Designation: B790/B790M – 16 (Reapproved 2021)

Standard Practice for Structural Design of Corrugated Aluminum Pipe, Pipe-Arches, and Arches for Culverts, Storm Sewers, and Other Buried Conduits[1]

This standard is issued under the fixed designation B790/B790M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This practice is intended for the structural design of corrugated aluminum pipe and pipe-arches, and aluminum structural plate pipe, pipe-arches, and arches for use as culverts and storm sewers and other buried conduits. This practice is for pipe installed in a trench or embankment and subjected to highway, railroad, and aircraft loadings. It must be recognized that a buried corrugated aluminum pipe is a composite structure made up of the aluminum ring and the soil envelope, and both elements play a vital part in the structural design of this type of structure.

1.2 Corrugated aluminum pipe and pipe-arches shall be of annular fabrication using riveted seams, or of helical fabrication having a continuous lockseam.

1.3 Structural plate pipe, pipe-arches, and arches are fabricated in separate plates that when assembled at the job site by bolting form the required shape.

1.4 This practice is applicable to design in inch-pound units as Specification B790 or in SI units as Specification B790M. Inch-pound units and SI units are not necessarily equivalent. SI units are shown in brackets in the text for clarity, but they are the applicable values when the design is done in accordance with Specification B790M.

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.6 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

B745/B745M Specification for Corrugated Aluminum Pipe for Sewers and Drains

B746/B746M Specification for Corrugated Aluminum Alloy Structural Plate for Field-Bolted Pipe, Pipe-Arches, and Arches

B788/B788M Practice for Installing Factory-Made Corrugated Aluminum Culverts and Storm Sewer Pipe

B789/B789M Practice for Installing Corrugated Aluminum Structural Plate Pipe for Culverts and Sewers

B864/B864M Specification for Corrugated Aluminum Box Culverts

D698 Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft^3 (600 kN-m/m^3))

D1556 Test Method for Density and Unit Weight of Soil in Place by Sand-Cone Method

D2167 Test Method for Density and Unit Weight of Soil in Place by the Rubber Balloon Method

D2487 Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)

D2937 Test Method for Density of Soil in Place by the Drive-Cylinder Method

D6938 Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

2.2 *FAA Standards:*[3]

AC No. 150/5320-5D Advisory Circular, "Airport Drainage Design" Department of Transportation, Federal Aviation Administration

[1] This practice is under the jurisdiction of ASTM Committee B07 on Light Metals and Alloys and is the direct responsibility of Subcommittee B07.08 on Corrugated Aluminum Pipe and Corrugated Aluminum Structural Plate.

Current edition approved Dec. 1, 2021. Published December 2021. Originally approved in 1990. Last previous edition approved in 2016 as B790/B790M – 16. DOI: 10.1520/B0790_B0790M-16R21.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from Standardization Documents Order Desk, DODSSP, Bldg. 4, Section D, 700 Robbins Ave., Philadelphia, PA 19111-5098. http://www.faa.gov/airports/resources/advisory_circulars/index.cfm/go/document.current/documentNumber/150_5320-5

2.3 *AASHTO Standards:*[4]
LRFD Bridge Design Specifications
LRFD Bridge Construction Specifications
2.4 *Other Standards:*[5]
American Railway Engineering and Maintenance-Of-Way Association (AREMA) Guidelines

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *arch, n*—a pipe shape that is supported on footings and does not have a full metal invert.

3.1.2 *bedding, n*—the earth or other material on which the pipe is laid consist of a thin layer of important material on top of the in-situ foundation.

3.1.3 *haunch, n*—the portion of the pipe cross section between the maximum horizontal dimension and the top of the bedding.

3.1.4 *invert, n*—the lowest portion of the pipe cross section; also, the bottom portion of the pipe.

3.1.5 *pipe, n*—a conduit having a full circular shape or, in a general contex, all structure shapes covered by this practice.

3.1.6 *pipe-arch, n*—a pipe shape consisting of an approximate semicircular top portion, small radius corners, and large radius invert.

3.1.7 *long span structures, n*—special shapes of any size having a crown or side radius greater than 13.0 ft [4000 mm]. Metal box culverts (rise/span ≤ 0.3) are not considered long-span structures and are discussed in Specification B864/B864M.

4. Symbols

4.1 The symbols used in this practice have the following significance:

A = required wall area, in.^{2}/ft [mm^2/mm],
AL = maximum highway design axle load, lbf [N],
d = depth of corrugation, in. [mm],
E = modulus of elasticity, 10×10^6 lbf/in.^{2} [69×10^3 MPa],
EL = earth load, lbf/ft^2 [kPa],
fc = critical buckling stress, lbf/in.^{2} [MPa],
FF = flexibility factor, in./lbf [mm/N],
Fu = specified minimum tensile strength,
= 31 000 lbf/in.^{2} [215 MPa] for corrugated aluminum pipe in accordance with Specification B745/B745M using Alclad Alloy 3004–H34,
= 27 000 lbf/in.^{2} [185 MPa] for corrugated aluminum pipe in accordance with Specification B745/B745M using Alclad Alloy 3004–H32,
= 35 500 lbf/in.^{2} [245 MPa] for 0.100 through 0.150 in. [2.52 through 3.81 mm] thick aluminum structural plate in accordance with Specification B746/B746M,
= 34 000 lbf/in.^{2} [235 MPa] for 0.175 through 0.250 in. [4.44 through 6.35 mm] thick aluminum structural plate in accordance with Specification B746/B746M,
Fy = specified minimum yield strength,
= 24 000 lbf/in.^{2} [165 MPa] for corrugated aluminum pipe in accordance with Specification B745/B745M using Alclad Alloy 3004–H34,
= 20 000 lbf/in.^{2} [140 MPa] for corrugated aluminum pipe in accordance with Specification B745/B745M using Alclad Alloy 3004–H32,
= 24 000 lbf/in.^{2} [165 MPa] for all other corrugated aluminum pipe and structural plate in accordance with Specification B746/B746M,
H = depth of fill above top of pipe, ft [m],
H_{max} = maximum depth of fill, ft [m],
H_{min} = minimum depth of fill, ft [m],
I = moment of inertia of corrugation, in.^{4}/in. [mm^4/mm], see Tables 2-7),
IL = impact load, lbf/ft^2 [kPa],
k = soil stiffness factor (0.22 for good sidefill material compacted to a minimum of 90 % of standard density based on Test Method D698),
LL = live load, lbf/ft^2 [kPa],
P = total design load or pressure, lbf/ft^2 [kPa],
P_f = factored crown pressure, lbf/ft^2 [kPa],
r = radius of gyration of corrugation, in. [mm], see Tables 1-7,
r_c = corner radius of pipe-arch, ft [mm],
R_f = factored resistance for each limit state, lbf/ft [kN/m],
R_n = nominal resistance for each limit state, lbf/ft [kN/m],
s = pipe diameter or span, in. [mm],
S = pipe diameter or span, ft [m],
SF = safety factor,
SS = required seam strength, lbf/ft [kN/m],
T = thrust in pipe wall, lbf/ft [kN/m], and
T_f = factored thrust in pipe wall, lbf/ft [kN/m],
W = the unit force derived from 1 ft^3 [m^3] of fill material above the pipe, lbf/ft^3 [kN/m^3]. When the actual fill material is not known, use 120 lbf/ft^3 [19 kN/m^3],
φ = resistance factor.

[4] Available from American Association of State Highway and Transportation Officials (AASHTO), 444 N. Capitol St., NW, Suite 249, Washington, DC 20001, http://www.transportation.org.
[5] Available from AREMA Headquarters, 4501 Forbes Blvd., Suite 130, Lanham, MD 20706, Tel: +1.301.459.3200 / Fax: +1.301.459.8077, www.arema.org