NATIONAL CORRUGATED STEEL PIPE ASSOCIATION **ISSUED: March 2001**

Technote 202

NCSPA Technical Notes are prepared by the NCSPA Technical Advisory Committee to provide up-to-date technical information about drainage structures and their proper use and application. User comments or questions are welcome. ■ *Technical Notes are not intended for detailed design purposes.*

Coupling Systems for Corrugated Steel Pipe

CSP COUPLING SYSTEMS

There are a number of types of coupling bands, coupling sleeves, and gasket systems for CSP. Each has its own special advantages. It is important to select the proper coupling for the application. Beyond tightness, the strength to maintain alignment and resist pull-apart forces are also important.

The functional requirements for pipe couplers are specified in the AASHTO Bridge Design Specification, Section 26.4.2 (see page 3).

PERFORMANCE CRITERIA

Regardless of the piping material (corrugated metal, concrete or plastic), pipe couplers must provide the proper degree of tightness while providing the necessary strength to maintain its performance over the design life. There are two general classifications of systems, **Standard Couplers** and **Gasketed Couplers**.

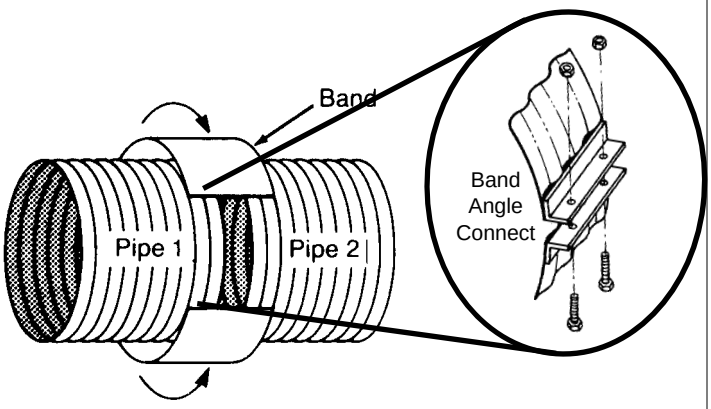
A. Standard Couplers

Standard coupler systems maintain structural integrity of the pipe connection while reducing the infiltration of soil particles into the pipe without the use of a gasket material. The specifier should consider the backfill surrounding the coupler along with the flow conditions the pipe will experience. Course sand and gravel, and fine clay materials, with a plastic index greater than 12, are generally too large or well adhered to infiltrate. Pipes with annular re-rolled ends and external coupling bands, that form a tight metal-to-metal contact around the pipe, provide adequate tightness to limit infiltration of courser backfill materials.

When pipe is buried in a silt or fine sand backfill and flows rise and fall quickly, tighter systems may be necessary. These very fine, granular backfill materials can be prevented from infiltrating into a pipe by providing a geotextile wrap around the exterior of the pipe. See AASHTO Section 26.4.2.4(e).

B. Gasketed Couplers

In those rare instances where excessive leakage may occur, a gasketed coupling system may be required. Leakage limits are dictated by specific project conditions such as when the pipe system is located below the groundwater table or when it is carrying hazardous pollutants. Gasketed coupling systems required to meet specific leakage limits should be pre-qualified through plant or laboratory testing, with the test conducted in a zero pressure environment. True "watertight" systems are rarely required.



Typical connecting band is wrapped around the joint and drawn together.

Table 1 Coupling Bands For Corrugated Steel Pipe

Type of Band	Cross Section	Gaskets					Pipe End		
		Angles	Bar Bolt, & Strap	O-Ring	Sleeve or Strip	Mastic	Annular Plain	Helical Plain	Helical Reformed
Universal		X	X	X	X	X	X	X	X
Corrugated		X	X		X	X	X		X
Semi-Corrugated		X	X	X		X	X	X	
Channel		X	X			X	X		X
Flat		X	X	X	X	X	X	X	X
Wing Channel		X	X			X			X

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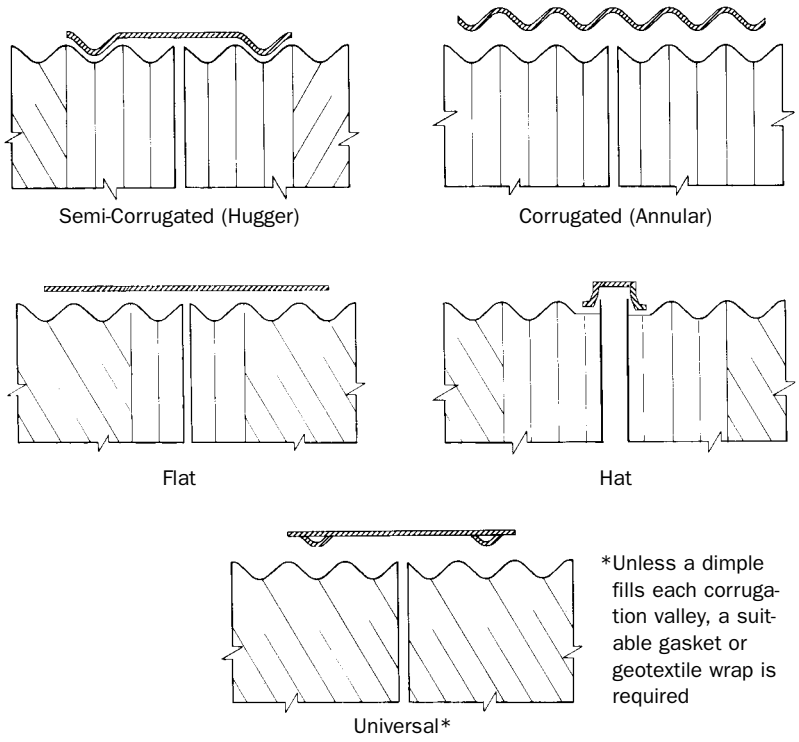
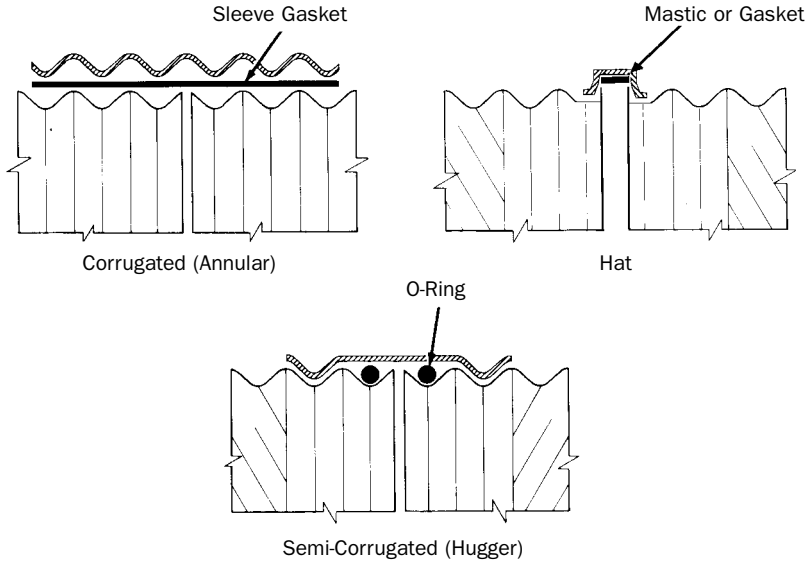
The following drawings illustrate and define the types of couplers that can be specified in order to meet the required performance criteria.

Standard Couplers



*Unless a dimple fills each corrugation valley, a suitable gasket or geotextile wrap is required

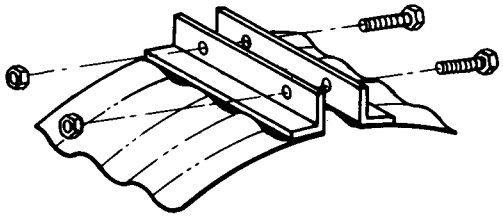
Gasketed Couplers



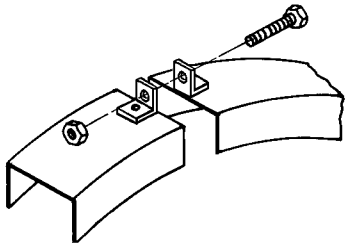
Standard CSP Band Connectors

The following band connectors are used with CSP coupling systems:

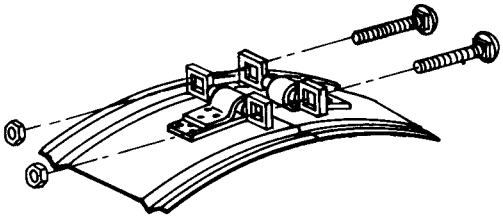
Band Angle Connector



Clip or Lug Angle Connector



Bar and Strap Connector

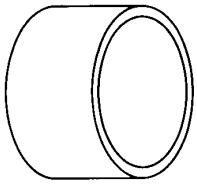


For unusual conditions (i.e., extreme disjointing forces, slip-lining pipe inside existing pipe, jacking or boring pipe, high pressures, and deep vertical drop inlets), a variety of special designs are available or a new special coupler may be designed by the manufacturer to meet required parameters.

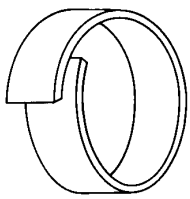
Gaskets and Geotextile Wraps

When infiltration is anticipated at the coupling point, the specifier may require inexpensive geotextile wraps that eliminate soil migration. The most common types of gaskets are shown below.

O-Ring Gasket



Sleeve Gasket



Strip Gasket or Geotextile Wrap

STRUCTURAL DESIGN FOR CSP COUPLERS

With any pipe material, adequate shear and moment strength levels are necessary to ensure that settlement and pipe joint misalignment will not allow the joint to open. Special or higher strength couplers are necessary where foundation conditions are poor or uneven and will result in differential settlement of the pipeline. Adequate pull-apart strength also becomes a factor where settlements are expected and where pipe grades are steep.

All joint requirements need to be determined in advance and properly specified. Coupler strength performance should be prequalified by laboratory testing prior to their installation in order to separate coupler performance from contractor installation problems.

Many specifiers have no ability to conduct tests and may be unsure of what calculation procedures to follow. Such tests and calculation procedures have been made by public agencies and are available. Rather than being unnecessarily concerned, it is generally advisable for specifiers to follow their local department of transportation requirement's to avoid testing or analyzing couplers to determine their properties.

It should be noted that the AASHTO Specification establishes values for required strength parameters of couplers. It does not define any test procedures to measure these values for a specific coupler design. It does provide that such values may be determined either by calculation or test. Section 26.4 of the AASHTO Bridge Specification contains this important design information. For the convenience of the reader, this section of the AASHTO Specification (adapted to metric format) is shown below.

AASHTO BRIDGE SPECIFICATION, SECTION 26.4

Couplers for corrugated metal culvert and drainage pipe shall meet the following performance requirements.

26.4.2 Joints

Joints for corrugated metal culverts and drainage pipe shall meet the following performance requirements.

26.4.2.1 Field Joints

Transverse field joints shall be of such design that the successive connection of pipe sections will form a continuous line free from appreciable irregularities in the flow line. In addition, the joints shall meet the general performance requirements described in items 26.4.2.1 through 26.4.2.3. Suitable transverse field joints, which satisfy the requirements for one or more of the subsequently defined joint performance categories, can be obtained with the following types of connecting bands furnished with the suitable band-end fastening devices.

(a) Corrugated bands.

(b) Bands with projections.

(c) Flat bands.

(d) Bands of special design that engage factory reformed ends of corrugated pipe.

(e) Other equally effective types of field joints may be used with the approval of the Engineer.

26.4.2.2 Joint Types

Applications may require either "standard" or "special" joints. Standard joints are for pipe not subject to large soil movements or disjointing forces; these joints are satisfactory for ordinary installations, where simple slip-type joints are typically used. Special joints are for more adverse requirements such as the need to withstand soil

movements or resist disjointing forces. Special designs must be considered for unusual conditions as in poor foundation conditions. Downdrain joints are required to resist longitudinal hydraulic forces. Examples of this are steep slopes and sharp curves.

26.4.2.3 Soil Conditions

(a) The requirements of the joints are dependent on the soil conditions at the construction site. Pipe backfill which is not subject to piping action is classified as "Nonerodible." Such backfill typically includes granular soil (with grain sizes equivalent to coarse sand, small gravel, or larger) and cohesive clays.

(b) Backfill that is subject to piping action, and would tend to infiltrate the pipe to be easily washed by exfiltration of water from the pipe, is classified as "Erodible." Such back fill typically includes fine sands and silts.

(c) Special joints are required when poor soil conditions are encountered such as when the backfill or foundation material is characterized by large soft spots or voids. If construction in such soil is unavoidable, this condition can only be tolerated for relatively low fill heights, because the pipe must span the soft spots and support imposed loads. Backfills of organic silt, which are typically semi-fluid during installation, are included in this classification.

26.4.2.4 Joint Properties

The requirements for joint properties are divided into the six categories given in Table 26.4. Properties are defined and requirements are given in the following paragraphs (a) through (f). The values for various types of pipe can be determined by a rational analysis or a suitable test.

(a) **Shear Strength**—The shear strength required of the joint is expressed as a percent of the calculated shear strength of the pipe on a transverse cross section remote from the joint.

(b) **Moment Strength**—The moment strength required of the joint is expressed as a percent of the calculated moment capacity of the pipe on a transverse cross section remote from the joint.

(c) **Tensile Strength**—Tensile strength is required in a joint when the possibility exists that a longitudinal load could develop, which would tend to separate adjacent pipe section.

(d) **Joint Overlap**—Standard joints that do not meet the moment strength alternatively shall have a minimum sleeve width overlapping the abutting pipes. The minimum total sleeve width shall be as given in Table 26.4. Any joint meeting the requirements for a special joint may be used in lieu of a standard joint.

(e) **Soil Tightness**—Soil tightness refers to openings in the joint through which soil may infiltrate. Soil tightness is influenced by the size of the opening (maximum dimension normal to the direction that the soil may infiltrate) and the length of the channel (length of the path along which the soil may infiltrate). No opening may exceed 25 mm (1 in.). In addition, for all categories, if the size of the opening exceeds 3 mm (1/8 in.), the length of the channel must be at least four times the size of the opening. Furthermore, for nonerodible or erodible soils, the ratio of D85 soil size to size of opening must be greater than 0.3 for medium to fine sand or 0.2 for uniform sand; these ratios need not be met for cohesive backfills where the plasticity index exceeds 12. As a general guideline, a backfill material containing a high percentage of fine grained soils requires investigation for the specific type of joint to be used to guard against soil infiltration. Alternatively, if a joint demonstrates its ability to pass a 14 kPa (2 lb/in^2) hydrostatic test without leakage, it will be considered soil tight.

(f) **Watertightness**—Watertightness may be specified for joints of any category where needed to satisfy other criteria. The leakage rate shall be measured with the pipe in place or at an approved test facility. The adjoining pipe ends in any joint shall not vary more than 13 mm (0.5 in.) diameter or more than 38 mm (1.5 in.) in circumference for watertight joints. These tolerances may be attained by proper production controls or by match-marking pipe ends."

Note: *Joints that do not meet these requirements may be wrapped with a suitable geotextile.*

Table 26.4 AASHTO Categories of Pipe Joints

	Soil Condition				
	Non-Erodible		Erodible		
	Joint Type		Joint Type		
	Standard	Special	Standard	Special	Downdrain
Shear	2%	5%	2%	5%	2%
Moment[a]	5%	15%	5%	15%	15%
Tensile 0 -1050 mm Dia.	0	22 kN	–	22 kN	22 kN
(0 - 42 in.)	(5000 lb)		(5000 lb)	(5000 lb)	
1200 - 2100 mm Dia.	–	44 kN	–	44 kN	44 kN
(42 - 84 in.)	(10,000 lb)		(10,000 lb)	(10,000 lb)	
Joint Overlap[c] (min.)	267 mm (10.5 in.)	NA	267 mm (10.5 in.)	NA	NA
Soiltightness[b]	NA	NA	0.3 or 0.2	0.3 or 0.2	0.3 or 0.2
Watertightness	See par. 26.4.2.4(f)				

Notes: 1. See paragraph 23.3.1.5.4(b).
2 Minimum ratio of D85 soil size to size of opening 0.3 for medium to find sand and 0.2 for uniform sand.
3 Alternate requirement. See article 23.3.1.5.4(e).
Structural plate pipe, pipe-arches, and arches shall be installed in accordance with the plans and detailed erection instructions.