Amend Section 503 - CONCRETE STRUCTURES to read as follows:

"SECTION 503 - CONCRETE STRUCTURES

503.01 Description. This section describes the construction of concrete bridges, grade separations, box 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
Grout	712.04
Macro-Synthetic Fibers for Concrete Reinforcement	719

Concrete materials and production methods must be selected so that the concrete temperature at delivery complies with the specified temperature limits. Ensure that the materials, means, and methods used prevent plastic shrinkage cracks from forming.

All concrete must comply with the concrete CO_2 footprint reduction requirements of Section 601 – Structural Concrete.

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.

The elevation of the bottom of the footings shown is approximate only. Upon completion of excavation work, request that the Engineer inspect the foundation excavation. 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 the foundation requires redesign because of unauthorized excavation, the Contractor must engage the services of a Hawaii Licensed Structural Engineer to prepare detailed drawings of a redesigned footing. Submit a redesign proposal and after the Engineer reviews and accepts the proposal, construct redesigned foundation at no additional increase in the 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 the 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 the system by the Engineer does not relieve the Contractor from the responsibility of results obtained by using such drawings and calculations.

Use AASHTO LRFD Bridge Specifications For The Design of

Falsework, Formwork, or Centering. For allowable stresses not specified in AASHTO, the Contractor's structural engineer may use UBC/ICBO industry specifications or codes upon acceptance. Avoid cantilevered falsework members. Limit maximum deflection due to the weight of dead and live loads to 0.4 percent of the span. Provide camber strips to compensate for deflections or other movements greater than 1/4 inch.

Take the length of spans to be the smaller of the center-to-center distance between supports or clear span plus member depth. Design formwork for the 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 the bottom slab is to carry loads of top slabs temporarily imposed upon it.

Arrange a 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 the design of supporting falsework to prevent the reduction in support capacity due to the effects of flood and standing water.

The design load for falsework or centering includes dead and live vertical loads, slope load of the structure, and lateral loads. The minimum vertical live load to be used in the design is 50 pounds per square foot of surface area plus 150 pounds per linear foot, applied at the outside edge of cantilevered members. Add minimum vertical live load to the 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 the top surface of falsework support.

When falsework, scaffolding, or work is over or adjacent to existing roadways, install the aforementioned to withstand vehicle impact. Maintain falsework, scaffolding, or work until its removal. When the aforementioned is within the clear zone install a barrier system with appropriate deflection and of sufficient length with a terminal impact attenuator. Both must have successfully passed a MASH TL-3 crash test. The falsework, formwork, centering, working platform, or work must be constructed so it does not allow any objects, e.g., water, debris, dust, tools, or material to fall on the traveling public, pedestrians, roadway, roadside, etc.

Show stresses and deflections of the 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 ± 3/8 inch from those indicated on falsework drawings. In such affected areas, provide corrective measures before the initial set of concrete. Remove unacceptable concrete.

In designing falsework and centering, assume the weight of 160 pounds per cubic foot for concrete. Design and construct falsework to provide the 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 the placement of concrete. Design falsework for support of superstructure to support loads that would be superimposed as if the entire superstructure were placed at once. Design vertical falsework members supporting spans with a single hinge, or double hinges within a span, for twice tributary falsework requirements at a distance of 10 feet on each side of hinges, measured parallel to the centerline of the girder. Apply requirements 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 the 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 the gradual lowering of centers and for rendering the arch self-supporting. Use jacks to correct slight settlements that may occur during the placement of concrete.

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

If the 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 the manufacturer's design criteria conforming to design specifications and recommendations, or perform tests, as necessary, to show the adequacy of the 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 a 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 the rate of depositing concrete.

Use forms for concrete surfaces not completely enclosed or hidden below the permanent ground surface that complies with 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 the 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 the 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 the 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 the finished structure. Three-ply panel boards may be used for forming soffit of unexposed portions of box girder top slabs.

Use plywood conforming to the 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 of uniform lengths of not less than 6 feet, except where dimensions of members formed are less than specified panel dimensions. Place plywood panels with the grain of outer plies in direction of the span.

Place form panels in a neat, symmetrical pattern, subject to acceptance of the Engineer. Place panels with long dimensions 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 the form securely in place and prevent the 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 a depth of at least 1 inch from the 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 the bottom of the 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 the 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. The metal thickness used for forms must 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, water tightness, 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 the condition of column concrete.

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

In continuous or rigid frame structures, release falsework only after the last concrete (excluding concrete above the bridge deck) in that span and the first adjoining spans on each side have been in place for 14 days. For falsework removal, consider spans with a single hinge within the span to be continuous. Consider hinges of suspended spans within a bridge, as ends of the bridge, for determining shoring requirements. In structures of these types, remove falsework gradually and uniformly over the 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 the 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 a reshoring system is installed, falsework supporting sides of girder stems that slope less than 45 degrees off vertical may be removed before placing deck slab concrete. Design reshoring system, consisting of lateral supports, to resist rotational forces acting on the stem, including those caused by the placement of deck slab concrete. Install reshoring system immediately after each form panel is removed and before the release of supports for adjacent form panel.

Do not remove falsework and forms supporting the bottom slab of box girders until 14 days after the final top slab is placed. Remove forms for webs of box girders before placing the 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 the 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 the top slab is reshored and the curing of the concrete is not interrupted. Do not impose loads (including backfill) on the structure until the concrete attains the 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 has elapsed since concrete placement, materials weighing no more than 50 percent of the design live load may be stored on the structure. Submit shop drawings showing locations and weights of stored materials.

Release falsework before placing loads on the structure.

Live loads will not be allowed on completed portions of the 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 must not cause aggregate segregation or unsound concrete and must 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 hardened will not be allowed. Allow no more than a 30-minute interval between placement of two consecutive batches or partially hardened will not be allowed. Allow no more than a 30-minute interval between the placement of two consecutive batches or loads of concrete.

Do not deviate from the schedule for placing concrete without

permission from the Engineer.

The project site's addition of water to concrete ready-mix concrete in a truck mixer after the arrival at the location of concrete placement **IS LIMITED**. The addition of water above the amount in the accepted mix design mixture may affect the concrete properties, such as the water/cementitious (W/C) ratio which may result in a reduction of concrete strength, aggregate segregation, durability, increased shrinkage, mix uniformity and the increased its susceptibility to cracking. These unwanted properties may cause a reduction in service life and may increase the possibility of catastrophic failure of the structure. Hence, exceeding the W/C ratio is prohibited.

When a truck mixer is used for mixing or the delivery of concrete, no water from the truck system or elsewhere will be allowed to be added after the initial introduction of mixing water for the batch. The additional water may be added to the concrete mix when all the following conditions exist:

(a) Job site water must be started to be added not later than 15 minutes after the concrete ready-mix truck had arrived at the project site. Parking the ready-mix truck off the project site, waiting in a queue or both will be considered arriving on the project site.

1. The addition of water later than 15 minutes may be requested only before use from the Engineer when justified with additional data. The additional time needed and justification must be stated in the request.

(b) The slump of the concrete is less than that specified in the accepted mix design.

(c) The water added will not exceed the total amount of water specified in the accepted mix design or specification, i.e., exceeds the accepted water/cementitious (W/C) ratio (W=weight of water in batch, in pounds; and C= weight of cementitious materials in batch, in pounds).

(d) The temperature of the concrete has not exceeded the amount set in the Contract Documents.

The maximum amount of water that may be added to the concrete at the project site must be the smallest amount of water used to obtain the result of the following three restrictions:

(a) Bring the slump up to the accepted mix design or specified level, or

(b) Must not exceed 1½ gallons of water per cubic yard of concrete, or

(c) Must not cause the total amount of water to exceed the amount of water in the accepted mix design, i.e., change the W/C.

For example: If 1½ gallons of water per cubic yard of concrete increases the W/C beyond the accepted W/C then 1½ gallons of water must not be used. The maximum amount of water that can be added must be limited to the amount of water that would bring the mix to the accepted W/C even though the design mix slump has not been reached.

Adjustments are usually made to achieve the design mix slump requirements and must not exceed the accepted design mix's maximum slump.

The addition of water within the initial 15 minutes at the project site must be injected into the mixer under pressure and direction to assure uniformity. The drum or blades must be turned an additional 30 revolutions or more, if necessary, at mixing speed, until the uniformity of the concrete is assured. **WATER MUST NOT BE ADDED TO THE BATCH AT ANY LATER TIME!**

When macro or micro fibers are part of the mix design, excessive rotation of the drum may cause a deleterious effect on the concrete fiber mix. The fiber manufacturer's recommendations must be followed.

Pertinent Required Controlling Measures:

(a) Maximum allowable slump established from the accepted concrete design mixtures and job specifications.

(b) The concrete slump from the first portion of concrete discharged from the truck needs to be estimated or determined. The estimated concrete discharged must be subtracted from the W/C calculation. For example, 10yds of concrete is in the truck, and ¼cy is discharged. The delivery tag indicates 1gal/cy can be added to the mix without exceeding the accepted W/C. The maximum amount of water that can be added is 9¾ gal providing the addition of that

amount of water does not cause the slump to be more than the accepted concrete nix design's slump requirement. The addition of water to obtain workability and meet job specifications is the contractor's responsibility. However, the quantity of water added must be documented on the collected delivery tickets. The delivery tags must note the amount of water that can be added at the project site and still not exceed the total amount of water in the accepted concrete mix design, i.e., held back water. When the amount of held back water is not shown on the delivery tag it will be assumed that the concrete mix has the maximum total water allowed by the accepted mix design and no additional water will be allowed to be added at the project site.

(c) Do not allow water to be added to the concrete if the maximum slump is already obtained, or more than ¼ cubic yard has been discharged from the mixer.

(d) 1½ gallons of water or less per cubic yard may be used to obtain the desired slump. The slump must not exceed the maximum design slump and job specifications. The added water must not cause the batch's accepted W/C to increase.

(e) Tests for the acceptance of concrete based on slump must be made in accordance with AASHTO T 141 & T 119. Tests must be made after the addition of water at the project site to determine if the concrete's slump is compliant.

(f) When the concrete mix does not meet the requirements of this Section the concrete will be considered non-conforming, i.e., non-compliant. The action taken will comply with Subsection 105.12 Removal of Non-Conforming and Unauthorized Work.

This portion of the Section applies to most ready mixed concrete delivered. Special concrete mixes, e.g., Superplasticized concrete, mixes that have conditions that do not fall in a normal range of concrete as determined by the Engineer or require a special sequence are not applicable without a prior written request with supporting documentation, e.g., the admixture manufacturers' and ready-mix supplier's recommendations and approval. The request must be submitted before its use to the Engineer for its acceptance. The Engineer has the right to unilaterally accept or reject the request and rescind its acceptance.

Water blast laitance and foreign material and moisten interface

surfaces with water immediately before placing concrete over subgrade or construction joint. Leave no ponding water or have the surface glistening. Remove excess water by vacuuming or dry, oil-free compressed air.

Submit method and sequence of concrete placement. Place concrete on the 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 the 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 a saturated surface dry foundation bed will be included in the price for structure excavation.

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

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

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

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

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

After concrete placement stops, remove accumulations of mortar on reinforcing steel and surfaces of forms before the next concrete placement. If concrete is wet, prevent dried mortar chips,

other foreign material, and dust from falling onto the wet concrete surface. If the concrete has set, clean reinforcing steel in a manner that will not be detrimental to concrete to reinforcing steel bond.

(2) Box Culverts. Place and allow base slab or footings of box culverts to set at least 12 hours before constructing the remainder of the culvert. Monolithically construct sidewalls and a 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 the top slab. Provide appropriate keys in sidewalls for anchoring the top slab.

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

The top slab of box girders may be placed 10 days after placing bottom slabs and stems, provided concrete test specimens of the 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 the 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 the superstructure until column forms have been stripped sufficiently to determine the character of column concrete. Do not allow superstructure loads to be placed on bents or piers until bents have been in place for 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 the 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 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 the direction of movement.

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

Do not drop concrete into forms from a 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 underwater, using high-frequency internal vibrators. The minimum transmitted vibration frequency must be 4,500 impulses per minute and must be such as to visibly affect the mass of concrete (radius of influence) of a 1-inch slump over a radius of at least 18 inches. Use a sufficient number of vibrators to properly consolidate incoming concrete within 15 minutes after depositing concrete in forms. Make at least two vibrators available at the structure site when placing more than 25 cubic yards of concrete. One vibrator must be used at the place where concrete is being deposited. This first vibrator must level the poured concrete and it must follow the depositing chute as it moves. During leveling the concrete is temporarily liquefied due to the rapid oscillatory motion transmitted to the concrete by the vibrator and the concrete flows into the corners of the forms and around the reinforcement.

The second vibrator must consolidate and de-aerate the concrete removing the entrapped air bubbles making them rise to the surface and escape. Have at least one additional vibrator in reserve in addition to the two being used to level and consolidate the concrete. Apply vibrators at a center-to-center insertion spacing approximately 1.5 times the radius of influence. Minimize lift lines by totally inserting the vibrator vertically at the depth of the lift being vibrated plus 6 inches into the previous lift. Insert vibrators in a vertical position,

perpendicular to the concrete surface, at a uniform spacing over the entire concrete placement area. Dragging vibrators through concrete to another vibration point must not occur. Attaching vibrators to or holding them against forms or reinforcing steel must also 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 embedded fixtures, and into corners and angles of forms. Do not use vibrators to cause concrete to flow or run into position, instead of placing the concrete and vibrating it. 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 complying with Section 601 – Structural Concrete unless specified otherwise, 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 the point of deposit.

Tremie consists of a tube having an 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 must 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 the tube, while the tube is being charged with concrete. Support tremie to permit free movement of discharge end over the entire top surface of work and rapid lowering, when necessary, to retard or stop the flow of concrete.

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

keeping the discharge end in deposited concrete. Maintain continuous flow until work is completed.

Use an underwater bucket with open top and bottom doors that open freely outward, when tripped. Completely fill and slowly lower the bucket, to avoid backwash. Discharge bucket only when bucket rests on the surface upon which concrete is to be deposited. After discharge, raise the bucket slowly until well above concrete. The use of bottom dump buckets for the 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. The exact thickness of the concrete seal must depend upon the hydrostatic head, bond, pile spacing, and cofferdam size. Construct a concrete seal after the Engineer accepts the design. Allow seal to remain in place for not less than 7 days before dewatering. After sufficient time has elapsed, dewater the cofferdam, and remove scum, laitance, and sediment from the concrete. Before depositing fresh footing concrete, remove local high spots, as necessary, to ensure proper clearance for footing reinforcing steel.

(7) Hot Weather Concreting. When the ambient temperature is expected to meet or exceed 75 degrees F or the concrete construction involves flatwork concrete construction, ACI 305 R-20 Guide to Hot Weather Concreting or its latest edition or variant must be part of the Contractor's means and methods. Handling, placing, protection, and curing procedures must limit the concrete temperatures or water evaporation, or both that can reduce the strength, serviceability, and durability of the member or structure. Submit a Hot Weather Concreting action plan to the Engineer for review and acceptance. Do not place concrete where the temperature is above 90 degrees F unless the design mix and placement method comply with ACI 305 R-20 Guide to Hot Weather Concreting or its latest edition or variant.

Weather conditions, e.g., rain, temperature, wind, 6and humidity, must be monitored and addressed. Include the assumed temperature of concrete to be used in the initial calculation of the evaporation rate using the ACI 305 R's evaporation rate chart or ACPA's Evaporation Rate Calculator. Have action plans that are to be used should bad weather conditions, e.g., high wind, rain, high temperature, occur or will occur during pour and under what condition weather conditions must cause a cancellation or delay of the concrete placement. Measurements of the conditions used to determine the evaporation rate must be taken at the location where the concrete is currently being placed, e.g., near the chute, the concrete bucket, the

discharge nozzle of the concrete pump, etc. List make and model of weather monitoring instruments, to be used at the location of concrete placement, to measure the ambient air temperature, relative humidity, and wind velocity to determine the on-site real-time evaporation rate. All-in-one meters that utilize the ACI 305 R's chart or other accepted method for determining evaporation rate may be used if found acceptable by the Engineer. Submit catalogs of weather monitoring instruments. Submit weather reports with evaporation rates within 48 hours of the completion of the concrete pour. Weather reports must be in a format and have information acceptable to the Engineer.

If the evaporation rate is, or is likely to become, or trending to be 0.05 lb/ft^2/hr or greater, employ the measures to prevent moisture loss such as but not limited to the application of evaporation retarder, application of supplemental moisture by fogging or reduction of the concrete temperature during batching, reduction of wind velocity or other means accepted by the Engineer that was included in the accepted hot weather concreting plan. Check evaporation rate every 15 minutes during and after placement until the concrete has taken a final set or use ACI 305 R-20's or its latest edition or variant if inspection requirements are more frequent.

If the temperature of any of the reinforcement, embedments, or forms is greater than 120°F, use a fine mist of water, e.g., fogger to moisten and cool hot surfaces to below 120°F. Remove all standing or ponding water immediately before placing concrete. If compressed air is used to remove the water the air must be oil-free.

(8) Evaporation Retarders and Finishing Aids. Evaporation retarders and finishing aid solutions may be used when accepted by the Engineer. Adjust dilution rates to fit the local climate following the manufacturer's recommendations and receiving the Engineer's acceptance. Evaporation retarders and finishing aids must be "stand-alone" products. Products that are both evaporation retarder and finishing aid must NOT be used. They must be designed for highway pavement use. Evaporation retarders and finishing aids must not deleteriously change the water to cementitious material ratio (W/CM), i.e., water to cement ratio (W/C) of the concrete's surface, or affect the physical properties of the surface it is being applied to causing defects, e.g., chalking, color change, dusting, weaken surface, popouts, brittleness, spalling, cracking, or other unacceptable properties, submit test results that show compliance to these requirements. Evaporation retarders and finishing aid solutions must have different tints and tints must not be noticeable on the hardened cured concrete. Apply solutions with equipment that is labeled in a manner that easily identifies them from a distance.

Evaporation retarders must be allowed to form their protective film before the finishing aid solution is applied. Evaporation retarders and finishing aids must not be used interchangeably, using them interchangeably will damage the concrete surface. Misuse or adverse effects occurring to the concrete attributed to the evaporation retarders or finishing aids or both by the Engineer may result in the withdrawal of the Engineer's acceptance of the product and the immediate halting of the use of the product at no cost or increase in Contract time. The concrete will be considered non-compliant and must be removed or an Engineer accepted remedial repair be performed. The Engineer will solely decide what work method is to be used.

(9) Certified Concrete Flatwork Finisher Requirement. Perform the placement and finishing operations of concrete flatwork with a minimum ratio of one certified ACI Concrete Flatwork Finisher and Technician with 4,500 hours of acceptable work experience (certified craftsman) per three concrete finishers (concrete finishers without ACI Concrete Flatwork Finisher and Technician certification and 4,500 hours of acceptable work experience) at each location on the project site having flatwork done. The concrete flatwork must be under the direct supervision of a certified craftsman. Designate the certified craftsman who will be supervising and responsible for determining the quality of the finish of the concrete flatwork being performed. No flatwork must be performed without the required amount of certified craftsmen present.

(a) Flatwork concrete is defined as any concrete work that requires tools or machines to be used during the placement and finishing operations of concrete. Concrete flatwork includes concrete work that requires a specified finishing, smoothness, or rigid surface tolerances such as sidewalks, walkways, portland cement concrete pavement, concrete white-topping, girder seats, pier caps, bridge decks, on-grade concrete slabs, approach slabs, concrete overlays, and concrete repairs which exceed one square foot per day.

(b) Areas that are not considered flatwork concrete are the top of foundations or structures that will have backfill material placed directly on the concrete surface.

(c) Submit copies of the craftsman's current ACI certification 30 days before concrete flatwork begins for the Engineer's review and acceptance. The Engineer has the right to require the removal, replacement, retraining, and re-

certification of a certified craftsman if that person does not, in the opinion of the Engineer, demonstrate the ability to place and finish concrete in accordance with the practices recommended in the ACI Concrete Flatwork Finisher Certification Program and to meet the finishing standards required by the Contract Documents.

(d) Any cost or impact to the contractor in providing, training, certification, retraining, replacement, or re-certification is incidental to the contract items that require concrete flatwork.

(G) Joints. Before backfilling with earth or other materials against the joints, all construction, expansion, contraction, and control joints must be waterproofed with flashing compound waterproofing as detailed in the Standard Plans.

(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.

Before placing concrete on substrate concrete at the construction joint, the following work shall be performed:

(a) Remove laitance, loose particles, dust, dirt, impervious membrane curing compound, and any other material foreign to the construction joint and the projecting reinforcement.

(b) Roughen horizontal construction joint by abrasive blast cleaning, hydrodemolition, or other Engineer accepted methods to the full amplitude of approximately ¼ inch.

Before placing new concrete, draw forms tightly against the concrete already in place. Thoroughly clean, high-pressure water blast laitance and foreign material, and saturate the 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 the finished structure. Where vertical construction joints are necessary, extend reinforcing bars across joints to make the structure monolithic. Do not place construction joints through paneled wing walls or other large surfaces that are to be treated architecturally.

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

or contract time.

(2) Expansion Joints. Construct expansion joints of type and in the 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 the correct position. Plane sliding surfaces are true and smooth by following the direction of movement of the structure with the 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 the same shape as the area to be covered. Furnish one-piece, preformed joint filler, sized to leave a 1/4-inch gap along exposed surfaces. When specified, punch holes to accommodate dowels. Fix preformed joint filler firmly against the surface of concrete already in place with cold asphalt roofing cement conforming to ASTM D 4586. Do not nail the premolded expansion joint filler to the concrete or use a fastening method that will not compress more than the thickness of the premolded expansion joint filler. When necessary use more than one piece to cover the surface, fasten and hold abutting ends in shape by stapling. Cover joint between separate pieces with a 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 the 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 the expansion joint. Clean and remove concrete or mortar that may have been sealed across the 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 the shop to conform to the section of the 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 the surface of the finished plate true and free of warping. Maintain joints in the 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 a 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 the joint opening. Vibrate concrete surrounding embedded 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. Contraction joints in walls and other structures must be spaced at not more than 20 feet on centers and must be spaced, at abrupt changes in height or thickness and obtuse corners unless otherwise directed by the Engineer.

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

Waterproofing includes a coat of primer applied to a concrete surface, a firmly bonded membrane composed of two layers of saturated fabric conforming to ASTM D 1668, and three uniform mopping coats of waterproofing asphalt or an accepted method of waterproofing.

Apply a uniform coat of primer to the surface, extending 12 inches on each side of the joint. Allow the primer to dry before the first application of

asphalt. Heat asphalt to a temperature between 300 degrees F and 350 degrees F. Mop asphalt thoroughly onto the surface with no holidays.

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

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

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

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

(l) Joint Sealing.

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

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

Apply joint sealer so that joints are filled without forming air holes and discontinuities. The top of the joint sealer must be 1/4 inch below the 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 remove non-compliant joint sealer then place new joint sealer at no increase in the 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 a joint sealer, clean the joint thoroughly to remove mortar, laitance, scale, dirt, dust, oil, and other foreign matter from the joint with high pressure, oil-free, dry compressed air.

Install seal so that it will not be abraded by traffic and will effectively keep foreign material from entering the 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 the riding surface, and in a plane normal to the sides of the groove.

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

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

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

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

Steel angle protective nosing assembly must extend beyond the curb line and must terminate 1 inch from the edge of the deck. Apply flashing compound as recommended by the manufacturer.

(J) Concrete Exposed to Sea Water. In concrete structures exposed to seawater, construction joints will not be allowed between levels of extreme low water and extreme high water, as indicated in the Contract Documents, or as found in accepted reference 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 the sun, rain, and flowing water. Do not allow concrete to dry out from the time of concrete placement until the end of the minimum curing period. The minimum curing period must be as follows:

(1) Cure structures for at least 7 days. Maintain a 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 a written outline of the 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) Cast-in-place parts of a structure to be submerged in freshwater, let cure for at least 5 days. Cast-in-place parts of a structure to be submerged in brackish or seawater must leave the forms in place for at least 30 days to cure 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. Submit proposed curing methods, including copies of test results and manufacturer's catalog no later than 30 working days before the first concrete pour. There must be no concrete pouring until the Engineer accepts the curing method including the curing compound and its application method. The procedures for protecting and curing concrete will be considered adequate if (1) or (2) are satisfied:

(1) Average strength of field-cured cylinders at test age designated for determination of **f'c** is equal to or at least 85 percent of that of companion standard-cured cylinders.

(2) Average strength of field-cured cylinders test age exceeds f'c by more than 500 psi.

If the curing method does not meet one of the aforementioned criterions the curing method must be modified or changed until it is compliant. 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 fogging, 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 the concrete surface using a fog spray. Continue applying moisture to the surface until regular curing begins. Use adequate water supply and sufficient moisture to fog and water cure concrete without damaging the surface or texture of concrete. The temperature of water used must be at least 50°F and not be more than 35°F colder than the surface temperature of the concrete at the time the water and concrete come in contact.

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

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

(2) Impervious Membrane Curing. Seal the concrete surface thoroughly with a liquid membrane-forming compound. Apply compound uniformly in two or more applications. Use for each coat a ratio of at least 1 gallon for every 100 square feet of concrete surface.

The impervious membrane **c**uring compound must be applied to the concrete following the surface finishing operation. Start the application of the curing compound immediately before the moisture sheen disappears from the surface, but before any drying shrinkage or craze, cracks begin to appear. In the event of any drying or cracking of the surface, increase the humidity in the area by using a fog spray with an atomizing nozzle as specified in Subsection 503.03(F)(7) ”Hot Weather Concreting”, fogging must be started immediately, and must all be continued until the application of the compound is resumed or started; however, the compound must not be applied over any resulting freestanding water. Do not blend the free-standing water into the concrete surface, allow it to evaporate, If the free-standing water is due to the foggers, stop them and adjust the foggers so they comply with the Contract Documents. Should the film of the compound be damaged from any cause before the expiration of 7 days after the concrete is placed in the case of structures and 72 hours in the case of pavement, the damaged portion must be repaired immediately with an additional application of two coats of compound.

Use curing compounds that will not permanently darken concrete on exposed hardened surfaces of the concrete structure. Do

not apply membrane curing compound on surfaces to which concrete is to be bonded or to which waterproofing or epoxy is to be applied or will be deleterious to future work.

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

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

(4) If the construction joint requires that it bonds with the concrete poured against it a lithium curing compound will be acceptable as a curing compound. Lithium curing compound must not be used on the horizontal surface in place of other aforementioned curing methods unless specifically called for by the Contract Document, or a waiver is granted by the Engineer. A lithium sealer will not be accepted as a curing compound. The lithium curing compound must meet or exceed the requirements of ASTM C-309, and ASTM C-1315 and be a 28-day water cure equivalent. All work shall conform with the manufacturer's recommendations.

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

No additional water must be applied to the concrete surfaces to aid in the finishing operation. The application of water to aid the finishing operation will result in the concrete being non-compliant with the contract requirements and result in the rejection of the concrete pour. Finishing aids or evaporation retarders may be used only with written authorization by the Engineer. Only stand-alone finishing aids must be used to finish the concrete surface and only stand-alone evaporation retarders are used to minimize the evaporation rate of the plastic concrete. These solutions must not be used interchangeably.

(1) Class 1 Ordinary Surface Finish. Apply ordinary surface finish to concrete surfaces, either as a final finish or preparatory to applying a 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 a depth of at least 1 inch below the concrete surface. Clean, wet, and fill resulting holes or depressions with mortar. Mortar must 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 the surrounding concrete. Use mortar that is not more than 1 hour old and that bonds indistinguishably with concrete. After the mortar has thoroughly hardened, rub the surface with a carborundum stone to obtain the same color mortar as in the surrounding concrete. Remove fins caused by form joints and other projections. Remove stains and discolorations visible from the travel 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 or have exposed reinforcing steel. Pockets must not affect the strength of the structure or shorten the life of steel reinforcement. Fill pockets on surfaces visible to pedestrian traffic and surfaces exposed to streamflow, salt air, and saltwater. Use mortar for filling pockets, as specified for bolt and tie holes. When rock pockets affect the strength of a structure materially or shorten the life of the structure or steel reinforcement, the Engineer will declare concrete unacceptable and require removal and replacement of the 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 the 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, when 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. Sand with power sanders areas to 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. The extent of sanding and grinding must be as specified.

The final operation for this finish consists of removing powder on the surface resulting from sanding and grinding. When additional repairs are made after sanding and grinding, repeat sanding and grinding after a repair has cured. Leave the finished surface free from powder and other foreign matter by power washing and wiping with a clean cloth. Collect and dispose of 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 a smooth riding surface of uniform texture, true to the 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 the centerline of the roadway. Employ experienced operators and concrete finishers to finish the deck. Keep necessary finishing tools and equipment on hand at the worksite and in satisfactory condition for use.

Complete finishing operations only during daylight hours unless acceptable lighting facilities are provided.

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 a 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 before the initial concrete set, stop concrete placement, and install the bulkhead at a location designated by the Engineer. Remove concrete placed beyond the bulkhead.

Place the bridge deck and bridge approach slab concrete in a uniform heading, approximately perpendicular to the roadway centerline. Limit the rate of concrete placement to that which can be finished before the beginning of the initial set. Do not place deck surface concrete more than 10 feet ahead of strike-off. Spread concrete during its initial deposit on the deck forms to a uniform height, and it requires a strike-off that 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 the finishing operation while concrete is still plastic, test the surface with a 12-foot straight edge. Test surface from the side or from transverse finishing bridges, in presence of the Engineer. Make necessary corrections to attain the required tolerance after the concrete has hardened.

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

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

Grind high areas in the hardened surface, leaving a finished texture that is not smooth or polished. Produce final surface with a uniform texture of longitudinal 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 remedial repair submittal.

Strike off bridge deck surfaces under curbs, railings, and sidewalks to the same plane as the 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 the 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 the contract price or contract time.

1. Machine Finishing. Strike-off and finishing machines must 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 the surface of the bridge deck and bridge approach slab to specified line and grade. Screed rails must not deflect appreciably under applied loads.

The screed rails must be adjustable for elevations. The screed must be set to elevations, with allowances for anticipated settlement, camber, and deflection, as required to form the surface of the bridge deck to the line and grade shown in the contract. The

Contractor must install screed rail type such that the rails must not deflect appreciably under the applied loads. The supports for the screed rails must not be placed within the full width of the bridge.

The Contractor must not apply any additional water to the deck surface to aid his finishing operation. The unauthorized application of water will result in the rejection of that day's concrete placement.

Before beginning concrete operations, operate strike-off and finishing machines over the full length of the bridge segment to be paved. Test run with screed and the 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 the test run, use the same number of machines and finishing bridges, also, machines must be loaded with the same material and personnel that will be used during the production concrete placement, i.e., carrying production loads. Make necessary corrections at this time.

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

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

feet or less, provide two separate hand-operated float boards or a finishing machine accepted by the Engineer. Place the first, hand-operated float in operation as soon as concrete surface condition permits. Operate the second, hand-operated float as far back from the first float as concrete workability permits. Apply provisions in this subsection on hand-operated float boards, to the two separate float boards specified for longitudinal floating.

Use longitudinal floats, either hand-operated or machine-operated, with the long axis of float parallel to the bridge's 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 the previous pass by half-length of float. Continue floating until a smooth riding surface is obtained. Meet surface tolerances as specified herein.

In place of separate machines for strike-off and finishing, a single machine equipped with a rotating auger for strike-off and rotating element followed by a drag float pan for consolidating and finishing may be used or the Contractor may request acceptance of the use of substitute machines and methods from the Engineer. Submit previous project experience demonstrating that the 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 or other Engineer requested information. Operate the machine in accordance with the manufacturer's manual.

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

Use not less than two transverse finishing bridges unless directed otherwise by the Engineer. The Contractor may request a waiver from this requirement upon justification and acceptance from the Engineer.

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

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

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

After the surface sheen has disappeared; texture the pavement surface without tearing it. Texture final surface using artificial turf drag followed immediately by metal comb grooving device.

Use artificial turf made of molded polyethylene with synthetic turn blades measuring approximately 0.85 inches long and containing approximately 7,200 individual blades per square foot. Submit a sample of artificial turf at least twenty working days before placing PCC pavement.

Attach artificial turf to self-propelled equipment having external alignment control. The device must be a separate piece of equipment to be used exclusively for texturing operation and must not be attached to other paving-train equipment. Artificial turf must be full pavement width and of sufficient size that during finishing operation, approximately 2 feet of turf, parallel to pavement centerline, is in constant contact with the pavement surface. Maintain downward pressure on pavement surface with turf, to achieve uniform texturing without measurable variations in pavement profile. The artificial turf drag must not be wavy and must be parallel to the centerline of the pavement.

In addition to the artificial turf drag, grooving (tining) must be done immediately after the artificial turf drag is performed. It must be done by a self-propelled mechanical device (grooving device) having an external alignment control and capable of grooving the entire

width of pavement being paved in a single pass at a uniform speed. The grooving device must be a separate piece of self-propelled equipment to be used exclusively for texturing operation and must not be attached to other paving-train equipment. The metal comb which creates the tining marks must include a single line of evenly spaced, tempered spring steel tines of size and stiffness sufficient to produce grooves of specified dimensions in plastic concrete without edge slumping and severe surface tearing. Operate grooving device to produce a uniform pattern of grooves parallel to pavement centerline. The tines must not be left in the concrete when the tining machine stops. The tines must be lifted off the concrete and when ready to move in a forward motion lowered the tines down again. Leaving the tines in the fresh concrete can leave an indentation in the surface which must not be allowed. Attach the metal comb to a mechanical device capable of traversing the entire pavement width in a single pass at a uniform speed. Grooves in the hardened pavement surface must have a minimum spacing of 0.75 inches and must be 0.125 -inches wide by 0.125-inches deep. Provide hand combs with steel tines to use in event of mechanical comb breakdown.

Ramps, tapers, and miscellaneous areas may be textured manually when requested from the Engineer and accepted. Indicate in the paving plan the areas that will be manually textured.

Concrete bridge decks, concrete sleeper slabs, and concrete approach slabs must be textured longitudinally by mechanical grooving. Grooves must be cut into the hardened concrete using a mechanical water-cooled diamond edge blade saw device which must produce straight uniformly spaced grooves spaced at 3/4 inch. The groove width must be 1/8 inch plus or minus 0.02 inch and the groove depth must be 1/8 inch plus 1/16 inch or minus zero inches. If grooves cannot be cut into a continuous longitudinal operation, the continuation of grooves must be aligned such that joints are not visible. If the bridge deck texture is required to be Next Generation Concrete Surface (NGCS) the concrete sleeper slabs, and concrete approach slabs must be textured using NGCS texture.

Before grooves are cut into the accepted hardened concrete, the upper 1/8 inch of the concrete surface for the bridge deck, approach slabs, and sleeper slabs must be removed by grinding. Grooving must be done after the concrete has attained sufficient strength to prevent spalling and raveling, and before the structure is opened to traffic.

A working drawing to control, collect and dispose of run-off water at an accepted off-site facility must be submitted to the Engineer.

The requirements of Section 411.03(N) Surface Test must apply to concrete bridge decks and concrete approach slabs. If additional grinding is required to achieve the specified profile index, or IRI the grinding must be performed before the mechanical grooving and must be done only in the longitudinal direction.

2. Manual Finishing. After placing and consolidating concrete, finish providing 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 the concrete surface after the last pass of the 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 must not deflect under applied loads.

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

deck concrete.

Following the completion of the preliminary finish float the deck's concrete wearing surface from transverse bridges in a direction parallel to the roadway centerline.

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

Float with two separate floats made of acceptable material, 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 the 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 the previous pass by half-length of float. Continue floating until a smooth surface is obtained.

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

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

After completing the floating operation, the texture deck surface must be 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 and broom finish. Do not plaster the surface. Use an edging tool with a ¼-inch radius to finish the outside edges of the sidewalk. Finish sidewalk as a plane surface with 2-percent (allowable construction tolerance of plus or minus 0.4 percent maximum) cross slope towards the roadway or as shown in the Contract Documents. Test surface of concrete sidewalk with 12-foot straightedge. Correct any deviation above ¼ inch.

Wet down the base or ground onto which the concrete will be placed just before concrete placement. Remove any ponds or puddles or standing water before placing concrete.

For top surfaces of decks, ramps, and approach ramps for pedestrian structures and top surfaces of sidewalks provide an abrasive coating to the surface.

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

If reinforcement is required, the reinforcement must be supported off the base or ground to the location shown in the Contract Documents before the concrete placement starts. Enough support must be given so there is no sag in the reinforcement. Pulling up the reinforcement during the concrete placement or supporting the reinforcement with piles of concrete is not an acceptable method of support and all concrete placed in such a manner must be removed and replaced at the Contractor's cost.

(N) Cleaning Up. Upon completion of finishing operation and before prefinal inspection of the structure, remove falsework, excavated or useless material, rubbish, temporary structures, facilities, 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 the stream channel during construction before the pre-final inspection.

(O) Tolerance for Concrete Construction and Materials. Comply with the stricter tolerances specified in the specifications, ACI 117 Standard Specifications for Tolerance for Concrete Construction and Materials, PCI Tolerance for Precast and Prestressed Concrete, and PCI MNL-116 Manual for Quality Control of Plants and Production of Structural Precast Concrete Products.

503.04 Measurement. The Engineer will measure the concrete by cubic yard according to the dimensions shown in the contract or as ordered by the Engineer.

The Engineer will not make deductions for the volume occupied by reinforcing steel, piles, floor drains, weepholes, timber bumpers, pipes less than eight inches, conduits, or expansion joint materials.

503.05 Payment. The Engineer will pay for the accepted quantities of concrete complete in place at the contract unit price per cubic yard for the pay items listed below and contained in the proposal.

The contract unit price amount paid shall be full compensation for the concrete; for placing, curing, and finishing; for furnishing materials including admixtures, cement (including extra cement added to concrete deposited under water), SCMs; for carbon-footprint reduction methods and material; for the furnishing and installation of drains, scuppers, premolded joint fillers, joint seals, waterproofing at construction joints, waterstops, pipes, and conduits; for the furnishing and installation of anchor bolts, structural shapes for expansion joints and other similar items; for timber bumpers, forms, form lining, and falsework or centering, bearing pads, structural steel bearing plates; and for equipment, tools, labor, materials, and incidentals necessary to complete the work as 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 _____ (Class _____ if applicable)	Cubic Yard

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

END OF SECTION 503”