

ARTICLE 4

CONCRETE

4.1 GENERAL

4.1.1 DESCRIPTION

The work under this section shall consist of the furnishing of all labor and materials necessary for the placing and finishing of concrete in accordance with these specifications and conforming to the lines, grades, and dimensions shown on the drawings (approved by the Engineer) or the City Standard Details. Concrete shall consist of Portland cement, fine and coarse aggregates, and water, together with any specified additives or admixtures proportioned and mixed in conformity with the following specifications.

4.1.2 SUBMITTALS

4.1.2.1 General

Concrete submittals outlined below are required on all City contracts and any other project within the public right-of-way. All ready-mix suppliers furnishing concrete for placement within any City right-of-way shall furnish to the City once every two years, concrete mix designs for concrete intended to be used for placement within the right-of-way.

4.1.2.2 Mix Design

Unless a mix design has been previously approved as required under Section 4.1.2.1, the Contractor shall submit copies of all concrete mix designs to the Engineer for approval prior to placing any concrete. Separate mix designs shall be submitted for each type of concrete to be used in the project. Submittals shall include all information used in designing mixes, including admixture manufacturer's information.

4.1.3 QUALITY ASSURANCE

4.1.3.1 Plant Access

The Engineer shall be allowed access to the ready-mix batching plant at all times that the work is in progress. If required by the Engineer, samples of all concrete ingredients may be taken at the plant.

4.1.3.2 Record of Work

The Contractor shall keep a written record listing approximate locations, time and date of placement of all concrete for the project. Such record shall be kept until completion of the project and shall be available to the Engineer for review at any time.

4.1.3.3 Codes and Industry Standards

The Contractor is responsible for ensuring that all materials, formwork, and finishes comply with all applicable codes and industry standards as prescribed by ASTM, AASHTO, and/or ACI.

4.2 MATERIALS

All concrete shall be ready-mixed conforming to AASHTO M 157-13 (2017). No jobsite mixed concrete will be permitted unless written permission is granted by the Engineer.

4.2.1 GENERAL

4.2.1.1 Cement

Portland Cement shall conform to the specifications for Portland Cement (ASTM C-150) and specifications for air-entrained Portland Cement (ASTM C-175 or C-595) and shall otherwise be Type II cement unless sulfate conditions allow otherwise. Refer to Table 2.3 in Chapter 2.2 of ACI 201 for cement recommendations for sulfate resistances. In addition to the standard chemical requirements for Portland cement in ASTM C-150, the maximum percent of alkali shall be specified in Table 2 of ASTM C-150 for low alkali cement. Other types of cement or admixtures are only to be used upon approval by the Engineer.

Type II (6 Sack), Type IP, or Type IL is required for all sidewalks, driveways, curb and gutter, drainage pans, headwalls, wingwalls, and concrete paving. Type II (7 Sack), Type IP (HS), Type IL (HS) (in lieu of type V cement) will be acceptable for cast-in-place inlets and cast in place manhole bases. Type II (7 Sack), Type IP (HS), or Type IL (HS) is required for all *precast* box culverts, inlets, manhole bases, manhole barrel sections, and manhole cone sections.

4.2.1.2 Fly Ash and Natural Pozzolan FLY

Use of fly ash or natural pozzolan (ASTM C-618 **Class F; or Class N**) ~~for~~ as a partial substitute (25% maximum by weight) for Type I/II, Type IP (HS), Type IL (HS), or Type V cement may be used with written permission from the City Engineer. Fly ash or natural pozzolan shall conform to the requirements of ASTM C-618 – **Class F** or **Class N**, respectively. Cement containing **Class C** fly ash shall not be used for any concrete where these specifications are applicable.

4.2.1.3 Aggregate

(a) Fine Aggregate

Fine aggregate shall conform to ASTM C-33. Fine aggregate shall be natural sand composed of clean, hard, durable, uncoated grains, preferably of siliceous materials. Fine aggregate shall be thoroughly washed to remove shale, coal, mica, clay, loam, alkali, organic matter, or other deleterious matter.

- (1) Deleterious Substances. The percentage of deleterious substances in the washed aggregate shall not exceed the values in Table 4.1

Table 4.1. Maximum percentage of deleterious substances in the washed fine aggregate

Material	ASTM	Limit
Material finer than 200 mesh sieve	C117	3% by weight
Shale	Petrographic analyses	1% by weight
Coal & Lignite	C123	0.5% by weight
Clay lumps and friable particles	C142	3% by weight
Organic Impurities	C40	Plate 3
Sulfate Soundness	C88	10% by weight (Sodium Sulfate) 15% by weight (Magnesium Sulfate)

The sum of the percentages of the above deleterious substances shall not exceed 5% by weight.

- (2) Gradation. Fine aggregate shall be well graded and conform to AASHTO M6 as shown in CDOT Specifications Section 703, Table 703-1 and Table 4.3 below.

(b) Coarse Aggregate

Coarse aggregate shall conform to ASTM C-136. Coarse aggregate shall consist of crushed limestone, trap rock, granite, washed gravel, or other approved inert materials having clean, hard, strong, durable pieces, free from adherent coating, and conforming to the requirements of these specifications. Coarse aggregate shall be thoroughly washed of clay, loam, bark, sticks, alkali, organic matter, shale, coal, mica, or other deleterious material.

- (1) Deleterious Substances. The percentage of deleterious substances in the washed aggregate shall not exceed the values in Table 4.2.

Table 4.2. Maximum percentage of deleterious substances in the washed coarse aggregate

Material	ASTM	Limit
Material finer than 200 mesh sieve	C117	1% by weight
Lightweight fragments (specific gravity < 2.4)	C123	3% by weight
Coal and lignite (specific gravity < 2.4)	C123	0.5% by weight
Clay lumps and friable particles	C142	3% by weight
Abrasion	C131/C535	50% by weight
Sulfate Soundness	C88	12% by weight (Sodium Sulfate) 18% by weight (Magnesium Sulfate)

Non-aggregate materials such as wood, sealant, and backer-rod are considered deleterious substances. The sum of the percentages of the above deleterious substances shall not exceed 5% by weight.

- (2) Gradation. Coarse aggregate shall be well graded and conform to AASHTO M43 and CDOT Specifications Section 703, Table 703-1. The gradation shall be in compliance with designation No. 67 per Table 4.3.

Other gradations may be used when approved by the Engineer.

Table 4.3 Concrete Aggregate Gradation Table (Percent Passing Sieve Sizes)

Sieve Size	Fine aggregate No. M6, Class A	Coarse aggregate No. 67
1"	-	100%
3/4"	-	90-100%
1/2"	-	-
3/8"	100%	20-55%
No. 4	95-100%	0-10%
No. 8	80-100%	0-5%
No. 16	50-85%	-
No. 50	10-30%	-
No. 100	2-10%	-

4.2.1.4 Air Entraining Admixtures

All air-entraining admixtures shall comply with AASHTO M-154.

4.2.1.5 Chemical Admixtures

All chemical admixtures for concrete shall comply with AASHTO M-194. The use of calcium chloride as an accelerator is prohibited.

4.2.1.6 Water

Water used in mixing, curing, or other applications shall be reasonably clean and free of oil, salt, acid, alkali, sugar, vegetable matter, or any other substance injurious to the finished product. Concrete mixing water shall comply with ASTM C1602. Water known to be of potable quality may be used without further testing.

4.2.1.7 Curing Materials

Curing materials shall conform to the requirements in Table 4.4.

Table 4.4 Concrete curing materials

Material	Requirement
Burlap Cloth made from Jute or Kenaf	AASHTO M-182
Liquid Membrane-Forming Compounds for Curing Concrete	ASTM C309
Sheet Materials for Curing Concrete	AASHTO M-171*

*Only the performance requirements of AASHTO M-171 shall apply.

4.2.1.8 Expansion Joint

Expansion joints shall be constructed with 1/2" preformed expansion joint filler, conforming to Federal Specifications MR-F-341 or wood board conforming to AASHTO Designation M-90.

4.2.1.9 Joint Sealant, Backer Rod & Expansion Joint

The joint sealant for all sawed longitudinal and transverse joints shall be a silicone joint sealant meeting ASTM D5893. ASTM C1193 provides guidance for the use of joint sealants.

Blocking medium shall be an expanded closed cell polyethylene foam backer rod or non-plastic rope that is compatible with the joint sealant material and meets ASTM C1330, Type C or ASTM D5249.

Polyethylene expansion joint materials shall be flexible, low density, expanded extruded polyethylene plank formed by the expansion of polyethylene base resin, extruded as a multicellular, closed cell, homogeneous foamed polyethylene. Laminations shall not be permitted. The joint material shall conform to ASTM D1751, ASTM D1752, or ASTM D8139.

4.2.2 QUALITY OF CONCRETE

The proportioning of aggregate to cement shall be such as to produce a good workable mix and the slump shall be a maximum of 5" as per ASTM C-143 or as approved by the Engineer. The equipment for batching of the aggregates, cement, water, and air-entraining agent shall be such that accurate control can be held over the various constituents.

Ready-mixed concrete shall comply with ASTM C-94 for ready-mixed concrete and the following specifications:

4.2.2.1 Time of Haul

Concrete transportation in truck mixers or truck agitators shall be delivered to the site of work and completely discharged within a period of 90 minutes after the cement comes in contact with the mixing water or with the combined aggregates when the combined aggregates contain free moisture in excess of 2% by weight. If hot weather exists causing the temperature of the concrete to rise above 90° F, then the time of haul shall be within a period of 60 minutes.

4.2.2.2 Production and Delivery

The production and the delivery of ready-mixed concrete shall be such that placing and finishing shall be continuous so long as the operations require.

4.2.2.3 Concrete Mix Design

Concrete mix shall be designed per Tables 4.5, 4.6 or 4.7 based on the design criteria

Table 4.5. 6-Sack Concrete Mix

Specification	Requirement
Specified Compressive Strength at 28 Days	4,000 PSI
Minimum Cement Content per Cubic Yard	564 LBS (6 Sack)
Maximum Water/Cement Ratio by Weight	0.45
Air Content	6% +/- 1.5%
Slump	3" – 5"

Table 4.6. 7-Sack Concrete Mix

Specification	Requirement
Specified Compressive Strength at 28 Days	4,500 PSI
Minimum Cement Content per Cubic Yard	658 LBS (7 Sack)
Maximum Water/Cement Ratio by Weight	0.45
Air Content	6% +/- 2.0%
Slump	3" – 5"

Table 4.7. Caisson Concrete Mix

Specification	Requirement
Specified Compressive Strength at 28 Days	4,000 PSI
Minimum Cement Content per Cubic Yard	610 LBS/CY
Maximum Water/Cement Ratio by Weight	0.45
Air Content	N/A
Slump	6" – 9"

See CDOT specification 601.02, Class BZ for additional requirements.

4.2.3 CONTROLLED LOW STRENGTH MATERIALS (CLSM)

The term CLSM used in this Section shall mean the same as Removable CLSM or flowable backfill. This material is covered in detail due to the many time saving and engineering benefits of this type of backfill material. CLSM does not need compacting, or moisture density compaction testing. Only a few physical tests of the CLSM properties are needed to assure durability and future removability with light excavating equipment. A low strength is desired so that surrounding utilities or structures will be accessible without causing damage if the CLSM must be removed in the future. Air entrainment is required to prevent damage and heave displacement of trench patches due to freeze-thaw damage.

In addition, CLSM may be used for other applications apart from trench or street cut backfill. These include filling voids due to pipe abandonment or undercutting of excavation in caving or normal soils. CLSM offers quick restoration of the trench and improving other subgrade conditions for roadway or structure support in a rapid time frame without the need for traditional soil backfill testing requirements or when a quick strength is needed to support upper layers. These benefits may outweigh the extra costs vs. using traditional methods that require compaction and testing.

Other applications include: backfilling behind retaining walls and abutments, filling void areas including pipe abandonment, annular spaces, undercut areas and other approved void filling applications. Other suitable applications include structural support for utilities and replacement of unstable subgrade during pavement repairs. Utility types that can utilize CLSM include: conduits or pipes for electrical, wired or fiber optic communications, traffic signal or other utilities such as gas and water lines, sanitary and storm sewer lines, and other types of utilities under

existing pavements or ground surfaces to be built upon or improved later.

The objectives of requiring the use of the CLSM specified below, instead of reusing excavated soils, is to provide a self-leveling, frost heave-resistant, non-settling, controlled low-strength material (defined by American Concrete Institute in ACI 229 as a CLSM), that does not normally require compacting and compaction testing. Traditional use of compacted soil or aggregate materials for trench backfill shall require City approval and testing for acceptance.

4.2.3.1 Requirements for CLSM

This requirement specifies two distinct CLSM material products: Flashfill and Flow-Fill. The Flashfill products will allow trench backfill, temporary or permanent pavement restoration and traffic access to occur more quickly than Flow-Fill. The term 'CLSM' in this section shall mean either or both.

A **high slump** is required to aid in the self-leveling and void filling objective. The visual consistency may appear to range in appearance from thin batter or mud to thick water. It must be foremost removable with light machinery in the future, and quickly stabilize to support paving operations and traffic.

Minimum air contents are required in the top 4' of CLSM fill to limit permanent frost heave. This air content requirement should be used for the entire depth, to aid in the ability to remove or excavate CLSM in the future. The air content requirement may be forbidden by some utility applications, such as for thrust blocks or for pipe bedding normally used for lateral support of pressurized pipes.

A **Removability Modulus (RE)** is specified at a maximum 1.5 and is based on compressive strength and unit weight of the CLSM backfill.

4.2.3.2 CLSM Materials

(a) Flow-Fill

Shall consist of a controlled low strength, self-leveling concrete material composed of various combinations of cement, fly ash, aggregates, water, chemical admixtures and/or cellular foam for air-entrainment. Generally, Flow-Fill may be placed in a maximum of 3' thick layers, allowing bleed water to rise and divert away from placement before another layer may be added.

The Flow-Fill shall be limited to a maximum Removability Modulus of 1.5 to ensure ability to excavate in the future. Slumps of less than 7" will not be permitted for placement, since the flowability to fill voids and avoid future settlement is impaired, and strengths may increase beyond specified removability limits.

Submit a mix design for approval by the City Engineer prior to placement. The mix design shall be supported by laboratory test data verifying compliance with air content, slump, strength, and removability (RE) requirements.

Table 4.8. Flow-Fill requirements

Flow-Fill property	Flow-Fill specification
Air Content, ASTM C-231	15-25%
Compressive Strength, ASTM D-4832	125-150 psi at 28 days
Slump, ASTM C-143	7-10"
Removability Modulus, RE	1.5 MAX

See CDOT Section 206 for additional requirements for usage of Flow-Fill.

(b) Flashfill

Flashfill shall consist of a controlled low-strength, self-leveling cementitious material composed of various combinations of fly ash, water, chemical admixtures and/or cellular foam for air-entrainment. No aggregate or sand is usually needed. It shall have a minimum specified air content to provide suitable resistance to frost-heave. Flashfill may generally be placed without lift thickness limits.

Higher strengths may be permitted over Flow-Fill; however, the Flashfill shall still be limited to a maximum removability (RE) of 1.5. Slumps of less than 8" or spreads of less than 8" will not be permitted for placement, since the flowability to fill voids and avoid future settlement is impaired, and strengths may increase beyond removability limits.

Submit a mix design for approval by the City Engineer, prior to placement. The mix design shall be supported by laboratory test data verifying compliance with air content, slump, strength, and removability (RE) requirements.

Table 4.9. Flashfill requirements

Flashfill property	Flashfill specification
Air Content, ASTM C-231, or by Section 2D volumetric calculations	15 MIN
Compressive Strength, ASTM D-4832	100-300 psi at 28 days
Slump, ASTM C-143 (one lift, no rodding)	8-11"
Removability Modulus, RE	1.5 MAX
Spread, ASTM D-6103	8-12", or greater

See CDOT Section 206 for additional requirements for usage of Flashfill.

4.2.4 CURBS AND GUTTERS

4.2.4.1 General

This work shall consist of constructing curbs and gutters of the form and dimensions shown on the plans.

4.2.4.2 Materials

Concrete for construction of combination curbs and gutters shall be a 6-sack mix design per Table 4.5.

4.2.5 SIDEWALK AND CURB RAMPS

4.2.5.1 General

Sidewalks shall be 4" in thickness and a minimum of 5' in width for residential and 6' in width for commercial/industrial, unless approved by the City Engineer. Curb ramps shall be 6" in thickness. Sidewalks at driveway approaches shall have a minimum thickness of 6" (residential) and 7" reinforced (commercial) for the full width. Sidewalks shall have a maximum of 2% cross slope (1:50). All sidewalks and curb ramps shall be constructed to conform to the most current version of the Public Rights-of-Way Accessibility Guidelines (PROWAG) and these specifications.

4.2.5.2 Materials

Concrete for construction of sidewalks and pedestrian ramps shall be a 6-sack mix design per Table 4.5.

4.2.6 CROSSPANS

4.2.6.1 General

Minimum crossspan bases shall be 8' wide with a 45° angle slope on each side allowing 6' of exposed concrete surface. The crossspan shall be sloped from each edge to the middle at the slope rate of 1/4" per foot maximum. The depth of concrete shall be 7" using #4 @ 18" O.C. Longitudinal and 24" O.C. Transverse.

Concrete for construction of crossspans shall be as specified in Section 4.2.2.3. One inch (1") smooth steel dowls with sleeves or caps shall be installed at expansion joints, and when pouring half pans, spacing shall be @ 1' O.C. See ARTICLE 5 – STRUCTURAL CONCRETE for specifications.

4.2.6.2 Materials

Concrete for construction of crossspans shall be a 6-sack mix design per Table 4.5.

4.2.7 DRIVEWAY APPROACHES

4.2.7.1 General

Driveway approaches shall be of two types:

- (a) Alley & Driveway (Attached Sidewalk). Shall be constructed from cuts in 6" vertical curb. The curb head shall be transitioned from 6" to 1-1/2" at a distance of 4'. See detail SD6.
- (b) Alley & Driveway (Detached Sidewalk). Shall be as the Alley & Driveway (Attached Sidewalk), except the sidewalk is detached and 5' wide. See detail SD5.

4.2.7.2 Materials

Concrete for construction of drive approaches shall be a 6-sack mix design per Table 4.5. Depth of concrete shall be 6", except for commercial driveways in which case the depth shall be 7" reinforced minimum.

4.3 CONSTRUCTION REQUIREMENTS

4.3.1 GENERAL

- (a) All concrete construction in the City right-of-way requires that a concrete permit be obtained from the office of the Director of Public Works prior to start of construction. Permits will only be issued to Contractor's possessing a valid concrete license from the Pueblo Regional Building Department. When curb and gutter construction is incidental to a site upon which a building permit has been issued, that Contractor who was issued the building permit may be issued a permit for curb and gutter at the discretion of the Director of Public Works.
- (b) Provide ample notice (24-hour minimum) to the Engineer to allow for the examination of all forms and reinforcing before concrete is placed and to observe the placement of all concrete. Concrete may not be placed until approval has been given by the Engineer.
- (c) All concrete construction within the City Right-of Way shall be inspected and approved by a City Inspector. Inspections are scheduled by calling (719) 553-2295 or online at www.pueblo.us/PLACE.
- (d) This section provides for the operations and construction of concrete combination curbs and gutters, valley gutters, crossspans, driveway approaches, and sidewalks to be constructed within the City right-of-way except patterned concrete median.
- (e) No concrete shall be placed adjacent to concrete that has taken its initial set unless the specified expansion joint is provided.
- (f) No more concrete shall be poured in one day than can be finished before dark, the same day. No concrete that has begun to set shall be deposited in the forms.
- (g) When concrete pavement, curb & gutter, crossspans, or sidewalk are removed, the removal shall be to an existing joint or to a sawed joint which is made prior to removal. See Section 4.3.6.4 Sawcutting for specific requirements.
- (h) The final edge of asphalt removal for the 2' cut back shall be along a straight edge line sawed to full depth, prior to removal of the pavement, unless otherwise approved by the City Engineer.
- (i) The edges of the concrete or asphalt paving shall extend 1' beyond the excavation. Where flowable fill is used as backfill, extension is not required.

- (j) The final edge of asphalt removal for the 2' cut back shall be cut along a straight line, in an approved manner, to allow removal without disturbing adjacent asphalt or concrete. When the adjacent asphalt or concrete has been disturbed by the removal process, the Permittee shall replace all disturbed asphalt or concrete as directed by the City Engineer.

4.3.2 EXCAVATION

4.3.2.1 General

Excavation will include excavation of all materials encountered. Excavation shall be made to subgrade elevations and to a width equal to the width of the concrete to be placed plus 2' beyond the outer edges of the concrete to be placed or as directed by the Engineer.

If, after the excavation has been made to subgrade for the full width required, the top 6" of the cut have a relative density of less than that required by Section 6.3.3 COMPACTION, it shall be reworked to obtain such density.

4.3.2.2 Excavation of Unsuitable Material

No excavation shall be made below the specified elevation except to remove soft or saturated soils, organic matter or other unsuitable material, as ordered by the Engineer. In the event the Contractor does excavate below the specified elevation, and said excavation was not directed by the Engineer, the excavated material shall be replaced with material satisfactory to the Engineer. The material shall be thoroughly compacted, at the contractors' expense.

Whenever excavation below the specified elevation to remove soft or saturated soils, organic matter, or other unsuitable material is ordered by the Engineer, the Contractor shall remove and replace the excavated material with material acceptable to the Engineer.

The replacement material shall be placed according to Section 6.3.3 COMPACTION.

4.3.6 PREPARATION FOR PLACEMENT

4.3.6.1 General

- (a) Before placement, all equipment for mixing and transporting the concrete shall be cleaned, and all debris and ice shall be removed from the places to be occupied by the concrete. Forms shall be thoroughly oiled, and masonry filler units that will be in contact with concrete shall be water saturated (except in freezing weather). The reinforcement, placed according to Article 5 – REINFORCEMENT FOR STRUCTURAL CONCRETE, shall be free of ice, dirt, rust, mill scale, or other coatings.
- (b) Water shall be removed from place of deposit before the concrete is placed unless otherwise permitted by the Engineer. All laitance and other unsound material shall be removed from hardened concrete before additional concrete is added.
- (c) Preparation prior to concreting includes compacting, trimming, and moistening the subgrade, erecting the forms, and setting the reinforcing steel. A moist subgrade is especially important

in hot weather to prevent extraction of water from the concrete.

- (d) Forms shall be clean, tight, adequately braced, and constructed of materials that will impart the desired texture to the finished concrete.
- (e) Sawdust, nails, and other debris shall be removed before concrete is placed. Wood forms shall be oiled before placing concrete.
- (f) When concrete placed on earth surfaces is necessary, the surfaces shall be free from frost, ice, mud and water.

4.3.6.2 Preparation of Subgrade

Where soils are encountered with an R-value less than 32, and a California Bearing Ratio (CBR) less than 15, the soils engineer will decide on the requirement for base course under concrete based upon recommendations contained in the soils report. Select base course materials and/or subgrade shall be compacted to not less than 95% of maximum dry density, in accordance with AASHTO T-99 (Standard Proctor) or 95% of the maximum dry density in accordance with AASHTO T-180 (Modified Proctor) and at the moisture content as specified in the soils or pavement design report. If the moisture content is not specified, the soil shall be compacted at +/-2%.

When the temperature of the surrounding atmosphere is 50° F or above, the sub grade and/or base course shall be lightly moistened immediately before the placement of the concrete. See ARTICLE 7 – EARTHWORK for additional requirements.

4.3.6.3 Removal of Obstructions

Whenever an existing driveway or entrance walk must be removed to provide space for forms, the Contractor shall remove those to the nearest joint, or as the Engineer may direct. A sawed joint shall be required for said removal. Replacement will be done on a unit price basis.

4.3.6.4 Sawcutting

- (a) All concrete removal shall be to a sawcut joint unless it can be demonstrated that an existing joint is of such character that removal can be accomplished to a neat line.
- (b) Sawcutting will be done to a depth equal to at least half the depth of the concrete.
- (c) In no case will a piece of concrete be left which is closer than 5' to the nearest control joint.
- (d) All existing joints other than expansion joints shall be sawed prior to removal. A sawed joint will not be permitted within 5' of an existing joint.
- (e) Where water service line renewals cross existing concrete sections that have been previously saw-cut to less than 5' minimum distance to a joint, these sections shall be removed and replaced to meet the 5' minimum requirement to a joint.

- (f) The final edge of asphalt removal for the 2' cut back shall be cut along a straight line, in an approved manner, to allow removal without disturbing adjacent asphalt or concrete. When the adjacent asphalt or concrete has been disturbed by the removal process, the Permittee shall replace all disturbed asphalt or concrete as directed by the Engineer.

4.3.6.5 Removal of Tree Roots

Whenever a section of concrete is being replaced that has been uplifted by a tree root, the root shall be cut 12" behind the concrete to prevent the damage from reoccurring. Any roots within 6" of finished sub grade shall also be removed. If, in the opinion of the Engineer, cutting the root may seriously injure the tree, then the Engineer may order the removal of the tree. Except for City contracts with a tree removal bid item, the cost of the tree removal shall be at the adjacent property owner's expense. Prior to cutting the tree roots, the Engineer shall be consulted to determine the proper removal of the root and/or tree.

4.3.6.6 Placement on Hardened Concrete

When fresh concrete is placed on hardened concrete, certain precautions shall be taken to secure a well-bonded and watertight joint. The hardened concrete should be fairly level, reasonably rough, clean, and moist. Some coarse aggregate particles shall be exposed, and any laitance or soft mortar shall be removed from the top surface of the hardened concrete. For structures requiring more than one lift, the top of the lower course shall be broomed, just before it sets, with a steel or stiff fiber broom. The surface shall be level but heavily scored and free of laitance. It must then be protected and thoroughly cleaned just before the grout coat and top course are placed. Hardened concrete shall be moistened thoroughly before new concrete is placed on it. Where the surface has dried out it shall be saturated for 24 hours. No pools of water shall be left standing on the wet surface when the new concrete is placed.

4.3.6.7 Placement on Rock

Where concrete is to be placed on rock, all loose material should be removed and the rock should be thoroughly cleaned before concrete is placed. Concrete shall be placed to fill all irregularities in its surface.

When rock must be cut out, the surfaces in general should be vertical or horizontal rather than sloping.

4.3.7 FORMS

4.3.7.1 General

Forms shall be thoroughly cleaned of all dirt, mortar, and foreign matter before being used. Unit lengths of forms shall be jointed in advance of the time of placing concrete. Forms that are bent, twisted, warped, broken, or forms that have battered or splintered top faces shall be removed from the job. Repaired forms shall not be used until they have been inspected and approved by the Engineer. The top and face of a form shall not vary from a true plane by more than 1/4" in 10'.

Wood forms shall not be less than 1/2" thick after being surfaced. Metal forms shall be approved section and shall have a flat surface on the top of not less than 1-3/4". Steel stakes shall not be spaced more than 6' apart. Clamps, spreaders, and braces shall be used where required to ensure rigidity in the forms.

The building of pedestals of earth or other materials upon which to rest the forms to bring them to the grade will not be permitted. Sufficient forms shall be provided so that they may remain in place 72 hours or more after the concrete has been placed before it is necessary to move and reuse them. Forms shall be cleaned and oiled before concrete is placed against them. The alignment and grade of forms shall be checked and approved immediately before placing the concrete.

Forms which show a variation exceeding 1/2" from the alignment shall be reset or removed as directed.

Forms for concrete shall be used for all vertical surfaces, mortar type, true to required lines and grades, and of sufficient strength to maintain shape during the placing of the concrete and the mechanical finishing without springing or settling.

4.3.7.2 Removal of Forms

Remove forms in such a manner as to ensure the complete safety of the concrete. Forms in general may be removed from vertical surfaces after 24 hours from the time of placing the concrete and 72 hours for horizontal surfaces (i.e. structural slabs). Additional time may be required as specified in Section 4.3.7.2 PROTECTION IN COLD AND FREEZING WEATHER when directed by the City Engineer. Any damages or injuries resulting from premature formwork removal are the sole responsibility of the Contractor. After the forms have been removed, no honeycomb or minor defects will be acceptable by the City Engineer, unless acceptable repairs are made.

4.3.8 JOINT SEALING

Sealing material shall be applied in strict accordance with the manufacturer's directions. All expansion joints shall be sealed.

4.3.9 CONVEYING, PLACING AND FINISHING

4.3.9.1 Conveying

Each load shall be accompanied by a batch plant ticket with the following minimum information:

- Supplier Name
- Date
- Truck Number
- Project Name
- Time Batched
- Cubic Yards Batched
- Type, and amount of cement
- Design Mix Designation

Destination

Concrete shall be conveyed from the mixer to the place of final deposit by methods which will prevent the separation or loss of materials. The practice of moving concrete from one point to another using vibrators is expressly forbidden. Vibrators shall be used to consolidate the concrete, not to transport it.

Equipment for tramming, chuting, pumping, and pneumatically conveying concrete shall be of such size and design as to insure a practically continuous flow of concrete at the delivery end without separation of materials.

4.3.9.2 Placing

Concrete shall be placed, as practicable, in its final position to avoid separation due to rehandling or flowing and shall be placed at a rate that it maintains plasticity at all times. No concrete that has partially hardened or been contaminated by foreign materials shall be deposited on the job site nor shall retempered concrete be used. All concrete shall be thoroughly consolidated during placement. It shall be thoroughly worked around reinforcements and embedded fixtures and into the corners of forms.

Concrete shall not be free dropped from more than 4'.

Concrete shall be placed in horizontal layers of uniform thickness. The minimum layer thickness should be 4" for flatwork and 6" for walls and footings.

In depositing concrete against the forms, care shall be taken to work the fine portions of the aggregate surface to leave the surface in a uniform and smooth condition.

After placement in the forms, the concrete shall be thoroughly spaded or mechanically vibrated so that there will be no air spaces in the mass. The concrete shall be worked sufficiently to produce a dense mass.

Curb and gutter shall be brought to the proper surface by running a straightedge over the steel templates with a sawing motion, to fill all holes and depressions.

Crosspans shall be brought to the proper surface by wood floating to fill all holes and depressions.

Driveway approaches shall be brought to the proper surface by running a straightedge over the forms with a sawing motion to fill all holes and depressions.

Immediately after using the straightedge, the surface shall be floated with a wood float, trowel led with a steel trowel and edged with an approved edger. Finishing with a steel trowel shall be accomplished without adding water to the surface. Excessive water, laitance or other inert material shall be floated from the surface.

No more concrete shall be poured in one day than can be finished before dark the same day. No concrete that has begun to set shall be deposited in the forms.

4.3.9.3 Finishing

Just before the concrete takes its initial set, the surface shall first be troweled, then brushed with a soft bristle brush, except that pedestrian ramps shall be brushed with a coarse hair push broom, to remove all trowel marks and leave a uniform appearance.

Brushing shall be as follows:

- (a) At right angles to the centerline of the sidewalk or curb line,
- (b) parallel with the scoring for pedestrian ramps, or
- (c) parallel to the center line of the crossspan.

4.3.9.4 Contractor Stamp

The contractor shall mark in every 50 linear feet of sidewalk and curb & gutter, and in every crossspan, valley gutter and driveway by stamping their name and the year of construction. The stamped letters shall be 1" high and 1/4" deep.

4.3.10 FIELD TESTING

The preparation, handling, storage, and testing procedures of all samples shall be in conformance with the applicable ASTM and AASHTO standards. Field testing may be done by either an independent testing firm, contracted by the City, or hired by the contractor/developer. The testing and frequencies listed in the table below shall be conducted to verify applicable standards and specifications are met.

Table 4.10. Minimum testing requirements

Standard	Requirement	ASTM
Compressive Strength	One set (5 cylinders) per 100 cubic yards and at least one set per day	C31 C39
Air Content	First three trucks each day, then one test per 50 cubic yards and at least one test per day	C231
Slump	First three trucks each day, then one test 50 cubic yards and at least one test per day	C143
Unit Weight	First three trucks each day, then one test per 300 cubic yards and at least one test per day	C1064

Failure of the concrete to pass any of the above tests may cause the rejection of the load and/or removal of concrete. The Contractor shall furnish the concrete for the tests at no expense to the City. Except for City projects, the expense of testing the concrete shall be paid by the contractor/developer. Privately funded projects within the City of Pueblo right-of-way shall be sampled and tested in accordance with the above table.

Additional cylinders or tests may be required at the direction of the Engineer. If additional tests are required, the financial burden will be borne by the contractor/developer if the testing results fail to meet minimum city specifications. If the testing results meet or exceed the city

specifications the additional testing costs will be paid for by the requesting entity.

Compressive strength tests shall consist of at least five cylinders cast and cured in accordance with ASTM C31. Unless otherwise directed by the Engineer, one cylinder shall be broken at the end of seven days, two cylinders shall be broken at the end of 28 days, and the remaining cylinders shall be stored until its disposition is determined by the Engineer. Testing must be accomplished by AC1 Field Testing Grade 1 certified technician.

The Engineer reserves the right to stop all future concrete work, when the 7- or 28-day tests indicate unsatisfactory results, until in the opinion of the Engineer proper corrective measures have been taken to ensure quality concrete in future work or all corrections deemed necessary have been made.

If the 28-day compressive strength tests produce results less than the specified required minimum compressive strength, then any concrete represented by those tests shall be removed and replaced at the Contractor's expense. In lieu of removal, the Contractor has the option of having additional strength tests taken by an approved laboratory at the Contractor's expense to satisfy the Engineer that the concrete in question has achieved the required strength. The location, number and type of tests shall be subject to review by the Engineer prior to start of testing.

4.3.11 CURING AND PROTECTING

All concrete shall be cured for a period of seven days or until the concrete has reached 80% of the design compressive strength. Concrete shall be kept moist for at least five days after placement. The curing medium used shall be applied to prevent checking and cracking of the finished surface of the concrete immediately after the finishing operation is completed, and it shall be maintained to prevent loss of water from the surface and edges of the concrete for the entire duration of the curing period.

4.3.11.1 Curing Compounds

If curing compounds are used, they shall be thoroughly agitated during use and shall be uniformly sprayed in a single coat. Application shall be on all concrete surfaces at a rate not to exceed 150 square feet per gallon in place. Application shall be made as soon as all surface water sheen has disappeared from the concrete surface. If concrete surfaces become partially dry, they shall be thoroughly moistened with water immediately prior to the application of the compound. If in the opinion of the Engineer pinholes exist, a second coat shall be immediately applied at right angles to the first in the affected area. Under no circumstances shall curing compound be used on surfaces to which new concrete is to be bonded. All curing compounds shall conform to ASTM C-309.

If, at any time during the curing period any of the forms are removed, a coat of curing compound shall be applied immediately to the exposed surface.

4.3.11.2 Protection in Cold and Freezing Weather

Cold weather is defined as a period when, for more than three consecutive days, the following conditions exists:

- (a) The average air temperature is less than 35°F, and
- (b) The air temperature is not greater than 45°F for more than one half of any 24-hour period.

The Contractor is responsible for the strength and quality of the concrete placed during cold weather. Before starting paving operations, the Contractor shall be prepared to protect the concrete from freezing.

The placing of concrete will be permitted only when the temperature of the concrete placed is between 55°F and 90°F. Cold weather concrete placement shall follow the requirements and recommendations of the American Concrete Institute (ACI) 306R-10 (or the most current revision).

Concrete may be placed when the air temperature in the shade is 40°F and rising. No concrete shall be placed regardless of the present temperature, when the National Weather Service forecast predict weather to be below 32°F before final set of the concrete unless special means of heating and protection are used. Protection against freezing is the Contractor's responsibility regardless of the weather forecast or climatic conditions at the time of placing.

The Contractor shall protect the concrete from falling below 55°F surface temperature until the concrete has developed a compressive strength of at least 3,500 psi or 80% of the required 28-day concrete design strength.

If concrete placement is performed when the temperatures are below or are projected to fall below 15°F for more than 24 hours, the Contractor shall measure the internal temperature of the concrete at regular intervals during the curing using automated sensors provided by the Contractor. Data obtained shall be provided to City Engineering Division. The Contractor shall be responsible for the placement, protection, and maintenance of all measuring devices. Locations where measuring devices are installed shall be protected in the same manner as the rest of the concrete.

The following procedures shall be followed if the temperature of the concrete falls below 32°F before the concrete reaches 3,500 psi or 80% of the required 28-day concrete design strength:

- (a) The Contractor will take cores at locations designated by the Engineer.
- (b) The Engineer will take immediate possession of the cores and submit the cores to a petrographer for examination in accordance with ASTM C856.
- (c) All costs associated with coring, transmittal of cores, and petrographic examination shall be borne by the Contractor regardless of the outcome of the petrographic examination.
- (d) Pavement damaged by frost as determined by the petrographic examination, shall be removed and replaced at the Contractor's expense.

Under no circumstances shall the placement of concrete be permitted, regardless of temperature conditions, if the supporting ground is frozen or contains frost. Use of salt or other additives to prevent concrete from freezing is not permitted. Concrete that has been frozen will

be completely removed and replaced as directed by, and to the satisfaction of, the City Engineering Division. Additional field testing may be directed by the City Engineering Division per Section 4.3.6 of this document.

4.3.11.3 Hot Weather Placement

When the air temperatures are expected to exceed 100°F, the Contractor shall obtain approval from the Engineer on the procedures to be used in protecting, depositing, finishing and curing of concrete. A concrete retarding agent may be used upon approval of the Engineer. The use of fog sprays is prohibited. The time allowed for hauling and placement shall be reduced to 60 minutes. Concrete shall not be placed when the temperature of the mix exceeds 90°F. Any concrete placed when the ambient temperature is 100°F or greater will be at the contractor's risk, regardless of any prior verbal authorization.

4.3.12 PATCHING

Patch all voids, tie holes, honeycombs, or damaged areas. Cut or chip out large defective areas a minimum of 1 ½" deep or 1 ½" below the reinforcement, if present, until sound and clean concrete is exposed, and patch as required. Add white cement to patching grout as required to match color of existing concrete where patches are exposed to view.

When allowed by the Engineer, spalls in curb and gutter or sidewalk shall be patched with a product from the CDOT approved list for the appropriate application. Grout color shall match that of concrete being patched. Contractor shall submit Material Data Sheets for City review prior to application.

4.3.13 TRENCH BACKFILL WITH CLSM

Except as otherwise provided or approved by the City, after the pipe or conduit is laid, trenches shall be backfilled with CLSM 24" below the asphalt. The Utility Owner shall dictate any variance to these CLSM separation distances. Where depths of Flashfill exceed 3' over wastewater mains please contact Pueblo Wastewater or Stormwater Departments for bedding depths.

CLSM should be well mixed and discharged directly from the truck into the space to be filled, or by other methods approved by the City. When used as backfill in the pipe zone, care should be taken to prevent flotation or misalignment of the pipe by means of straps, soil anchors or other approved means of restraint. Material may be placed in stages with initially lesser flowability, to prevent movement or flotation of pipe. CLSM shall not be placed when the trench bottom or walls are frozen or contain frozen materials.

Compaction of CLSM shall not be performed.

The maximum layer thickness for Flow-Fill shall be determined by the Contractor. Additional layers shall not be placed until the backfill has lost sufficient moisture to be walked on without indenting more than 2". Allow bleed water to rise and divert away from placement area before another layer may be added. Do not place CLSM on top of bleed water or on any water above the bearing layer. Any damage resulting from placing Flow-Fill in layers that are too thick or from not allowing sufficient strength gain time between placement of layers shall be repaired at the

CONTRACTOR's expense.

The maximum layer thickness for Flashfill is not restricted except to prevent flowing or running into undesired areas.

Contractor shall observe all other Construction Requirements as provided in CDOT Section 206 for placement of CLSM.

4.3.14 STREET SURFACING AND PATCHING

Placement of pavement materials for vehicle traffic shall not be allowed until the removable CLSM backfill has cured 24 hours (Flow-Fill only) or achieved sufficient resistance to allow paving. CLSM (either type) should be subjected to standard proof roll criteria, or penetration resistance tests. CLSM should achieve a penetration resistance of at least 3.6 tsf (tons per square foot) (equivalent to 50 psi) using a hand-held soil penetrometer, typically pushed to 1/4" depth, in accordance with the penetrometer manufacturer's instructions. Alternately, penetration resistance shall be considered achieved when a person weighing 100 pounds by use of their body weight as an axial load, cannot penetrate the CLSM backfill with the square cut end of a 1/2" diameter (#4) steel reinforcing bar.

4.3.15 TOLERANCES

Finished horizontal concrete surfaces shall not vary from a true plane by more than 3/16" in 10' and the upstanding face shall not vary from a true plane by more than 1/4" in 1'. Any concrete not adhering to these tolerances may be rejected by the City and shall be replaced by the Contractor's at expense.

4.3.16 EMBANKMENTS

Embankments shall be constructed of suitable excavated, borrow or select materials approved by the Engineer, placed in successive layers no greater than 6" in thickness, parallel to the finished subgrade. Each layer of embankment placed shall contain the amount of moisture necessary to obtain a minimum density outlined in Section 6.3.3 COMPACTION, when thoroughly compacted with the proper equipment.

In fill sections the material shall be placed for the full width of the concrete to be placed plus 2' beyond the outer edges of the concrete to be placed and shall slope to the existing ground on a 2:1 slope.

4.3.17 POST CONSTRUCTION

4.3.17.1 Backfilling After Construction

In fill sections, a 2' minimum wide berm shall be constructed against the back of the curb or sidewalk if applicable and sloped to the existing ground at a 2:1 slope, unless shown otherwise on the drawings.

In cut sections, a level bench shall extend from the back of the curb a distance of 7' before the cut slope extending to daylight, or as shown on the drawings. The void behind the back of the

curb and gutter shall be backfilled after the removal of the back form and the concrete has attained a minimum strength of 3,000 psi. Care should be exercised during this operation so that the alignment or grade of the sections shall not be disturbed. Any that are shifted, cracked, or in any way damaged, shall be removed and replaced at the Contractors own expense.

4.3.17.2 Asphalt Patch

Where asphalt and base have been removed for the gutter face form, the patch shall have a minimum width of 2' when a cut back is required. The patch shall be constructed using asphalt conforming to the requirements of ARTICLE 8 – PAVEMENT and having an asphalt thickness equal to that of the adjacent street except that a minimum thickness of 6" shall be maintained.

4.3.17.3 Site Restoration

Restoration of the area behind the new concrete shall include, but not be limited to replacing sod, shrubs, gravel, asphalt, concrete, irrigation components, and other landscaping items. Restoration is considered subsidiary to the concrete construction and shall not be paid as a separate item, unless noted otherwise in the Special Provisions.

4.3.18 SPECIFIC CONSTRUCTION TYPES

4.3.18.1 Curbs and Gutters Construction

- (a) General. No concrete shall be placed if there is not enough to completely fill one complete 5' curb and gutter section. No concrete shall be deposited adjacent to concrete that has already taken its initial set (90 minutes or older), unless the specified expansion joint is provided.
- (b) Expansion Joints. Expansion joints of 1/2" wide shall be constructed in curbs and gutters at 100' intervals, at each side of structures, and at the ends of all curb returns; except that expansion joints shall not be installed within 20 feet of an island nose. Expansion joints shall be filled with joint filler strips 1/2" thick conforming to 4.2.1.8 Expansion Joint requirements. The filler for the joint shall be furnished in a single piece for the full depth and width required for the joint. Filler strips shall be secured to forms or subgrade to avoid displacement while or after concrete is placed; or attached to a bulkhead. Expansion joint filler shall be shaped to the cross section of the curb and gutter. Expansion joints shall be constructed at right angles to the line of curb and gutter.
- (c) Contraction Joints. Contraction joints shall be installed every 10' and shall be inserted by a 1/8" thick steel template at right angles to the curb and 1-1/2" deep into the concrete.
- (d) Forms. All forms shall have dimensions of the City of Pueblo specified curb and gutter sections. Flexible, curved, or wood forms of the proper radii shall be used for curbs having a radius of less than 200'.
- (e) Finished Work. The work shall be performed in a manner which results in a curb and gutter constructed to a specified line and grade, uniform in appearance and structurally sound. Curbs found with unsightly bulges, ridges, low spots in the gutter or other

defects shall be removed and replaced at the Contractor's expense. When checked with a 10' straightedge, grade shall not deviate more than 1/4" inch and alignment shall not vary more than 3/8".

- (f) Backfill. Immediately after the curb and gutter have been properly cured, backfill shall be placed and compacted against the back of the curb to the satisfaction of the Engineer, to prevent any movement of the curb and/or gutter during the placing of the street pavement. Placement of asphalt paving shall be no sooner than three days after placing of concrete except when threat of erosive rains exists.

4.3.18.2 Sidewalk and Curb Ramps Construction

- (a) Expansion Joints. Transverse expansion joints 1/2" wide shall be constructed at all sidewalk returns and in-line with expansion joints in the adjacent curb. Where the curb is not adjacent, expansion joints shall be constructed at intervals of 100'. Expansion joints shall coincide with curb and gutter control joints. Expansion joints shall have joint filler strips placed between or within pours. The filler shall be 1/2" thick conforming to 4.2.1.8 Expansion Joint requirements. The filler for the joint shall be furnished in a single piece for the full depth and width required for the joint unless otherwise authorized by the AGENCY. The joint filler shall be placed with the top edge 1/4" below the concrete surface and shall be held in place by means of steel pins driven into the subgrade and spaced sufficiently close to prevent warping of the filler during floating. Upon completion of floating, the pins shall be removed and when finishing operations have been completed, the joint shall be edged with an edging tool having a radius of 1/8".
- (b) Contraction Joints. Contraction joints shall be installed every 5' and shall be at least 1-1/2" deep into the concrete.
- (c) Tolerance. The top face of the slab shall not vary from the true grade and alignment by more than 1/4" in 10' when checked with a straightedge. Slope of the grass portion of the parkway shall be 1/4" to 1-1/2" per foot above the top of curb. Slope of sidewalk shall be maximum 2% cross slope (1:50). Curb ramps shall have a maximum running slope of 8.33%. The counter slope of the gutter or street at the foot of the ramp run shall be 5% maximum. The maximum difference in grades between the curb ramp and the adjacent gutter pan shall be 13.3%. The transition between the two surfaces shall be flush.
 - (1) Where applicable, turning spaces shall be provided with the curb ramps and shall have a maximum slope of 2% in all directions (1:50). The counter slope of the gutter or street at the turning space shall be 5% maximum. The maximum difference in grades between the turning space and the adjacent gutter pan shall 13.3%. The transition between the two surfaces shall be flush.
 - (2) Detectable warnings (Tactile band) shall extend a minimum of 2' in the direction of pedestrian travel and extend the entire width of the curb ramp. Detectable warnings shall be cast iron castings containing truncated domes. Castings shall comply will all provisions of the Americans with Disabilities Act Accessibility Guidelines (ADAAG) and the Public Rights-of-Way Accessibility Guidelines (PROWAG) with Supplements.

- a. Castings shall be cast-in-place truncated dome tactile system, Neenah R-4984, East Jordan Iron Works 700571 (4' ramp), 700721 (5' ramp), or approved equal, at the sizes denoted on the plans. Radial castings shall be East Jordan Iron Works 700621 (20' radius), 700625 (25' radius), 700631 (30' radius) or approved equal, at the sizes denoted on the plans.

- b. Finish shall be Natural Patina or Colonial Red (FED 20109).

- (3) Sidewalk, curb ramps, and portions of the curb that are determined to be out of the acceptable tolerances shall be removed and replaced by the Contractor at no additional cost to the City.

4.3.18.3 Crossspans

Expansion Joints. Expansion joints shall be placed completely through the section at 50' intervals and at curb returns. One-inch (1") smooth steel dowels with sleeves or caps at 2' centers shall be placed in the joint.

4.3.18.4 Driveway Approaches

- (a) Expansion Joints. Expansion joints shall be placed between drive approaches and either existing sidewalk or the driveway beyond the property line.
- (b) Contraction Joints. Contraction joints shall be installed every 10' and shall be insertion of a 1/8" thick steel template at right angles to the curb and 1-1/2" deep into the concrete.

4.4 METHOD OF MEASUREMENT

4.4.1 CURB AND GUTTER

Curb and gutter to be measured in linear feet.

4.4.2 SIDEWALK AND CURB RAMPS

All sidewalk and pedestrian ramps shall be measured in square feet.

4.4.3 CROSSPANS

Crossspans shall be measured in square feet.

4.4.4 DRIVEWAY APPROACHES

Driveway approaches shall be measured in square feet.

4.5 PAYMENT

4.5.1 CURB AND GUTTER

Shall be paid for at the contract unit price, per linear foot, for the actual length of authorized curb and gutter constructed. This item includes all materials such as concrete, forming and form removal, finishing and curing of concrete, grading, compaction, and any other work items required by the plans and specifications.

4.5.2 SIDEWALK AND CURB RAMPS

Payment will be based on the number of square feet constructed in place at the contract unit price per square foot, unless otherwise noted in the bid proposal.

4.5.3 CROSSPANS

Crosspans shall be paid for at the contract unit price for each unit installed by project end. Each gutter apron with a monolithic curb radius shall be paid for separately. This item includes forming and form removal, purchase and placement of concrete, finishing and curing of concrete, grading, compaction, and any other work items required by the plans and specifications.

4.5.4 DRIVEWAY APPROACHES

Driveway Approaches shall be paid for at the contract unit price for each unit installed by project end. This item includes forming and form removal, purchase and placement of concrete, finishing and curing of concrete, grading, compaction, and any other work items required by the plans and specifications.