# SECTION 503 - CONCRETE STRUCTURES

**503.01 Description.** This section describes construction of concrete bridges, grade separations, culverts, head walls, retaining walls, and other concrete structures.

**503.02 Materials.**

| | |
|---|---|
| Structural Concrete | 601 |
| Reinforcing Steel | 602 |
| Joint Filler | 705.01 |
| Joint Sealer | 705.04 |
| Flashing Compound | 705.05 |
| Waterproofing | 705.06 |
| Waterstops | 705.07 |
| Dowels | 709.01(E) |
| Curing Materials | 711.01 |
| Admixtures | 711.03 |
| Bearing Devices and Related Materials | 712.09 |
| Abrasive Coating | 712.11 |

**503.03 Construction.**

**(A) Foundation.** Excavate and backfill foundations in accordance with Section 205 - Excavation and Backfill for Bridge and Retaining Structures, Section 206 – Excavation and Backfill for Drainage Facilities and as indicated in the contract documents.

Elevation of bottom of footings shown is approximate only. Upon completion of excavation work, request that the Engineer inspect foundation. The Engineer may order changes in dimensions or elevations of footings as may be necessary to secure a satisfactory foundation.

Backfill unauthorized excavation made below required footing elevation or beyond lines shown, with Class D concrete. When foundation

requires redesign because of unauthorized excavation, the Contractor shall engage the services of a Hawaii Licensed Structural Engineer to prepare detailed drawings of a redesigned footing. Submit redesign proposal and after the Engineer reviews and accepts proposal, construct redesigned foundation at no additional increase in contract price or contract time. Claim for delay or additional cost resulting from foundation redesign will not be allowed. The State will deduct costs to review the redesign from the Contractor.

Place pilings in accordance with Section 505 - Piling. Place drilled shafts in accordance with Section 511 – Drilled Shafts.

**(B) Falsework, Formwork, or Centering.** Falsework, formwork, or centering is temporary construction work on which other work is wholly or partially supported until permanent construction is strong enough to support itself. This includes form lining and sheathing, as well as necessary supporting members, hardware, and bracing.

Submit falsework and centering erection plans including soil bearing value, stress sheets, superstructure placing diagram and sequence, falsework and centering removal procedures, and design calculations for falsework and centering, as a complete package, stamped and signed by a Hawaii Licensed Structural Engineer. Submit manufacturer's certificates or perform tests, as necessary, to demonstrate adequacy of devices proposed for use or to verify design assumptions.

Do not start falsework, formwork, or centering construction until the Engineer has accepted drawings and calculations. Acceptance of drawings or inspections of system by the Engineer does not relieve the Contractor from responsibility of results obtained by using such drawings and calculations.

Use AASHTO *LRFD Bridge Specifications* for design of falsework, formwork, or centering. For allowable stresses not specified in AASHTO, structural engineer may use UBC/ICBO industry specifications or codes upon acceptance. Avoid cantilevered falsework members. Limit maximum deflection due to weight of dead and live loads to 0.4 percent of span. Provide camber strips to compensate for deflections or other movements greater than 1/4 inch.

Take length of spans to be the smaller of center-to-center distance between supports or clear span plus member depth. Design formwork for bottom slab of box girders to carry dead and live loads of both top and bottom slabs, as well as loads of webs, unless calculations indicate bottom slab is to carry loads of top slabs temporarily imposed upon it.

Arrange falsework system so that loads imposed produce symmetrical and approximately equal reactions. Submit falsework soil pressure, pile capacity, and ground preparation, with supporting data and documentation. Show these items on working drawings. When structures cross over waterways and other flood prone areas, use special consideration in design of supporting falsework to prevent reduction in support capacity due to effects of water.

Design load for falsework or centering includes dead and live vertical loads, slope load of structure, and lateral loads. Minimum vertical live load to be used in design is 50 pounds per square foot of surface area plus 150 pounds per linear foot, applied at outside edge of cantilevered members. Add minimum vertical live load to actual weight of required construction equipment. Use minimum lateral load in design to be the greater of either 3 percent of total dead load or 150 pounds per linear foot. Apply minimum lateral load at top surface of falsework support.

When falsework is over or adjacent to existing roadways, install falsework system to withstand vehicle impact and maintain until falsework removal.

Show stresses and deflections of load supporting members in design calculations. Show anticipated total settlements of falsework and forms on falsework drawings, including falsework footing pressure and settlement, and joint take-up. Construct deck slab form between girders with no allowance for settlement relative to girders. Do not exceed 1 inch for anticipated settlements of falsework. Provide tell-tales attached to soffit forms, readable from the ground, at sufficient locations to determine total settlements resulting from concrete placement. Discontinue concrete placement when settlements deviate more than $\pm$ 3/8 inch from those indicated on falsework drawings. In such affected areas, provide corrective measures prior to initial set of concrete. Remove unacceptable concrete.

In designing falsework and centering, assume weight of 160 pounds per cubic foot for concrete. Design and construct falsework to provide necessary rigidity and to support loads without appreciable settlement or deformation. Use screw jacks or hardwood wedges to take up settlement in formwork either before or during placement of concrete. Design falsework for support of superstructure to support loads that would be superimposed as if entire superstructure were placed at once. Design vertical falsework members supporting spans with single hinge, or double hinges within span, for twice tributary falsework requirements at distance of 10 feet on each side of hinges, measured parallel to centerline of girder. Apply requirement to conventionally reinforced and prestressed concrete structures. Design falsework for prestressed concrete structures for additional loads caused by prestressing.

Place falsework or centering upon footing safe against undermining and softening when footing type foundations are to be used. Show bearing value of soil in shop drawings of falsework or centering.

When used, space, drive, and remove falsework piling as accepted by the Engineer. Set falsework to give finished structure camber specified. Construct arch centering in accordance with centering plans accepted by the Engineer. Make provisions for gradual lowering of centers and for rendering arch self-supporting. Use jacks to correct slight settlement that may occur during placement of concrete.

In design of bottom slab plywood forms and timber joists for concrete box girders, top slab loads may be omitted when placing top slab separately from webs and bottom slab.

If lost post method of concrete box girder deck forming is used, 2 by 6 continuous mudsills beneath posts will not be required when 2 by 4 or smaller timber posts, with soft wood wedges, are used for supports.

Use manufactured items conforming to AASHTO standards. When items are not covered by AASHTO, use standards of nationally known organizations such as AISC for steel, ACI for concrete, and NFPA for lumber. In all cases, furnish data listing manufacturer's design criteria conforming to design specifications and recommendations, or perform tests, as necessary, to show adequacy of proposed device.

Install falsework lighting in accordance with Section 633 – Falsework Lighting.

**(C) Forms.**

**(1) Construction.** Use wood or metal forms that are mortar tight and sufficiently rigid to prevent distortion due to pressure of concrete and other loads, including vibration, incidental to construction. Construct and maintain forms to prevent joints from opening.

Unless otherwise indicated in the contract documents, place minimum 3/4 inch by 3/4 inch chamfer at sharp corners. Give girder and coping forms a bevel or draft to ensure easy removal.

Set and maintain forms true to lines designated. When forms appear to be unsatisfactory, either before or during concrete placement, the Engineer may stop work until defects are corrected.

When forms are submerged in water and concrete is placed in the dry, make forms watertight below high water level.

Cover knotholes and damaged areas in wood forms with metal patches.

Control rate of depositing concrete in forms to prevent form deflection or form panels that exceed permitted deflections. When structure height is greater than 6 feet, submit rate of depositing concrete.

Use forms for concrete surfaces not completely enclosed or hidden below permanent ground surface that conform to requirements, in this subsection, for exposed-surface forms. Interior surfaces of underground drainage structures will be considered completely enclosed surfaces.

Before using forming systems for exposed surfaces, submit form design and materials data for each system.

Design and construct forms for exposed concrete surfaces so that formed surface of concrete does not undulate excessively between studs, joists, form stiffeners, form fasteners, or walls. Undulations exceeding either 3/32 inch or 1/270 of center-to-center distance between studs, joists, form stiffeners, form fasteners, or walls will be considered to be excessive. The Engineer will reject portions of concrete structure with surface undulations over limits specified herein.

Form exposed surfaces of each concrete structure element with same forming material or with materials that produce similar concrete surface textures, color, and appearance.

For exposed surfaces, provide form panel facing consisting of continuous sections of form facing material, unbroken by joint marks, against which concrete is placed.

**(2) Form Lumber.** Use form lumber, except for curved and special surfaces, of five ply panel boards or dressed shiplap, used with or without form liners. Rough lumber may be used for unexposed surfaces in finished structure. Three-ply panel boards may be used for forming soffit of unexposed portions of box girder top slabs.

Use plywood conforming to latest edition of "United States Product Standard PS-1 for Construction and Industrial Plywood" for forms. Place form panels in uniform widths of not less than 36 inches and in uniform lengths of not less than 6 feet, except where dimensions of members formed are less than specified panel dimensions. Place plywood panels with grain of outer plys in direction of span.

Place form panels in neat, symmetrical pattern, subject to acceptance of the Engineer. Place panels with long dimension horizontal and with horizontal joints level and continuous. Stagger and position perpendicular to vertical joints, as shown in the contract documents.

**(3) Form Ties.** Use form ties of sufficient strength and number to hold form securely in place and prevent spreading of forms during concrete placement. The following will not be allowed:

**(a)** Ties consisting of twisted wire loops to hold forms in position.

**(b)** Non-metallic forming ties, anchorages, forming supports or other accessories that may be embedded permanently in concrete.

**(c)** Driven type anchorages for fastening forms or form supports to concrete.

Construct form ties or anchorages within forms to permit removal to depth of at least 1 inch from face, without injury to concrete. Design fittings for form ties or anchorages so that, upon removal, cavities left are of the smallest possible size. Fill cavities completely with cement mortar and leave surface sound, smooth, even, and uniform in color.

**(4) Walls.** For narrow walls and columns where bottom of form is inaccessible, leave lower form boards loose.

**(5) Surface Treatment.** Immediately before each use, clean and treat forms with non-staining form oil that will permit ready release of forms and will not discolor concrete.

**(6) Metal Forms.** Specifications for forms regarding design, mortar tightness, filleted corners, beveled projections, bracing, alignment, removal, reuse, and oiling apply to metal forms. Metal thickness used for forms shall be such that forms will remain true to

shape. Countersink bolts and rivet heads. Design clamps, pins, or other connecting devices to hold forms rigidly together and to allow removal without injury to concrete. Metal forms that are rough or crooked will not be allowed.

**(7) Reuse of Forms.** Maintain shape, strength, rigidity, watertightness, and surface smoothness of reused forms. Resize warped or bulged lumber before using.

**(D) Removal of Falsework and Forms.** Before removing shoring beneath beams or girders, remove forms from columns to allow the Engineer to inspect condition of column concrete.

Remove supports using method that permits concrete to uniformly and gradually take stresses caused by its own weight.

In continuous or rigid frame structures, release falsework only after last concrete (excluding concrete above bridge deck) in that span and first adjoining spans on each side have been in place for 14 days. For falsework removal, consider spans with a single hinge within span to be continuous. Consider hinges of suspended spans within a bridge, as ends of bridge, for determining shoring requirements. In structures of these types, remove falsework gradually and uniformly over whole length.

After placing concrete, remove or release falsework and forms no earlier than removal times specified in Table 503.03-1 – Removal of Falsework and Forms. The Engineer will determine exact removal time.

**TABLE 503.03-1 - REMOVAL OF FALSEWORK AND FORMS**

| | | | | | | |
|---|---|---|---|---|---|---|
| Railing and Barriers – 4 Hours and Concrete Has Hardened | | | | | | |
| Centering Under Beams, Arches, And Other Members - 14 Days | | | | | | |
| Slabs With Maximum Thickness of (Inches) | 9 | | 12 | | more than 12 | |
| Removal Time (Days) | 7 | | 10 | | 14 | |
| Walls, Columns, and Vertical Sides of Beams With Maximum Height of (Feet) | 2 | 5 | 10 | 20 | 30 | 40 or More |
| Removal Time (Days) | 0.5 | 1 | 2 | 3 | 5 | 7 |
| Note: Where forms also support vertical or horizontal loads imposed on slab or beam soffits, use longer requirements for removal time. | | | | | | |

Do not release falsework for cast-in-place prestressed portions of structures until after prestressing steel has been tensioned.

Do not release falsework supporting overhangs and girder stems that slope 45 degrees or more off vertical until 7 days after placing deck concrete. If reshoring system is installed, falsework supporting sides of girder stems that slope less than 45 degrees off vertical may be removed prior to placing deck slab concrete. Design reshoring system, consisting of lateral supports, to resist rotational forces acting on stem, including those caused by placement of deck slab concrete. Install reshoring system immediately after each form panel is removed and prior to release of supports for adjacent form panel.

Do not remove falsework and forms supporting bottom slab of box girders until 14 days after final top slab is placed. Remove forms for webs of box girders before placing deck slab. Forms supporting concrete top slab of box girder may be left in place. Completely remove interior forms in box girders except those permitted to remain in place. Where minimum crawl space dimensions and unobstructed access to enclosed utilities are provided, interior forms of box girders may be left in place. Clear and sweep loose material from inside of box girder.

Removal time of falsework may be reduced to 10 days when concrete test specimens develop compressive strengths equal to or greater than required 28-day compressive strength. Cure concrete test specimen in accordance with paragraph 9.4 of AASHTO T 23.

After removing forms of railing or barriers, protect exposed concrete surfaces from damage after form removal.

Falsework for concrete box culverts and other concrete structures with top slabs or decks lower than roadway pavement and with spans of 14 feet or less, may be released when concrete strength reaches 1,500 psi, provided top slab is reshored and the curing of the concrete is not interrupted. Do not impose loads (including backfill) on structure until concrete attains required 28-day compressive strength.

**(E) Loading.** Inducing loading, outside its own weight, onto any part of a structure, except abutment walls and wing walls, will not be allowed until the following conditions have been met: at least 15 days have elapsed since placing concrete; and test specimens show that concrete has developed compressive strength of either 3,000 psi or required 28-day compressive strength, whichever is greater.

Material storage of any kind on structure, within 15 days of concrete placement, will not be allowed. After a minimum of 15 days have elapsed since concrete placement, materials weighing no more than 50 percent of design live load may be stored on structure. Submit shop drawings showing locations and weights of stored materials.

Release falsework before placing loads on structure.

Live loads will not be allowed on completed portions of structure when such live loads will produce more than allowable stresses permitted by AASHTO LRFD *Bridge Design Specifications*.

Backfill abutment and wing walls in accordance with Section 205 - Excavation and Backfill for Bridge and Retaining Structures.

**(F) Placing Concrete.**

**(1) General.** Place and consolidate concrete by methods that shall not cause aggregate segregation or unsound concrete and shall result in dense, homogeneous concrete, free of voids, rock pockets and other defects. Use concrete while it is plastic and has sufficient workability for placement. Retempering or remixing concrete that has partially partially hardened will not be allowed. Allow no more than 30 minute interval between placement of two consecutive batches or partially hardened will not be allowed. Allow no more than 30 minute interval between placement of two consecutive batches or loads of concrete.

Do not deviate from schedule for placing concrete without permission from the Engineer.

Water blast laitance and foreign material and moisten interface surfaces with water immediately before placing concrete over subgrade or construction joint.

Submit method and sequence of concrete placement. Place concrete on structure only after forms have been cleared of debris and the Engineer has checked and accepted forms and reinforcing steel.

Place concrete for foundations, bottom slabs of box culverts, and aprons on ground that is free from water. Dewater, sheath, place filter material, and do other work, as required by field conditions, to ensure saturated surface dry foundation bed. Costs for obtaining saturated surface dry foundation bed will be included in price for structure excavation.

Excavate and place sides of concrete or masonry footings not supported on piles or rock to neat lines.

Begin placing concrete at low point and proceed upgrade. Remove struts, stays, braces, or blockings when concrete placed has reached elevation rendering them unnecessary.

Deposit concrete in approximate horizontal layers to avoid flowing along forms. When less than a complete layer is placed in one operation, terminate layer in vertical bulkhead. Layer depth shall not exceed 20 inches and shall be such that succeeding layer shall be placed before previous layer has attained its initial set. Place concrete in layers than can be satisfactorily consolidated with vibrators.

Thoroughly work external surface of concrete with vibrator. Work to force coarse aggregate from surface and to bring mortar against forms, producing a smooth finish, nearly free from water and air pockets, and honeycomb.

Fill each part of form by depositing concrete as close to final position as possible. Work coarse aggregate back from forms and around reinforcement without displacing bars. After initial set of concrete, do not jar forms and do not place stress on ends of projecting reinforcing.

After concrete placement stops, remove accumulations of mortar on reinforcing steel and surfaces of forms, before next concrete placement. If concrete is wet, prevent dried mortar chips, other foreign material, and dust from falling onto wet concrete surface. If concrete has set, clean reinforcing steel in a manner that will not be detrimental to concrete-steel bond.

**(2) Box Culverts.** Place and allow base slab or footings of box culverts to set at least 12 hours before constructing remainder of culvert. Monolithically construct sidewalls and top slab of box culverts 4 feet or less, in height.

When constructing box culverts that are more than 4 feet in height, place and allow concrete in walls to set at least 12 hours before placing top slab. Provide appropriate keys in sidewalls for anchoring top slab.

**(3) Box Girder Spans.** Place bottom slab of box girder spans monolithically with girder stems.

Top slab of box girders may be placed 10 days after placing bottom slabs and stems, provided concrete test specimens of bottom slab and stem concrete have attained compressive strength equal to or greater than 3,000 psi. Cure concrete test specimens in accordance with paragraph 9.4 of AASHTO T 23.

Place concrete in columns in one continuous operation.

Allow concrete to set at least 12 hours before placing columns, caps, or beams.

Do not place horizontal members or sections until concrete in supporting vertical members or sections has consolidated and shrinkage has occurred. When plans require construction joints, allow at least 12 hours to elapse between concrete placements.

Do not place concrete in superstructure until column forms have been stripped sufficiently to determine character of column concrete. Do not allow superstructure loads to be placed on bents or piers until bents have been in place at least 14 days.

Do not place concrete in suspended span until adjacent continuous spans are complete in place.

In structures with one or two hinges in a span, place supporting ends of hinges, including top slabs, before placing supported end.

Do not place concrete sidewalks and curbs not monolithic with bridge deck until falsework for spans has been released.

**(4) Chutes and Troughs.** The use of aluminum for chutes, tremies, troughs or pipes will not be allowed. Place concrete so as to avoid segregation of materials and displacement of reinforcement.

When plans require steep slopes, equip chutes with baffle boards, or furnish chutes in short lengths that reverse direction of movement.

Use of long troughs, chutes, and pipes of minimum 6-inch diameter will be allowed only with written authorization by the Engineer. Incline chutes or pipes to allow concrete to flow at required consistency. Addition of water to concrete mix to promote free flow in chutes of low inclination will not be allowed.

Do not drop concrete into forms from vertical distance of more than 5 feet unless confined by closed chutes or pipes.

Keep chutes, troughs, and pipes clean and free from coatings of hardened concrete by thoroughly flushing them with water after each run. Discharge flushing water away from in-place concrete.

**(5) Vibrating.** Consolidate concrete, except for concrete placed under water, using high frequency internal vibrators. Minimum transmitted vibration frequency shall be 4,500 impulses per minute, and shall be such as to visibly affect mass of concrete of 1-inch slump over radius of at least 18 inches. Use sufficient number of vibrators to properly consolidate incoming concrete within 15 minutes after depositing concrete in forms. Make at least two vibrators available at structure site when placing more than 25 cubic yards of concrete. Apply vibrators at uniformly spaced points and not farther apart than is visibly effective. Attaching vibrators to or holding them against forms or reinforcing steel will not be allowed. Insert vibrators in vertical position at a uniform spacing over the entire concrete placement area. Dragging vibrators through concrete will not be allowed.

External vibrators accepted by the Engineer may be used to consolidate concrete when concrete is inaccessible for adequate consolidation, provided forms are constructed sufficiently rigid to resist displacement or damage from external vibration.

When required, supplement vibration by hand spading with suitable tools to ensure proper and adequate compaction. Manipulate vibrators to work concrete thoroughly around reinforcement and imbedded fixtures; and into corners and angles of forms. Using vibrators to cause concrete to flow or run into position, instead of placing, will not be allowed. Vibrate sufficiently to compact, but avoid prolonging vibration to the point where segregation occurs.

**(6) Depositing Concrete Underwater.** Do not deposit concrete underwater except cofferdam seals, tremie concrete, and drilled shaft concrete. Use seal concrete conforming to Section 601 – Structural Concrete for cofferdam seal concrete deposited underwater. Deposit drilled shaft concrete underwater in accordance with Section 511 – Drilled Shafts.

Place concrete underwater in a compact mass in its final position by tremie or closed-bottom dump bucket. Do not disturb deposited concrete after placement. Maintain still water at point of deposit.

Tremie consists of a tube having inside diameter at least 6 times the maximum size of aggregate used in concrete mix and not less than 10 inches, constructed in sections having flanged couplings, fitted with gaskets. Tremie shall not contain aluminum parts that will come in contact with concrete, including pump and discharge lines. Equip tube with receiving hopper at the top and device that closes discharge end to prevent water from entering tube, while tube is being charged with concrete. Support tremie to permit free movement of discharge end over entire top surface of work and rapid lowering, when necessary, to retard or stop flow of concrete.

Close and seal discharge end entirely at start of work to prevent water from entering tube. Keep tremie tube full to bottom of hopper. When a batch is dumped into hopper, induce concrete flow by slightly raising discharge end, always keeping discharge end in deposited concrete. Maintain continuous flow until work is completed.

Use underwater bucket with open top and bottom doors that open freely outward, when tripped. Completely fill and slowly lower bucket, to avoid backwash. Discharge bucket only when bucket rests on surface upon which concrete is to be deposited. After discharge, raise bucket slowly until well above concrete. The use of bottom dump buckets for bottom seal around foundation piling will not be allowed.

Submit concrete seal design calculations and working drawings, prepared, stamped, and signed by Hawaii Licensed Structural Engineer. Exact thickness of concrete seal shall depend upon hydrostatic head, bond, pile spacing, and cofferdam size. Construct concrete seal after the Engineer accepts design. Allow seal to remain in place for not less than 7 days before dewatering. After sufficient time has elapsed, dewater cofferdam and remove scum, laitance, and sediment from concrete. Before depositing fresh footing concrete, remove local high spots, as necessary, to ensure proper clearance for footing reinforcing steel.

**(7) Hot Weather Concreting.** Do not place concrete where temperature is above 90 degrees F unless design mix and placement method conform to ACI 305 R-91 Hot Weather Concreting. When ambient temperature is above 90 degrees F, cool reinforcing steel, forms, and other surfaces to below 90 degrees F with water spray or other acceptable methods before placing of concrete.

**(G) Joints.**

**(1) Construction Joints.** Place construction joints only at locations indicated in the contract documents, perpendicular to principal lines of stress and at points of minimum shear.

After placing substrate concrete to construction joint and letting concrete set, thoroughly clean by abrasive blast cleaning, the entire joint surface, including projecting reinforcement. Remove laitance, curing compound, and other material foreign to concrete, and expose cleaned coarse aggregate, and roughen construction joint surface to full amplitude of approximately 1/4 inch, after curing period or immediately before placing concrete on substrate concrete at construction joint, whichever occurs first.

Before placing new concrete, draw forms tightly against concrete already in place. Thoroughly clean, water blast laitance and foreign material, and saturate old surface with water to a saturated surface-dry condition immediately before placing new concrete. Place concrete in substructures so that horizontal construction joints are truly horizontal. Where possible, place joints such that they will be hidden from view in finished structure. Where vertical construction joints are necessary, extend reinforcing bars across joint to make structure monolithic. Do not place construction joints through paneled wing walls or other large surfaces that are to be treated architecturally.

When construction joint is necessary because of emergency, furnish and place reinforcing steel across construction joint as ordered by the Engineer, at no increase in contract price or contract time.

**(2) Expansion Joints.** Construct expansion joints of type and in location indicated in the contract documents. Expansion joints may be of friction, open, filled compression, mortise, or special type.

**(a) Metal Friction Joints.** Metal friction joints include cast iron or bronze plates. Anchor plates in correct position. Plane sliding surfaces true and smooth by following direction of movement of structure with planing tool. Do not impede movement by allowing surfaces to make contact, except for bearing surfaces.

**(b) Open Joints.** Construct open joints of removable bulkheading forms so that forms may be removed without damage to concrete.

**(c) Filled Compression Joints.** Construct filled compression joints with premolded expansion joint filler. Cut preformed joint filler to same shape as area to be covered. Furnish one-piece, preformed joint filler, sized to leave 1/4-inch gap along exposed surfaces. When specified, punch holes to accommodate dowels. Fix preformed joint filler firmly against surface of concrete already in place with cold asphalt roofing cement conforming to ASTM D 4586. When necessary to use more than one piece to cover surface, fasten and hold abutting ends in shape by stapling. Cover joint between separate pieces with layer of two-ply roofing felt, and cover one side with cold asphalt roofing cement conforming to ASTM D 4586. Fill 1/4-inch space along edges at exposed faces with wooden strips of same thickness as joint material. Saturate wooden strips with oil and provide sufficient draft to make wooden strips readily removable after placing concrete. Immediately after removing forms, inspect expansion joint. Clean and remove concrete or mortar that may have sealed across joint.

**(d) Mortised Joints.** Construct mortised joints where indicated in the contract documents. Mortised joints include a concrete or metal part sliding in a concrete or metal socket. Construct joint to be watertight, rustproof, and free to move in two directions.

**(e) Steel Joints.** Steel joints include plates, angles, or other structural shapes. Shape steel joints accurately at shop to conform to section of concrete deck. Fabricate and paint steel joints in accordance with requirements indicated in the contract documents. When specified, zinc-coat material instead of painting. Keep surface of finished plate true and free of warping. Maintain joints in correct position during concrete placement. Set opening at expansion joints as indicated in the contract documents. Avoid impairment of joint clearance.

Place metal joints so that they are free from kinks. Rivet and solder joints. At bends, use one-piece strip.

Remove stones, forms, and other foreign matter that might interfere with joint efficiency.

**(f) Waterstops.** When required, furnish and install waterstops as indicated in the contract documents. Position waterstops correctly in formwork, so that bulb is aligned and centered with joint opening. Vibrate concrete surrounding

imbedded waterstops to attain impervious concrete near joints. Cut and splice waterstops at changes in direction, as necessary, to avoid buckling or distortion of web or flange. Field splice waterstops in accordance with Subsection 705.07 - Waterstop.

**(3) Contraction Joints.** Place contraction joints in walls and other structures at spacing of not more than 30 feet on centers, at locations indicated in the contract documents, at abrupt changes in height or thickness, and at obtuse corners unless otherwise directed by the Engineer.

**(H) Waterproofing.** Make concrete surfaces smooth and free from holes and projections that might puncture waterproofing membrane. Dry and clean surfaces thoroughly of dust and loose materials before waterproofing. Do not waterproof in wet weather or when temperature is below 65 degrees F.

Waterproofing includes coat of primer applied to concrete surface, firmly bonded membrane composed of two layers of saturated fabric conforming to ASTM D 1668,, and three moppings of waterproofing asphalt.

Apply coat of primer to surface, extending 12 inches on each side of joint. Allow primer to dry before first application of asphalt. Heat asphalt to temperature between 300 degrees F and 350 degrees F. Mop asphalt thoroughly onto surface.

Place 18-inch-wide strip of fabric immediately on hot asphalt. Carefully press fabric into place to eliminate trapped air bubbles and to obtain close contact with surface.

Apply second layer of asphalt onto fabric, 3 inches beyond edges. Immediately following operation, press second layer of fabric into place on top of first layer.

Apply third and final layer of asphalt onto fabric, 3 inches beyond edges. Use 12-inch laps at ends of fabric.

Apply primer to concrete surface at rate of one gallon per 100 square feet. Apply asphalt at rate of 15 gallons per 100 square feet of finished work.

**(l) Joint Sealing.**

**(1) Joint Seal (Poured) for Bridge Deck.** Immediately before applying joint sealer, clean joints thoroughly by abrasive blasting. Remove mortar, laitance, scale, dirt, dust, oil, and other foreign matter, then blow out joint with high pressure, oil-free compressed air to remove residue.

Apply joint sealer after the Engineer inspects and accepts joint; and only when concrete and ambient temperatures are not less than 50 degrees F and no greater than temperature allowed by manufacturer.

Apply joint sealer so that joints are filled without forming air holes and discontinuities. Top of joint sealer shall be 1/4 inch below finished surface.

Remove joint sealer that does not do the following: cure to homogeneous and rubber-like compound; bond to joint faces; or comply with other requirements of this section.

Reclean joint and place new joint sealer at no increase in contract price or contract time.

After completion of joint sealing, prohibit vehicles from traveling over joints until the Engineer grants permission.

**(2) Joint Seal (Preformed) for Bridge Deck.** Immediately before installing joint sealer, clean joint thoroughly to remove mortar, laitance, scale, dirt, dust, oil, and other foreign matter.

Install seal so that it will not be abraded by traffic and will effectively keep foreign material from entering joint. Correct spalls and protrusions in joint before installation.

Install preformed seal in one continuous piece without field splices.

Place seal so that its top edge is 1/4 inch below riding surface, and in a plane normal to sides of groove.

Place top edge of gasket in contact with vertical walls of joint. Repair spalls and other unsound concrete. Depress seal below minor spalls so that its top edge is in contact with vertical wall of joint.

Twisting, curling, and nicking of seal will not be allowed.

Protect joint from intrusion of earth, gravel, mortar, or other foreign matter so that structure can expand and contract as designed.

Groove width indicated in the contract documents is width of expansion joint at time of concrete placement. When width is less than manufacturer's minimum width for proper installation of joint seal, defer installation until concrete has been placed. Install seal after increasing joint width to width equal or greater than minimum width recommended by manufacturer.

Steel angle protective nosing assembly shall extend beyond curb line and shall terminate 1 inch from edge of deck.

**(3) Flashing Compound for Joints.** At retaining wall joints and other construction joints indicated in the contract documents in contact with soil, apply flashing compound as recommended by manufacturer.

**(J) Concrete Exposed to Sea Water.** In concrete structures exposed to sea water, construction joints will not be allowed between levels of extreme low water and extreme high water, as indicated in the contract documents. Between these levels, leave forms in place for at least 30 days.

**(K) Protection and Curing.** Protect concrete from mechanical damage and damage caused by exposure to sun, rain, and flowing water. Do not allow concrete to dry out from time of concrete placement until end of minimum curing period. Minimum curing period shall be as follows:

**(1)** Cure structures for at least 7 days. Maintain temperature of structural concrete at not less than 45 degrees F for 72 hours after placing. Maintain temperature at not less than 40 degrees F for an additional 4 days. Submit written outline of proposed method for protecting concrete.

**(2)** Cast-in-place parts of a structure to be submerged permanently in freshwater, may be cured for a period sufficient to prevent washing out of cement, and then submerged immediately.

**(3)** Cure with freshwater for at least 5 days, cast-in-place parts of a structure to be submerged permanently in brackish or seawater. Then submerge in accordance with Subsection 503.03(J) - Concrete Exposed to Sea Water.

**(L) Curing Methods.** Cure concrete for cast-in place structures, other than bridge decks, by water curing, impervious membrane curing, or forms-

in-place curing. Cure full width of concrete bridge decks using a combination of impervious membrane curing and water curing. Cure concrete surfaces that are to receive Class 2 Rubbed Finish, by water curing or forms-in-place curing. Cure surfaces of construction joints by application of water curing or non-membrane curing compound that seals concrete without reducing interface bonding capacity. Before applying curing compound, submit proposed curing methods, including copies of test results and manufacturer's catalogue. Precast concrete members may be steam cured in accordance with Subsection 504.03(G) - Curing.

**(1) Water Curing.** Water cure by keeping concrete continuously wet with fresh water, using water sprays, acceptable water saturated coverings, or ponding. Keep wood forms that remain in place sufficiently damp to prevent opening at joints and drying of concrete.

After surface water has evaporated, apply moisture to concrete surface using fog spray nozzle. Continue applying moisture to surface until regular curing begins. Use adequate water supply and sufficient moisture to fog and water cure concrete without damaging surface or texture of concrete.

Begin water curing for bridge decks after curing compound is applied and immediately after concrete surface is hard enough to receive water without damaging surface or texture of concrete. Continue water curing until end of specified curing period.

Prevent curing water from falling on traveled roadways under structure. Channel curing water away from falsework and structure foundations.

**(2) Impervious Membrane Curing.** Seal concrete surface thoroughly with liquid membrane-forming compound. Apply compound uniformly in two or more applications. Use ratio of at least 1 gallon for each 125 square feet of concrete surface.

Use curing compounds that will not permanently darken concrete on exposed surfaces of completed structure. Except for full width of bridge decks, do not apply membrane curing compound on surface to which concrete is to be bonded or to which waterproofing or epoxy is to be applied.

Keep concrete surfaces moist before applying impervious membrane. If membrane film is broken or damaged during specified curing period, apply new treatment to affected area, duplicating first application.

**(3) Forms-In-Place Curing.** Cure formed surfaces of concrete by retaining forms in place. Maintain forms in place for minimum period of 7 days after concrete placement. Keep all form joints and joints between end of forms and concrete, moisture-tight during curing period. Reseal cracks in forms and cracks between forms and concrete by methods accepted by the Engineer.

**(M) Finishing Concrete Surfaces.** Apply the following requirements to several classes of surface finishes that ordinarily apply to various parts of concrete structures.

**(1) Class 1 Ordinary Surface Finish.** Apply ordinary surface finish to concrete surfaces, either as final finish or preparatory to applying higher-class finish. On surfaces to be buried underground or that are enclosed, such as cells of box girders, removal of fins and form marks and rubbing of mortared surfaces to obtain a uniform color will not be required.

After removing forms, remove form bolts and ties to depth of at least 1 inch below concrete surface. Clean, wet, and fill resulting holes or depressions with mortar. Mortar shall consist of one part cement to two parts sand by volume. Add white cement to mortar in sufficient quantity to tint mortar a shade lighter than surrounding concrete. Use mortar that is not more than 1 hour old and that bonds indistinguishably with concrete. After mortar has thoroughly hardened, rub surface with carborundum stone to obtain same color in mortar as in surrounding concrete. Remove fins caused by form joints and other projections. Remove stains and discolorations visible from traveled way.

Clean and fill pockets with mortar, except for those scattered pockets or pinholes less than 1/2-inch long or wide and less than 3/8-inch deep. Pockets shall not affect strength of structure or shorten life of steel reinforcement. Fill pockets on surfaces visible to pedestrian traffic and surfaces exposed to stream flow, salt air, and salt water. Use mortar for filling pockets, as specified for bolt and tie holes. When rock pockets affect strength of structure materially or shorten life of steel reinforcement, the Engineer will declare concrete unacceptable and require removal and replacement of affected structure.

Clean, wet, and fill with mortar, all holes or depressions in surfaces that are to receive Class 2 Rubbed Finish. Clean, wet, and fill at least 7 days before starting Class 2 Rubbed Finish.

**(2) Class 2 Rubbed Finish.** Apply Class 2 Rubbed Finish to the

following surfaces:

**(a)** Surfaces of bridge superstructures, including pedestrian overpasses, except for the following: inside vertical surfaces of "T" girders; slab soffits of interior bays of "T" girders; enclosed surfaces of box girders; top surfaces of bridge decks; walkway surfaces; and median strips.

**(b)** Surfaces of bridge and pedestrian overpass piers, piles, columns, pier caps, abutments, wing walls, and retaining walls above finished ground, to at least 1 foot below finished ground.

**(c)** Surfaces of open spandrel arch rings, spandrel columns, and abutment towers.

**(d)** Surfaces above finished ground of culvert headwalls, and endwalls, where visible from a traveled way.

**(e)** Surfaces of inside box culvert barrels having a height of 4 feet or more, for a distance inside the barrel equal to the height of culvert or as far as is visible from a Traveled Way, whichever is greater.

**(f)** Surfaces of concrete railings, end posts, and curbs.

After completing Class I Ordinary Surface Finish, sand with power sanders areas that do not exhibit a smooth, even surface of uniform texture and appearance.

Use power carborundum stones or disks to remove unsightly bulges or irregularities.

The intent is to secure a smooth, even surface of uniform appearance and to remove unsightly bulges or depressions due to form marks and other imperfections. Scattered pockets or pinholes permitted under ordinary finish will not be considered to affect uniformity or texture. Extent of sanding and grinding shall be as specified.

Final operation for this finish consists of removing powder on surface resulting from sanding and grinding. When additional repairs are made after sanding and grinding, repeat sanding and grinding after repair has cured. Leave finished surface free from powder and other foreign matter by washing or wiping with clean cloth. Collect and dispose wash water.

**(3) Class 6 Float Finish.** Attain Class 6 Float Finish as follows:

**(a) Finishing Bridge Decks and Bridge Approach Slabs.** For bridge decks and bridge approach slabs, obtain smooth riding surface of uniform texture, true to required grade and cross section.

Place concrete in bridge decks and bridge approach slabs at a minimum finished deck placement rate of 20 linear feet per hour. Measure rate along centerline of roadway. Employ experienced operators and concrete finishers to finish deck. Keep necessary finishing tools and equipment on hand at work site and in satisfactory condition for use.

Unless acceptable lighting facilities are provided, complete finishing operations during daylight hours.

Immediately before placing bridge deck concrete, check falsework and wedges. Minimize settlement and deflection due to added weight of bridge deck concrete. Furnish suitable instruments, such as settlement gages, to permit ready measurement of settlement and deflection by the Engineer.

When settlement or other unanticipated events occur, stop deck concrete placement until corrective measures have been submitted and accepted. If accepted corrective measures have not been provided prior to initial concrete set, stop concrete placement and install bulkhead at location designated by the Engineer. Remove concrete placed beyond bulkhead.

Place bridge deck and bridge approach slab concrete in uniform heading, approximately perpendicular to roadway centerline. Limit rate of concrete placement to that which can be finished before beginning of initial set. Do not place deck surface concrete more than 10 feet ahead of strike off. Spread concrete to uniform height, such that required strike off does not exceed 3 inches of concrete.

Finish bridge decks and bridge approach slabs with concrete wearing surfaces in accordance with Subsection 503.03(M)(3)(a)1. - Machine Finishing.

Bridge decks and bridge approach slabs with asphalt wearing surfaces may be finished as described in this subsection.

During finishing operation while concrete is still plastic, test surface with 10-foot straight edge. Test surface from side or from transverse finishing bridges, in presence of the Engineer. Make necessary corrections to attain required tolerance, with minimum amount of remedial work after concrete has hardened.

After concrete has hardened sufficiently, test finished surface in presence of the Engineer with 10-foot straight edge. Surface for concrete deck finish shall not vary more than 1/8 inch from lower edge of straight edge.

Where concrete of bridge deck and bridge approach slab is to be covered with minimum 1-inch-thick layer of bituminous surfacing, earth, or other cover, surface of concrete shall not vary more than 1/4 inch from lower edge of 10 foot straight edge.

Grind high areas in hardened surface, leaving finished texture that is not smooth or polished. Produce final surface with uniform texture of transverse grooves, with tine dimensions in accordance with Subsection 503.03(M)(3)(a)1. - Machine Finishing.

Submit method of correcting low areas. Begin remediation of low spots only after the Engineer accepts submittal.

Strike off bridge deck surfaces under curbs, railings, and sidewalks to same plane as roadway. Leave bridge deck surfaces under curbs, railings, and sidewalks undisturbed when future widening is shown on Plans.

When deck width is 4 feet or less, finishing methods other than those specified herein may be used, provided completed deck surface conforms to specified requirements.

Perform remedial measures on completed bridge decks and bridge approach slabs not meeting specified requirements, at no increase in contract price or contract time.

**1. Machine Finishing.** Strike off and finishing machines shall be of the self-propelled types, operating on rails and conforming to specified requirements.

Use elevation-adjustable screed rails. Set screed to elevations, with allowances for anticipated settlement, camber and deflection, as required to form surface of bridge deck and bridge approach slab to specified line and grade. Screed-rails shall not deflect appreciably under applied loads.

Before beginning concrete operations, operate strike off and finishing machines over full length of bridge segment to be paved. Test run with screed and float adjusted to their finishing positions. While testing machines, perform the following: check screed rails for deflection; make required adjustments; measure cover on slab reinforcement; check controlling dimensions of slab reinforcement and forms.

During test run, use same number of machines and finishing bridges that will be used during production concrete placement, carrying production loads. Make necessary corrections at this time.

After placing and consolidating concrete, strike off surface of concrete carefully, using strike off machine. Make uniform deck surface, true to required grade and cross section.

When strike-off machine has wheelbase greater than 6 feet, float concrete by the following means: hand-operated longitudinal float board; or finishing machine equipped with longitudinal float; or rotating element followed by drag float pan.

Use longitudinal float on finishing machine not less than 8 feet or more than 12 feet long. When both strike off and floating are to be performed by machines, provide two separate machines with separate operators, one for strike off and one for floating. Perform final float pass as far back of strike off as concrete workability will permit.

When strike off machine has wheelbase of 6 feet or less, provide two separate hand-operated float boards or finishing machine accepted by the Engineer. Place first hand-operated float in operation as soon as concrete surface condition permits. Operate second hand-operated float as far back from first float as

concrete workability permits. Apply provisions in this subsection pertaining to hand-operated float boards, to the two separate float boards specified for longitudinal floating.

Use longitudinal floats, either hand-operated or machine-operated, with long axis of float parallel to bridge roadway centerline. Operate longitudinal floats with combined longitudinal and transverse motion. Operate rotating float with rotational and transverse movements. Use floats to plane off high areas and float material removed into low areas. Lap each pass with previous pass by half-length of float. Continue floating until smooth riding surface is obtained. Meet surface tolerances as specified herein.

In lieu of separate machines for strike off and finishing, a single machine equipped with rotating auger for strike off and rotating element followed by drag float pan for consolidating and finishing may be used. Submit previous project experience demonstrating that proposed machine is capable of meeting specified requirements for satisfactory bridge deck and bridge approach slab finishing. When requested by the Engineer, submit three copies of manufacturer's operators and parts manual for dual-purpose alternative machine. Operate machine in accordance with manufacturer's manual.

Hand-operated float boards and transverse finishing bridges shall meet requirements in accordance with Subsection 503.03(M)(3)(a)2. - Manual Finishing.

Use not less than two transverse finishing bridges.

Texture surfaces to meet skid resistance requirements. Submit proposed surface treatment methods to form skid-resistant texture. The Engineer will conduct skid resistance testing.

At specified time, produce uniform, transverse pavement grooves by combing with single row of spring metal tines. Make tines as follows: 1/32 inch in thickness; 3/32 inch in width; 4 inches in length; and 3/4 inch centers along row.

Position tines so that their widths are perpendicular to groove direction. Make grooves 1/8 to 3/16 inch in depth.

**2. Manual Finishing.** After placing and consolidating concrete, finish to provide a uniform surface.

Use template or strike board to alternately tamp and strike off concrete, and move forward with combined longitudinal and transverse motions. Leave uniform mortar or grout film of suitable consistency on concrete surface after last pass of template or strike board.

Use template or strike board of rigid construction, capable of resisting deflection and distortion when in use.

Set supports or headers to required elevations to form bridge deck and bridge approach slab surfaces to line and grade indicated in the contract documents. Allow for anticipated settlement, camber, and deflection when computing elevations.

Furnish and install supports or headers such that they shall not deflect under applied loads.

Supports or headers for deck concrete placement shall be completely in place for full length of concrete placement and shall be secured before placing deck concrete.

Following completion of preliminary finish and from transverse bridges, float deck for concrete wearing surface in direction parallel to roadway centerline.

Transverse finishing bridges, from which floats are to be operated, shall completely span bridge roadway area to be floated. Provide easily moveable finishing bridges of rigid construction, free of wobble and springing during floating operation. Use sufficient number of finishing bridges to permit floating operation to follow preliminary finishing operations without undue delay. Use not less than two transverse finishing

bridges.

Float with two separate wooden floats, each between 12 to 16 feet long. Use float boards 1 inch thick and 4 to 8 inches wide, with rigid ribs. Provide adjusting screws at not more than 24-inch centers between rib and float board. Maintain float board flat and true. Equip each float with adjustable handles at each end. Rib and truss each float, as necessary, to ensure float board has a true, rigid surface.

Operate floats with combined longitudinal and transverse motions, planing off high areas and floating material removed into low areas. Lap each pass with previous pass by half-length of float. Continue floating until smooth surface is obtained.

Place first float into operation as soon as concrete surface condition permits. Keep first float in continuous operation until subsidence has taken place.

Operate second float as far back of first float as concrete workability permits.

After completing floating operation, texture deck surface in accordance with Subsection 503.03(M)(3)(a)1. - Machine Finishing.

**(b) Sidewalks and Median Strips.** Provide final finish for concrete sidewalks and median strips using wooden float. The Engineer will determine degree of roughness. Provide abrasive coating for top surfaces of decks, ramps, and approach ramps for pedestrian structures and top surfaces of sidewalks.

Create abrasive coating by sprinkling 1/4 pound of grain per square foot, uniformly, on fresh concrete. Finish surface with wooden float.

**(N) Cleaning Up.** Upon completion of finishing operation and before final acceptance of structure, remove falsework, excavated or useless material, rubbish, and temporary buildings. Replace or restore public or private fences or property damaged during prosecution of work. Leave bridge site and adjacent highway in neat and presentable condition. Remove excavated material or falsework placed in stream channel during construction before final acceptance.

**503.04 Measurement.** Concrete will be paid on a lump sum basis. Measurement for payment will not apply.

The Engineer will consider wingwalls to be a part of the structure.

**503.05 Payment.** The Engineer will pay for the accepted concrete on a contract lump sum basis. Payment will be full compensation for the work prescribed in this section and the contract documents.

The Engineer will pay for the following pay item when included in the proposal schedule:

| **Pay Item** | **Pay Unit** |
|---|---|
| Concrete _____ | Lump Sum |

The Engineer will pay for excavation and backfill for foundations in accordance with and under Section 205 – Excavation and Backfill for Bridge and Retaining Structures and Section 206 – Excavation and Backfill for Drainage Facilities.

The Engineer will pay for reinforcing steel in accordance with and under Section 602 - Reinforcing Steel.

**END OF SECTION 503**