Amend **Section 601 - Structural Concrete** to read as follows:

"**SECTION 601 - STRUCTURAL CONCRETE**

601.01 Description. Structural concrete shall consist of portland cement, fine aggregate, coarse aggregate, and water. Proportion and mix the structural concrete according to the contract. Admixtures for entraining air, retarding or accelerating the set, tinting and other purposes as required or permitted may be added.

601.02 Materials. Materials shall conform to the following:

Portland Cement	701.01
Fine Aggregate for Concrete	703.01
Coarse Aggregate for Concrete	703.02
Admixtures	711.03
Water	712.01

Coarse aggregates for lightweight concrete shall conform to ASTM C 330 except the contract waives Sections 5, 7, and 9.

601.03 Quality Control. In portland cement concrete production, the Contractor shall be responsible for the quality control of materials during the handling, blending, mixing, curing, and placement operations. The person responsible for concrete production control and sampling and testing for quality control shall be proficient in concrete technology and shall have a sound knowledge of the contract. The person responsible shall be able to adjust concrete mix designs for improving workability and contract compliance.

Sample, test, and inspect the concrete necessary to assure quality control of the component materials and the concrete. Sampling and testing for quality control shall be according to the standard methods prescribed in this contract. Do the quality control tests for slump, air content, temperature, and unit weight during the production of structural concrete other than concrete for incidental construction. Notify the Engineer of the test results.

601.04 Design and Designation of Concrete. The Contractor shall be responsible for the design of concrete mixture for the concrete work specified. When requested by the Engineer, the Contractor shall submit the mix designs using State Highways Division form DOT 4-151. Work shall not start until the Engineer accepts the mix design. The Engineer will accept the concrete mix design using information given in Table 601-I - Design of Concrete and other pertinent requirements of the contract. This acceptance will not relieve the Contractor from obligations to furnish a workable mixture.

Whenever the 28-day compressive strength, f'_c, is 4,000 psi or greater, consider the concrete to be designated by compressive strength and shall be the minimum required at 28 days.

The class of concrete for 28-day compressive strengths, f'_c, that are less than 4,000 psi are designated in Table 601-I - Design of Concrete. They are not a requirement for acceptance of concrete.

Proportion the concrete designated by compressive strength such that the concrete will conform to the strength specified in this contract.

Concrete deposited in water shall be seal concrete.

Design concrete placed in bridge decks and pavements exposed to the wearing of traffic with an air content of 3% which includes entrapped and entrained air. Maintain the air content for plastic concrete within a tolerance of ± 1% during the work. Unless the contract designates the concrete by compressive strength, the concrete shall be Class BD.

When placing concrete in bridge decks, incorporate a water-reducing and set-retarding admixture into the concrete. The water-reducing and set-retarding admixture shall have the capability of varying the degree of retardation without adversely affecting the other characteristics of the concrete. Submit a design dosage for the admixture to the Engineer for acceptance.

Unless specified in other parts of the contract, the concrete shall be Class A.

The design of concrete shall be as required in Table 601-I.

TABLE 601-I - DESIGN OF CONCRETE

Class of Concrete	28-Day Strength f'_c, psi	Minimum Cement Content 100 lbs./c.y. (8.0 Maximum)	Maximum Water-Cement Ratio, lb./lb.
A	3000	5.6	0.55
B	2500	5.0	0.62
C	2000	4.4	0.71
D	1500	4.0	0.80
BD	3750	6.1	0.49
SEAL	3000	6.1	0.55
Designated by Strength f'_c or $^*f'_r$	As Specified	6.1	0.49

$^*f'_r$ = Specified Modulus of Rupture

Proportion the concrete materials according to the requirements for each concrete designated by class, cement content in pounds per cubic yards, or 28-

day compressive strength specified in the contract using the absolute volume method. Use the volumetric proportioning methods as outlined in:

(1) the American Concrete Institute (ACI) Standard 211.1-89, "Recommended Practices for Selecting Proportions for Normal and Heavyweight Concrete."

The coarse aggregate size for concrete shall be No. 57 (one inch to No. 4) or No. 67 (3/4 inch to No. 4). For concrete placed in the bottom slab and stems of box girders, use the No. 67 size aggregate. When accepted by the Engineer in writing, the Contractor may use smaller size aggregates where encountering limited spacing between forms and reinforcement.

When called for in the contract, lightweight concrete shall have a minimum compressive strength of 3,000 psi at 28 days. The lightweight concrete shall contain not less than 560 pounds of portland cement per cubic yard. Make, cure, and determine the compressive strength of lightweight concrete cylinders according to AASHTO T 22 and T 23. Lightweight concrete shall have a maximum wet plastic unit weight of 135 pcf and a nominal slump of 3.5 inches.

Determination of compliance with the requirements shown in this subsection shall be according to the following standard methods:

STANDARD METHODS	
Sampling Fresh Concrete	AASHTO T 141
Weight Per Cubic Foot Yield and Air Content of Concrete	AASHTO T 121
Slump of Portland Cement Concrete	AASHTO T 119
Air Content of Freshly Mixed Concrete by the Pressure Method	AASHTO T 152
Specific Gravity and Absorption of Fine Aggregate	AASHTO T 84
Specific Gravity and Absorption of Coarse Aggregate	AASHTO T 85
Temperature of Freshly Mixed Concrete	ASTM C 1064

Test for strength shall be according to the following:

TEST FOR STRENGTH	
Making and Curing Concrete Compressive and Flexural Test Specimens in the Field	AASHTO T 23
Compressive Strength of Molded Concrete Cylinders	AASHTO T 22 (6 inch by 12 inch cylinders only)
Flexural Strength of Molded Beams	AASHTO T 97

When concrete is designated by compressive strength, f'_c, or flexural strength, f'_r, the Engineer will require prequalification of materials and mix proportions proposed for use before placing such concrete. The Engineer will prequalify the concrete on past performance records using statistical computations of the population sizes and (n-1) weighting, or trial batch test reports according to the computed minimum average strength for the material and mix proportions. The Engineer will resolve the minimum average strength on a probability of not more than one in 20 tests falling below the specified strength for the following conditions:

(1) When past performance records are available, the documented performance records shall include:

(a) a minimum of 15 consecutive 28-day strength tests from projects having the same materials and mix proportions or

(b) two groups totaling 30 or more test results representing similar materials in which the mix proportion strengths are within 20% of the specified strength from within the last one year.

The Engineer will analyze the performance records to establish a standard deviation. The Engineer will resolve the minimum average strength on the computed standard deviation.

(2) When no sufficient past performance records are available, the Engineer will assume the current standard deviation to be 500 psi for compressive strength, f'_c, and 50 psi for flexural strength, f'_r.

Unless sufficient performance records are available from other projects at the DOT Materials Testing and Research Branch, submit test performance records or trial test reports for prequalifications of concrete provided:

(1) such data shall be the most recent tests made on concrete of the proposed mix design and

(2) the Contractor has obtained such data within one year of the proposed use.

The test data and trial batch test reports shall include the following information:

(1) Date of mixing.

(2) Mixing equipment and procedures used.

(3) The size of batch in cubic yards and the weight, type, and source of ingredients used.

(4) Slump of concrete.

(5) The air content of the concrete when using an air entraining agent.

(6) The age and strength of concrete cylinders tested.

Trial batch test reports shall show that the concrete equals or exceeds the minimum average strength. The test is the average 28-day test results of five consecutive concrete cylinders or concrete beams taken from a single batch. No cylinder or beam shall have a strength less than 85% of the minimum average strength.

An official of the firm that did the tests shall sign the test data and trial test reports.

The Engineer reserves the right to stop the work when the mix properties are sufficiently out of control and a series of excessively low strength tests are occurring. Do not continue concrete work until after establishing the cause and informing the Engineer the necessary corrective action taken. The corrective action may range from a minor adjustment of proportions to the establishment of a new mix design.

601.05 Batching. Measure and batch the materials according to the following provisions:

(A) Portland Cement. Sacked or bulk cement may be used. Do not use fraction of a sack of cement in a batch of concrete unless the cement is weighed.

Weigh bulk cement on an accepted weighing device. Seal and vent the bulk cement weighing hopper properly to preclude dusting during operation. Do not suspend the discharge chute from the weighing hopper. Also, arrange the discharge chute so that cement will not lodge in the hopper or leak from the hopper.

Accuracy of batching shall be ± 1% of the required mass.

(B) Water. Measure water by volume or by mass. The device for measurement of water shall be readily adjustable and shall have an accuracy within 1% of the quantity of water required for the batch. Arrange the device so that variable pressures in the water supply line does not affect the measurements. Equip the measuring tanks with outside taps and valves or other accepted means to provide for checking their calibration. Water, as measured, shall be within 1% of the required quantity.

(C) Aggregates. Store and stockpile the aggregates so that the Contractor avoids separation of coarse and fine particles within each size and does not intermix the various sizes before proportioning. Protect the stored or stockpiled aggregates from dust or other foreign matter.

Do not stockpile the aggregates from different sources and of different gradings together.

Handle aggregates from stockpiles or other sources to the batching plant by maintaining a uniform grading of the material. Do not use aggregates that have become segregated or mixed with earth or foreign matter. Stockpile or bin the aggregates at least 12 hours for draining before batching the aggregate when producing or handling the aggregates by hydraulic methods and washing the aggregates for draining. When the aggregates contain a high or non-uniform moisture content, the Engineer will require storage or stockpile over 12 hours.

Proportion the aggregates by weight. The exception is that the aggregates in concrete for minor structures, curbs, and sidewalks may be proportioned by volume or weight. For volume proportioning, use the measuring boxes of known capacity to measure the quantity of each size of aggregate.

Use the batch weight based on dry materials plus the total weight of moisture (both absorbed and surface) contained in the aggregate. The individual aggregates shall be within ± 2% of the required weight. The total mass of the aggregates shall be within ± 1% of the required weight.

(D) Admixtures. Store, proportion, and dispense admixtures according to the following provisions:

(1) Liquid Admixtures. Dispense chemical admixtures, air entraining admixtures, and calcium chloride in liquid form. Dispense such liquid admixture by automatic dispensing equipment. Dispensers for liquid admixtures shall have sufficient capacity to measure the prescribed quantity for each batch of concrete. Each dispenser shall include a graduated measuring unit into which liquid admixtures can be measured to within ± 5% of the prescribed quantity for each batch. Locate and maintain the dispenser where the graduations can be read accurately from the point at which proportioning operations are controlled to permit a visual check of batch accuracy before discharging. Mark each measuring unit clearly for the type and quantity of admixture.

Arrange with the supplier to provide safe and suitable facilities for sampling admixtures.

When using more than one liquid admixture for the concrete mix, provide a separate measuring unit for each liquid admixture. Dispense the liquid admixture by injecting so that the admixture is

not mixed at high concentrations and not interfere with the effectiveness of each other.

When using liquid admixtures in concrete, the dispensers shall operate automatically with the batching control equipment. Equip such dispensers with an automatic warning system in good operating condition that will provide a visible or audible signal at the point that the proportioning operations are controlled:

(a) when the quantity of admixture measured for each batch of concrete varies from the pre-selected dosage by more than 5% or

(b) when not emptying the entire contents of the measuring unit from the dispenser into each batch of concrete.

Unless liquid admixtures are added to the pre-measured water in the batch, arrange their liquid discharges into the batch of concrete to flow into the stream of water that will disperse the admixture throughout the batch.

Measure and disperse special admixtures as recommended by the admixture manufacturer and as accepted by the Engineer. Special admixtures shall include "high range" water reducers requiring dosages greater than the capacity of conventional dispensing equipment.

(2) Mineral Admixtures. Protect mineral admixtures from exposure to moisture until used. Pile the sacked material to permit access for tally, inspection and identification for each shipment.

Provide adequate facilities to keep the mineral admixtures separated and to assure inserting only the specified mineral admixtures in the work. Provide safe and suitable facilities for sampling mineral admixtures.

Incorporate the mineral admixtures into concrete using equipment conforming to Subsection 601.05(A) - Portland Cement.

When completely mixing the concrete in paving or continuous mixers, weigh the mineral admixture in a separate weigh hopper. Introduce the mineral admixture and cement simultaneously into the mixer proportionately with the aggregate.

When requiring interlocks for cement charging mechanisms and weighing the cement and mineral admixtures cumulatively, interlock their charging mechanisms to prevent the introduction of mineral admixture until the weight of cement in the weigh hopper is within the tolerances specified in Subsection 601.05(A) - Portland Cement.

In determining the maximum amount of free water that may be used in the concrete, consider the mineral admixture to be cement.

(E) Bins and Scales. The batching plant shall include separate and adequate bins for each size of aggregate. When using cement in bulk, include a separate and adequate bin and weighing hopper for the cement.

Attach the cement weighing hopper to a separate scale for individual weighing or to the aggregate scale for cumulative weighing. When weighing the cement cumulatively, weigh the cement before the other ingredients.

Scales for batching shall be of the springless-dial or beam-type. When using beam-type scales, make provisions to show the operator that the required load in the weighing hopper is approaching. The device shall make the indication within the last 200 pounds of load and within 50 pounds of overload.

Scales shall be accurate to 0.5% throughout the range of use. Design poises to lock thus preventing unauthorized change of position. Use scales inspected the State Measurement Standards Branch of the Department of Agriculture to assure their continued accuracy. Provide not less than ten 50 pounds weight for testing scales.

Batching plants may be equipped with automatic weighing devices of accepted types to proportion aggregates and bulk cement.

(F) Batching and Hauling. To check the accuracy of batch mass, resolve the gross and tare mass of batch trucks, truck mixers, and truck agitators when specified by the Engineer. Weigh the equipment on certified scales at no cost to the State.

When mixing is at the work site, transport the aggregates in batch boxes, vehicle bodies, or other containers of adequate capacity and construction. Partitions separating batches shall be adequate and effectively prevent spilling from one compartment to another while in transit or dumping. When using bulk cement, use a suitable method for handling the cement from weighing hopper to transporting container or into the batch itself for transportation to the mixer. Arrange batching

and hauling to provide positive assurance of the actual presence in each batch of the entire cement content specified.

Transport bulk cement to the mixer in tight compartments carrying the full quantity of cement required for the batch. When placing cement in contact with the aggregates, the Engineer may reject the batches unless they are mixed and placed within 1.5 hours from contact. The Contractor may transport cement in original shipping packages on top of the aggregates, provided each batch contains the number of sacks required by the job mix.

Deliver the batches to the mixer intact. Dump each batch into the mixer without loss of cement. Also, when carrying more than one batch on the truck, dump the batch into the mixer without spilling the material from one batch compartment into another.

601.06 Mixing. Mix the concrete in mechanically operated mixers. When the Engineer permits, mix batches by hand methods according to the last paragraph of this section.

Mixers may be stationary or truck mixers. The mixer shall produce concrete uniform in color, appearance and distribution of the materials throughout the mass. Variation in the mixed concrete attributable to worn pickup or throw over blades will be just cause for inspection. When such inspection reveals the blades to be worn down more than one inch below the original height of the manufacturer's design, repair or replace the blades. Make a copy of the manufacturer's design, showing dimensions and arrangement of blades upon request.

Charge the batches into central or truck mixers so that part of the mixing water enters ahead of the cement and aggregates. The flow of water shall be uniform. The total water of each batch shall be in the mixer by the end of the first quarter of the mixing period. When using mixers having multiple compartment drums, the Engineer will consider the time required to transfer material between compartments mixing time. The speed at which the drum shall rotate shall be as designated by the manufacturer. If such mixing does not provide concrete of uniform and smooth texture, perform additional revolutions at the same speed until each batch of concrete is thoroughly mixed. The Engineer will consider the mixing time from the time cement, aggregates, and 60% of the water are in the drum. Concrete mixed in each batch shall not exceed the manufacturer's guaranteed capacity. The Engineer will consider the guaranteed capacity of a mixer to be the manufacturer's rated capacity.

Equip central or truck mixers with an attachment for automatically timing the mixing of each batch of concrete. The timing device includes an automatic arrangement for locking the discharge chute and a device for warning the operator when the materials have been mixed the required length of time. When the timing or locking device becomes broken or fail to operate,

immediately place before the mixer operator a clock or watch having a second hand. When failing to make repairs within three days after the timing or locking device becomes unserviceable, shut down and make the proper repairs.

The required mixing time in stationary mixers shall be between 50 seconds and five minutes. The mixing time shall be as necessary to produce concrete that meets the uniformity criteria when tested according to Section 11.3.3 of ASTM C 94. The Contractor may designate the mixing time between 50 seconds and five minutes to do the uniformity tests. The mixed concrete shall meet the uniformity requirements specified before using concrete for pavements or structures. The Engineer may allow the use of test concrete for appropriate incidental construction. Furnish labor, sampling equipment, and materials required for uniformity tests of the concrete mixture. The Engineer will furnish required testing equipment including scales, cubic measure, and air meter. The Engineer will do the test. The Engineer will not make payment for the labor, equipment, materials, or testing. The Engineer will consider them incidental to the concrete. After establishing operational procedures of batching and mixing, the Engineer will not permit changes in procedure without re-establishing procedures by uniformity tests. Repeat the mixer performance tests whenever the appearance of the concrete or the coarse aggregate content of samples is not according to ASTM C 94. For paving mixers, add four seconds to the specified mixing time when timing starts as soon as the skip reaches its maximum raised position.

Mix the truck mixed concrete at the proportioning plant. The mixer shall operate at agitating speed while in transit. The Contractor may mix the truck mixed concrete at the point of delivery provided the cement, or cement and mixing water, is added at that point. Mixing of truck mixed concrete shall begin immediately after the introduction of the mixing water to the cement and aggregates, or introduction of the cement to the aggregates.

A truck mixer includes a water tight revolving drum suitably mounted and fitted with adequate blades, and equipped with electrically or mechanically actuated revolution counters. Truck mixers shall produce a thoroughly mixed and uniform mass of concrete and shall discharge concrete without segregation.

Attach a metal manufacturer's standard rating place to each truck mixer permanently. The rating plate shall state the truck mixer's maximum volume of mixed concrete for the various uses. Also attach a manufacturer's data plate stating the maximum and minimum mixing speeds and other data needed by the manufacturer to each truck mixer. When using the truck mixers for mixing, concrete in each batch shall not exceed the maximum capacity shown on the metal rating plate. When the equipment does not have a rating plate, an attested copy of the manufacturer's rating shall suffice or the batch volume shall not exceed 63% of the gross interior volume.

Operate truck mixers at the speed of rotation designated by the manufacturer. The mixing speeds for the revolving drum type shall be not less than 6 nor more than 18 revolutions per minute.

Initially mix each batch of truck mixed concrete not less than 70 nor more than 100 revolutions of the drum after all the ingredients including water are in the mixer. When the batch volume is less than 63% of the gross volume of the drum or less than 91% of the rated maximum capacity, the number of revolutions required for mixing shall be not less than 50 nor more than 100 revolutions per minute.

Water may be added to the mixture not more than two times after the completion the initial mixing. Each time water is added, turn the drum an additional 30 revolutions or more if necessary at mixing speed until the concrete is uniformly mixed.

When furnishing shrink-mixed concrete, transfer the concrete that has been partially mixed at a central plant to a truck mixer. Requirements for transit-mixed concrete shall apply. The Engineer will not allow credit in the number of revolutions at mixing speed for partial mixing in a central plant.

When the Engineer permits hand mixing, use hand mixing in batches not more than 0.33 cubic yard and mix on a watertight, level platform. Measure the proper amount of coarse aggregate in measuring boxes and spread on the platform. Spread the fine aggregate on this layer. The coarse aggregate and fine aggregate layers shall not be more than one foot in total depth. Spread dry cement on this mixture. Turn the whole mass not less than two times dry. Then add and distribute evenly sufficient clean water. Turn the whole mass again not less than three times not including placing in the carriers or forms.

601.07 Transporting Mixed Concrete. The Contractor may transport mixed concrete to the delivery point in:

(1) truck agitators, or

(2) truck mixers operating at the speed designated by the manufacturer of the equipment as agitating speed, or

(3) non-agitating hauling equipment, provided the:

(a) consistency and workability of the mixed concrete upon discharge at the delivery point is suitable for adequate placement and consolidation in place and

(b) mixed concrete after hauling to the delivery point conforms to the uniformity criteria when tested as specified in Section 11.5.1 of ASTM C 94.

A truck agitator includes a watertight revolving drum or a watertight container suitably mounted and fitted with adequate revolving blades and a removable cover. Operate truck mixers or truck agitators within the limits of

capacity and speed of rotation designated by the manufacturer for agitating. Agitators shall not exceed 80% of gross drum volume. Agitating speed for both the revolving drum mixers and revolving blade type agitators shall be between two and six revolutions per minute of the drum or of the mixing blades. Truck mixers or truck agitators shall have electrically or mechanically actuated counters. Actuate the counters after introducing the cement to aggregates.

Bodies of non-agitating hauling equipment shall be smooth and watertight metal containers equipped with gates that will permit control of discharge of the concrete. Provide accepted covers for protection against weather. When hauling concrete in non-agitating trucks, complete the discharge within 30 minutes after introducing the mixing water to the cement and aggregates.

When using a truck mixer or agitator for transporting concrete to the delivery point, complete the discharge:

(1) within 1.5 hours or

(2) before 250 revolutions of the drum or blades for central mixed concrete, or 300 revolutions of the drum or blades for truck mixed concrete, whichever comes first after introducing the mixing water to the cement and aggregates, or cement to the aggregates.

In hot weather or under conditions contributing to quick stiffening of the concrete, the Engineer will reduce the time.

The manufacturer of truck mixed concrete and of central mixed concrete shall furnish the Engineer a delivery ticket with each truck load of concrete before unloading at the jobsite. The delivery ticket shall have the following information, printed, stamped, or written:

(1) Name of concrete plants,

(2) Serial number of ticket,

(3) Date and truck number,

(4) Name of Contractor,

(5) Specific project, route, or designation of job (name and location),

(6) Specific class or designation of concrete according to the contract,

(7) Quantity of concrete in cubic yards,

(8) The time the Contractor loads the batch or first mixing of cement and aggregates occurs,

(9) Name and quantity of admixture, if any,

(10) Readings of non-resettable revolution counters of truck mixers after the introduction of the cement to aggregates, or the introduction of the mixing water to the cement and aggregates,

(11) "Central Mixed" or "Premixed" when mixing the concrete completely in a central mixer.

Furnish additional information designated by the Engineer and required by the job specification upon request.

601.08 Consistency. Regulate the water used in concrete mixes so that the consistency of the concrete as determined according to AASHTO T 119 is within the nominal slump range shown in Table 601-II. When the slump of the concrete is found to exceed the nominal slump, adjust the mixture of subsequent batches.

The ability of the equipment to properly place the concrete gages the consistency of the concrete. The difficulty in mixing, transporting, or pumping does not gage the consistency of the concrete. The Engineer will reject harsh or unworkable concrete that cannot be placed properly. Remove them at no cost to the State.

The slump for concrete shall be as specified in Table 601 -II.

TABLE 601-II - SLUMP FOR CONCRETE

Type of Work	Nominal Slump Inches	Maximum Slump Inches
Concrete Pavements	0 - 3	3-1/2
Reinforced Concrete Structures:		
Sections Over 12 Inches	0 - 4	5
Sections 12 Inches Thick or Less	2 - 5	6
Non-Reinforced Concrete Facilities	1 - 3	4
Concrete Placed Underwater	6 - 8	9
Bridge Decks	0 - 3	3-1/2

When adverse or difficult conditions exist, the Contractor may exceed the above specified slump limitation if permitted by the Engineer in writing and maintains the water-cement ratio before placement. The cost of additional cement and water, or admixture shall be at no cost to the State. The Engineer will not allow additional compensation.

601.09 Forms. Construct forms according to the applicable sections of the contract.

601.10 Placing Concrete. Place concrete according to the applicable sections of the contract.

601.11 Finishing Concrete Surfaces. Finish concrete surfaces according to the applicable sections of the contract.

601.12 Curing Concrete. Cure the concrete according to the applicable sections of the contract.

601.13 Method of Measurement. The Engineer will measure concrete in accordance with applicable sections.

601.14 Basis of Payment. The Engineer will pay for the accepted concrete under the applicable sections."

END OF SECTION 601