

The following changes have been made to the Supplemental Specifications:

Section 7.17 – Page 37 – Delete the first paragraph and replace with the following:

CONTRACTOR'S RESPONSIBILITY FOR WORK - The Contractor is responsible for the work until final written acceptance of the project by the Engineer, except as set forth in Section 4.4.B.1. The Contractor shall protect the work against injury or damage from all causes, whether arising from the execution or from the non-execution of the work. The Contractor shall rebuild, repair, restore, and replace all work that is injured or damaged prior to final written acceptance at no additional cost to the Department. Damage to work due to unforeseeable causes beyond the control of and without the fault or negligence of the Contractor, including but not restricted to acts of God, acts of the public enemy or acts of governmental authorities shall be restored by the Contractor at the Department's expense according to subsection 4.2 or 4.3, as applicable.

Section 8.6.B – Page 45 – Delete the 3rd sentence of the 2nd paragraph and replace with the following:

- B. Fixed Completion Date Contracts** - When the contract time is a fixed calendar date it shall be the date on which all work on the project shall be completed. If work is not completed by the date specified, the Engineer will keep a record of working days charged after that date and furnish the Contractor a biweekly statement showing the number of days charged to the contract for the preceding two weeks. The Contractor will be allowed one week in which to file a written protest setting forth in what respect said biweekly statement is incorrect, otherwise, the statement shall be deemed to have been accepted by the Contractor as correct. If the Area Engineer and the Contractor fail to reach an agreement on any statement of working days, the Area Engineer shall refer the statement and the written protest to the Region Engineer for review and final decision.

A working day shall be defined as any calendar day except Saturdays or legal holidays. If a Contractor utilizes a Saturday or holiday for construction work, it will then be considered a working day. The Contractor shall not carry on construction operations on holidays, either prior to, or after the completion date, without written permission from the Region Engineer except for purpose of making emergency repairs and providing proper protection of the work such as curing of concrete. Written permission from the Region Engineer will not be required to carry on construction operations the second Monday in October. Days designated by the Governor of this State as a holiday for State employees, will be considered for working day purposes the same as Saturday.

Section 120.3.B.3.a – Page 69 – Delete and replace with the following:

3. Compaction: Unless the plan notes indicate otherwise, Specified Density Method shall be the method of compaction used.

a. Specified Density Method: Soil shall be compacted within the moisture specification range at not lower than four percentage points below nor more than four percentage points above optimum moisture, in accordance with Table 1, unless otherwise specified. Optimum moisture will be determined in accordance with SD 104 (AASHTO T99). Moisture tests will be determined by SD 108.

Table 1

<u>Optimum Moisture of Embankment Soil</u>	<u>Density Specification (Percent of Maximum Dry Density)</u>	<u>Moisture Specification (Percent of Optimum Moisture)</u>
<u>0% to 15%</u>	<u>95% or Greater</u>	<u>-4% to +4%</u>
<u>15% or Greater</u>	<u>95% or Greater</u>	<u>-4% to +6%</u>

Excess moisture in the embankment material shall be removed by drying operations. ~~The drying shall be carried on until the moisture content is such that the specified density can be attained.~~

Earth embankment shall be compacted to the percentage of maximum dry density specified in Table 1, ~~95 percent of maximum dry density~~ as determined by SD 104 (AASHTO T99) unless otherwise specified.

Roadway embankment within the area bounded by the toe of the berm slope and extending to a line 100 feet (30 meters) from the bridge end shall be compacted to a minimum of 97 percent of maximum dry density as determined by SD 104 (AASHTO T99). Soil used to construct the embankment in this area shall have an optimum moisture of less than 25%.

Density shall be determined in accordance with SD 105 (AASHTO T 191), SD 106 (AASHTO T 205) or SD 114 (AASHTO T 310). The percent compaction shall be calculated after making the proper adjustment for the weight and volume of any aggregate larger than that used in the laboratory compaction procedure.

Prior to placement of granular surfacing materials, the upper 6 inches (150 mm) of subgrade shall be reworked and recompacted to moisture and density requirements. This requirement shall be waived for A-3 and A-2-4(0) soils.

~~Roadway embankment within the area bounded by the toe of the berm slope and extending to a line 100 feet (30 meters) from the bridge end~~

~~shall be compacted to 97 percent of maximum dry density as determined by SD 104 (AASHTO T99).~~

Material retained on a 3/4 inch (19.0 mm) sieve will be considered durable when, after soaking in water for 24 hours, it cannot readily be broken with the fingers and passed through the sieve. When embankment contains over 40 percent by weight of durable material passing an eight inch square (200 mm square) opening and retained on a 3/4 inch (19.0 mm) sieve, specified density requirements will be waived. The embankment shall be compacted with sheepsfoot or other approved rollers to the satisfaction of the Engineer. Moisture requirements will be determined in accordance with SD 104 , except the optimum and field moisture will be determined using material passing a 3/4 inch (19.0 mm) sieve.

When A-1 soil (gravelly) is encountered, density requirements shall be adhered to, the moisture content shall be as needed to obtain density.

When A-3 soil (fine sand) or A-2-4 (0) soil consisting of primarily fine one grain size sandy material is encountered, specified density requirements will be waived. Embankment shall be spread in layers not exceeding an 8 inch (200 mm) loose depth and adequately compacted, with approved vibratory or pneumatic rollers, at the moisture content needed to obtain stability.

Section 380.3.O.2.h – Page 145 – Delete this section and replace with the following:

- h. Incentive Payment:** Incentive payments will be made based on the chart below:

<u>Profile Index Inches per Mile</u>	<u>Profile Index mm/km</u>	<u>Price Adjustment Percent of Contract Unit Price</u>
10.0 or less	160 or less	104.7
10.1 to 15.0	161 to 235	103.5
15.1 to 20.0	236 to 315	102.4
20.1 to 25.0	316 to 395	101.2
25.1 to 35.0	396 to 550	100.00
35.1 to 40.0	551 to 630	97.7
40.1 and greater	631 and greater	grind*

* Pavement at 40.1 (631 mm) and greater shall be corrected (ground or removed and replaced) to a value of 35.0 (550 mm) or less in any 0.1 mile (100 m) section.

Incentive payments cannot be improved due to grinding regardless of the average profile index.

The adjustments in the unit price will apply to the total area of the 0.1 mile-long section. The area will be computed using the total lane width (12 feet [3.7 m] or less) and the total length of the section (0.1 mile [100 m] or less if it is the segment at the end of the days pavement).

Areas excluded from profilograph testing shall be shoulders, transitions, areas within 50 feet (15 m) of existing pavement and bridges, curb and gutter sections, ramps and sharp curves. These areas will be checked for surface deviations using a 10 foot (3 m) straightedge as per Section 380.3 O.1.

Section 380.3.U – Page 148 – Add the following sentence to the end of the first paragraph.

Tolerance in Pavement Thickness: The pavement thickness will be determined by average caliper measurement of cores tested in accordance with AASHTO T 148. Cores shall be sampled in accordance with AASHTO T 24.

Section 460.3.N.2.a – Page 227 – Delete the last sentence of this paragraph:

The surface to be cured shall be entirely covered with burlap mats. The mats shall cover the entire surface with sufficient material beyond the periphery of the area to assure adequate curing of the edges. The mats shall be thoroughly saturated with water and shall be placed with the wettest side down. ~~As an alternate method, the deck may be flooded with water, the burlap placed immediately on the flooded deck and the burlap thoroughly saturated.~~

Section 490.2.D.1 – Page 256 – Delete the first paragraph and replace with the following:

- 1. Concrete:** The test cylinders shall be cured with the beams, or in a similar manner (similar curing method and concrete curing temperature, as approved by the Concrete Engineer) as the beams, until minimum compressive strength has been obtained.

Section 510.3.E – Page 268 – Delete this section and replace with the following:

E. Test Piles: The Contractor shall drive test pile of the lengths shown on the plans and at locations directed. The Contractor shall cooperate with the Engineer in facilitating the keeping of accurate records of driving and shall drive test piles to the bearing ordered by the Engineer. Test piles shall be driven to no more than 120% of the plans required bearing.

Section 510.3.F – Page 268 – Delete this section and replace with the following:

- F. ~~Order Lists for Piling~~**Bearing Piles:** Bearing pile shall be furnished at the specified length, and driven to the required bearing and location as shown on the plans. Bearing Piles shall be driven to no more than 110% of the plans required bearing.~~in accordance with an itemized list furnished by the Engineer. This list will show the number and length of all piles as determined from the results obtained by driving the test piles. The list shall be subject to alteration should unforeseen conditions develop.~~

Section 510.3.H – Page 269 – Delete the third paragraph of this section and replace with the following:

Undamaged Cut-off material ~~with a of adequate~~ length greater than five feet shall~~may~~ be spliced to satisfy minimum pile length requirements. Unused pile cutoffs shall become the property of the Contractor, utilized if possible.~~The cutoff ends shall be retreated in the field in accordance with Section 510.3.G.~~

Section 510.4.A and B – Delete and replace with the following:

- A. ~~Furnishing Piles: Test Piles:~~ The length of test piles remaining in the completed structure will be measured on a lineal foot basis to the nearest foot (0.1 meter). If the actual quantity driven is less than the plans quantity, plans quantity will be used for payment.~~Test piles of the length specified will be measured to the nearest 0.1 foot (0.1 meter).~~

~~Bearing piles of the lengths specified on the order list will be measured to the nearest 0.1 foot (0.1 meter).~~

- B. ~~Driving Piles: Bearing Piles:~~ The length of ~~test or~~ bearing piles remaining in the completed structure will be measured to the nearest lineal foot (0.1 meter). Quantity for test pile will not be included in the measurement of pay footage for bearing piles.

Section 510.4.C – Page 269 – Delete this section.

Section 510.4.D – Page 269 – Delete the second sentence of this paragraph and replace with the following:

Splices: Splices ordered will be measured on a per each basis. Splices that qualify for payment are those required in test and bearing piling due to the specified length being insufficient,~~and those required in bearing piling due to the order list length being insufficient.~~ Payment will not be made for splices used to produce lengths that merely satisfy specified pile lengths.

Section 510.5.A and B – Page 270 - Delete and replace with the following:

- A. ~~Furnishing Test Piles:~~** ~~Test and bearing pile will be paid for at the contract unit prices per lineal foot (0.1 meter). If the plans quantity is greater than the actual quantity driven, the plans quantity will be used for payment. This payment will be full compensation for all labor, equipment, and incidentals necessary for furnishing and driving the piling in the leadstest pile.~~

~~Piles furnished in accordance with this specification but not placed in the leads will be handled as per Section 9.6.~~

- B. Driving Bearing Piles:** The furnishing and driving of steel and timber test and bearing pile will be paid for at their respective contract unit price per lineal foot (0.1 meter). This payment will be full compensation for all labor, equipment and incidentals necessary to furnish and satisfactorily drive the bearing piling. When the final in-place quantity of each size of bearing pile driven and accepted for payment varies from the plans quantity, the Contractor will be compensated for the difference as follows:

1. When the final quantity of each size underruns the total contract quantity by more than five feet times the number of piles, the Contractor will receive 20% of the contract unit price for the entire difference in quantity.
2. When the final quantity of each size overruns the plans quantity, the Contractor will receive the contract unit price plus 10% for the excess over plans quantity.

The provisions of Section 9.6 shall not apply for overruns and underruns in bearing pile quantity.

Section 560.3.B.7 – Page 289 – Insert the following after the third paragraph:

The test cylinders shall be cured with the precast units, or in a similar manner (similar curing method and concrete curing temperature, as approved by the Concrete Engineer) as the precast units, until minimum compressive strength has been obtained.

Section 630.3 - Page 313 - Add the following paragraph at the end of the section:

- D. W Beam End Terminal:** The W beam end terminal to be used shall be the Contractor's choice selected from the approved products list. The W beam end terminal is to be installed according to the manufacturer's installation instructions. A copy of the installation instructions for the W beam end terminal being installed shall be furnished to the Engineer prior to installation. ~~The Contractor shall provide written certification that the W beam end terminal has been installed according to the plans and manufacturer's instructions.~~ Surfacing and embankment shall be placed as detailed on the standard plates.

Section 650.4 – Page 342 – Delete the last sentence of this paragraph and replace with the following.

Concrete curb, gutter and combined curb and gutter will be measured to the nearest linear foot (0.1 meter). Measurement for concrete curb will be on the inside bottom face of the curb. Measurement for separate gutters and combined curb and gutter will be on the inside edge next to the pavement. Deductions will not be made for lengths of drop inlets, grates, etc., or for the tapering of curb for entrances. Separate measurements will be made for ~~straight sections and for curved sections of~~ the various types specified and constructed.

Section 730.2.C – Page 358 – Delete this section and replace with the following:

Seed Testing: Seed shall be tested within 9 months prior to planting, ~~exclusive of the calendar month in which the test was completed.~~ Testing shall be performed by a State Seed Lab, Commercial Seed Testing Lab, or a registered member of the Society of Commercial Seed Analysts (Registered Seed Technologist). A certified test report shall be furnished prior to the start of seeding operations. If the seed is not planted within the 9-month period, the Contractor shall have the seed retested (as described above) for noxious weed seed, dormant seed, hard seed and germination and a new certified test report shall be furnished prior to starting seeding operations. The retest will be based on a sample obtained from the seed out of compliance. A certified test report will not be required on projects where the plans quantity of seed is 100 pounds (45 kilograms) or less.

Section 734.3.C.3.d – Page 373 – Delete this section and replace with the following:

- d. Anchoring:** Prior to anchoring, adjust erosion ~~treatment material~~~~blanket~~ laterally in ditches and channels to bring both edges to the same elevation. ~~Material shall be held in place in accordance with the manufacturer's recommended spacing and pattern, or the following:~~

Material shall be held in place with T pins and/or U shaped wire staples driven vertically through the ~~mesh~~~~blanket~~ into the soil. A line of T pins ~~or U shaped wire staples~~ shall be placed ~~three feet (one meter)~~ apart down the center of the mesh in the low point of the ditch or channel, with heads perpendicular to the centerline of the ditch. ~~Either a~~ row of T pins shall be placed head to head, ~~or U shaped wire staples placed 1 foot (300 mm) apart,~~ across the width of material and every 25 feet (7.5 meters) along the length of the treatment.

At all other points U shaped wire staples shall be placed ~~three feet (one meter)~~ apart in a staggered or diagonal pattern along the edges and in the center of the strips.

Material shall not be drawn taut in stapling. Material which bridges over surface depressions shall be secured with extra staples or T pins to ensure good contact with the soil.

Section 800.2.F – Page 383 – Add the following after the first paragraph:

- F. Uniformity of Grading:** The gradation requirements given in Section 800.2.E represent the extreme limits which shall determine suitability for use from all sources of supply. The gradation from any source shall be uniform and not subject to the extreme percentages of gradation specified above. For the purpose of determining the degree of uniformity, a fineness modulus shall be made upon representative samples from sources proposed for use. Fine aggregate from any source shall maintain a fineness modulus within ± 0.2 from the design mix fineness modulus. If the fineness modulus falls outside this limit contact the Concrete engineer. A new or adjusted design mix may be provided. The uniformity of grading requirements do not apply to fine aggregate for Low slump Dense Concrete and Class M (I) concrete.

For determining the Fineness Modulus (FM) deviation from the representative sample, the average of the five most recent FM tests shall be used. Until five FM tests have been made, base the deviation on the first FM test; then, on the average of the first 2, 3, 4, 5 tests.

Section 820.1 – Page 386 – Delete the entire section and replace with the following:

- A. Coarse Aggregate for Concrete Pavement and Class A Concrete:** The coarse aggregate shall consist of crushed ledge rock conforming to the gradation requirements of Size Number 1.

~~**B. Coarse Aggregate for Class A Concrete:** The coarse aggregate shall consist of gravel, crushed gravel, or crushed rock conforming to the gradation requirement of Size Number 1.~~

- C.B. Coarse Aggregate for Bridge Deck Resurfacing:** The coarse aggregate shall be produced from crushed quarry stone from sources approved by the Engineer. The coarse aggregate shall conform to the gradation requirement of Size Number 3.

- D.C. Coarse Aggregate for Class M (I) Concrete:** Coarse aggregate for Class M (I) Concrete shall meet the gradation requirements for Size Number 1.

- E.D. Coarse Aggregate for Prestressed and Precast Concrete:** The coarse aggregate shall be the product of crushed limestone or quartzite ledge rock or other ledge rock. Coarse aggregate shall meet the gradation requirements of either Size No. 1 or Size No. 1A. The aggregate size shall be consistent

throughout the entire structure. Only one source shall be used to produce each aggregate size.

Section 821.1.A – Page 389 – Delete and replace with the following:

Burlap Cloth made from Jute or Kenaf.....AASHTO M 182-~~Class 3~~
(It will be permissible to use Class 1 or 2 provided it is placed in double layers.)
(A double layer of burlap is required for all classes.)

Section 840.2 – Page 394 – Add the following before the first paragraph:

840.2 SPECIFIC REQUIREMENTS

Granular material of which 30% of the particles retained on the No. 4 (4.75 mm) sieve shall contain one or more fractured faces.

The crushed gravel when mixed with filler, sand, crushed rock, or crushed stone shall meet the following gradation and quality requirements:

Section 840.2 – Page 394 – Add the following to the Sampling and Testing List:

Sampling and Testing:

- Sampling.....SD 201
- Gradation.....SD 202
- L.L. & P.I.....SD 207
- LA Abrasion.....AASHTO T 96
- Soundness Test (Sodium Sulfate Solution, five cycles)SD 220
- Shale Content (less than 1.95 S.G.).....SD 208
- Crushed Particles Test.....SD 211

Section 882.3 – Page 406 – Add the following to the end of the section:

- Sampling SD 201
- Gradation SD 202
- Liquid Limit and Plasticity Index SD 207
- L.A. Abrasion Test AASHTO T 96
- TestingCrushed Particles Test..... SD 211

Section 890.2.F - Page 410 – Delete and replace with the following:

Performance Graded Asphalt Binder shall conform to AASHTO Performance Graded Binder Specification (MP1) and the Combined State Binder Group Method of Acceptance for Asphalt Binders.

The asphalt binder shall, if necessary, be blended at the terminal with permissible additives styrene-butadiene styrene (SBS) or styrene-butadiene rubber (SBR) necessary

to meet the specifications. The type of modifier supplied shall be listed on the certificate of compliance. Air blown asphalts and other modifiers will not be allowed.

SHRP Performance Graded Asphalt Binders PG 58-34, PG 64-28, PG 64-34 and PG 70-28 shall also meet the following requirements:

<u>Test</u>	<u>Specification</u>	<u>Test Method</u>
<u>Elastic Recovery, RTFO Residue, 77° F (25°C), %</u>	<u>Min 60</u>	<u>AASHTO T301</u>

Section 890.2.K – Page 414- Add Table 4 after Table 3:

TABLE 4 Requirements for Polymer Modified Emulsified Asphalt

Emulsions shall comply with AASHTO M 140, with the following exceptions:

	HFMS-2P		HFRS-2P	
	Min	Max	Min	Max
<i>TESTS ON EMULSIONS:</i>				
Viscosity, Saybolt Furol @ 122°F (50 °C)	3550	200 400	7550	400
Storage Stability Test (see note 1)	Passes		Passes	
Cure Test (see note 2)	Passes		Passes	
Sieve (%)		0.1		0.1
Demulsibility 50ml 0.10 N CaCl ₂ , %	40		40	
Demulsibility 50ml 0.02 N CaCl ₂ , %			30	
Distillation Oil Distillate, by Volume of Emulsion %		3.0		3.0
<i>TESTS ON RESIDUE FROM DISTILLATION TESTS:</i>				
Penetration @ 77° F (25°C)	100	200	100	200
Ductility @ 39° F (4°C) 5cm/min., cm	30		30	
Softening Point (R&B) Deg. F	100		100	
Elastic Recovery (Iowa Method Test No. 631)	55		55	
Float Test @ 140°F (60°C), sec	1200		1200	
<u>Residue by Distillation, %</u>	<u>65</u>		<u>65</u>	

Note 1: Storage Stability: In addition to requirements of AASHTO T-59, on examination of the test cylinder after the emulsion has been standing undisturbed for 24 hours, the surface shall show no white, milky covered substance but shall be a homogenous brown color throughout.

Note 2: The cure test is performed as follows: Pour approximately 1 gram of (HFMS-2P or HFRS-2P) emulsion onto a metal surface (lid of a 3oz. Ointment tin). Allow the test

sample to cure at temperatures of at least 80° F under a heat light for 4 hours. The outdoor sunlight may be used as a testing site. After the 4-hour curing period, the (HFMS-2P or HFRS-2P) emulsion shall show no tackiness or tendency to stick to the fingers when pressed.

Section 982.2.C – Page 445 – Insert the following paragraph after the first paragraph:

Anchor plates for perforated tube posts and flanged channel posts shall be galvanized in accordance with ASTM A123, or painted with a dark green high quality enamel. The steel plates shall be trapezoidal in shape with bases of 6 and 12 inches (150 mm and 300 mm), a depth of 6 inches (150 mm), and shall be either 10 gauge, 1/8” (3 mm), or 1/4” (6 mm) in thickness. The steel shall meet the requirements of ASTM A36 or ASTM A1011 Structural Steel grade 36. Bolt holes of 3/8” (9mm) shall be provided centered on the plate with a spacing of 4 inches (100 mm). Punching or boring of holes shall be done prior to painting. If galvanized plates are used, the punching or boring of holes will be allowed after galvanizing.

Section 982.2.C.1 – Page 445 – Delete the first paragraph and replace with the following:

- 1. Perforated Tube Posts:** Perforated tube posts shall conform to ASTM A 653, Grade 33 (230), modified to 42,000 psi (290 MPa) minimum yield strength, or shall conform to ASTM A ~~570 with a minimum yield strength of 50,000 psi (345 MPa).~~1011 Structural Steel Grade 50 (340).

Section 982.2.C.2 – Page 446 – Delete the ninth paragraph.

~~Anchor plate material shall be steel meeting the requirements of ASTM A 499. Anchor plates shall be galvanized or painted with dark green, high quality enamel. Punching or boring shall be done prior to galvanizing or painting.~~

Section 982.2.F.3 – Page 447 –Delete and replace with the following:

- 3. Anchor Plates:** ~~Anchor plates shall be painted steel plates of trapezoidal shape with bases of 6 and 12 inches (150 and 300 mm), a depth of 6 inches (150 mm) and 1/8 inch (3 mm) thick. Bolt holes of 3/8 inch (9.5 mm) shall be provided centered on the plate with a spacing between holes of 4 inches (100 mm).~~Anchor plates shall be galvanized in accordance with ASTM A123, or painted with a dark green high quality enamel. The steel plates shall be trapezoidal in shape with bases of 6 and 12 inches (150 mm and 300 mm), a depth of 6 inches (150 mm), and shall be either 10 gauge, 1/8” (3 mm), or 1/4”(6 mm) in thickness. The steel shall meet the requirements of ASTM A36 or ASTM A1011 Structural Steel grade 36. Bolt holes of 3/8” (9mm) shall be provided centered on the plate with a spacing of 4 inches (100 mm). Punching or boring of holes shall be

done prior to painting. If galvanized plates are used, the punching or boring will be allowed after galvanizing.

Section 982.2.G.4 – Page 448 – Delete and replace with the following:

4. **Anchor Plates:** ~~Anchor plates shall be painted steel plates of trapezoidal shape with bases of 6 and 12 inches (150 and 300 mm), a depth of 6 inches (150 mm) and 1/8 inch (3 mm) thick. Bolt holes of 3/8-inch (9.5 mm) shall be provided centered on the plate with a spacing between holes of 4 inches (100 mm). Anchor plates shall be galvanized in accordance with ASTM A123, or painted with a dark green high quality enamel. The steel plates shall be trapezoidal in shape with bases of 6 and 12 inches (150 mm and 300 mm), a depth of 6 inches (150 mm), and shall be either 10 gauge, 1/8" (3 mm), or 1/4"(6 mm) in thickness. The steel shall meet the requirements of ASTM A36 or ASTM A1011 Structural Steel grade 36. Bolt holes of 3/8" (9mm) shall be provided centered on the plate with a spacing of 4 inches (100 mm). Punching or boring of holes shall be done prior to painting. If galvanized plates are used, the punching or boring will be allowed after galvanizing.~~

Section 985.1.E.3 – Page 460 – Delete and replace with the following:

3. Anchorage Method:

- a. Anchor bolts shall either be threaded full length or ~~swaged equipped with a satisfactory mechanical end anchorage. Details for any mechanical end anchorage shall be included in the shop plans for prior approval. Submit proposed alternate mechanical anchorage details for prior approval.~~ Swaged anchor bolts and anchor bolts with hooked end anchorage are not allowed.
- b. ~~**Swaged Anchorage:** A minimum of 20 % of the embedded bolt surface shall be covered with deformations whose radial dimensions are 15% to 20% of the bolt diameter.~~