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REPUBLIC OF THE PHILIPPINES
DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS
OFFICE OF THE SECRETARY
MANILA

16 MAR 2018

DEPARTMENT ORDER)
)
No. 40)
Series of 2018) 03.20.18

SUBJECT: DPWH Standard Specification for ITEM 419 – Corrugated Steel Plate (CSP)

In line with the continuing efforts to upgrade the construction technology thru adoption of innovative technologies, this Department has approved the DPWH Standard Specification for **ITEM 419 – Corrugated Steel Plate (CSP)**, subject to the Specification hereto attached.

This Standard Specification will form part of the on-going revision of the DPWH Standard Specifications for Highways, Bridges and Airports, Volume II, 2012 Edition.

This Order shall take effect immediately.

MARK A. VILLAR
Secretary

14.1.2 FET/RGT

DPWH Standard Specification for
ITEM 419 – Corrugated Steel Plate (CSP)

419.1 Description

This Item shall consist of furnishing and placing of prefabricated Corrugated Steel Plate (CSP) of the type, size, shape and grade required in accordance with this Specification and in conformity with the requirements shown on the Plans or as directed by the Engineer.

419.2 Material Requirements

419.2.1 CSP Corrugation Type

Table 419.1 - Corrugation Type

Type	Thickness (t) mm	Pitch (p) mm	Depth (d) mm	Radius (r) mm
Deep Corrugated Steel Plate	3.0 - 8.0	400	150	81
Multi-Plate	2.7 - 7.0	150	50	28.6

Deep Corrugated Steel Plate is used for heavy load condition and long span structures like open-cut tunnel, long span culvert and bridge.

Multi Plate is usually used for light load condition and shorter opening structures like pipe (a conduit having a full circular shape) and for pipe-arch (a pipe shape consisting of an approximate semi-circular top portion, small radius corners, and large radius invert).

419.2.2 CSP Fabrication

1. Sinusoidal Corrugation

CSP shall be fabricated from flat sheets or plates, punched for bolted lap seams, and curved to the required radius. Corrugations shall form smooth continuous curves and tangents and annular rings (complete or partial) about the axis of the structure.

2. Plate Tolerances

The plate thickness shall be measured on the tangents of the corrugations. The thickness shall include both the base metal and the coating. The required minimum thickness of the plate must not be lesser than the specified thickness minus 0.3 mm. There is no limit on over-thickness. Cross-section dimensions, such as diameter, span and rise, and radius of curvature, shall be measured to the inside crest of corrugations. The span and rise of pipe-arch, arch, underpass, and other noncircular structures shall be as specified within ±2 percent.

3. Bolt holes

The bolt holes shall be punched ahead of bending and plates having like dimensions, curvature, and same size and number of bolts per foot of seam can be interchangeable.

Holes shall be provided as required for connecting headwall anchors, structural reinforcement, and miscellaneous attachments.

For 150 mm x 50 mm corrugations, the diameter of the bolt holes in the longitudinal seams shall not exceed the bolt diameter by more than three (3) mm except those in plate corners. Bolt holes in circumferential seams, including plate corners, shall be round holes with the diameter not exceeding the bolt diameter by more than six (6) mm, or shall be slotted holes with a width equal to the bolt diameter plus three (3) mm and a length equal to the bolt diameter plus ten (10) mm.

For 400 mm x 150 mm corrugations, the diameter of bolt holes in the longitudinal seams shall not exceed the bolt diameter by more than six (6) mm, except for those in the plate corners and two (2) other locations (aligned with the center hole of the group of three (3) corner holes, and in adjacent corrugations) which will be the same as the circumferential holes. The bolt holes in the circumferential seams shall be slotted holes with a width not greater than the bolt diameter plus five (5) mm and a length not greater than the bolt diameter plus 110 mm.

4. Plate Section Properties

The plate shall conform to the requirement of Table 419.2 - Deep Corrugated Steel Plate Section Properties (400 mm x 150 mm) or by Table 419.3 - Multi-Plate Section Properties (150 mm x 50 mm). Thickness shall be measured on the tangents of the corrugations. The thickness shall include both the base metal and the coating.

Table 419.2 - Deep Corrugated Steel Plate Section Properties (400 mm x 150 mm)

Specified Thickness mm	Area of Section, A mm^2/mm	Moment of Inertia, I mm^4/mm	Radius of Gyration, r mm
3.0	3.905	10,886	52.80
4.0	5.351	14,944	52.85
5.0	6.811	19,060	52.90
6.0	8.260	23,154	52.95
7.0	9.640	27,071	52.99

Table 419.3 - Multi Plate Section Properties (150 mm x 50 mm)

Specified Thickness mm	Area of Section, A mm^2/mm	Moment of Inertia, I mm^4/mm	Radius of Gyration, r mm
3.0	3.522	1,057.25	17.326
4.0	4.828	1,457.56	17.325
5.0	6.149	1,867.12	17.425
6.0	7.461	2,278.31	17.475
7.0	8.712	2,675.11	17.523

419.2.3 Steel

Steel shall be produced by the electric or oxygen process.

Steel shall have the chemical composition specified in Table 419.4 - Chemical Composition of Steel.

Steel used for manufacturing structural plate products shall have the mechanical properties specified in Table 419.5 - Mechanical Properties of Structural Plate.

Table 419.4 - Chemical Composition of Steel

Properties	Heat analysis, % Maximum	Specification
Phosphorous	0.04	ASTM A1018M*
Sulphur	0.04	ASTM A1018M*

*ASTM A1018M, Standard Specification for Steel, Sheet and Strip, Heavy-Thickness Coils, Hot Rolled, Carbon, Commercial, Drawing, Structural, High Strength Low Alloy, High Strength Low Alloy with Improved Formability, and Ultra-High Strength

Table 419.5 - Mechanical Properties of Structural Plate

Material	Minimum Yield Strength MPa	Minimum Tensile Strength MPa	Minimum Elongation in 50mm %	Specification
Structural Steel Plate SS-(Grade 40)	275	380	19	ASTM A1018M
High Strength Low-Alloy Steel HSLAS-(Grade 50)	340	450	20	ASTM A1018M
High Strength Low-Alloy Steel HSLAS-(Grade 65)	450	550	14	ASTM A1018M

419.2.4 Bolts and Nuts

Bolts shall be M20 (20 mm Ø) or M22 (22 mm Ø).

Bolts and nuts shall conform to the requirements specified in ASTM A761M, Standard Specification for Corrugated Steel Structural Plate, Zinc-Coated, for Field-Bolted Pipe, Pipe-Arches, and Arches, Table 2, Bolt and Nut Requirements. Bolts shall have sufficient length to provide at least "full nut" engagement when tightened in place.

Washers may not be required.

419.2.5 Rubber Gaskets

Gaskets shall conform to ASTM C564, Standard Specification for Rubber Gaskets for Cast Iron Soil Pipe and Fittings or equivalent.

419.2.6 Base Channel

The base channel on footing shall be formed in accordance with the approved Plans and Specifications. It shall be formed from five (5) mm thick galvanized steel. The zinc coating mass (total on both sides) on the base channel shall not be less than 910 g/m^2.

Bolt holes for anchoring bearings to foundation shall be punched as shown on the Plans, with a spacing that is a multiple of the structural plate pitch, but not more than 600 mm on centers. Bolt holes shall be punched in the vertical leg of bearings to match corresponding bolt holes in the bottom arch plate.

419.2.7 Anchorage Bolts and Nuts

Anchorage bolts shall be M20 in diameter.

Bolts and nuts for head wall anchorage and for anchoring arch bearings to foundation shall be fabricated as shown on the Plans and shall conform to the requirements of ASTM A761M, Table 2, Standard Specification for Corrugated Steel Structural Plate, Zinc-Coated, for Field-Bolted Pipe, Pipe-Arches and Arches.

Table 419.6 - CSP Structure Material Components

Type	Dimensions	Length (mm)	Specification
Bolts	M20, M22	55 / 75	ASTM A761M
Nuts	M20, M22	-	ASTM A761M
Anchor bolts	M20	225 / 305	ASTM A761M
Base channel (Deep Corrugated Steel Plate)	180 x 175 x 35	3600	ASTM A761M
Base channel (Multi-Plate)	118 x 76 x 45	3600	ASTM A761M

419.2.8 Coating

The zinc coating of all fabricated parts shall be as specified in ASTM B6, Standard Specification for Zinc. The zinc coating mass on both sides shall be not less than 910 g/m^2.

For aluminum coated CSP, it shall be in accordance to ASTM A463M, Standard Specification for Steel Sheet, Aluminum-Coated, by the Hot-Dip Process.

419.2.8.1. Repair of Damage Coating

Plate or accessory material on which the metallic coating has been burned by welding, or has been otherwise damaged in fabricating or handling shall be repaired. The repair shall be done so that the completed material shall show careful finished workmanship in all

particulars. Zinc-rich paint shall be applied to a dry film thickness of at least 0.013 mm over the damaged section and surrounding cleaned area.

In the case that aluminum coating was applied, the aluminum coating mass on both sides shall be not less than 300 g/m^2.

419.2.9 Sampling and Testing

Sampling and testing of plate for chemical composition shall be in accordance to ASTM A751, Standard Test Methods, Practices, and Terminology for Chemical Analysis of Steel Products. Mechanical requirements shall be according to the procedure for sheet-type specimens in AASHTO T 244, Standard Method of Test for Mechanical Testing of Steel Products.

419.2.9.1 Coating Mass Determination

Coating mass shall be determined according to AASHTO T 65M, Standard Method of Test for Mass [Weight] of Coating on Iron and Steel Articles with Zinc or Zinc-Alloy Coatings, using a specimen with an area of 3,000 mm^2 or greater. The average coating mass shall be the average of three (3) or more single-spot tests, each taken from different plates in the order. Alternately, the coating mass may be determined by the x-ray fluorescence procedure according to ASTM A754M, Standard Test Method for Coated Weight (Mass) of Metallic Coatings on Steel by X-ray Fluorescence.

419.2.9.2 Mechanical Test

Determine the mechanical properties on plate prior to corrugating or other fabrication, except testing by the purchaser after fabrication is permitted for tensile and yield strengths. The plate shall comply with the requirements of Table 419.5 - Mechanical Properties of Structural Plate.

419.3 Construction Requirements

419.3.1 Site Preparation

1. Check alignment in relation to the Plans as well as the actual site conditions.
2. Make the CSP(s) necessary appurtenances and ensure that these are correct.
3. Excavate to the correct width, line and grade.
4. Provide a uniform and stable foundation.

419.3.2 CSP Assembly

419.3.2.1 Structural Assembly

The final installed shape shall be within the design criteria, exhibit smooth uniform radii, and provide acceptable clearances for its intended use. Structures having a span greater than six (6) m shall be within two (2) percent of the calculated dimensions as given in ASTM A761M before structural backfill placement.

419.3.2.2 Bolts and Bolt Torque

It is advisable not to tighten bolts on the loosely assembled structure within a distance of nine (9) m of where plate assembly is ongoing. All bolts shall be tightened using an applied torque of between 135 N·m and 405 N·m. It is important not to over torque the bolts.

419.3.3 Backfilling

419.3.3.1 Structural Backfill Materials

The type of compacted density and strength properties of the soil envelope immediately adjacent to the CSP shall be established. Good side-fill material is considered to be a granular material with little or no plasticity and free of organic material. Soils meeting the requirements of Groups GW, GP, GM, GC, SW, and SP as described in ASTM D2487, Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System) are acceptable, when compacted to 90 percent of maximum density as determined by ASTM D698, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort [12400 ft-lb/ft^3 (600 kN-m/m^3)].

419.3.3.2 General

Regular backfill shall consist of tested or accepted materials and shall be placed and compacted as required by job specifications. Large boulders shall not be permitted in regular backfill in trenches that are under surface structures. Construction equipment shall not be used over or alongside the CSP without sufficient compacted soil in between it and the CSP to prevent distortion, damage, or overstressing.

The Contractor shall set up a shape monitoring system, prior to placement of structural backfill, to aid in establishing and maintaining proper installation procedures. Direct measurement of span and rise, offset measurements from plumb bobs hanging over reference points, and similar types of measurements are effective means for monitoring shape change during backfill placement and compaction.

419.3.3.3 Placement

The backfill shall be placed and compacted in layers not exceeding 200 mm of compacted thickness, with each layer compacted to the required density prior to the addition of the next layer. The difference in levels of structural backfill on the two sides of a conduit at any transverse section shall not exceed 200 mm. The structural backfill within 300 mm of the conduit walls shall be free of stones exceeding 75 mm in any dimension. Heavy equipment shall not be allowed within one (1) m of the conduit walls.

All equipment runs parallel to the length of the installed CSP until such time as the elevation of the backfill reaches a point that is at three-fourth (3/4) of the rise of the structure.

Where space permits, sheep foot, rubber-tired and other types of tamping rollers can be used to compact backfill around the structure. If rollers are used, fill adjacent to the structure shall be tamped with hand-held power equipment. Be sure to keep the rollers from hitting the structure. Mechanical soil compaction of layers is preferred.

Pedestrian-type compactors are used for close work, while heavier self-propelled vibratory drum compactors are used away from the structure and for the rest of the soil envelope once minimum cover is achieved. Hand work, or very light equipment, is used over the top of the structure until minimum cover is achieved for the rest of the soil envelope once minimum cover is achieved.

All equipment shall be in accordance with all the requirements of Subsection 106.2.1-Compaction Equipment of Item 106 - Compaction Equipment and Density Control Strips.

419.3.3.4 Minimum Clear Spacing between Conduits

For multi span structures, the minimum clear spacing between adjacent conduits shall be 900 mm.

419.3.3.5 Deformation during Backfilling

For all conduit shapes, the upward or downward crown deflection shall not exceed ± 2 percent of the rise unless approved by the Engineer. Longitudinal and transverse alignment shall be maintained.

419.3.4 Quality Control

419.3.4.1 Material Inspection

1. Check the pitch and depth of corrugations of plates
2. Provide a uniform and stable foundation.
3. Unload, handle and store the CSP correctly.

419.3.4.2 Checking Section Displacement

Check CSP structure after assembly, during backfilling and after construction. It shall be checked for changes in size and shape of section. On every stage of construction, three (3) or more spots shall be checked for displacement. If the displacement exceeds the tolerance, the construction shall be stopped immediately to find out the cause and conduct the treatment to reduce the displacement to within the tolerance range of ±2 percent rise of structure.

419.5 Method of Measurement

The quantity to be paid for shall be in square meter of specified CSP actually completed and accepted by the Engineer, that area of CSP encompass all of its ancillary materials.

419.6 Basis of Payment

The accepted quantity shall be paid for at the contract unit price for CSP, which price and payment shall be full compensation for furnishing and placing all materials including all labor, equipment, tools and incidentals necessary to complete this Item.

Payment shall be made under:

Pay Item Number	Description	Unit of Measurement
419 (1)	Corrugated Steel Plate	Square Meter

References:

1. *ASTM A761 / A761M -15, Standard Specification for Corrugated Steel Structural Plate, Zinc-Coated, for Field-Bolted Pipe, Pipe-Arches, and Arches*
2. *ASTM A1018/A1018M – 15, Standard Specification for Steel, Sheet and Strip, Heavy – Thickness Coils, Hot-Rolled, Carbon, Commercial, Drawing, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength*
3. *ASTM A 807/A 807M – 02, Standard Practice for Installing Corrugated Steel Structural Plate Pipe for Sewers and Other Applications*
4. *ASTM A 463/A 463M -02a, Standard Specification for Steel Sheet, Aluminum-Coated, by the Hot-Dip Process.*
5. *ASTM A 754 / 754M – 2000, Standard Test Method for Coating Weight (Mass) of Metallic Coatings on Steel by X-Ray Fluorescence*
6. *ASTM A796/A796M -15A, Standard Practice for Structural Design of Corrugated Steel Pipe, Pipe-Arches, and Arches for Storm and Sanitary Sewers and Other Buried Applications*
7. *ASTM A 798/A 798M – 01, Standard Practice for Installing Factory-Made Corrugated Steel Pipe for Sewers and Other Applications*
8. *ASTM D 2487 – 00, Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)*
9. *ASTM A449 Standard Specification for Hex Cap Screws, Bolts and Studs, Heat Treated, 120/105/90 ksi Minimum Tensile Strength, General Use*
10. *ASTM A563 Standard Specification for Carbon and Alloy Steel Nuts*
11. *ASTM A153 Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware*
12. *CSA G401 Corrugated Steel Pipe Products*
13. *CSA-S6-06 Canadian Standard Association (CHBDC Canadian Highway Bridge Design Code) Section*
14. *Corrugated Steel Pipe Institute (2007), Handbook of Steel Drainage and Highway Construction Products*
15. *DPWH Standard Specifications for Public Works and Highways: Volume II, Highways, Bridges and Airports (2012*