Construction Specification 31—Concrete for Major Structures

1. Scope

The work consists of furnishing, forming, placing, finishing, and curing Portland cement concrete as required to build the structures designated in section 25 of this specification.

The following BioPreferred® product category is applicable to this specification.

— concrete release fluids (aka form-release agents)

2. Material

Aggregates shall conform to the requirements of section 25 and Material Specification 522, Aggregates for Portland Cement Concrete, unless otherwise specified.

Portland cement shall conform to the requirements of Material Specification 531, Portland Cement, for the specified type. One brand only of any type of cement shall be used in any single structure as defined in section 25.

Fly ash shall conform to the requirements of Material Specification 532, Supplementary Cementitious Materials.

Blast-furnace slag used as a partial substitution of Portland cement in concrete shall conform to the requirements of Material Specification 532, Supplementary Cementitious Materials.

Silica fume shall conform to the requirements of Material Specification 532, Supplementary Cementitious Materials.

Air-entraining admixtures shall conform to the requirements of Material Specification 533, Chemical Admixtures for Concrete. If air-entraining cement is used, any additional air-entraining admixture shall be of the same type as that in the cement.

Plasticizing admixtures shall conform to the requirements of Material Specification 533, Chemical Admixtures for Concrete.

Water-reducing and/or retarding admixtures shall conform to the requirements of Material Specification 533, Chemical Admixtures for Concrete.

Accelerating and water-reducing and accelerating admixtures, if specified in section 25, shall conform to the requirements of Material Specification 533, Chemical Admixtures for Concrete.

Curing compound **shall conform to the requirements of Material Specification 534, Concrete Curing** Compound.

Preformed expansion joint filler shall conform to the requirements of Material Specification 535, Preformed Expansion Joint Filler.

Sealing compound for joints shall conform to the requirements of Material Specification 536, Sealing Compound for Joints in Concrete and Concrete Pipe.

Waterstops shall conform to the requirements of Material Specifications 537, Nonmetallic Waterstops, and 538, Metal Waterstops, for the specified kinds.

Dowels shall be a plain, round steel bar conforming to the requirements of Material Specification 539, Steel Reinforcement (for concrete).

Metal plates shall conform to the requirements of Material Specification 581, Metal, for structural quality or commercial or merchant quality steel. Structural quality shall be used only if specifically designated in the drawings or specifications.

Water used in mixing and curing concrete shall be clean and free from injurious amounts of oil, salt, acid, alkali, organic matter, or other deleterious substances.

3. Concrete mix design

Method 1

Responsibilities—The contractor is responsible for the design and proportioning of the concrete. Job mixes shall be prepared to meet the quality, consistency, and strength of concrete specified.

Submittals—At least 15 calendar days before the placement of any concrete, the contractor shall provide the engineer with full documentation to support each job mix and any admixtures to be used in the work. The contractor shall furnish test results to the engineer for each admixture showing that it meets the requirements of Material Specification 533, Chemical Admixtures for Concrete. Job mixes are reviewed and accepted or rejected by the engineer within 8 calendar days following the date of submittal. After a job mix has been accepted, neither the source, character, or gradation of the aggregates nor the type or brand of cement or admixtures shall be changed without prior notice to the engineer. Revisions or changes in a job mix that are determined to be significant by the engineer shall follow the same submittal and acceptance process as that for the initial job mix.

Design criteria—The class of concrete shall be as specified in Section 25 and in accordance with the following specified compressive strength.

Class of concrete	**Specified compressive strength (f'_c) at 28 days (lb/in^2)**
5000	5,000
4000	4,000
3000	3,000
2500	2,500

Maximum water-cement ratio shall be 0.50, unless otherwise specified.

Unless otherwise specified the air content (by volume) of the concrete at the time of placement shall be:

Maximum size aggregate	Air content (%)
3/8 inch to l inch	5 to 7
Over l inch	4 to 6

The consistency of all concrete shall allow it to be placed without segregation or excessive laitance. Unless otherwise specified, the slump shall be:

Type of structural section	Slump (inches)
Massive sections, pavements, footings	2 ± 1
Heavy beams, thick slabs, thick walls (>12 inches)	3 ± 1
Columns, light beams, thin slabs, thin walls (12 inches or less)	4 ± l

Superplasticized concrete shall be a concrete mix containing either a water-reducing, high range admixture (ASTM C494, Type F or G) or a plasticizing admixture (ASTM C1017) at a dosage rate that: (1) reduces the quantity of water required to produce a concrete mix within the above slump range by 12 percent or more, or (2) produces an increase in the slump of at least 2 inches above the slump of the design mix containing no water reducer or plasticizing admixture.

A water-reducing admixture (ASTM C494, Type F or G) and/or a plasticizing admixture (ASTM C1017) may be added to an approved job mix without resubmittal and reapproval of the job mix if the following requirements are met:

a. The admixture shall be introduced into the concrete mix as specified by the manufacturer and be compatible with other admixtures in the job mix.

b. The water content shall be equal to or less than that required in the job mix without the admixture.

c. The cement content shall be the same as that required in the job mix without the admixture.

d. The air content shall be within the specified range.

e. The slump shall not exceed 7.5 inches unless the contractor can demonstrate before placement that the job mix can be placed without segregation or excessive laitance at a slump greater than 7.5 inches. The concrete shall retain the increased slump for not less than 30 minutes.

f. If the admixture is added at the job site, the slump of the concrete before the addition of the admixture shall not exceed the slump specified above for concrete that does not contain the admixture.

Calcium chloride or other corrosive accelerators shall not be used unless otherwise specified.

Fly ash may be used as a partial substitution for Portland cement in an amount not greater than 25 percent (by weight) of cement in the concrete mix unless otherwise specified.

Ground granulated blast-furnace slag may be used as a partial substitution for Portland cement in amounts between 25 to 70 percent (by weight) of cement in the concrete mix unless otherwise specified.

Silica fume may be used as a partial substitution for Portland cement in an amount ranging from 5 to 10 percent (by weight) of cement in the concrete mix unless otherwise specified.

Job mix criteria—Proportioning of concrete for job mixes shall be based on the standard deviation computed from compressive strength tests of previous batch records or established by laboratory trial mixes. Unless otherwise specified a compressive strength test is the average of the compressive strengths of two standard cured cylinders prepared and tested in accordance with section 4.

For a job mix based upon the standard deviation computed from compressive strength tests of previous batch records, the previous batches shall represent similar material and conditions to those expected for the job mix and have a strength within 1,000 pounds per square inch of the specified compressive strength (f'_c) at 28 days for the class of concrete specified. The contractor shall provide to the engineer copies of the facility's previous batching records that show the compressive strength results and the batch mix design used.

For a job mix based upon a laboratory trial mix, the trial mix shall contain the actual material to be used in the final job mix, have a slump within 0.75 inches of the maximum allowable slump, and have an air content within 0.5 percent of the maximum allowable air content. The contractor shall provide the engineer with copies of the actual compressive strength test records for the trial mix from the testing facility performing the test.

The trial job mix or previous batch records shall include the water reducing admixture when a water reducing admixture is used in a concrete mix specifically to improve the physical properties of the hardened concrete or change portions of the mix components.

In meeting strength requirements, the selected job mix proportions must produce an average strength, f_{cr}, exceeding the specified compressive strength, f'_c, by the amount specified.

n	s_{30}	f_{cr}
>30	1.00 s	The larger of these
25	1.03 s	two equations:
20	1.08 s	f'_c + 1.34 s30
15	1.16 s	f'_c + 2.33 s30–500
<15		f'_c + 1,000 for $f'_c < 3{,}000$
		f'_c + 1,200 for $3{,}000 \leq f'_c \leq 5{,}000$
		f'_c + 1,400 for $f'_c > 5{,}000$

where:

n = number of consecutive compressive strength tests
s_{30} = standard deviation adjusted to 30 tests, lb/in^2
f_{cr} = required average compressive strength, lb/in^2
f'_c = specified compressive strength of concrete, lb/in^2
s = standard deviation (lb/in^2) computed as $\{[sum(Xi-Xa)^2]/[n-1]\}^{1/2}$
where:
Xi = individual strength test result, lb/in^2
Xa = average of n strength test results, lb/in^2

Method 2

Responsibilities—The engineer is responsible for the design and proportioning of the job mix. The initial job mix will be as specified in section 25. The engineer may adjust the initial job mix proportions to establish the designated job mix. The engineer will provide the contractor with a copy of each job mix as soon as the material and proportions have been determined. After the job mix has been designated, neither the source, character, or gradation of the aggregates nor the type or brand of cement or admixtures shall be changed without prior approval of the engineer. During the course of the work, the engineer may adjust the job mix proportions and batch weights whenever necessary to meet special job conditions.

The contractor, for each class of concrete, shall be responsible for:

a. Taking the following actions and furnishing the engineer with the following information at least 35 calendar days before any placement of concrete, unless otherwise designated:
   (1) Select the source of aggregates and sample and test the gradations of aggregates available.
   (2) Select the brand and type of cement.
   (3) Select the brand of admixtures and obtain manufacturer's test data and recommendation of use.
   (4) Identify the concrete production facility, the type of mixer, and the mixing methods that will be used.
   (5) Provide from the concrete production facility consecutive compressive strength test records and batching records for concrete mixes that have material, proportions, and compressive strengths within 1 000 pounds per square inch of the proposed design mix.

b. Batching at least 3 cubic yards of the initial job mix, in the presence of the engineer, for testing and evaluation not less than 30 calendar days before any placement of concrete.

4. Inspecting and testing

During the course of the work, the engineer performs quality assurance testing as required to assure the concrete meets the contract requirements. The engineer shall have free entry to the plant and equipment furnishing concrete under the contract. Proper facilities shall be provided for the engineer to inspect material, equipment, and processes, and to obtain samples of the concrete. All tests and inspections are conducted so as not to interfere unnecessarily with the manufacture, delivery, and placement of the concrete.

Any portion of a batch may be tested by the engineer for any of the purposes shown below. Samples taken for testing shall be representative of that part of the batch.

a. Determining uniformity of the batch.

b. Checking compliance with requirements for slump and air content when the batch is discharged over an extended period.

c. Checking compliance of the concrete with the specifications when the whole amount being placed in a small structure, or a distinct part of a larger structure, is less than full batch.

If concrete is conveyed to the placement location by pumping or conveyor belts, the samples shall be collected at the discharge end.

When a plasticizing admixture is added to the concrete mix at the job site, slump tests are made both before the addition of the admixture to the concrete mix and after the admixture has been incorporated into the concrete mix.

The tests on concrete are performed by the following methods unless otherwise specified:

Type of test	**Test method (ASTM designation)**
Sampling	C172
Slump test	C143
Air content	C231 or C173
Compression test specimens	C31 or C42
Compressive strength testing	C39
Unit weight	C138
Temperature	C1064

A strength test for concrete is the average of two standard cured concrete cylinders prepared in accordance with ASTM C31 from the same sample of concrete and tested in accordance with ASTM C39 at 28 days, unless otherwise specified. If one cylinder shows manifest evidence of improper sampling, molding, curing, or testing, it shall be discarded and the strength of the remaining cylinder shall then be considered the compressive strength of the concrete. Should both cylinders show such defects, the entire test shall be discarded.

If both cylinders are discarded or inplace concrete that was not sampled is in question, the inplace concrete may be sampled by coring in accordance with ASTM C42. For core tests, these requirements shall be followed:

a. At least three representative cores shall be taken from each area of concrete in question. If one or more of the cores shows signs of being damaged before testing, it shall be replaced by a new one.

b. Test cores shall be prepared for testing in accordance with moisture conditioning in ASTM C42 unless the engineer determines that the concrete in the structure will be dry under service conditions. If the concrete is determined to be dry under service conditions, the cores shall be air dried (temperature 60 °F to 80 °F and relative humidity less than 60%) for 7 days before testing and shall be tested dry.

5. Handling and measurement of material

Aggregates shall be stored or stockpiled in such a manner that separation of coarse and fine particles of each size is avoided and that various sizes do not become intermixed before proportioning. Methods of handling and transporting aggregates shall avoid contamination, excessive breakage, segregation, degradation, or intermingling of various sizes.

Unless otherwise specified, scales shall be beam type or springless dial type. They shall be accurate when static load tested to plus 0.4 percent of the total capacity of the scales. All exposed fulcrums, clevises, and similar working parts of scales shall be kept clean.

Measuring tanks for mixing water shall be of adequate capacity to furnish the maximum amount of mixing water required per batch. Tanks shall be equipped with outside taps and valves to verify their calibration unless other means are provided for readily and accurately determining the amount of water in the tank.

The quantities of each component of the concrete mix shall be measured by the following methods and to the accuracy indicated below:

Cement, fly ash, slag—Cement, except as otherwise specifically permitted, shall be measured by weight or in bags on which the weight is plainly marked. When cement, fly ash, and slag are supplied in bulk and are measured by weight, they shall be weighed on a scale separate from that used for other material and in a hopper entirely free and independent of the hopper used for weighing the aggregate. When fly ash or slag is used in the job mix, the cement and the fly ash or slag may be weighed separately or cumulatively by weighing the cement first and then adding the fly ash or slag to arrive at the composite weight. The weight of the cement and the combined weight of the cement and fly ash or slag shall be within plus or minus 1 percent of the required weight of the cementitious material. When cement is measured in bags, no fraction of a bag shall be used unless weighed.

Aggregates—Aggregates shall be measured by weight unless otherwise specifically permitted. Mix proportions shall be based on saturated, surface-dry weights. The batch weight of each aggregate shall be the required saturated, surface-dry weight corrected by the weight of surface moisture it contains. The weight of each of the specified aggregates shall be within plus or minus 2 percent of the required weight.

Mixing water—Mixing water shall consist of water added to the batch, ice added to the batch, water occurring as surface moisture on the aggregates, and water introduced in the form of admixtures. The added water shall be measured by weight or volume to an accuracy of l percent of the required total mixing water. Added ice shall be measured by weight. Wash water shall not be used as part of the mixing water for succeeding batches.

Admixtures—Dry admixtures shall be measured by weight. Paste or liquid admixtures shall be measured by weight or volume. The admixtures shall be within plus or minus 3 percent of the required weight or volume for each specific admixture.

6. Mixers and mixing

Mixers are either stationary parts of a central mixing plant or portable equipment, such as revolving drum truck mixers and volumetric batching/continuous mixing truck mixers. Mixers shall be capable of thoroughly mixing the concrete ingredients into a uniform mass within the specified mixing time and of discharging the mix without segregation. Each mixer or agitator shall bear a manufacturer's rating plate indicating the gross volume of the drum, the capacity of the drum or container in terms of the volume of mixed concrete, and the minimum and maximum mixing speeds of rotation of the drum, blades, or paddles. When the truck mixer is used for truck mixed concrete as described in section 6a(2) or for shrink mixed concrete as described in section 6a(3), the capacity of the drum or container in terms of the volume of mixed concrete shall not exceed 63 percent of the gross volume of the drum. When the truck mixer is used to transport central-mixed concrete as described in section 6a(1), the capacity of the drum or container in terms of the volume of mixed concrete shall not exceed 80 percent of the gross volume of the drum. The mixer shall be operated in accordance with these recommendations.

Concrete shall be uniform and thoroughly mixed when delivered to the forms in a freshly mixed and unhardened state. Variations in slump of more than 1 inch within a batch is considered evidence of inadequate mixing and shall be corrected by changing batching procedures, increasing mixing time, changing mixers, or other means. Mixing time shall be within the limits specified below unless the contractor demonstrates by mixer performance tests that adequate uniformity is obtained by different times of mixing.

No mixing water in excess of the amount called for by the job mix shall be added to the concrete during mixing or hauling or after arrival at the delivery point. Water to compensate for up to a 1-inch loss in slump may be added, not to exceed the design maximum water cement ratio. Withholding some of the mixing water until the concrete arrives on the job, then adding the remaining water and turning the mixer 30 revolutions at mixing speed is allowed to overcome transporting conditions. When loss of slump or workability cannot be offset by these measures, complete mixing shall be performed by onsite batching and mixing or by using a combination of centrally batching and transporting material to the site and adding remainder of material onsite.

Concrete may be furnished by ready-mix methods, by volumetric batching and continuous mixing at the site, or by batch mixing at the site.

a. Ready-mixed concrete

Ready-mixed concrete shall be mixed, transported, and placed in a freshly mixed and unhardened state. The contractor shall furnish the engineer a batch ticket showing amount of concrete in cubic yards, the time of loading, the time the load was discharged, the revolution counter reading at the time of loading and discharge, and the type and actual quantity of each material including all admixtures used in each batch of concrete.

Truck mixers and truck agitators shall be equipped with revolution counters by which the number of revolutions of the drum or blades may be readily verified. Ready-mixed concrete shall be mixed and delivered by one of the following methods:

(1) Central-mixed concrete—Central-mixed concrete is mixed completely in a stationary mixer and transported to the point of delivery either in a truck agitator, a truck mixer operating at agitating speed, or nonagitating equipment.

When a truck agitator or a truck mixer is used as an agitator and transports concrete that has been completely mixed in a stationary mixer, mixing during transportation shall be at the speed designated by the manufacturer of the equipment as agitating speed. When concrete is transported in a truck mixer or truck agitator, the volume of the mixed concrete shall not exceed 80 percent of the gross volume of the drum. The total number of revolutions of the truck mixer or truck agitator shall not exceed 200 before discharge of the concrete, unless otherwise specified.

The use of nonagitating equipment to transport concrete to the site of the work is permitted only if the consistency and uniformity of the concrete as discharged at the point of delivery meet the requirements of this specification. Bodies of nonagitating hauling equipment shall be constructed so that leakage of the concrete mix, or any part thereof, does not occur. Concrete hauled in opentop vehicles shall be protected from rain and from more than 20 minutes exposure to the sun and wind when the air temperature is above 75 degrees Fahrenheit.

(2) Truck-mixed concrete—Truck-mixed concrete is completely mixed in a truck mixer. The total volume of all ingredients to be mixed in a revolving drum truck mixer shall not exceed 63 percent of the gross volume of the drum. The concrete ingredients shall be mixed between 70 and 100 revolutions of the drum or blades at the speed designated by the manufacturer as mixing speed. Mixing in excess of 100 revolutions shall be at the speed designated by the manufacturer of the equipment as agitating speed.

(3) Shrink-mixed concrete—Shrink-mixed concrete is partly mixed at a central plant and the mixing is completed in a truck mixer. The mixing time in the central plant mixer is the minimum required to intermingle the ingredients. The volume of the mixed concrete in a truck mixer shall not exceed 63 percent of the gross volume of the truck drum. The mixing shall be completed in a truck mixer. The number of revolutions of the truck mixer drum or blades shall be between 50 and 100 revolutions at the speed designated by the manufacturer as mixing speed. Mixing in excess of 100 revolutions shall be at the speed designated by the manufacturer of the equipment as agitating speed. The total number of revolutions shall not exceed 300 before discharge of the concrete unless otherwise specified.

b. Volumetric batching and continuous mixing at the site

Volumetric batching and continuous mixing at the site is commonly referred to as mobile concrete mixers. Unless otherwise specified volumetric batching and continuous mixing at the construction site is permitted. The batching and mixing equipment shall conform to the requirements of ASTM C685 and shall be demonstrated before placement of concrete by tests with the job mix to produce concrete meeting the specified proportioning and uniformity requirements. Concrete made by this method shall be produced, inspected, and documented in conformance with sections 6, 7, 8, 13, and 14 of ASTM C685.

c. Batch mixing at the site

This method of batching and mixing concrete is either by batching and mixing all material onsite using paving mixers or stationary construction mixers or by using a combination of centrally batching part of the mix, transporting it to the site, and adding the rest of the material and mixing onsite.

Paving mixers or stationary construction mixers and associated transport vehicles shall be in accordance with recommended practices described in method 1 for central mixed concrete. The time for mixing a batch of concrete in the mixer drum shall be according to manufacturer's recommendations, but not less than 1 minute plus 0.25 minute for each cubic yard of concrete being mixed (8 yd^3 batch = 3 minutes).

When a combination of centrally batching and transporting material to the site and adding rest of material onsite is used, the contractor shall prepare a written plan detailing how the batching and mixing of the concrete material will be accomplished and controlled. This written batching and mixing plan shall be submitted to the engineer for review and approval not less than 10 working days before the placement of concrete. The volume of the mixed concrete in a truck mixer shall not exceed 63 percent of the gross volume of the drum.

The contractor shall furnish the engineer a batching ticket for each batch of fresh concrete. The ticket shows the type, brand, and amount of cement; the type, name, and amount of each admixture; total water added to the batch, which includes free water on the aggregate; maximum size of aggregate; the type and dry weight of fine aggregate; the type and dry weight of coarse aggregate; the time of loading (the time that water was introduced to the cement); and the time the load was discharged.

7. Forms

Forms shall be of good quality wood, plywood, steel, or other approved material and shall be mortar tight. The forms and associated falsework shall be substantial and unyielding and shall be constructed so that the finished concrete conforms to the specified dimensions and contours. Form surfaces shall be smooth and free from holes, dents, sags, or other irregularities and shall be maintained in this condition throughout the work. Forms shall be coated with a nonstaining form release agent before being set into place. Acceptable tolerances for formed structure members are specified in section 23.

When a superplasticized concrete mix is used, forms shall be designed to withstand the increased pressures of the superplasticized concrete and the increased impact forces resulting from larger drop heights used in placing the superplasticized concrete. Form release agents shall be specifically formulated, when specified, for use with plasticized concrete or documentation from the release agent manufacturer shall be provided stating that formed concrete surfaces made using the form release agent with plasticized concrete have not varied significantly from nonplasticized concrete surfaces made using the same form release agent. If the form release agent is not specifically formulated for use with plasticized concrete and, after observing its performance, it is suspected the release agent is responsible for causing increased surface imperfections (bug-holes), a release agent specifically formulated for use with plasticized concrete shall be used for all formed concrete to be subsequently placed.

Metal ties or anchorages that will be embedded in the concrete shall be equipped with cones, she-bolts, or other devices that permit their removal to a depth of at least 1 inch without injury to the concrete. Ties designed to break off below the surface of the concrete shall not be used without cones. If approved fiberglass or plastic form ties are used, the tie ends shall be cut flush with the finished concrete and ground smooth.

All edges that will be exposed shall be chamfered unless finished with molding tools as specified in section 18.

8. Preparation of forms and subgrade

Before placement of concrete, the forms, embedments, and subgrade shall be free of chips, sawdust, debris, water, ice, snow, extraneous oil, mortar, or other harmful substances or coatings. Any form release agent on the reinforcing steel or other surfaces required to be bonded to the concrete shall be removed.

Rock surfaces shall be cleaned by high pressure air-water cutting, sandblasting, or wire brush scrubbing, as necessary, and shall be wetted immediately before placement of concrete. The earth surface shall be firm and damp. Placement of concrete on mud, dried earth, noncompacted fill, or frozen subgrade is not permitted. All ice, snow, and frost shall be removed, and the temperature of all surfaces, including the reinforcing steel and other steel inclusions, to be in contact with the new concrete shall be no colder than 40 degrees Fahrenheit.

Items to be embedded in the concrete shall be positioned accurately and anchored firmly.

Weepholes in walls or slabs shall be formed with nonferrous material.

9. Conveying

Concrete shall be delivered to the site and discharged completely into the forms within 1.5 hours or before the drum of truck has revolved a total of 300 revolutions, whichever comes first, after the introduction of the mixing water to the cement and aggregates or the introduction of the cement to the aggregates. In hot weather or under conditions contributing to quick stiffening of the concrete, or when the temperature of the concrete is 85 degrees Fahrenheit or above, the time between the introduction of the cement to the aggregates and discharge shall not exceed 45 minutes.

Superplasticized concrete can be conveyed and placed when the temperature of the concrete is below 95 degrees Fahrenheit and the slump of the concrete remains within the allowable slump range.

The engineer can allow an appropriate extension of time when the setting time of the concrete is increased a corresponding amount by the addition of an approved admixture. In any case concrete shall be conveyed from the mixer to the forms as rapidly as practicable by methods that prevent segregation of the aggregates or loss of mortar.

10. Placing

Concrete shall not be placed until the subgrade, forms, steel reinforcement, and other embedments are inspected and approved by the engineer. For walls and columns, subsequent higher placements of concrete shall not be placed until the concrete below the new placement has gained sufficient strength to support the concrete dead load and any superimposed loads without distress. Placement sequences and timing shall consider form removal timing covered in section 16.

If a placement plan is required in section 25, concrete shall not be placed until the placement plan has been reviewed and approved by the engineer. The contractor shall have all equipment and material required for curing available at the site ready for use before placement of concrete begins.

Concrete shall be placed only in the presence of the engineer. The contractor shall give reasonable notice to the engineer before each placement. Such notice shall be far enough in advance to give the engineer adequate time to assure that the subgrade, forms, steel reinforcement, and other preparations comply with specifications. Other preparations include, but are not limited to, the concrete batching plant, mixing and delivery equipment and system, placing and finishing equipment and system, schedule of work, workforce, and heating or cooling facilities, as applicable. All deficiencies are to be corrected before concrete is delivered for placing.

Concrete shall be placed and consolidated to prevent segregation of the mix components. The concrete shall be deposited as closely as possible to its final position in the forms. It shall be worked into the corners and angles of the forms and around all reinforcement and embedded items to prevent segregation of aggregates or excessive laitance. The depositing of concrete shall be regulated so that the concrete can be consolidated with a minimum of lateral movement. Concrete placed against a sloping surface shall start at the lowest elevation and work upwards to the highest elevation.

Concrete other than architectural concrete shall not be dropped more than 5 feet vertically unless suitable equipment is used to prevent segregation. Architectural concrete shall not be dropped more than 3 feet vertically unless suitable equipment is used to prevent segregation. When a superplasticized concrete mix is used, concrete other than architectural concrete shall not be dropped more than 12 feet vertically and architectural concrete shall not be dropped more than 10 feet vertically unless suitable equipment is used to prevent segregation.

11. Layers

Slab concrete shall be placed to design thickness in one continuous layer unless otherwise specified. Formed concrete shall be placed in horizontal layers not more than 20 inches deep. Where a superplasticized concrete mix is used, formed concrete may be placed in horizontal layers not more than 5 feet deep.

Successive layers of fresh concrete between construction joints shall be placed at a rate fast enough that the preceding layer is still plastic and can be easily mixed with the fresh concrete such that seams (cold joints) or plane of weakness do not occur. If the surface of a previously placed layer of concrete has taken a set to the degree that it will not flow and mix with the succeeding layer when vibrated, the contractor shall discontinue placing concrete

and shall make a construction joint according to the procedure specified in section 13. If placing is discontinued when a layer is incomplete, the ends of the incomplete layer shall be formed by a vertical bulkhead.

12. Consolidating

All concrete shall be consolidated with internal type mechanical vibrators capable of transmitting vibration to the concrete at frequencies not less than 8,000 impulses per minute, unless otherwise specified or approved before placement. Vibration shall be supplemented by spading, rodding, and hand tamping as necessary to ensure smooth and dense concrete along the form surface, in corners, and around embedded items. The contractor shall provide a sufficient number of vibrators to properly consolidate the concrete immediately after it is placed. A sufficient number of standby vibrators shall be kept onsite during the placement of concrete.

Vibration shall compact the concrete and bring it into intimate contact with the forms, reinforcing steel, and other embedded items while removing voids and pockets of entrapped air. The location, insertion, duration, and removal of the vibrators shall be such that maximum consolidation of the concrete is achieved without causing segregation of the mortar and coarse aggregate or causing water or cement paste to flush to the surface. Vibration shall be applied to the freshly deposited concrete by rapidly inserting the vibrator and slowly, in an up and down motion, removing the vibrator at points uniformly spaced at not more than 1.5 times the radius of the area visibly effected by vibration. Generally, this is at 5 to 10 seconds per foot on 14-inch spacings or less. The area visibly effected by the vibrator shall overlap the adjacent, just vibrated area. The vibrator shall extend vertically into the previously placed layer of fresh concrete by at least 6 inches at all points. This ensures effective bond between layers. In thin slabs the vibrator(s) should be sloped toward the horizontal to allow operations in a fully embedded position.

Vibration shall not be applied directly to the reinforcement steel, the forms, or other embedded items unless otherwise specified. Vibration shall not be applied to concrete that has hardened to the degree that it does not become plastic when vibrated. If surface vibrators are used, they may contact forms when consolidating thin slabs.

The use of vibrators to transport concrete in the forms or conveying equipment is not permitted.

Surface vibrators may be used to consolidate slabs 8 inches and less in thickness. Slabs more than 8 inches thick shall be consolidated with internal vibration and may be augmented through use of surface vibrator, such as vibrating screeds, plate or grid vibratory tampers, or vibratory roller screeds. If concrete is to be consolidated using surface vibration methods, the contractor shall detail how this work is to be performed in writing to the engineer for review and approval. This report must be submitted no less than 30 calendar days before placing concrete by this method. It includes equipment selection and specifications.

13. Construction joints

Construction joints shall be made at the locations shown on the drawings unless otherwise specified or approved by the engineer. If construction joints are needed that are not shown on the drawings, they shall be placed in locations approved by the engineer.

Where a feather edge would be produced at a construction joint, as in the top surface of a sloping wall, an insert form shall be used so that the resulting edge thickness on either side of the joint is not less than twice the maximum aggregate diameter used in the concrete mix.

Nonvertical construction joints in structural elements, such as walls and columns, shall be consolidated and screeded to grade unless otherwise specified. Construction joints shall be covered and wet cured for 7 days or until concrete placement resumes unless otherwise specified.

Steel tying and form construction next to concrete in place shall not be started until the concrete has cured at least 12 hours. Before new concrete is deposited on or against concrete that has hardened, the forms shall be retightened. New concrete shall not be placed until the hardened concrete has cured at least 12 hours.

Method l—The surface of construction joints shall be cleaned of all unsatisfactory concrete, laitance, coatings, stains, or debris by sandblasting or high-pressure air-water cutting, or both. Sandblasting can be used after the concrete has gained sufficient strength to resist excessive cutting, and high-pressure air-water cutting can be used as soon as the concrete has hardened sufficiently to prevent the jet from displacing the coarse aggregates. The surface

of the concrete in place shall be cut to expose clean, sound aggregate, but not so deep as to undercut the edges of larger particles of the aggregate. After cutting, the surface shall be thoroughly washed to remove all loose material. If the surface is congested by reinforcing steel, is relatively inaccessible, has cured beyond the ability to cut with air-water blasting, or disturbing the concrete before it is hardened is considered undesirable, cleaning of the joint by air or water jets is not permitted. The sandblasting method is required after the concrete has hardened.

Immediately before new concrete is placed, all construction joints shall be wetted and standing water removed.

Method 2—The surface of construction joints shall be cleaned of all unsatisfactory concrete, laitance, coatings, stains, or debris by washing and scrubbing with a wire brush or wire broom, or by other means approved by the engineer. Immediately before new concrete is placed, all construction joints shall be wetted and standing water removed.

14. Expansion and contraction joints

Expansion and contraction joints shall be made only at locations shown on the drawings. Exposed concrete edges at expansion and contraction joints shall be carefully tooled or chamfered, and the joints shall be free of mortar and concrete. Joint filler shall be fully exposed for its entire length with clean and true edges.

Where open joints or weakened plane "dummy" joints are specified, joints formed in fresh concrete shall be constructed by the insertion and subsequent removal of a wood strip, metal plate, or other suitable template. This will be done so that the corners of the concrete do not chip or break. The edges of the fresh concrete at the joints shall be finished with an edging tool before the joint strips are removed. Open joints or weakened plane dummy joints may also be sawcut joints conforming to the depth and extent specified.

Preformed expansion joint filler shall be held firmly in the correct position as the concrete is placed.

15. Waterstops

Waterstops shall be held firmly in the correct position as the concrete is placed. Joints in metal waterstops shall be brazed or welded. Joints in rubber or plastic waterstops shall be cemented, welded, or vulcanized as recommended by the manufacturer. Joints shall be watertight and of a strength equivalent to that specified in Material Specification 537. Intersecting waterstop joints shall be prefabricated and supplied by the same manufacturer providing the waterstop.

16. Removal of forms, supports, and protective coverings

Forms, supports, and protective coverings shall be removed as soon as practical after the concrete has gained sufficient strength to support its own weight and superimposed loads. Removal shall be done so that the concrete surface is not damaged and sudden or excessive stresses are not induced. The minimum period from completion of the concrete placement to the removal of the forms shall be based on either strength tests or cumulative times.

Strength tests—The strength of the inplace concrete is determined by testing concrete cylinders specifically cast for this purpose and cured adjacent to the member in accordance with the ASTM C31 method for determining removal time. Unless otherwise specified, forms supporting the weight of the concrete member may be removed after the concrete strength is 70 percent of that specified for the class of concrete. Forms not supporting the weight of the concrete member or other superimposed loads may be removed after the concrete strength has reached the strength specified in section 25.

Cumulative time—The total accumulated time, not necessarily continuous, that the air adjacent to the concrete is above 50 degrees Fahrenheit and the specified concrete curing has occurred concurrently will be determined. Forms may be removed after the total accumulated time shown:

Accumulated form removal times

Forms		Time [1/]
Sides of slabs or beams		12 hours
Undersides of slabs or beams	Clear span	[2/]
	< 10 ft	4 days
	10 - 20 ft	7 days
	> 20 ft	14 days
Sides of walls or columns	Height above form	[3/ 4/]
	< 10 ft	12 hours
	< 20 ft	24 hours
	> 20 ft	72 hours

1/ Table values apply to normal concrete. Values for concrete that contains cements or admixtures that significantly retard or accelerate strength gain will be determined by the engineer and based on actual design mix data.
2/ Values apply to members designed to support significant superimposed loads. Values for members designed for only self weight when placed in service shall be 50 percent greater.
3/ Values apply to members not subject to significant horizontal loads. Additional time or rebracing is needed for members subject to significant wind or other horizontal loads.
4/ Subsequent higher lifts may be placed after 12 hours.

17. Finishing formed surfaces

All formed concrete surfaces shall be true and even, and shall be free from overtolerance depressions, holes, projections, bulges, or other defects in the specified surface finish or alignment, unless otherwise specified in section 25. Depressions are measured as the distance from the bottom of a 5-foot-long template or straight edge.

A surface to be backfilled or otherwise concealed when construction is completed shall have the following surface treatment unless otherwise specified:

- Repair defective concrete.
- Fill all form tie holes.
- Correct surface depressions deeper than 1 inch.
- Remove or smooth fins and abrupt projections that exceed 0.75 inch.

A surface to be permanently exposed, where other finishes are not specified, shall have the following treatment:

- Repair defective concrete.
- Fill all form tie holes.
- Remove or smooth all abrupt irregularities greater than 0.25 inch in depth or projection.
- Treat all depressions and irregularities so that they do not exceed 0.5 inch in depth.

Form bolt and tie holes and other holes of similar size and depth shall be repaired and filled as specified in section 20.

18. Finishing unformed surfaces

All exposed surfaces of the concrete shall be accurately screeded to grade and then float finished unless otherwise specified. The float finish shall result in a surface that has no irregularities of more than 0.25 inch when checked with a template or straight edge that is 10 feet long.

All exposed surfaces of concrete shall be accurately struck off to grade after placement and consolidation are completed. Following strikeoff, the surface shall be immediately smoothed by darbying or bull floating before any free water has bled to the surface. The concrete shall then be allowed to rest until the bleed water and water sheen have left the surface and the concrete has stiffened to where it will sustain foot pressure with only about 0.25-inch indentation. At this time all joints and edges that are exposed to view and are not chamfered shall be finished with edging tools. After edging and hand jointing is complete, all exposed surfaces shall be floated with wood or magnesium floats. The floating should work the concrete no more than necessary to remove screed, edger, and jointer marks and to produce a compact surface uniform in texture.

Water shall not be sprinkled or added to the surface of the concrete during the darbying, bull floating, floating, or other finishing operations to facilitate finishing.

19. Curing

Freshly placed concrete shall be cured a minimum of 7 days in accordance with the recommended practices set forth in this section. A curing process shall be started as soon as the concrete has hardened sufficiently to prevent surface damage. Curing concrete, including exposed surfaces of formed concrete and concrete in forms, shall be maintained at a satisfactory moisture content for at least 7 days following placement. If forms are removed before the end of the 7-day curing period, the interrupted curing process shall be reestablished and maintained until a full 7-day curing period is achieved. A satisfactory moisture condition is:

- Continuous or frequent application of water or use of a saturated cover material, such as canvas, cloth, burlap, earth, or sand.
- Prevention of excessive water loss from the concrete by use of an impermeable coating (curing compound) or covering (plastic, paper).

The application of water or covering shall not erode, mar, or otherwise damage the concrete. Plastic film or paper shall meet the requirements of ASTM C171. Black covering shall not be used when concreting in hot weather.

Except as otherwise specified in section 25, curing compound may be used for exposed surfaces or formed surfaces after patching and repair are completed. Curing compounds shall not be used on a surface that is to receive additional concrete, paint, tile, or other coatings unless the contractor demonstrates that the membrane can be satisfactorily removed or can serve as a base for the later application.

Curing compound shall be thoroughly mixed before applying and be agitated during application. Except as otherwise specified in section 25, the compound shall be applied at a pressure of 75 to 100 pounds per square inch. A continuously agitating pressure sprayer is used for application at a uniform rate of not less than 1 gallon per 175 square feet of surface. Manual hand pump sprayers shall not be used unless otherwise specified. For individual concrete placements or repairs having a surface area of 400 square feet or less, curing compound may be applied with a soft-bristled brush, paint roller, or hand sprayer. The compound shall form a uniform, continuous, adherent film that shall not check, crack, or peel and shall be free from pinholes or other imperfections.

All surfaces covered with curing compound shall be continuously protected from damage to the protective film during the required curing period.

A surface subjected to heavy rainfall or running water within 3 hours after the compound has been applied or that is damaged by subsequent construction operations during the curing period shall be resprayed in the same manner as for the original application.

Water for curing shall be clean and free from any substances that cause discoloration of the concrete.

20. Concrete patching, repair or replacement

Patching—All form bolts, metal ties, and similar forming restraints shall be removed to a depth of 1 inch below the surface of the concrete and their cavities repaired unless otherwise specifically permitted or specified. Small cavities, large air holes, minor honeycombed areas, and other superficial imperfections that require patching to meet the specified finish requirements shall be thoroughly cleaned and filled. Holes left by bolts or straps that pass through the concrete section shall be filled solid with a dense, well-bonded, nonshrink patching material. Dry-pack mortar and replacement concrete shall follow the appropriate procedure detailed in the Repair and Maintenance chapter of the Concrete Manual, Bureau of Reclamation, U.S. Department of the Interior. Proprietary patching material shall be appropriate for the type of repair, used within the manufacturer's recommended limits, and applied according to the manufacturer's recommendations.

Repair or replacement—The contractor shall repair or replace concrete that does not meet the requirements of this specification. Before starting any repair or replacement work, the contractor shall prepare a written plan for the repair or replacement. The primary reference for material and repair methods for the plan shall be the appropriate sections of the Repair and Maintenance chapter of the Concrete Manual, Bureau of Reclamation, U.S. Department of the Interior. The repair plan shall be submitted to the engineer for review at least 10 days before any repair or replacement work. Approval of the plan will be authorized in writing by the contracting officer.

When proprietary patching material is proposed in the plan, the manufacturer's data sheets and written recommendations shall be included in the plan.

Repair material or replacement concrete shall have properties, color, and texture similar to and compatible with the concrete being repaired or replaced. Repair or replacement concrete work shall be performed only when the engineer is present.

Curing of repaired or replaced concrete shall be started immediately after finish work is completed and as specified in section 19 or as specified by the manufacturer of proprietary compounds.

21. Concreting in cold weather

Methods for concreting in cold weather shall be performed when, for more than 3 consecutive days, the following conditions exist:

- The average daily air temperature at the job site is less than 40 degrees Fahrenheit. (The average daily air temperature is the average of the highest and lowest temperatures occurring during the period from midnight to midnight.)
- The air temperature at the job site is less than, or equal to, 50 degrees Fahrenheit for more than half of any 24-hour period.

Concrete shall be protected against freezing during the first 24 hours after placement whether or not the average weather conditions specified above for cold weather concreting exist. The following provisions also shall apply unless otherwise specified:

a. When the cement is added to the mix, the temperature of the mixing water shall not exceed 140 degrees Fahrenheit nor shall the temperature of the aggregate exceed 150 degrees Fahrenheit.

b. The temperature of the concrete at the time of placing shall be within the placement temperature range shown below, unless otherwise specified.

Least dimension of section, inches	Placement temperature, °F
Less than 12	55 – 75
12 to 36	50 – 70
36 to 72	45 – 65
Greater than 72	40 – 60

c. The minimum temperature of the concrete for the first 72 hours after placement shall not be less than the minimum temperature shown above. Concrete structures shall be immediately protected after concrete placement by covering, housing, insulating, or heating concrete structures sufficiently to maintain the minimum temperature adjacent to the concrete surface. If the minimum temperature requirements are not met and the concrete did not freeze, the protection time will be extended a period equal to twice the number of hours the temperature was below the minimum temperature.

d. Exhaust flue gases from combustion heaters shall be vented to the outside of the enclosure. The heat from heaters and ducts shall be directed in such a manner as to not overheat or dry the concrete in localized areas or to dry the exposed concrete surface.

e. At the end of the protection period, the concrete shall be allowed to cool gradually. The maximum decrease at the concrete surface in a 24-hour period shall not exceed 40 degrees Fahrenheit.

22. Concreting in hot weather

Methods for concreting in hot weather shall be in accordance with the requirements set forth below.

For the purpose of this specification, hot weather is defined as the weather condition at the job-site that causes acceleration in the rate of moisture loss or rate of cement hydration of freshly mixed concrete, including an ambient temperature of 80 °F or higher, and an evaporation rate that exceeds 0.2 lb/ft^2/hour. The rate of moisture loss and rate of cement hydration may be accelerated if one or a combination of the following conditions exists:

- High ambient temperature
- High concrete temperature
- Low relative humidity
- Wind velocity
- Solar radiation

Whenever the above conditions exist or when climatic conditions are such that the temperature of the concrete may reasonably be expected to exceed 90 degrees Fahrenheit at the time of delivery to the worksite or during the placement operations, the following provisions shall apply:

a. The contractor shall maintain the temperature of the concrete below 90 degrees Fahrenheit during mixing, conveying, and placing.

b. Exposed concrete surfaces that tend to dry or set too rapidly shall be continuously moistened using fog sprays or other means to maintain adequate moisture during the time between placement and finishing. Water shall not be sprinkled or added directly to the surface of the concrete before finishing.

c. Finishing of slabs and other exposed surfaces shall be started as soon as the condition of the concrete allows and shall be completed without delay. Water shall not be sprinkled or added to the surface of the concrete during the darbying, bull floating, floating, or other finishing operations to facilitate finishing.

d. Formed surfaces shall be kept completely and continuously wet from the time the concrete takes initial set to when the forms are removed. After the forms are removed, the concrete surfaces shall be kept completely and continuously wet for the duration of the curing period or until curing compound is applied in accordance to section 21.

e. Exposed and unformed concrete surfaces, especially flat work placed with large areas of surface, shall be kept completely and continuously wet for the duration of the curing period or until curing compound is applied in accordance to section 19. The concrete shall be protected against thermal shock from rapid cooling (5 °F per hour or more than 40 °F per 24-hour period) of the concrete by application of curing water or temperature changes during the first 24 hours of the curing period.

f. When any single or combination of conditions may result in very rapid setting or drying of the concrete, extreme conditions exist. For flat work and slab construction, extreme conditions exist when the evaporation rate exceeds 0.2 pound per square foot per hour. The engineer may:
   (1) Restrict placement to the most favorable time of the day.
   (2) Restrict the depth of layers to assure coverage of the previous layer while it will still respond readily to vibration.

(3) Suspend placement until conditions improve.
(4) Restrict the removal of forms, repair, and patching to small areas that can be protected with curing compound immediately.

The evaporation rate for flat work and slab construction may be determined by calculating the evaporation rate from a shallow cake pan having a surface area of at least 1 square foot or by other methods approved by the engineer or designated in section 25.

23. Acceptance of the concrete work

Acceptance of the concrete work will be a cumulative acceptance process based upon progressively meeting the requirements of the specifications and drawings for:

- Fresh concrete
- Concrete strength and durability
- Structure dimensions
- Structure appearance

Fresh concrete—Fresh concrete conforming to the mix proportions and quality requirements of the approved job mix and the handling and placement requirements of previous sections will be satisfactory.

Concrete strength—A strength test is the average of the compressive strengths of two standard cured cylinders prepared and tested in accordance with section 4, unless otherwise specified. The strength of the hardened concrete is satisfactory if the following requirements are met:

a. If method 1 from section 3 is specified and the concrete work is less than 75 total cubic yards for the class of concrete specified, the compressive strength of the concrete is satisfactory if no individual strength test falls more than 500 pounds per square inch below the specified compressive strength (f'_c) for the respective class of concrete.

b. If method 1 from section 3 is specified and the concrete work is 75 total cubic yards or more for the class of concrete specified, the compressive strength of the concrete is satisfactory if both of the following requirements are met:

   (1) No individual strength test falls more than 500 pounds per square inch below the specified compressive strength (f'_c) for the class of concrete specified.

   (2) The average of any three consecutive strength tests is not less than the specified compressive strength (f'_c) for the class of concrete specified.

   The contractor shall take steps to increase the average of subsequent strength tests when the average of any three consecutive strength tests falls below the specified concrete strength (f'_c).

c. The engineer determines the structural adequacy and evaluates the durability of the in-place concrete when the concrete strength based on the standard cured concrete cylinders is unsatisfactory. The engineer determines the need for additional quality assurance testing.

d. The contractor may core the concrete, have the cores tested by a certified testing laboratory at the contractor's expense, and submit test results to the engineer for consideration and evaluation of concrete strength adequacy when the concrete strength based on the standard cured concrete cylinders is unsatisfactory.

e. Sampling and testing concrete by coring shall conform to section 4. The strength of the concrete based upon concrete cores is satisfactory if both of the following requirements are met:

   (1) The average compressive strength of the three cores equal or exceed 85 percent of the specified compressive strength (f'_c).

   (2) The compressive strength of any individual core does not fall below 75 percent of the specified compressive strength (f'_c).

f. If method 2 from section 3 is specified, the engineer is responsible for the concrete job mix design and the quality concrete that results from the job mix.

   The hardened concrete is satisfactory if the required batch tickets or other documentation acceptable to the engineer clearly show that the batch ingredients and weights of each ingredient including all admixtures conforms to the job mix provided by the engineer. Random periodic inspection of the batching operations may be made by the engineer to verify that ingredients and ingredient proportions conform to the batching documentation.

   If the concrete ingredients, proportions, or admixtures varies from the job mix provided by the engineer, the concrete may be rejected if, in the judgment of the engineer, the variance will significantly affect the strength or durability of the concrete or will adversely affect the life expectancy or other components of the structure.

Structure dimensions and appearance

The appearance of the concrete shall meet the requirements of sections 17 and 18.

The dimensions of formed members, unless otherwise specified, are satisfactory if they conform to the requirements of the specifications, the locations shown on the drawings, and are within acceptable tolerances:

a. Variation from plumb for walls and column shall be not more than 0.2 percent of the total wall or column height.

b. Variation from specified elevations for slabs, floors, or other horizontal members shall be not more than 0.2 percent of the length of the member in the direction of grade.

c. Variations in the cross-sectional dimensions of columns and beams and in the thickness of walls and above-grade slabs shall not be more than minus 0.25 inch or plus 0.5 inch from the shown dimensions.

24. Measurement and payment

For items of work for which specific unit prices are established in the contract, concrete is measured to the neat lines or pay limits shown on the drawings, and the volume of concrete is computed to the nearest 0.1 cubic yard. No deduction in volume is made for chamfers, rounded or beveled edges, or for any void or embedded item that is less than 5 cubic feet in volume. Where concrete is placed against the sides or bottom of an excavation without intervening forms, drainfill, or bedding, the volume of concrete required to fill voids resulting from overexcavation outside the neat lines or pay limits is included in the measurement for payment where such overexcavation is directed by the engineer to remove unsuitable foundation material. However, this payment is only to the extent that the unsuitable condition is not a result of the contractor's improper construction operations, as determined by the engineer.

Method 1—Payment for each item of concrete is made at the contract unit price for that item. The payment for concrete will constitute full compensation for completion of the concrete work, including joint fillers, waterstops, dowels or dowel assemblies, and metal plates, but not including reinforcing steel or other items listed for payment elsewhere in the contract.

Method 2—Payment for each item of concrete is made at the contract unit price for that item. The payment for concrete constitutes full compensation for completion of the concrete work, including joint fillers, waterstops, metal plates, dowels, and other assemblies. It does not include furnishing and placing reinforcing steel or furnishing and handling cement or other items listed for payment elsewhere in the contract.

Cement is measured by dividing the volume of concrete accepted for payment by the yield of the applicable job mix. The yield is determined by the procedure specified in ASTM C138. If the amount of cement actually used per batch exceeds the amount in the job mix specified by the engineer, the measurement is based on the amount of cement specified by the engineer for the job mix. Unless otherwise stated in section 25, a bag of cement is considered 94 pounds. Payment for each type of cement will be made at the contract unit price for furnishing and handling that type of cement and such payment will constitute full compensation for furnishing and handling the cement.

All methods—The following provisions apply to all methods of measurement and payment. Compensation for any item of work described in the contract, but not listed in the bid schedule, will be included in the payment for the item of work to which it is make subsidiary. Such items and the items to which they are made subsidiary are identified in section 25 of this specification.

25. Items of work and construction details