

Mechanical Connections of Reinforcing Bars

reported by ACI Committee 439

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Properly designed splices are a key element in any well-executed design. The lap splice, when conditions permit and when it will satisfy all requirements, is generally the most common method for splicing reinforcing bars. However, when lap splices are undesirable or impractical, or when their use is not permitted by the design code or design specification, mechanical or welded connections should be used to splice the reinforcing bars.

The objective of this report is to provide engineers and contractors with basic information about mechanical connections and the types of proprietary mechanical connection devices currently available, but not to state conditions of acceptance, or to endorse or rate a particular mechanical connection device over another. These mechanical connection devices are proprietary, and the information herein provided by the connector manufacturers has been compiled, but none of the information has been specifically verified by this committee. Consequently, the relative merits of the different mechanical connection devices are not noted or compared. However, the information given is useful, because it is not presently available elsewhere in such an assembled and detailed format. An attempt was made to include all the mechanical connection devices generally commercially available in North America at the time the report was written. However, it must be realized that some devices new in the market may not be included, merely due to ignorance of their existence at the time of writing.

Reasons for using mechanical connections are discussed, as well as various engineering considerations that must be made when specifying mechanical connections, such as the need to avoid notch effects in seismic joints that could result in the bar rupturing at one location before it yields generally elsewhere. Mechanical connection devices are described in terms of configuration, procedure for connecting, clearance requirements, and other characteristics. Illustrations of the various mechanical connection devices are included.

Keywords: bolted connections; connections; couplers; dowels; reinforced concrete; reinforcing steels; sleeves; splicing.

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CHAPTER 1-GENERAL

1.1-Introduction

In reinforced concrete design, the structural engineer is faced with the task of determining where and how reinforcing bars must be spliced in a structure. The structural engineer must do this because of his familiarity with the particular requirements of the structure. Drawings or specifications must clearly show or describe all splice locations and the performance re-

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quired. The importance and necessity of clearly prescribing splice requirements is evident in two sections of ACI 318. Section 1.2.1 describes nine specific items to be included on the design drawings, details, and specifications. These items include Section 1.2.1.h, which requires that location and length of lap splices and reinforcement anchorage lengths be shown. Section 1.2.1.i requires showing the type and location of welded splices and mechanical connections of reinforcement. Section 12.14.1 of ACI 318 also addresses this subject, and states: "Splices of reinforcement shall be made only as required or permitted on design drawings, or in specifications, or as authorized by the engineer."

In the design of beams, columns, and slabs, lap splices are usually permitted. When lap splices of straight bar extensions cannot be used, or when their use causes congestion, field placing problems, or detailing or design problems, then mechanical connections, welded joints, or lap splice connections involving field bending and subsequent bar straightening may be used, as appropriate.

This report provides basic information about proprietary mechanical connections generally available in North America and known to the committee at the time the report was submitted for publication.* Design requirements and usage of mechanical connections, as well as capabilities and features of selected mechanical connection devices, are described.

Three basic types of mechanical connections are considered in this report. They are: (1) the "compression-only" mechanical connection, which is also known as the "end-bearing mechanical connection," (2) the "tension-only" mechanical connection, and (3) the "tension-compression" mechanical connection. The "tension-compression" mechanical connection can resist both tensile and compressive forces. Dowel bar mechanical connections are included in this category.

In this report, pertinent terms are defined as follows:

Bar-end check-Check of the ends of reinforcing bars to determine whether they fit the devices intended for connecting the bars.

Coupler-Threaded device for joining reinforcing bars for the purpose of providing transfer of either axial compression or axial tension or both from one bar to the other.

Coupling sleeve-Nonthreaded device fitting over the ends of two reinforcing bars for the eventual purpose of providing transfer of either axial compression or axial tension or both from one bar to the other.

End-bearing sleeve-Device fitting over the abutting ends of two reinforcing bars for the purpose of assuring transfer of only axial compression from one bar to the other.

Mechanical connection-Complete assembly of an end-bearing sleeve, a coupler, or a coupling sleeve, and

possibly additional intervening material or other components to accomplish the connection of reinforcing bars.

It is beyond the scope of this report to cover welded splices or other currently available special proprietary splicing systems. Engineers are referred to the AWS code for welding reinforcing steel (ANSI/AWS D1.4) and the ASTM specifications for reinforcing bars, such as ASTM A 706 and ASTM A 615. Further discussion of the AWS code and welded splices is given in Reference 1.

1.2-Usage

There are numerous situations that require or make the use of mechanical connections feasible or more practical. Some of the most common conditions are:

1. Where #14 and #18 bars are used. This occurs most often in columns, raft mat foundations, and other heavily reinforced structures. Codes do not permit #14 and #18 bars to be lap spliced, except in compression only with #11 and smaller bars.

2. Where spacing of the reinforcing bars is insufficient to permit lapping of the bars. This generally occurs in situations requiring large amounts of reinforcement and the use of larger bars, as in heavily loaded columns.

3. When requirements in current codes and specifications for tension lap splices result in long lap splice lengths, especially for bar sizes such as #9, #10, and #11 in Grade 60 steel or in epoxy-coated reinforcing bars. Lap splices may thus be less practical than mechanical connections.

4. Where "tension tie members" are used. Tension lap splices of reinforcing bars in tie members are not permitted.

5. When the location of construction joints and provision for future construction dictates use of mechanical connections to provide tensile continuity. Mechanical connections are often preferable to having long bar lengths projecting from existing concrete construction. A minimum of a 12 in. (305 mm) bar extension provides sufficient length for application of most mechanical connections without damaging the existing concrete during installation. If mechanical connections must be staggered, the projecting bar extension should be greater than 12 in. (305 mm).

1.3-General considerations

Available proprietary mechanical devices have particular physical features, both in the splice device itself and in the required installation equipment or procedure that can influence design and construction methods.

1.3.1 Spacing and cover requirements-Minimum clear distances between adjacent reinforcing bars are specified in codes and design specifications. For example, ACI 318 Sections 7.6.2 and 7.6.3 set an absolute minimum clear distance between parallel bars in a layer of not less than the nominal diameter of the bar or 1 in. (25 mm), except that for columns the minimum clear distance is not less than 1½ times the nominal bar di-

*ANCON (MBT) mechanical connectors, which involve a clamping device generically different from devices described in the present report, are not included in this report because they were unknown to the committee at the time of final committee ballot on the report.

iameter or 1½ in. (38 mm). Section 7.6.4 of ACI 318 indicates that the clear distance limits shall also apply adjacent to lapped splices, but Section 7.6.4 does not address clearance limits for mechanical connections.

Appropriate clearance limits for mechanical connections are listed in **Tables 3.1** and **3.2**. Clearance limits may be a factor in the selection and positioning of the mechanical connection. The outside diameter of the mechanical connection device should be known. By knowing the diameter of the mechanical connection device, a decision can be made whether the mechanical connections have to be staggered on the basis of the clearance required. It has been the practice in the past to stagger splices of any types whether lapped, welded, or mechanically connected, but there is currently some evidence documented by research that some mechanical connections providing adequate longitudinal stiffness and adequate ductility for the reinforcement, as well as the specified strength, need not be staggered. However, pending any future code revisions, the minimum stagger length should be specified by the engineer consistent with the requirements of the applicable code, e.g., Sections 12.15.4.1, 12.15.5, 12.17, and 21.3.2.4 of ACI 318.

The size and operation of the equipment required for making mechanical connections can also dictate a minimum spacing or a stagger pattern. Some information to evaluate these requirements is available in subsequent sections of this report.

Several of the proprietary mechanical connection devices currently available have an outside diameter substantially larger than the reinforcing bars. Special consideration should be given to the minimum concrete cover of the stirrups, ties, or spirals at these splice locations. In many cases, the stirrup or tie patterns adjacent to the mechanical connections, or the location of the splice itself, can be adjusted to avoid a reduced concrete cover. However, where required close spacing of stirrups and ties necessitates their placement over the coupling sleeves, it may be necessary to design greater cover over the longitudinal reinforcement so that stirrups and/or ties encompassing the mechanical connections have adequate cover. Ideally, the confinement reinforcement would have greater dimensions at a connector, but that is not generally the practice. In dowel bar mechanical connections that have flanged sleeves, all portions of the mechanical connection should meet appropriate cover requirements.

1.3.2 Matching of end alignments, end preparation of bars, special bar deformations, and equipment-The engineer/specifier should be aware of any special end preparations of bars required for a method of mechanical connection or for certain couplers. For example, Section 12.16.4.2 of ACI 318 requires for end-bearing splices that the ends of the bars be cut to within 1½ deg of square with respect to the longitudinal axis. By definition, couplers are threaded, and some require matching threads on the bar ends. One mechanical connection device requires reinforcing bars with special thread-like deformations. In all mechani-

cal connections, it is important to have the mechanical connection device in good alignment with the longitudinal bar axis so that the bar is not prone to wide swings when being rotated in a field assembly.

The reinforcing bar fabricator must be made aware of any special end preparations or threads. Special requirements may entail the use of end-threading machines or special tools and equipment at the construction site. Availability or delivery requirements for reinforcing bars with the special deformation pattern, and for required tools and equipment, should be determined for the specific project before final decisions are made. Related to this, a bar-end check is sometimes advisable before proceeding with certain mechanical connections. The mechanical connection manufacturer can advise accordingly.

1.3.3 Coated reinforcing bars-Reinforcing bars can be epoxy coated or zinc coated (galvanized) for use as a corrosion-protection system. Mechanical connections of coated reinforcing bars are made with proprietary mechanical connection devices in a similar way as for uncoated bars. To properly install some types of coupling sleeves on coated bars, the coating has to be completely removed from the ends of the bars over the length of the sleeve and a short distance, perhaps 2 in. (50 mm) or so, beyond the ends of the sleeve. Information on preparation of bar ends for installation of proprietary mechanical connection devices, including removal of epoxy or zinc coatings, is presented in **Tables 3.1** and **3.2**.

After installation of mechanical connections on coated reinforcing bars, the sleeves and any damaged coating on the bars adjacent to the sleeve should be touched up with appropriate compatible patching material with anticorrosive quality equal to that of the original coating. Typically, there will be provisions in the project specifications requiring such touch-up of the sleeves and repair of damaged coating-for example, see Chapter 5 of ACI 301. Flame cutting of coated bars in any location should be avoided when possible because of damage to the epoxy coating. Where mechanical connections are used, flame-damaged epoxy coating may be more difficult to remove properly to obtain an effective connection than undamaged epoxy coating.

1.3.4 Field erection-In many applications, mechanical connections may be staggered for clearance, access, and some code requirements. If staggered mechanical connections are used in columns, for example, free-standing erection and assembly of the reinforcement may be required rather than preassembled cages.

There is a considerable difference in the time and equipment required to install different mechanical connections. Therefore, it is imperative to coordinate the field erection procedure and schedule with the selection and installation procedure of the mechanical connections.

For some projects, the engineer may find it appropriate to control the types of mechanical connection devices to be utilized. Also, the method of construction

may determine the types of mechanical connection devices that can be most readily utilized. It is important that the unique requirements of any selected mechanical connection device be considered by all parties prior to beginning construction. Study of the subsequent descriptions will assist in determining these requirements.

CHAPTER 2-DESIGN REQUIREMENTS FOR MECHANICAL CONNECTIONS

2.1-Codes and specifications

Design requirements of the applicable code (ACI 318, 349, or 359) or specification (AASHTO Standard Specifications for Highway Bridges) for reinforcing bar mechanical connections are not reproduced or discussed herein in detail. Codes generally specify a minimum connection strength. For example, ACI 318, Section 12.14.3.4, states, "A full mechanical connection shall develop in tension or compression, as required, at least 125 percent of specified yield strength f_y of the bar," so that yielding will tend to occur in the reinforcing bar adjacent to the mechanical connection before failure in the mechanical connection. For further background information and some of the considerations made in developing the ACI 318 provisions, the reader is encouraged to review ACI 318R.

Due to the minimum connection strength required, it is generally assumed in design that the occurrence of a mechanical connection of two reinforcing bars does not result in a reduction of the anticipated structural strength, as well as the longitudinal stiffness and longitudinal ductility, of the reinforcing steel, which the reinforced concrete member would have had with a continuous unspliced bar. That is, it is assumed that the use of a mechanical connection does not introduce a structural weakness that could jeopardize the overall structural performance. Design codes cover basic strength requirements for splices and mechanical connections, but generally do not specify how to avoid other potential weaknesses that may be directly attributed to the specific details and/or materials of a mechanical connection, as follows:

1. In a flexural member, the mechanical connection should not result in a low effective longitudinal stiffness of the reinforcement that violates the strain conditions assumed in the member design.

2. Where inelastic straining must be anticipated, as in yielding zones of seismic structures, the mechanical connection device must not introduce notch effects that would cause the bar to rupture at the mechanical connection device before the required yielding can occur in the adjoining bar stock.

3. The selection of appropriate mechanical connections must consider that notch effects, if present, are more severe with dynamic loadings, fatigue loadings, and cold temperatures.

4. Where potential inelastic straining may occur during seismic excitation, the assembly consisting of the connector and the reinforcing bars connected must possess adequate ductility so that failure initiates in the concrete rather than in the steel reinforcement. Manu-

facturers' information, as well as that in the literature, should be reviewed by the engineer when evaluating a mechanical connector for service where large load reversals are possible.

CHAPTER 3-MECHANICAL CONNECTION DEVICES AND INSTALLATION DESCRIPTIONS

3.1-General

A variety of proprietary mechanical connection devices are currently available. In this part of the report, the physical features, mechanical characteristics, and installation procedure of various available mechanical connection devices are described. The mechanical connection devices are divided into three basic categories: compression-only mechanical connections, tension-only mechanical connections, and tension-compression mechanical connections, all meeting Section 12.14.3.4 of ACI 318.

To assist the reader, a list of characteristics summarizing the detailed descriptions is included in [Tables 3.1](#) and [3.2](#) for compression-only and tension-compression mechanical connections, respectively. These tables should be helpful in determining which mechanical connection devices may be utilized for specific design applications.

Descriptions of the mechanical connection devices are presented in the following sections in alphabetical order by generic name. Similarly, the locations of the devices in [Tables 3.1](#) and [3.2](#) are by alphabetical order. The committee does not endorse, or rate a particular mechanical connection device over another. An attempt was made to include all devices generally commercially available in North America in the following section. These descriptions of the mechanical connection devices are based on information furnished by the manufacturers. When no information could be secured from a manufacturer, no description of their products could be included in this report. At the time that this report was submitted for publication, the committee was not aware of mechanical connection devices currently manufactured in North America that were not included in the report.

3.2-Compression-only mechanical connections

In most compression-only mechanical connections, compressive stress is transferred by concentric bearing from one bar to the other bar. Except for a steel-filled coupling sleeve, the ends of the bars must be saw cut, or cut by some other means, within $1\frac{1}{2}$ deg of square to the bar axis. Square cutting generally will increase the cost over conventionally sheared bars. An end-bearing splice device must be capable of holding the bars in concentric contact.

Four commercially available compression-only mechanical connection devices are described in terms of the following:

1. Configuration.
2. Bar sizes which can be spliced.
3. Capability of splicing bars of different sizes.
4. Installation procedure.

Table 3.1- Compression-only mechanical connections

		Boiled steel sleeve			Wedge-locking coupling sleeve (Fig. 3.2.3)
		Solid-type steel coupling sleeve (Fig. 3.2.1.1*)	Strap-type steel coupling sleeve (Fig. 3.2.1.2)	Steel-filled coupling sleeve (Fig. 3.2.2)	
Coupling sleeve	Bar size range	#8-#18	#7-#18	#11-#18	#7-#18
	Connects different bar sizes	Yes	Yes	Yes	Yes
Clear spacing required between adjacent connections	#18	$1\frac{1}{2} d_b$	$1\frac{1}{2} d_b$	$1\frac{1}{2} d_b$	$1\frac{1}{2} d_b$
	#14	$1\frac{1}{2} d_b$	$1\frac{1}{2} d_b$	$1\frac{1}{2} d_b$	$1\frac{1}{2} d_b$
	#11	$1\frac{1}{2} d_b$	$1\frac{1}{2} d_b$	$1\frac{1}{2} d_b$	$1\frac{1}{2} d_b$
#18 coupling sleeve installation requirements (normal)	Minimum dowel projection	6 in. [†]	6 in.	1 ¼ in.	6 in.
	Coupling sleeve length	12 in.	12 in.	3 in.	12 in.
	Coupling sleeve maximum diameter/across corners	2 ¾ in.	4 in.	3 ¾ in.	2 ¾ in.
	Coupling sleeve side wall thickness (nominal)	Nil	Nil	⅝ in.	Nil
Bar-end preparation	Cut square within 1 ½ deg	Yes	Yes	No	Yes
	Cleaning-special cleaning	No	No	Remove concrete and loose rust	No
	Predrying/heating	No	No	Yes	No
	Thread cutting/rolling	No	No	No	No
	Special coating removal (epoxy, zinc)	No	No	Remove coatings 2 in. above sleeve	No
Installation tools	Hand-held tools adequate	Yes	Yes	No	Yes
	Special tools required	No	No	Yes	No
	Weather restrictions	No	No	Bars must be dry	No
	Fire precaution	No	No	Yes	No
	Ventilation required	No	No	Yes	No

*Reference figure.
[†]1 in. = 25.4 mm.
 d_b = nominal diameter of bar.

3.2.1 Bolted steel coupling sleeves--There are two types of bolted steel coupling sleeves, as shown in Fig. 3.2.1.1 and 3.2.1.2. Lateral clamping action produced by the bolt-tightened coupling sleeves assures concentric bearing of the mechanical-connected bars. The only tool needed to install these coupling sleeves is a wrench.

3.2.1.1 Solid-type steel coupling sleeve--These coupling sleeves are cylindrical shells with split flanges at one side. Bolts are inserted through holes in the flange and drawn up, pulling the coupling sleeve tightly around the square cut bars (Fig. 3.2.1.1).

In the installation procedure, the coupling sleeve is placed on the lower bar and the lower bolt drawn up to lock the coupling sleeve on the bar. The upper bar is lowered into the coupling sleeve and the bar is seated. Inspection is through center holes in the side of the coupling sleeve from where both the centering of the sleeve and the seating of the bars can be observed. The remaining bolts are then drawn up tightly. Bolting may be done with either a hand wrench or a power tool.

Coupling sleeve lengths range from 8 in. (203 mm) to 12 in. (305 mm), depending on the bar sizes to be spliced. Special transition wedges are available for insertion into the sleeve to allow for splicing bars of different sizes, even for bars which differ by two sizes, e.g., #11 to #18. The flange section of the mechanical connection device should be arranged at the back of the bar to maintain concrete cover at the form line and clear spacing between the bars. There must be sufficient space to work on the side where the mechanical connection flange is located or to allow for the inser-

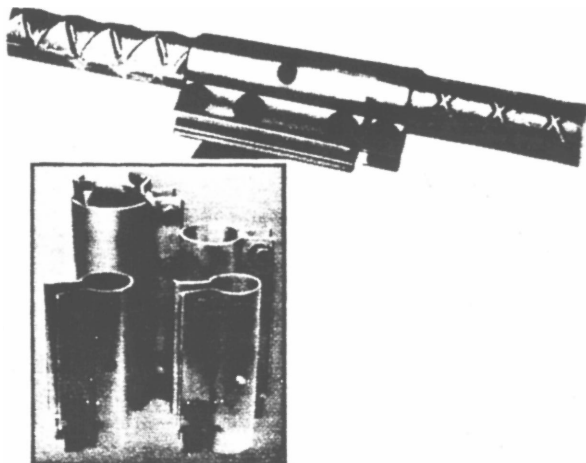


Fig. 3.2.1.1-Solid-type steel coupling sleeve

Table 3.2 – Tension-compression mechanical connections

		Cold-swaged steel coupling sleeve (Fig. 3.3.1*)	Cold-swaged coupling sleeve with threaded ends acting as a coupler (Fig. 3.3.2 and 3.4.4)	Extruded steel coupling sleeve (Fig. 3.3.3)	Hot-forged steel coupling sleeve (Fig. 3.3.4)	Grout-filled coupling sleeve (Fig. 3.3.5)	Coupler for thread-deformed ¹ rebars (Fig. 3.3.6 and 3.4.3)	Steel-filled coupling sleeve (Fig. 3.3.7)	Taper-threaded steel coupler (Fig. 3.3.8)	Integrally-forged coupler with upset NC thread (Fig. 3.4.1)	Three-piece coupler with NC thread (Fig. 3.3.9, 3.4.2.1, and ² 3.4.2.2)	Steel coupling sleeve with wedge ³ (Fig. 3.5.1)
Coupling sleeve/coupler	Bar size range	#3-#18	#3-#18	#5-#18	#5-#18	#5-#18	#6-#18	#4-#18	#4-#18	#4-#11	#4-#18 ²	#3-#7
	Connects different bar sizes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
Clear spacing required between adjacent connections	#18	2¾ in.	1½ in.	5⅝ in.	1½ d _b	4.72 in.	1½ d _b	1½ d _b	1½ in.	NA	1½ in.	NA
	#14	2¾ in.	1 in.	4½ in.	1½ d _b	3.90 in.	1½ d _b	1½ in.	1½ in.	NA	1 in.	NA
	#11	2 in.	1 in.	4½ in.	1½ d _b	3.50 in.	1½ d _b	1½ d _b	1½ in.	1½ in.	1 in.	NA
# 18 coupling sleeve/coupler installation requirements (normal)	Minimum dowel projection	12 in.	None	21¾ in.	(V)-18 in. (H)-20 in.	18 in.	4 and 7½ in. [§]	3⅞ in.	3½ in.	NA	4 in.	NA
	Coupling sleeve/coupler length	12 in.	14 in.	12¼ in.	9 in.	36¼ in.	8 and 15 in. [§]	7 in.	6¼ in.	NA	6 in.	NA
	Coupling sleeve/coupler maximum diameter/across corners	3¾ in.	3⅝ in.	3¾ in.	4¼ in.	4¾ in.	3½ in.	3⅝ in.	3 in.	NA	3 in.	NA
	Coupling sleeve/coupler side wall thickness (nominal)	⅝ in.	⅞ in.	⅝ in.	½ in.	½ in.	⅝ in.	½ in.	Varies Min. ⅜ in.	NA	NA	NA
Bar-end preparation	Cut square within 1½ deg	No	No	No	No	No	No/Yes*	No	No	No	No	No
	Cleaning-special cleaning	No	No	No	Remove loose particles	No	No	Remove concrete and loose rust	No	No	No	No
	Predrying/heating	No	No	No	Yes, coupling sleeve	No	No	Yes	No	No	No	No
	Thread cutting/rolling	No	No	No	No	No	No	No	Yes**	No	Yes	No
	Special coating removal (epoxy, zinc)	No	No	No	Yes	No	No	Yes	No	No	No	No
Installation tools	Hand-held tools adequate	No	Yes	No	No	Yes	Yes:<#11 No:>#11	No	Yes	Yes	Yes	No
	Special tools required	Yes	No	Yes	Yes	Yes, grout pump	Yes	Yes	No	No	No	Hydraulic wedge driver
	Weather restrictions	No	No	No	Bars must be dry	No	No	Bars must be dry	No	No	No	No
	Fire precaution	No	No	No	Yes	No	No	Yes	No	No	No	No
	Ventilation required	No	No	No	No	No	No	Yes	No	No	No	No

*Reference Figure(s).

¹Accepted for general use for tension-only, pending current experimental work in progress to evaluate the general applicability to connecting longitudinal reinforcement in compression.²#4-#14 meet ACI 318, Section 12.14.3.³When jam nuts are used.

**Bar-end threading normally done by bar fabricator.

1 in. = 25.4 mm.

d_b = nominal diameter of bar.

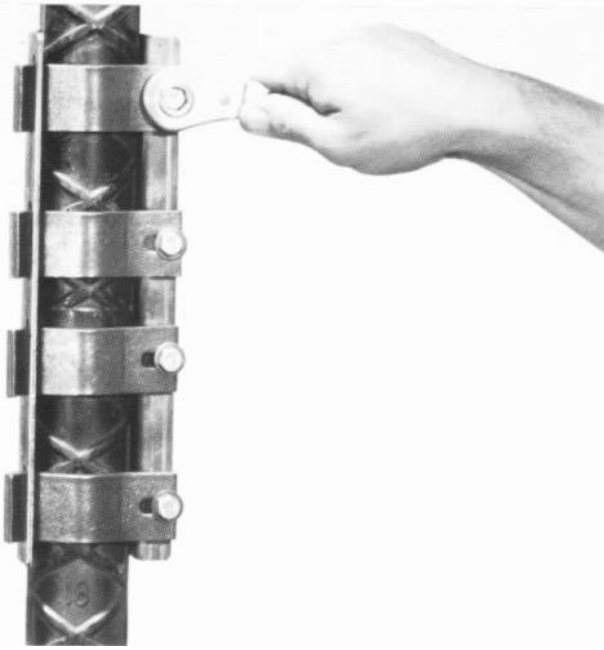


Fig. 3.2.1.2-Strap-type steel coupling sleeve

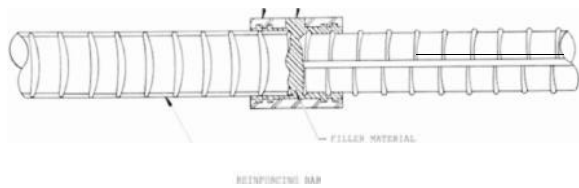


Fig. 3.2.2-Steel-filled coupling sleeve, compression only

tion of the tightening tools from outside. A clear spacing of 2 in. (50 mm) or more between bars should normally provide for an efficient work operation from outside the cage of reinforcing steel.

3.2.1.2 Strap-type steel coupling sleeve—These coupling sleeves are approximately a half-cylindrical shell with a bent flange at one side and slots along the other side. L-shaped straps clip through the slots of the coupling sleeve and are bolted to the flange (Fig. 3.2.1.2).

Coupling sleeve lengths vary with bar size up to 12 in. (305 mm) for #18 bars. Special adapter wedges are available for insertion into the coupling sleeve to allow for mechanically connecting bars of different sizes.

Installation procedures, clear spacing between bars, and work space requirements are similar to those described previously for the solid-type sleeve.

3.2.2 Steel-filled coupling sleeve—A steel-filled coupling sleeve is available for compression-only applications (Fig. 3.2.2). The configuration of this coupling sleeve and its installation procedure are the same as the description of the steel-filled coupling sleeve that is given under tension-compression connections (Section 3.3.6) and will not be repeated here.

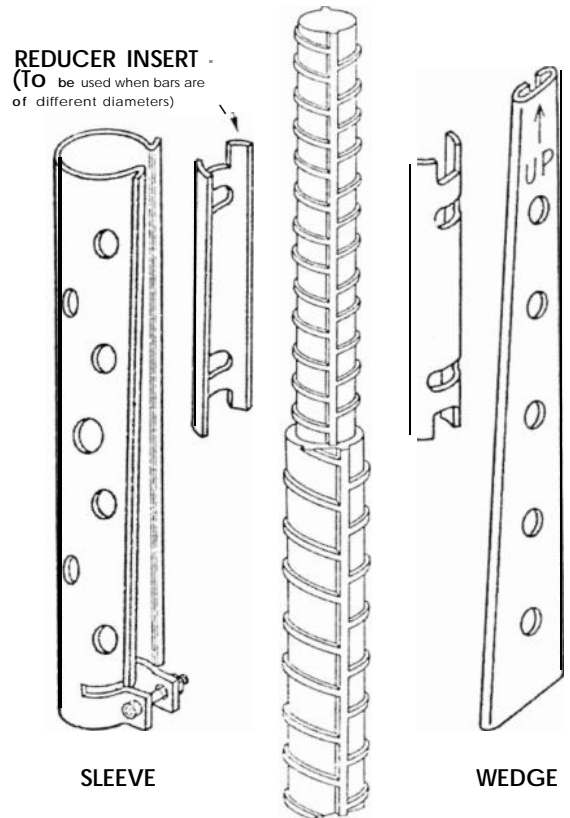


Fig. 3.2.3-Wedge-locking coupling sleeve

Steel-filled coupling sleeves are available to connect bar sizes # 11, # 14, and # 18. Transition mechanical connections for different bar sizes can be made with special inserts, varying up to two sizes, e.g., #11 to #18. Bar ends do not require special end preparation; however, a bar-end check is recommended to prevent fitting problems in the field between the inside of the sleeve and the most outstanding bar deformation. The ends can be shear cut, or flame cut because the molten filler metal (steel) fills the space between the ends of the bars to insure bearing. Although intended for compression-only applications, this coupling sleeve by its nature is capable of developing some tensile strength, but it is not intended to resist significant tensile loading. Bars can be connected in a vertical, horizontal, and diagonal position. A clear spacing of $1\frac{1}{4}$ nominal bar diameters is required to provide clearance for the connecting equipment.

The difference between this steel-filled coupling sleeve for compression-only applications and the tension coupling sleeve is in the length of the sleeve. For example, a 3 in. (76 mm) long coupling sleeve is used for connecting #18 bars in compression only, while a 9 in. (229 mm) long coupling sleeve is used for the tension mechanical connection.

3.2.3 Wedge-locking coupling sleeve—A wedge-locking coupling sleeve holds the abutting bar ends in concentric bearing by lateral clamping action when the wedge is driven onto the sleeve (Fig. 3.2.3.). These coupling sleeves are cylindrical, with flattened collar

flanges that are formed to provide a tapered opening that extends nearly full length of the shell. A flat wedge-shaped piece with the edges wrapped around to grip the collar flanges is designed to slide down over the coupling sleeve flanges.

During installation, the coupling sleeve is placed over the lower bar, and the bottom clamp is tightened with a wrench to secure the sleeve. The flat wedge is slipped over the coupling sleeve flanges and slid down by hand. Next, the upper bar is placed in the coupling sleeve and the bar is seated. Finally, the wedge is driven down with a hand sledgehammer. Inspection is through a center hole in the side of the coupling sleeve from where both the centering of the sleeve and the seating of the bars can be observed.

Coupling sleeve lengths vary between 5 ½ and 12 in. (140 and 305 mm) depending on the bar sizes to be connected. Reducer inserts are available for connecting different bar sizes.

The flange and wedge lock should be arranged at the back of the bars or the side to maintain concrete cover at the form line. Clear bar spacing should be at least 3 in. (76 mm) to provide for clearance for the worker to drive the wedges tight.

3.3.1 Tension-compression mechanical connections

Nine types of commercially available couplers are described in terms of the following:

1. Configuration.
2. Capability of connecting bars of different sizes.
3. Preparation of bar ends.
4. Positions of mechanical connections.
5. Equipment, tools, and materials required to make mechanical connections.
6. Installation procedure.

All manufacturers claim full tension-compression capability per Section 12.14.3.4 of ACI 318. Dowel bar mechanical connection systems are addressed in [Section 3.4](#).

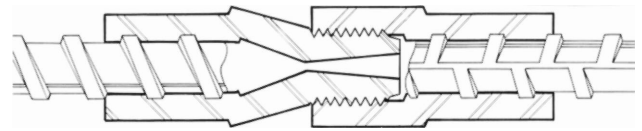
3.3.1 Cold-swaged steel coupling sleeve--A cold-swaged steel coupling sleeve consists of a seamless steel tube which slips over the ends of two reinforcing bars and is deformed onto the reinforcing bar profile to produce mechanical interlock ([Fig. 3.3.1](#)). Bar sizes #3 through #18 can be connected together plus certain bars of different sizes.

A hydraulic press fitted with a removable two-piece die set is used for field installation. The die set uniformly deforms the coupling sleeve onto the reinforcing bar in a series of overlapping pressings along its length ([Fig. 3.3.1](#)). Field-type presses, including dies, weigh between 20 and 230 lb (9 and 105 kg). They come with lifting handles or eyebolts as appropriate for support in vertical, horizontal, and diagonal positions from formwork, scaffold, or the reinforcing bar itself.

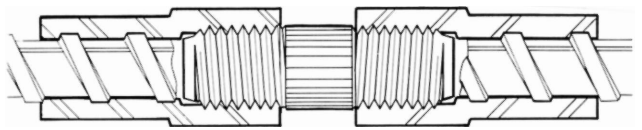
Larger bench-type presses with adjustable stops and insertion probes are available for field or shop use. These machines, which weigh approximately 1600 lb (726 kg), can be used to swage a coupling sleeve onto



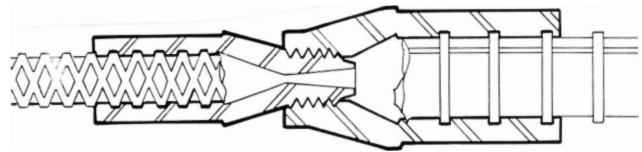
Fig. 3.3.1-Cold-swaged steel coupling sleeve



(a) *Two-piece*



(b) *Three-piece*



(c) *Transition*

Fig. 3.3.2-Cold-swaged steel coupling sleeves with threaded ends acting as a coupler

the end of a reinforcing bar prior to placing it onto the other. Adaptor kits allow the field presses just described to be used in the same way.

No special bar end preparation is required, so ends can be sheared, sawed, or flame cut; however, a bar-end check is recommended. Bars can be connected from any orientation since special positioning of the press around the bar is not required.

For very closely spaced bars, access of the equipment to make the mechanical connections should be checked with the manufacturer.

3.3.2 Cold-swaged steel coupling sleeve with threaded ends acting as a coupler--This type of coupler consists of two pieces, in addition to the bars connected, both of which are manufactured from a seamless steel tubing. Each piece meets the definitions of both a coupling sleeve (the unthreaded portion) and a coupler (the threaded portion). The female coupler has a precut thread inside one half; a preformed male coupler has a thread to match [[Fig. 3.3.2\(a\)](#)].



Fig. 3.3.3-Cutaway of extruded steel coupling sleeve

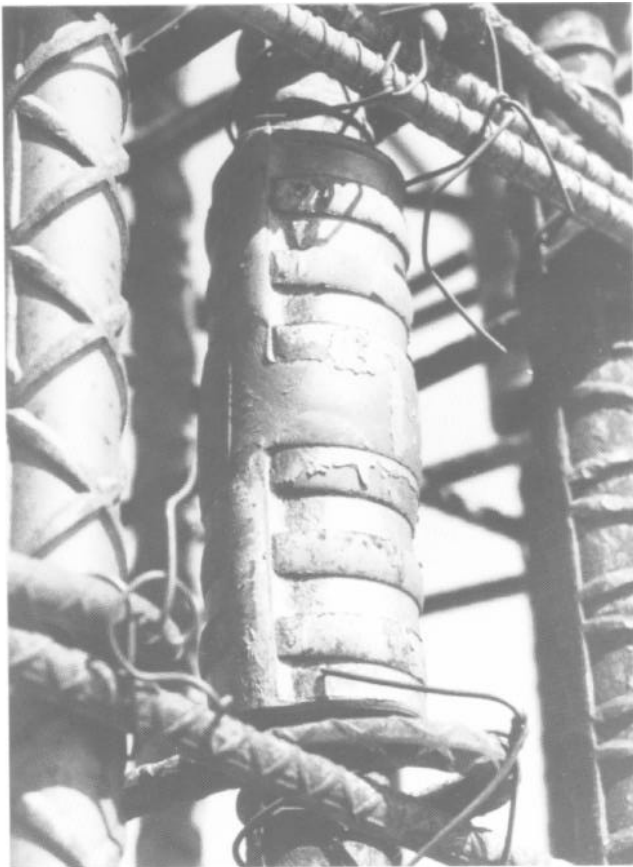


Fig. 3.3.4-Hot-forged steel coupling sleeve

The bar ends may be sheared, sawed, or flame-cut; however, a bar-end check is recommended. Reinforcing bars are correctly positioned inside the couplers by means of internal stops. The couplers are deformed onto the bar profile to produce mechanical interlock.

The coupling sleeves/couplers are waged on the reinforcing bar using a bench press or a field-type press as described in Section 3.3.1. The waging can take place on the jobsite or at a fabricator's plant. A single pressing per coupler half is needed to install most bar sizes when using a bench press.

A tapered shoulder on the leading thread on the male coupler helps to align the threads before rotating one of the two bars. No special equipment is needed for this operation. Because threads are cut on the couplers and

not on the reinforcing bar, the cross-sectional area of the bars is not reduced.

Another type of coupler consists of two threaded female ends and an interconnecting steel stud. This three-piece variation is used where neither reinforcing bar can be rotated to engage the threads (e.g., where bars are bent). The stud has a right-hand thread on one end and a left-hand thread on the other. Rotating the stud draws the two female couplers together [(Fig. 3.3.2(b))].

Bar sizes #3 through #18, including transition sizes [Fig. 3.3.2(c)], can be joined by either the two-piece or three-piece type couplers. Weldable female connectors are available for connections to structural steel members.

These types of couplers are generally swaged before placing the reinforcing steel.

3.3.3 Extruded steel coupling sleeve-This type of mechanical connection consists of a steel coupling sleeve, which is hydraulically cold, extruded over both ends of the butted reinforcing bars in one operation. First, the coupling sleeve is slipped over the ends of the butted reinforcing bars and fixed to one of them by tightening a setscrew. A hydraulic extruder then pushes a drawing die over the entire length of the coupling sleeve, causing the coupling material to flow tightly around the deformations of both reinforcing bars. An extruded coupling sleeve connection is shown in Fig. 3.3.3.

Any type of deformed reinforcing bar, from size #5 through #18, may be connected with this method. Extruded transition coupling sleeves for connecting bars of the next size are also available. The bar ends may be cut by any available method; however, a bar-end check is recommended. Reinforcing bars in any position, from vertical to horizontal, may be connected.

The hydraulic extruders are available for use at construction sites. They come together with the corresponding die sets, hydraulic pump, and spring load balancer, for the sizes of the reinforcing bars to be spliced. The extruders weigh 125 lb (57 kg) for #5 to #9; 500 lb (227 kg) for #10 to #14; and 1000 lb (454 kg) for #18. The extruder is designed to be suspended with a spring load balancer, in whatever position is required.

3.3.4 Hot-forged steel coupling sleeve-This type of coupling sleeve consists of a specially machined malleable steel sleeve which slips over the ends of the reinforcing bars being connected and is deformed to the bar configuration (Fig. 3.3.4)

Installation of the coupling sleeve requires a special forge or furnace for heating the sleeve, and a hydraulic pump and press for deforming the sleeve. The procedure for installation is to set a support clamp on the lower bar at a predetermined location, set the hydraulic press in position, place the heated coupling sleeve over the bar to be connected, place the other bar into the coupling sleeve, and deform the sleeve with the hydraulic press, while the sleeve is still hot.

No special end preparation of the bars is required, so the ends can be sheared or flame cut. However, a bar-

end check is recommended, and the ends of the bars must be dry and cleaned of any foreign matter or epoxy coating before being connected.

The coupling sleeves are preheated in a proprietary gas-heated furnace to approximately 2000 F (1093 C). The furnace is approximately 4 ft (1.2 m) high by 3 ft (0.9 m) square and weighs about 500 lb (227 kg). The furnace can handle about 200 lb (91 kg) of mechanical-connection steel per hour.

Coupling sleeves are available to splice bar sizes ranging from #5 to #18. Transition splices for different bar sizes can be made. The mechanical connection length varies with bar size up to 9 in. (229 mm) for #18 bars. A clear spacing of 1 ½ bar diameters is needed to provide space for the connecting equipment. Some consideration should be given to the location of the mechanical connections, as the oven must be near the work area. The gas containers must also be located relatively close to the work area. Sufficient space should be available to provide for this equipment and additional scaffolding may be required in some instances. As flammable materials are involved in the work area, consideration must also be given to fire protection.

3.3.5 Grout-filled coupling sleeves-Grout-filled coupling sleeves consist of double-tapered frustum-shaped steel sleeves with deformations similar to reinforcing bar patterns on the inner wall (Fig. 3.3.5). A nonshrink, high-strength, proprietary mortar grout is introduced into the coupling sleeve and around the bars using a low-pressure grout pump. Special preparation of the bar ends is not required. Bar ends may abut or be separated up to 1 in. (25 mm). This coupling may also be epoxy-coated or zinc-coated and may be used to connect epoxy-coated and zinc-coated bars.

The grout-filled coupling sleeve is designed to achieve a minimum of 125 percent of the yield strength of Grade 60 reinforcing bars. However, couplings for bar sizes #14 and #18 may be used as manufactured for mechanically connecting either Grade 60 or Grade 75 bars. To mechanically connect other size Grade 75 reinforcing bars, one size larger sleeve than that corresponding to the coupling specified for the corresponding Grade 60 bar size is used. With this coupling sleeve, bars varying by two sizes may be mechanically connected.

The grout-filled coupling sleeve is used to splice vertical bars by placing the sleeve over the lower bar until it contacts the reinforcing bar stop inside the sleeve, filling the sleeve with a cementitious grout, then inserting the upper bar fully and supporting it until the grout is strong enough to support the bar. It is used to splice horizontal bars by inserting the ends of both bars into the sleeve the proper length, sealing the sleeves at each end, and filling the sleeves with grout by means of pressure-grouting.

The grout-filled coupling sleeve is particularly applicable to precast concrete, in which a bar is inserted into the sleeve to the reinforcing bar stop and both ends of the sleeve are sealed. The assembly is held in place in the forms, and concrete for the precast element is

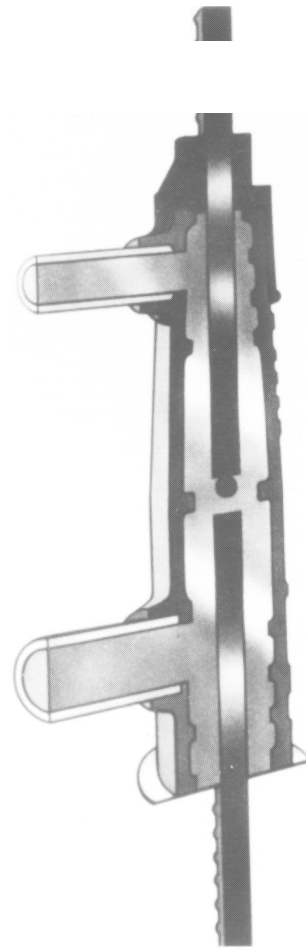


Fig. 3.3.5-Grout-filled coupling sleeve

placed. The connecting precast element is cast with projecting bars that are inserted into the sleeves at the interface. The system can be assembled by prefilling the grout in the coupling sleeves in vertical applications. They may be post-grouted with a grout pump for both vertical and horizontal applications.

Special precautions must be taken to insure that movement does not take place after any of the grouting operations until sufficient strength in the grout is achieved to permit removal of supporting devices. Braces, shores, cables, and other types of supports are used for this purpose. Typical grout strength of 3000 to 5000 psi (21 to 34 MPa) may be achieved in 24 hr, depending upon temperature. Precast elements may thus be assembled without any closure pour or formwork. Spaces between precast elements are grouted with nonshrink mortars.

3.3.6 Coupler for thread-deformed reinforcing bars-A reinforcing bar conforming to ASTM A 615, except for markings, with rolled-on deformations forming a thread is used. The reinforcing bars can be mechanically connected, using threaded couplers and nuts as shown in Fig. 3.3.6. This mechanical connection is available in sizes from #6 through #18. Accessories to provide end anchorages in concrete are also available.



Fig. 3.3.6-Coupler for thread-deformed reinforcing bars

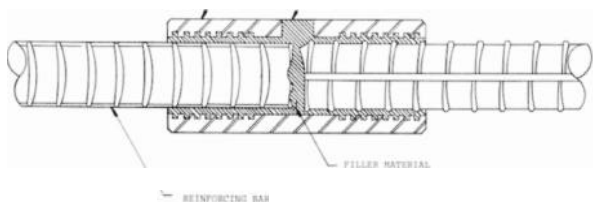


Fig. 3.3.7-Steel-filled coupling sleeve, tension-compression

The bars are mechanically connected together using one of two methods:

1. In installations where one of the two bars can be turned, a coupler sleeve is engaged on the ends of the two opposing bars, and the two bars are tightened against each other. For mechanical connections working in compression, the bar ends must be perpendicular to within $1\frac{1}{2}$ deg and may be either saw cut or abrasion wheel cut.

2. In installations where neither of the bars to be connected can be turned, the coupler is engaged on the end of the two opposing bars and a jam nut is tightened against each end of the coupler as shown in Fig. 3.3.6. In this case, bars may be cut by any available means, including shear, torch, or abrasion cutoff wheel.

In all mechanical connections described, the assembly components are torqued together. Torque values range from 150 to 750 ft-lb (203 to 1016 Nm) for the #6 through #11 sizes, and are 1500 and 3000 ft-lb (2032 and 4065 Nm) for the #14 and #18 sizes, respectively. Hydraulic torque wrenches are available to achieve the larger torque values. Required torque values may be less, depending on specific project requirements. No special cleanliness requirements for the bar ends apply.

Different size bars can be spliced. Bars should have a clear spacing of $1\frac{1}{4}$ bar diameters to provide room for tightening.

3.3.7 Steel-filled coupling sleeve-The steel-filled coupling sleeve consists of a cylindrical steel shell with machined interior grooves into which a molten steel filler material is introduced. Loads are transferred across the mechanical connection via the filler material to the coupling sleeve (Fig. 3.3.7). Coupling sleeves and prepackaged filler material packets are also available to provide mechanical connections that work in tension-compression (or compression-only-see Section 3.2.2).

Except for a bar-end check, no special bar-end preparation is required. Sheared or flame-cut bar ends are acceptable, since forces are transmitted through the

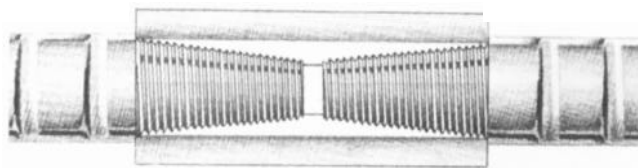


Fig. 3.3.8.1-Cutaway of taper-threaded steel coupler



Fig. 3.3.8.2-Taper-threaded steel coupler for straight bars

filler material. Ends of bars must be dry and cleaned of any foreign matter or epoxy coating before being connected.

The installation procedure is to slide the coupling sleeve over one bar, position the other bar, and then center the coupling sleeve over the bar ends. A pouring basin and crucible are attached to the coupling sleeve and a filler material packet is placed in the crucible and ignited. The exothermic reaction created produces a molten metal that flows into the coupling sleeve, filling the void between the coupling sleeve and reinforcing bars and the bar ends.

Space required between bars is dependent on bar size. Minimum clear distance between exterior rows of vertical bars to be mechanically connected varies from 2 to $2\frac{1}{4}$ in. (51 to 64 mm). Because an exothermic reaction is involved, consideration must be given to fire protection in the work area. Adequate ventilation should be provided where natural air flow is not sufficient, or if the new “smoke eater” is not being used to prevent concentration of smoke. Because exothermic reactions can be somewhat violent, care must be taken by workers in the immediate area.

3.3.8 Taper-threaded steel coupler-Taper-threaded steel couplers have internal tapered threads. They require matching tapered threads on the ends of the reinforcing bars (Fig. 3.3.8.1). The tapered thread eliminates possible thread damage or jamming before full thread engagement is achieved. There are two manufacturers of this coupler, called Manufacturer A and Manufacturer B herein. The particular type of thread used by each manufacturer differs, so that their products are not interchangeable.

Both manufacturers make a coupler intended to connect straight bars where the ends of the bars are free to turn (Fig. 3.3.8.1 and 3.3.8.2). Both manufacturers also make a coupler with a special integral collar. This coupler is used for mechanically connecting bent or curved bars where the ends of the bars cannot be turned (Fig. 3.3.8.3). Both manufacturers also have couplers to

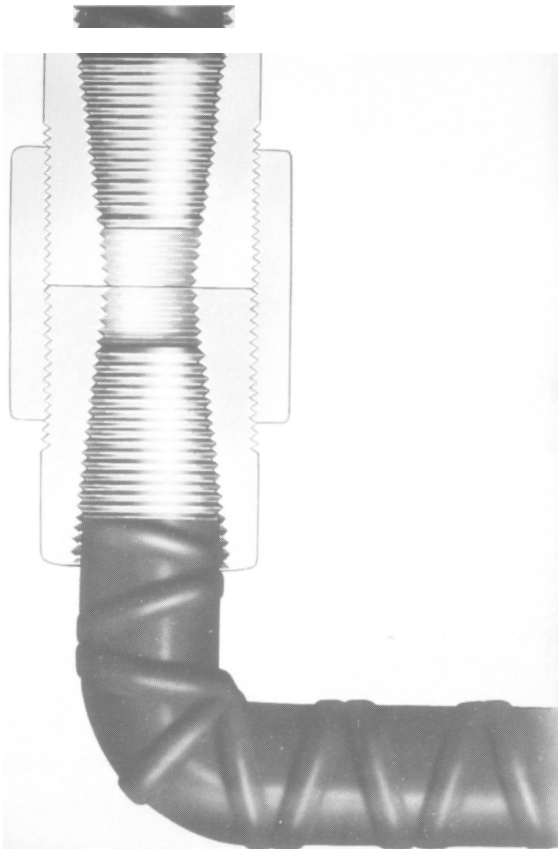


Fig. 3.3.8.3-Taper-threaded steel coupler with collar

connect reinforcing bars to structural steel members, or for use as end anchorages in concrete (Fig. 3.3.8.4).

Thread cutting of the bar ends can be done by machine at the reinforcing bar fabricator's shop or in the field. The threaded ends of the bars must be protected against damage during shipping and handling until the bars are connected.

Bars can be mechanically connected in any position. Installation is performed by threading the coupler on one bar and fitting the matching bar into the coupler. A pipe wrench is used to torque the connection, and a torque wrench is used to verify the tightness. For #14 and #18 bars, the minimum torque required is 200 ft-lb (270 Nm). Due to the take-up of the tapered threading, about four to five turns are required to tighten the mechanical connection.

Manufacturer A-Couplers are available from Manufacturer A for mechanically connecting #7 through #18 bars. Mechanical connections of different bar sizes can be made. A clear spacing between bars of 1½ in. (38 mm) is normally needed to insert the movable jaw of a pipe wrench that grips and turns the coupler or bar. The outside diameter of the coupler for straight bar applications varies from 1⅞ in. (33 mm) for a #7 bar to 3 in. (76 mm) for a #18 bar. The outside diameter of the coupler for use with bent or curved bars is slightly larger.

Manufacturer B-Couplers are available from Manufacturer B for mechanically connecting #4 through #18

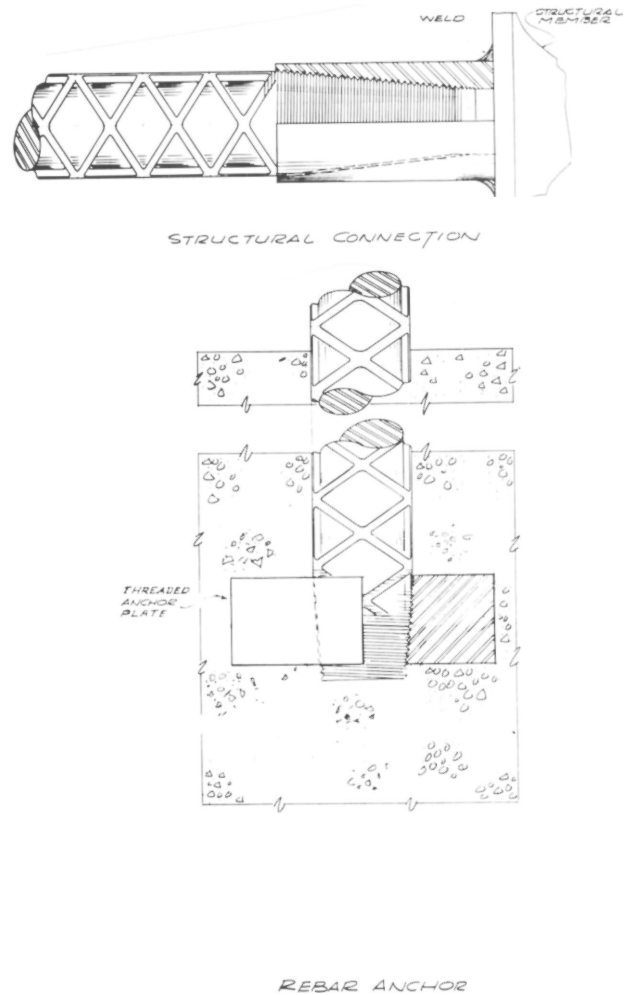


Fig. 3.3.8.4-Taper-threaded anchorage connections



Fig. 3.3.9-Three-piece coupler with NC threads

bars. A clear spacing between bars of 1½ in. (38 mm) or at least 1¼ bar diameters is normally needed to insert the movable jaw of a pipe wrench that grips and turns the coupler or bar. Overall diameter of the coupler across the flats varies from 1⅞ to 2⅞ in. (29 to 75 mm).

3.3.9 Threaded couplers with standard national coarse threads-These steel couplers have internally machined threads and require matching exterior threads on the ends of the reinforcing bars. Fig. 3.3.9 illustrates a three-piece coupler. (The three pieces are the coupler plus the two reinforcing bars). There is also a two-piece (two reinforcing bars) integrally forged coupler similar to the coupler shown in Fig. 3.4.1, but without the flange shown. The matching external threads may be machined or rolled. Roll-threading would be expected to increase the bar strength somewhat through cold work, but this effect is not quanti-

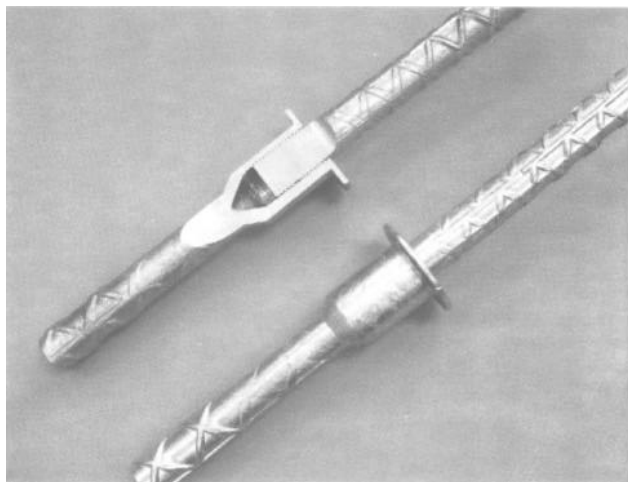


Fig. 3.4.1-Integrally-forged coupler with upset NC threads

tatively predictable. Therefore, the specified reinforcing bar should be sized on the basis of specified yield strength (psi) and the net area, unless suitable testing and quality control procedures are able to justify a less conservative evaluation of bar strength at the threads.

Threading a bar end will reduce the cross section of the nominal bar by approximately 15 to 25 percent depending on the thread size. The effect of the area reduction on strength may be offset by specifying a higher grade material, by increasing the specified bar diameter, or by upsetting the threaded ends proportionally to the thread reduction. However, it must be cautioned that just using a stronger or a size larger reinforcing bar could prove unsatisfactory for a seismic joint if the cross section through the threads ruptures before the unthreaded portion of the bar yields.

Threading of the bar ends can be prefabricated by coupler suppliers or may be accomplished in the field. Actual strength obtained from field-threaded connections should be verified. Precautions should be taken to protect the ends of the bars during shipping and handling. Bar lengths up to 40 ft (12 m) are available in all sizes from #4 through #18 with compatible steel couplers. A common installation practice is to connect the coupler to at least one bar end prior to reinforcing bar placement. The coupler may have a thread stop to assure proper thread engagement of the matching reinforcing bars. Use of a pipe wrench may be necessary to abut the matching bar against the thread stop. The outside diameter of the coupler varies from $\frac{3}{4}$ in. (19 mm) for the #4 to 3 in. (76 mm) for the #18 bar.

3.4-Dowel bar mechanical connection systems

Dowel bars are employed at construction joints to transfer tension and/or compression across these joints between reinforcing bars on either side of the joints. The following information does not apply to a mechanical connection of a reinforcing bar on one side of the joint with some other type of anchorage device on the other side of the joint.

Several manufacturers make dowel-bar mechanical connections. All are flanged couplers that achieve the same full tension-compression capability as the tension-compression connections in the previous section. The flanged couplers have holes that permit nailing them to the sides or ends of the formwork. In each case, the coupler with internal threads permits threading a dowel bar or long length of reinforcing bar.

These systems have the advantage of permitting continuity of reinforcement across construction joints without formwork penetration. These systems eliminate the projecting bar, which can interfere with construction and can be a cause of accidents.

There are four different systems for dowel-bar connections. Although each is specifically designed for connecting bars to dowel bars, nothing precludes their use as an ordinary tension-compression mechanical connection device as covered in [Section 3.3](#).

3.4.1 Integrally forged coupler--In this system, the mechanical connection device is manufactured directly from two reinforcing bars. This is an extension of the integrally forged two-piece coupler described in [Section 3.3.9](#). Each reinforcing bar composing the mechanical connection is altered by a manufacturing operation that produces a female or male portion for connecting the two bars. One reinforcing bar is forged to provide one end with an integrally flanged coupler with internal threads. Another reinforcing bar (the dowel end) has an integrally forged upset end with external threads. This coupling system is shown in [Fig. 3.4.1](#).

The dowel end has a standard thread size larger than the nominal diameter of the reinforcing bar. The thread size is such that the system is capable of achieving the minimum tensile strength of 90,000 psi (620 MPa) for Grade 60 reinforcing bars. For #4 through #7 reinforcing bars, the threads are standard national coarse (NC) series $\frac{1}{8}$ in. (3 mm) larger than the nominal diameter. For #8 through #11 bars, the threads are NC series at eight threads per inch of $1\frac{1}{8}$, $1\frac{1}{4}$, $1\frac{3}{16}$, and $1\frac{1}{2}$ in. (29, 32, 37, and 40 mm) diameter, respectively. The flanged coupler is forged on a reinforcing bar of the same size as the dowel-end bar with matching threads.

The female piece and the male piece can be obtained straight or with a 90-deg hook having the desired dimensions. A bar with a coupler at each end can transfer continuity of reinforcement across construction joints at two opposite faces of a member.

In the event a transition mechanical connection is required, the female piece can be formed on a larger bar with appropriately matched threads to accommodate the smaller step-down dowel-end bar.

3.4.2 Separate coupler with standard threads--In this system a separate flanged coupler is used as shown in [Fig. 3.4.2.1](#) and [3.4.2.2](#). This is an extension of the three-piece coupler shown in [Fig. 3.3.9](#) and described in [Section 3.3.9](#).

The coupler in [Fig. 3.4.2.2](#) is fabricated from material conforming to ASTM A 108 and has an internal positive stop at midlength. The stop assures that the reinforcing bar threaded from each end is threaded to the

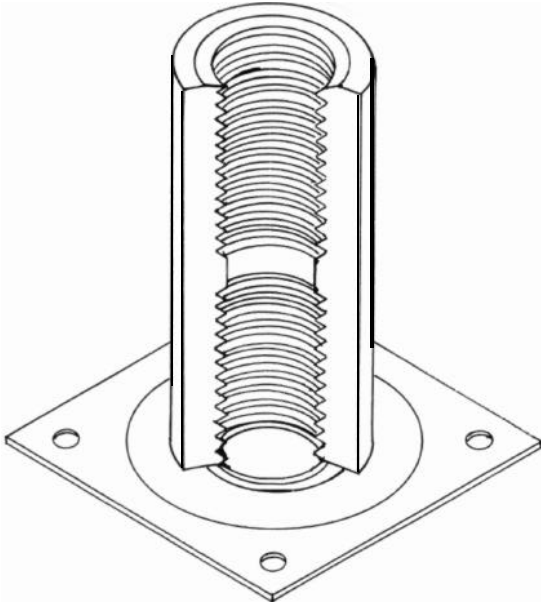


Fig. 3.4.2.1--Separate coupler with standard threads

proper depth. The square flange plate is swaged or welded to one end of the coupler. The standard coupler has the same thread size on each side of the stop. Transition couplers with different thread sizes on each side can be obtained by special order if two sizes of reinforcement are to be mechanically connected.

Grade 60 reinforcing bars conforming to ASTM A 615 are threaded with a standard thread series of the same or similar size as the nominal bar diameter. Threading for #4 through #9 bars use the standard NC series threads, whereas the #10 and #11 bars are threaded with the NC series which has eight threads per inch. Since standard threading of standard reinforcing bars is employed, the threaded bars may be fabricated locally or may be purchased from the coupler manufacturer.

In an extension of the system, a bent reinforcing bar is cast in concrete with the flange coupler attached to the bulkhead form face. After the formwork is removed, the straight bars are turned into the flange coupler to extend the reinforcing bar. These couplers are available for #4 through #18 bars with the appropriate consideration for loss of area due to threading of the reinforcing bars. Reducer flange couplers are also available to connect reinforcing bars of different diameters.

Since the section at the extended threads is less than that of the reinforcing bar, the strength of the system is limited by the section at the threads or by the coupler itself. If the full strength of a certain size reinforcing bar is required, it is necessary to upset the bar end before threading or to use a reinforcing bar that is one size larger or that is fabricated from a stronger steel. It is also necessary to use a mechanical connection device one size larger to achieve the force capacity required by Section 12.14.3.4 of ACI 318. However, it must be cautioned that just using a stronger or one size larger

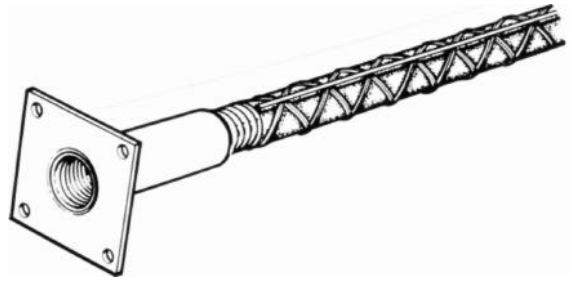


Fig. 3.4.2.2--Separate coupler with standard threads



Fig. 3.4.3--Coupler for thread-deformed reinforcing bars

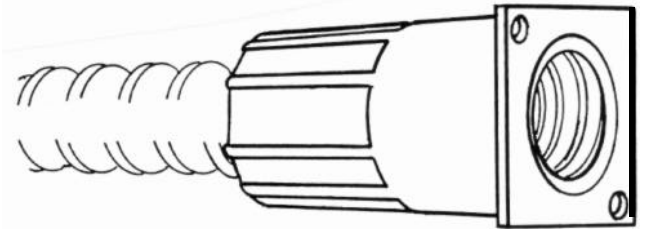


Fig. 3.4.4--Cold-swaged steel coupler with nail-on flange connector

reinforcing bar could prove unsatisfactory for a seismic joint if the cross section through the threads ruptures before the unthreaded portion of the bar yields.

3.4.3 Coupler for thread-deformed reinforcing bars—This system is an extension of the system shown in Fig. 3.3.6 and described in Section 3.3.6. A hexagonally shaped coupler with a triangular shaped flange as shown in Fig. 3.4.3 is used to provide dowel connecting capability. Since the reinforcing bar is a special bar with thread-like deformations, no special end preparation of the bars is required, except that either the bar ends must be within $1/4$ deg of square or jam nuts must be employed.

These couplers are available for #6 through #11 bars. The extension bar, if straight, is typically torqued tight against the bar embedded in the concrete. If the extension bar is bent or hooked, a jam nut is employed to make the bar tight to the coupler while maintaining the desired orientation.

3.4.4 Cold-swaged steel coupler—The cold-swaged coupler shown in Fig. 3.4.4 is basically the same as the female coupler with threaded ends covered in Section 3.3.2 and shown in Fig. 3.2.2. These couplers have



Fig. 3.5.1-Steel coupling sleeve with wedge

flanges with holes for nailing to wooden forms, as do the other dowel bar connections. Steel bolts can be used to attach these couplers to a steel bulk head.

3.5-Tension-only mechanical connection

Only one mechanical connection with a tension capability, as defined by ACI 318, Section 12.14.3.4, and as yet with no presently assigned compression capability, is described in the following paragraph. This type of mechanical connection has been used in situations where the reinforcement is required only for tension, such as column ties, stirrup-ties, flexural reinforcement in bridge decks and slabs on grade, or shrinkage-temperature reinforcement.

3.5.1 Steel coupling sleeve with wedge-The steel coupling sleeve with a hydraulically driven wedge is designed primarily for mechanical connection of the smaller diameter reinforcing bars, sizes #3 through #7. The steel coupling sleeve is oval in cross-section, permitting the overlapping of two reinforcing bars of the same diameter in the coupling sleeve as shown in Fig. 3.5.1. Each bar extends out of the sleeve about one bar diameter. After the coupling sleeve is correctly positioned, a wedge-shaped round pin is driven through a hole in the flat face of the sleeve. The wedge passes between the reinforcing bars and extends through a hole opposite the hole of insertion. The wedge pin is driven with a hand-held hydraulic ram. For connecting epoxy-coated bars, two couplings in tandem are required. This connector is presently rated only in tension, as current experimental work is in progress to evaluate the general applicability of this mechanical connection device to primary longitudinal reinforcement in compression and to verify that the eccentricity of the connected bars would not tend to spall the concrete.

CHAPTER 4-SUMMARY

Basic information about mechanical connections is presented together with information on mechanical connection devices currently available in North America.

The structural engineer should also consider these points:

1. Where no special requirements or job conditions exist that either favor or preclude the use of a particu-

lar mechanical connection device, project specifications should be left open to assure competition and lowest cost to the owner.

2. Performance data should be secured directly from the manufacturers of the mechanical connection devices.

3. It may be necessary to determine whether particular mechanical connection devices are acceptable to local code or building officials, or are appropriate for certain conditions of inelastic behavior or repeated reverse loading such as must be considered in seismic design.

4. Availability of required materials and equipment and service capabilities of the suppliers should be reviewed prior to specifying particular mechanical connection devices.

CHAPTER 5-REFERENCES

5.1-Recommended references

The documents of the various standards-producing organizations referred to in this report are listed below with their serial designations.

American Association of State Highway and Transportation Officials (AASHTO)

Standard Specifications for Highway Bridges, 13th Ed., 1983

American Concrete Institute (ACI)

301-89 Specifications for Structural Concrete for Buildings

318-89 Building Code Requirements for Reinforced Concrete

318R-89 Commentary on Building Code Requirements for Reinforced Concrete

349-85 Code Requirements for Nuclear Safety Related Concrete Structures

359-83 Code for Concrete Reactor Vessels and Containments (published as Section III, Division 2, of the ASME Boiler and Pressure Vessel Code, American Society of Mechanical Engineers, 345 E. 47th St., New York, NY 10017)

American Society for Testing and Materials (ASTM)

A 108-89 Standard Specification for Steel Bars, Carbon, Cold-Finished, Standard Quality

A 615-89 Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement

A 706-89 Standard Specification for Low-Alloy Steel Deformed Bars for Concrete Reinforcement

American Welding Society

ANSI/AWS D1.4-79 Structural Welding Code-Reinforcing Steel

These publications may be obtained from the following organizations:

American Association of State Highway and Transportation Officials
444 North Capitol Street, NW
Suite 225
Washington, DC 20001

American Concrete Institute
PO Box 19150
Detroit, MI 48219

ASTM
1916 Race Street
Philadelphia, PA 19103

American Welding Society
PO Box 351040
Miami, FL 33135

5.2.Cited reference

1. Gustafson, D. P., "Welded Splices of Reinforcing Bars," *Concrete Construction*, V. 26, No. 10, Oct. 1981, pp. 807, 809, 810, and 812.

ACKNOWLEDGMENTS

The following manufacturers are to be thanked for permitting the committee to exhibit a picture or sketch of their product in this report.

Fig. 3.2.1.1- Harris Rebar, Inc., Stricon Products Div., Stoney Creek, Ontario, Canada.

Fig. 3.2.1.2 and 3.2.2- Erico Products, Inc., Cleveland, OH.

Fig. 3.2.3- Gateway Building Products, Chicago, IL

Fig. 3.3.1 and 3.3.2- Barsplice Products, Inc., Dayton, OH

Fig. 3.3.3- Dywidag Systems International, U.S.A. Inc., Lemont, IL

Fig. 3.3.4- Harris Rebar, Inc.

Fig. 3.3.5- Splice Sleeve North America, Inc., Sacramento, CA

Fig. 3.3.6- Dywidag Systems International, U.S.A. Inc.

Fig. 3.3.7 and 3.3.8.1- Erico Products, Inc.

Fig. 3.3.8.2, 3.3.8.3, and 3.3.8.4- Fox-Howlett Industries, Inc., Berkeley, CA

Fig. 3.3.9 and 3.4.2.1- Williams Form Engineering Corp., Grand Rapids, MI

Fig. 3.4.1- Richmond Screw Anchor Co., Inc., Fort Worth, TX

Fig. 3.4.2.2- Dayton Superior Corp., Miamisburg, OH

Fig. 3.4.3- Dywidag Systems International, U.S.A. Inc.

Fig. 3.4.4- Barsplice Products, Inc.

Fig. 3.5.1- Splice Sleeve North America

This document was submitted to letter ballot of the committee and approved according to the ACI standardization procedures.