panel, repairing minor surface damage, and filling up surface voids over 0.5 in. in diameter using an approved proprietary patching material.
5. Rounding the top edges of the panels with a hand stone.
6. Checking for dowel bar alignment.
7. Checking for dimensional tolerances.

All forms and casting bed areas will be cleaned after each use.

5.8 Dimensional Tolerances

Typical dimensional tolerances for JPrCP panels from fabricator shop drawings are in Table 3.

TABLE 3 – PRECAST PANEL DIMENSIONAL TOLERANCES

Panel Feature	Tolerance
Length and width	+/- ¼ in.
Thickness	+/- 1/16 in.
Squareness of corner - plan view (from corner to corner, measured diagonally)	+/- 3/16 in.
Local smoothness of top surface	¼ in. over 10 ft in any direction
Vertical location of reinforcement (Minimum cover requirements must be met)	+/- ½ in.
Vertical location of pretensioning strand, if applicable	+/- ¼ in.
Blockout dimensions (if applicable)	+/- ¼ in.
Position of lifting inserts – plan view	+/- 3 in.
Alignment of embedded dowel bars	As per agency practice

5.9 Panel Marking

Panel marking typically is applied to a longitudinal edge face to include the following information, as a minimum:

1. Fabrication date.
2. Manufacturer information.
3. Panel number.
4. Panel type.
5. Panel weight.
6. Panel dimensions (thickness, length and width).

5.10 Panel Inspection

Each fabricated panel typically is inspected, after removal from the form and before the panel is moved to the plant storage area, for the following:

1. Dimensional tolerances described in Para. 5.4.
2. Surface defects.
3. Improper surface texture.
4. Spalling along edges.
5. Cracking.
6. Location of dowel bar and tie-bar slots.
7. Any other damage to the concrete or the panel that may impact performance of the panel.

Panels not meeting the specified dimensional and dowel bar alignment tolerances, exhibiting poor surface texture, or surface defects and damage typically will be considered defective.

Defective panels typically will be mitigated as described in Para. 8.1 - Defective Panels

Embedded dowel bars and tie bars, if present in the panels, should be protected against damage during panel lifting, handling, and shipping.

5.11 Panel Storage and Shipping

The panels typically are stored at the plant site for a period of at least 14 days before shipping to the project site. The panels should be stacked on solid dunnage at locations that minimize panel warping due to self-weight and creep. The dunnage arrangement typically will be as shown on the fabricator shop drawings.

The panels are shipped with due care to ensure that the panels do not suffer any damage during the transfer to the project site. The panels may be stored near the project site for an additional period of time using the procedures described for storage at the plant location.

Care must be taken to ensure that the correct type of panel is shipped and that the panel identification numbers match the panel numbers designated for placement during a specific lane closure.

6.0 PANEL INSTALLATION

6.1 Technical Assistance

If the precast panels have installation procedures that must be performed in accordance with the panel designer's instructions, the panel designer or his trained representative typically will provide on-site technical assistance at the beginning of panel installation and continuing for the installation of additional panels, typically up to 10 panels.

6.2 Test Section

A test section will be constructed in accordance with an approved test-section plan. The test section is not to be used to train the Contractor's crew. The test section typically is constructed to verify the following, as a minimum:

1. Contractor's understanding of project requirements.
2. Availability of equipment.
3. Panel handling at the work site.
4. Base preparation.
5. Sand-cement bedding layer placement, if applicable.
6. Panel installation.
7. Bedding grout application, if applicable.
8. Dowel slot grout or patching material application.
9. Timing of all activities.

As a minimum, a total of 10 panels typically will be installed at the test section. The acceptance of the test section typically is constructed in accordance with Para. 7.0, except for Smoothness Testing (Para. 7.5) and Defective Panels or Defective Panel Installation (Para. 8.0). A determination of defective panels or defective panel installation will result in non-acceptance of the test section and construction of another test section. Production panel installation will not begin until the Engineer has provided written authorization to proceed with panel installation.

6.3 Weather Limitations

The Contractor typically will ensure that the grout and patching materials are suitable, based upon manufacturers' recommendations, for the weather conditions that may exist at the time of installation.

Contingency instructions and alternate materials for potential installation during extreme weather events should be provided by the Contractor. Extreme weather events typically are defined as steady rain, and air temperature lower than 32 ^{o}F and higher than 90 ^{o}F.

Work stoppages due to extreme weather events typically will be discussed at the Preconstruction Meeting (Para. 1.4).

6.4 Existing Pavement Removal

The existing pavement may be an asphalt pavement or a concrete pavement. Typically, not more than three days before panel installation at a designated location, the existing concrete pavement areas to be removed will be saw-cut full-depth in a grid pattern, approved by the Engineer. During the lane closure for the panel installation, the existing pavement within a given work area typically will be removed using a method, approved by the Engineer, that will minimize damage to the existing base. If during the pavement removal process any adjacent existing pavement is damaged, the damaged pavement section typically will be repaired as directed by the Engineer.

The removal of the existing asphalt pavement in a given work area typically will be done, using a method approved by the Engineer, during the lane closure for the panel installation in that work area. If during the pavement removal process any adjacent existing pavement is damaged, the damaged pavement section typically will be repaired as directed by the Engineer.

Disposal of all removed existing concrete pavement or existing asphalt pavement typically will be in accordance with the requirements of [INSERT REFERENCE TO HIGHWAY AGENCY SPECIFICATION].

6.5 Base Preparation

6.5.1 Existing Base

An existing base to be left in place typically will be a granular base or a stabilized base.

If the existing base is a granular base, the base typically will be re-graded and compacted using vibratory roller compaction in accordance with [INSERT REFERENCE TO HIGHWAY AGENCY SPECIFICATION]. The moisture content in the upper 6 in. of the granular base typically will be adjusted, as necessary, to allow the compacted base to achieve a dry density of 95% of the ASTM D 1557 maximum dry density for that material. The compacted base density typically will be verified using the procedures of ASTM C 6938. The base typically will be finished to the required grade to provide a smooth surface for panel placement. The finished base surface typically will have no areas, in excess of two square feet, at the bedding surface that exhibit low spots in excess of 0.25 in.; and, the prepared base surface should not be disturbed before placement of the panel.

If necessary, the Contractor typically will use a sand-cement bedding layer, as described in Para. 3.6, to correct the base grade. The bedding layer typically will be finished to the required grade and compacted to provide a smooth surface for panel placement. The finished bedding surface typically will have no areas, in excess of two square feet, at the bedding surface that exhibit low spots in excess of 0.25 in.; and, the prepared bedding surface should not be disturbed before placement of the panel.

6.5.2 New Base

A new base typically will be constructed, if required by the highway agency's project plans. The new base typically will be constructed to the width and thickness designated in the project plans. The new base typically will be constructed and tested in accordance with the requirements of [INSERT REFERENCE TO HIGHWAY AGENCY SPECIFICATION].

The base surface typically will be finished to ensure that the panels can be placed at the correct surface elevation. The finished base surface typically will have no areas, in excess of two square feet, that exhibit low spots in excess of 0.25 in.

As required by the highway agency's project plans, one of the following treatments typically will be applied over the new base:

1. Prior to panel placement, apply sand-cement granular bedding, as per Para. 3.6. The bedding material is to be compacted and graded.
2. Prior to panel placement, apply bedding grout material, as per Para. 3.7. The bedding grout material is to be applied using grout ports.
3. Apply other bedding layer, as per Para. 3.8.

The sand-cement granular bedding layer typically will be finished to the required grade and compacted to provide a smooth surface for panel placement. The finished bedding surface typically will have no areas, in excess of two square feet, at the bedding surface that exhibit low spots in excess of 0.25 in.; and the prepared bedding surface should not be disturbed before placement of the panel.

6.6 Panel Placement

Each panel typically will be placed to the line and grade depicted in the contract layout plans, within the tolerances required by the highway agency, and in accordance with the panel designer’s instructions (if applicable). The grade-placed panels typically will be removed and reset prior to placement of slot grout or patching material and undersealing grout, if the vertical elevation difference at the panel transverse joints is greater than 0.125 in.

The panels typically will be placed using one of the following methods as shown in the fabricator shop drawings.

1. Grade-placed panels - The dowel- and tie-bar slots (at either the panel surface or bottom) if used, and/or the embedded dowel bars and tie bars, if used, will be positioned to match the locations of the corresponding embedded or drilled and grouted dowel bars and tie bars or corresponding dowel-bar or tie-bar slots, as applicable, in accordance with the details shown in the panel layout plans and the fabricator shop drawings.

2. Grout-supported panels - The panels will be set at the desired elevation using leveling lifts fabricated within each panel and at four symmetrically located points and comprising leveling bolts and companion steel plates. The steel plates typically will be a minimum of 6 in. by 6 in. in plan and have a thickness of 0.50 in. The approved bedding grout material will be used in conjunction with this placement method to fill the gap between the base and the panel bottom. The leveling bolts typically are removed from the panel as soon as the bedding grout has attained a compressive strength of 100 psi.

6.6.1 Panel Placement Adjacent to Exiting Concrete Pavement

The panels to be installed adjacent to existing concrete pavement typically will be placed in accordance with the requirements of Para. 4.1. Drilled holes for inserting dowel bars in the existing concrete pavement must be completely filled with the epoxy after dowel bar insertion. An epoxy-retention disc is used at the joint face to prevent the epoxy from flowing out.

For intermittent single panel installation or when work area length limits the use of roller compaction of the granular base and the sand-cement bedding layer, compaction typically is achieved using vibratory tamping plates approved by the Engineer.

Panels typically will be installed adjacent to existing concrete pavement in accordance with the details provided in the approved fabricator shop drawings.

6.7 Joints

6.7.1 Joint Gap

The panels typically are placed so that the width of the transverse joints incorporating the panels will not exceed 0.5 in. The width of the longitudinal joints typically is set to be within 0.5 in. of the width shown in the project layout plans or as directed by the Engineer.

If the panels are opened to traffic before the dowel slots are grouted or patched, shims typically will be used in transverse joints at the approach joint side of the panels to prevent backward drift of the panels under traffic.

6.7.2 Load Transfer at Transverse Joints

Following are methods available to provide load transfer at transverse joints:

1. Using panels with dowel slots at the panel bottom at one transverse edge and embedded dowels at the other transverse edge, as detailed in the approved fabricator shop drawings.
2. Using panels with narrow-mouthed dowel slots at the surface at one transverse edge and embedded dowels at the other transverse edge, as detailed in the approved fabricator shop drawings.
3. Using panels with dowel slots at the surface of one transverse edge and holes in the other transverse edge to receive the dowel, as detailed in the approved fabricator shop drawings.
4. Using other approved load transfer techniques, as detailed in the approved fabricator shop drawings.

6.7.3 Tie Bars along Longitudinal Joints

Tie bars can optionally be installed along the longitudinal joints as detailed in the fabricator shop drawings. The following methods, as detailed in the panel shop drawings and approved by the Engineer, may be used to install tie bars:

1. Drilling and installing tie bars in the existing pavement. Tie bars will be located as shown in the fabricator shop drawings. This method requires the use of panels with the tie bar slots at the slab bottom.
2. Using a top slot system.
3. Using a cross-stitching technique as detailed in the fabricator shop drawings.

6.7.4 Dowel-Bar and Tie-Bar Slot Patching or Grouting

Dowel-bar and tie-bar slots typically will be patched or grouted using one of the following methods:

1. For panels with dowel slots at the panel bottom, the approved rapid-setting dowel-slot grout typically is poured through grout ports into each slot. The grout also needs to be poured into the panel perimeter joint gap until the grout material is at the top of the joints. Using these panels, a joint gap does not exist around the perimeter of the panel. This technique requires the use of a bond-breaking material on one face of the joint. Also, during the joint sawing for the sealant reservoir, care must be taken to align the saw-cut along the unbonded side the joint, otherwise spalling of the dowel grout material will result and the joint sealant will be ineffective.

2. For panels with narrow-mouth dowel slots at the surface, the approved rapid-setting dowel-slot grout or patching material typically is used to fill the surface slots. If grout is used to fill the surface slots, the grout needs to be poured into the panel perimeter joint gap until the grout material is at the top of the joints. Using this system, a joint gap does not exist around the perimeter of the panel. This technique requires use of bond-breaking material on one face of the joint. Also, during the joint sawing for the sealant reservoir, care must be taken to align the saw-cut along the unbonded side the joint, otherwise spalling of the dowel grout material will result and the joint sealant will be ineffective. If a patching material is used, the Contractor typically will need to take care to ensure that no patch material flows into the transverse joint gap.

The provisions for load transfer at joints at the beginning and the end of the project work area typically will be as detailed in the approved fabricator shop drawings.

Whether a grout or a patching material is used for the dowel slots, the material typically will attain a compressive strength of 2,500 psi before opening the work area to traffic.

The grout or patching material or another approved material typically will be used to fill in the lift insert holes and the top two inches of grout ports.

6.8 Panel Bedding Grout Application

For panels placed using leveling lifts, after the panels are set at the correct elevation, the Contractor typically will apply the approved bedding grout material using grout ports. Grout ports typically will be uniformly distributed across the panel area as shown in the fabricator shop drawings. As a minimum, one grout port typically will be used for every 2.5 square-yard area of the panel. The contractor typically will adjust the grout fluidity to result in the efflux time described in Para. 3.7. It is the Contractor's should ensure that the undersealing grout application results in no voids under the panel bottom. The bedding grout thickness typically will be a maximum of 1/2 in.

The bedding grout typically will attain a compressive strength of 500 psi at the time of opening to traffic. The grout typically is mixed in a batch pump and fed continuously from a grout hopper.

The bedding-grout ports typically are filled with the grout to within two inches from the top of the ports. The top portion of the port typically will be filled with the dowel-slot grout or patching material or another approved high-strength rapid-set patching material.

6.9 Panel Undersealing

For panels placed directly over the base or the sand-cement bedding material, the Contractor typically will underseal all panels using the approved cementitious undersealing grout material. Grout ports typically will be uniformly distributed across the panel area as shown in the fabricator shop drawings. As a minimum, one grout port typically will be used for every 2.5 square-yard area of the panel. The contractor typically will adjust the grout fluidity to ensure that the undersealing grout application results in no voids remaining under the panel bottom.

The undersealing grout typically will attain a compressive strength of 500 psi at the time of opening to traffic. The grout typically will be mixed in a batch pump and fed continuously from a grout hopper.

The undersealing grout ports typically will be filled with the undersealing grout to within two inches of the top of the ports. The top portion of the port typically will be filled with the slot grout or patching material or another approved high-strength rapid-set patching material.

6.10 Opening to Traffic

The repair areas typically will be opened to traffic only after the following applicable conditions are met:

1. All cleanup work has been completed over the installed precast concrete panels.
2. The dowel slot grout or patching material has attained the minimum strength level specified for opening to traffic.
3. The bedding grout material, if applicable, has attained the minimum strength level for opening to traffic.
4. The undersealing grout material, if applicable, has attained the minimum strength level for opening to traffic.
5. The average transverse joint elevation difference for the repair area is not greater than ¼ in. and no transverse joint elevation difference for the repair area is greater than ½ in.

6.11 Diamond Grinding

The vertical elevation difference at transverse joints between the panel and the existing pavement or another panel typically should not exceed 0.125 in. If the elevation difference is larger, the joint areas typically will be ground full-width to bring the repair area into compliance. Diamond grinding typically will be performed as directed by the Engineer, using approved diamond grinding equipment.

6.12 Joint Sealing

All transverse and longitudinal joints of the JPrCP pavement typically will be sealed. Joint widths typically will vary from repair area to repair area. The backer rods, if used, typically will be sized for actual joint width.

6.13 Use of Temporary (Dummy) Panels

The Contractor typically will use a temporary panel at the end of a night's (day's) panel placement if panel placement is to continue. The temporary panel typically will be appropriately reinforced, full lane-width, and at least 2 ft in length. The temporary panel typically will incorporate bottom slots to cover the embedded dowel bars in the last panel placed. The bottom slots are not necessary if the last panel does not incorporate embedded dowel bars that need to be protected.

7.0 INSTALLED PANEL ACCEPTANCE TESTING

The acceptance of installed panels typically will be based on the following considerations.

7.1 Vertical Elevation Difference at Transverse Joints

For each installed panel, measure the vertical difference at transverse joint between the panel and the existing concrete pavement or another panel at 2 ft and 10 ft from the outside edge of each panel. The measurement may be conducted using a straight edge or the Georgia Faultmeter. Panels exhibiting a vertical elevation difference greater than 0.125 in. typically will be considered as defectively installed and treated as per Para. 8.2.

If approved by the Engineer, the defectively installed precast panels typically may be opened to traffic if all installed panels are required to be ground as per the project requirements or if diamond grinding is approved for each defectively installed section.

7.2 Joint Width at Transverse and Longitudinal Joints

The panels typically will be placed so that the width of the transverse joints between the panels and between a panel and the existing pavement will not exceed 0.5 in. Transverse joints exhibiting joint gap greater than 0.5 in. typically will be considered as defectively installed and treated as per Para. 8.2.

The width of the longitudinal joints typically will be set to be within 0.5 in. of the width shown in the project layout plans or as directed by the Engineer. Longitudinal joint sections, panel by panel, exhibiting joint gap greater than 0.5 in. more than the width shown in the project layout plans typically will be considered as defectively installed and treated as per Para. 8.2.

7.3 Damaged or Defective Panels

The Contractor typically will repair or replace all damaged panels prior to final acceptance. The repairs typically will be performed as described in [INSERT HIGHWAY AGENCY REFERENCE FOR CONCRETE PAVEMENT REPAIR] at no cost to the [HIGHWAY AGENCY NAME]. Damage and defects typically include, but are not limited to, cracking and spalling caused by inadequate panel protection during installation, use by construction traffic after opening to regular traffic, and/or faulty construction practices.

7.4 Deflection Testing

At the discretion of the highway agency, a selected number of precast panels may be tested for load transfer effectiveness at transverse joints using a falling weight deflectometer with an applied nominal load level of 9,000 lb. The measure of the load transfer effectiveness is the relative deflection (RD) across the tested joint between a precast panel and the existing concrete pavement or another adjacent precast panel. Acceptable RD values typically are equal to or less than 2 mils (0.002 in.). Typically, if the Engineer determines that the measured RD values indicate poor load transfer effectiveness at the tested joints, the Engineer may elect to test all precast panel joints. All panels exhibiting RD values greater then 2 mils (0.002 in.) at the transverse joints typically will be considered defective and treated as per Para. 8.2.

7.5 Smoothness Testing

Smoothness testing of the completed panel installation typically will be performed within two weeks of each 1,000-ft panel installation. Smoothness acceptance criteria typically will be applied in accordance with (INSERT HIGHWAY AGENCY REFERENCE FOR SMOOTHNESS TESTING OF NEW CONCRETE PAVEMENTS).

Areas not meeting the smoothness requirements typically will be corrected by the Contractor, at no cost to the highway agency, based on a smoothness corrective plan typically submitted by the Contractor within two weeks of testing. The corrective work typically will be performed within 60 days after approval of the smoothness corrective plan, as approved in writing by the Engineer.

7.6 Grout Testing

The joint slot grout and patching material, undersealing material, and bedding grout typically will be tested using cube samples in accordance with ASTM C 109. Two sets of tests typically will be performed for each night (day) of panel installation. Typically, one set of cubes will be made at the start of the material use, and a second set of cubes will be made near the end of the material use, or at a time determined by the Engineer. Each set of samples will be tested as follows:

1. Three samples at one hour.
2. Three samples at proposed time of opening to traffic.
3. Three samples at a later time to verify strength for opening to traffic.
4. Three samples at 7 or 14 or 28 days to verify strength at desired age.

The installed panels typically will not be opened to traffic until the opening strength desired by the highway agency is achieved.

8.0 DEFECTIVE PANELS AND DEFECTIVE PANEL INSTALLATION

8.1 Defective Panels

If the Engineer determines that a defective panel, as fabricated or as shipped or with the Contractor's proposed mitigation treatment, will result in an unacceptable product, the affected panel typically will be rejected before shipment to the work site or at the work site.

8.2 Defective Panel Installation

If the Engineer determines that a defective panel installation, as originally installed or with the Contractor's proposed mitigation treatment, will result in an unacceptable product, the affected panel typically will be removed and replaced.

9.0 METHOD OF MEASUREMENT

The work typically will be measured for payment as the number of square yards of accepted in-place precast concrete panels, measured to the nearest 0.1 square yard.

10.0 BASIS OF PAYMENT

The unit bid-price typically will include the cost of all engineering, design, fabrication, quality control, labor, material and equipment necessary to satisfactorily perform the work, including technical assistance from the JPrCP panel designer, as needed.

Payment will be made under:

Item Number	Item	Pay Unit
[Insert item number]	Precast Concrete Pavement	Square Yards

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