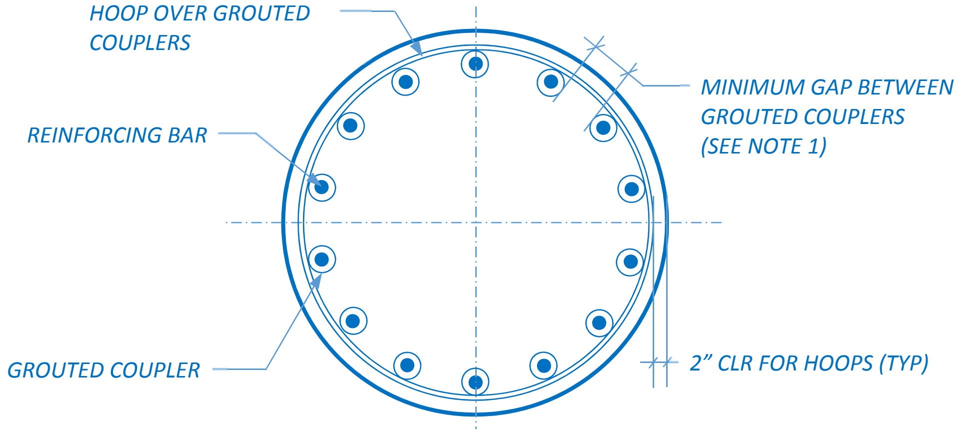
5.10.8.4.2b MECHANICAL CONNECTIONS

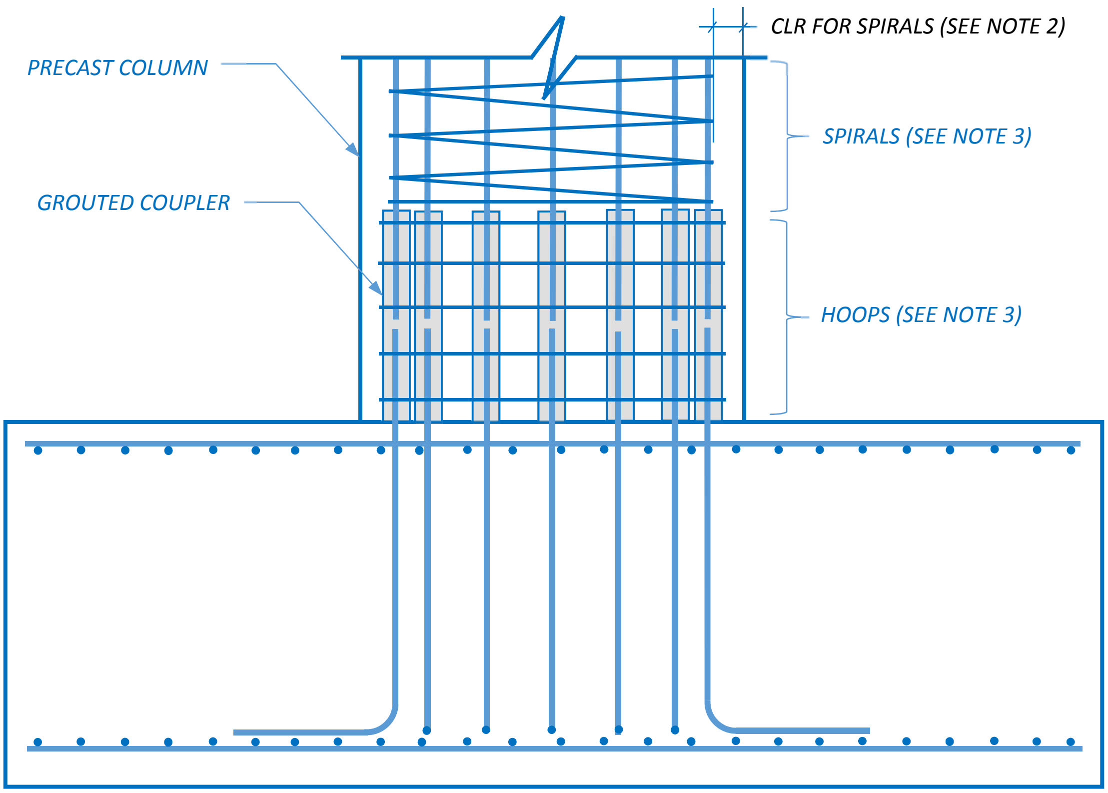
- Grouted splice couplers may be used to connect precast columns to footings or cap beams for columns with less than 4% drift. (Drift is determined by dividing the maximum displacement at the top of a column by its height. Column displacements under seismic loads may be obtained by non-linear analysis or linear-elastic analysis using cracked column section moment of inertia and displacement magnification factors as per AASHTO Art. 4.7.4.5)
- The total length of grouted splice couplers shall not exceed $15d_b$, where d_b is the longitudinal bar diameter.
- Type 1 mechanical connections shall develop min 125% of the specified yield strength of the connected reinforcing bar. Type 2 mechanical connections shall develop min 150% of the specified yield strength of the connected reinforcing bar.
- Grouted couplers in plastic hinge zones must develop 150% of the specified yield strength of the connected reinforcing bar (only Type 2 couplers are permitted). See Table 1 for a list of approved grouted couplers.
- NMB Splice Sleeve: Splice Sleeve North America, Inc. NMB Splice Sleeve grouted couplers for Grade 60 bar with sizes of No. 6, 8, 11 and 14 met at least 150% of specified bar tensile yield strength. Assuming a specified 90 ksi ultimate strength for Grade 60 bars, these couplers meet the ACI Type 2 and AASHTO Full Mechanical Connection (FMC) coupler strength requirements (i.e., 1.0 f_u and 1.50 f_y, respectively).
- Erico Lenton Interlok: All Lenton Interlok grouted couplers listed in Table 1 meet ACI Type 1 requirement in tension and compression and the ACI Type 2 requirement in tension. They also meet AASHTO FMC strength requirement.
- Minimum clear distance between grouted splice couplers is recommended to be the same as those specified for reinforcing bars. See typical detail drawings in Figure 1.
- The clear cover for the shear reinforcement over grouted couplers in the precast column shall be 2”.
- Grout for grouted couplers shall be provided by the manufacturer of the coupler.

Table 1. List of Approved Grouted Couplers

ASTM A706 or ASTM A615 Grade 60 Bar Size	NMB Splice Sleeve	Erico Lenton Interlok
#5	5U-X	LK5
#6	6U-X	LK6
#7	7U-X	LK7
#8	8U-X	LK8
#9	9U-X	LK9
#10	10U-X	LK10
#11	11U-X, SNX11	LK11
#14	14U-X	LK14
#18	--	LK18



COLUMN SECTION
NTS



COLUMN/FOOTING ELEVATION
NTS

NOTES:

1. LARGER OF (1) 1 IN., (2) 1.33 TIMES MAX. COARSE AGGREGATE SIZE, AND (3) NOMINAL DIAMETER OF CONNECTED REINFORCING.
2. CLEAR COVER FOR SPIRALS = 2" + (DIAM. OF COUPLER – DIAMETER OF BAR)/2
3. FOLLOW THE REQUIREMENTS OF AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS SECTION 5.10.6.

Figure 1. Typical Precast Column with Grouted Couplers to Footing Connection Details.

1. Background Information on Grouted Coupler Dimensions and Comparison of Grouted Coupler Lengths:

Figure 2 shows the connector configuration for the NMB Type U-X and A11W splice-sleeves. Figure 3 shows connector configuration for the NMB SNX11 splice-sleeve.
Tables 2 and 3 show the dimensions and the required rebar embedment lengths corresponding to Figures 2 and 3, respectively.

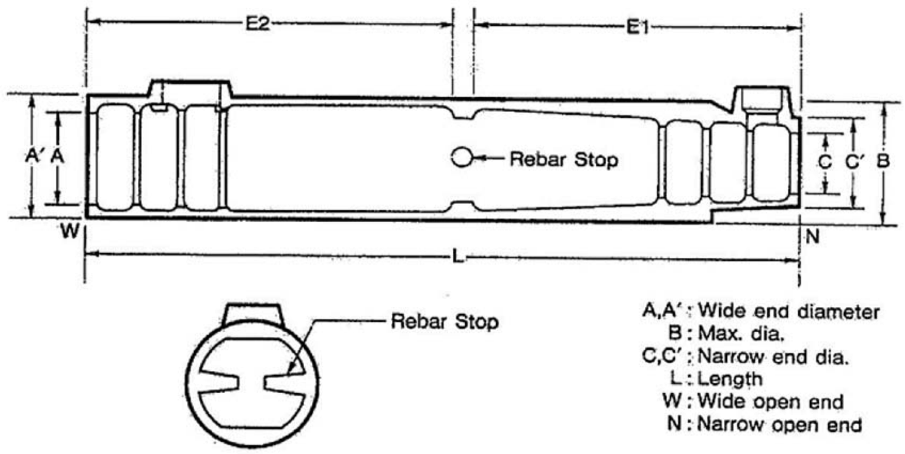


Figure 2. NMB Type U-X and A11W Splice Sleeves.
(ICC-ES Report ESR-3433, Splice Sleeve North America, Inc., 2016).

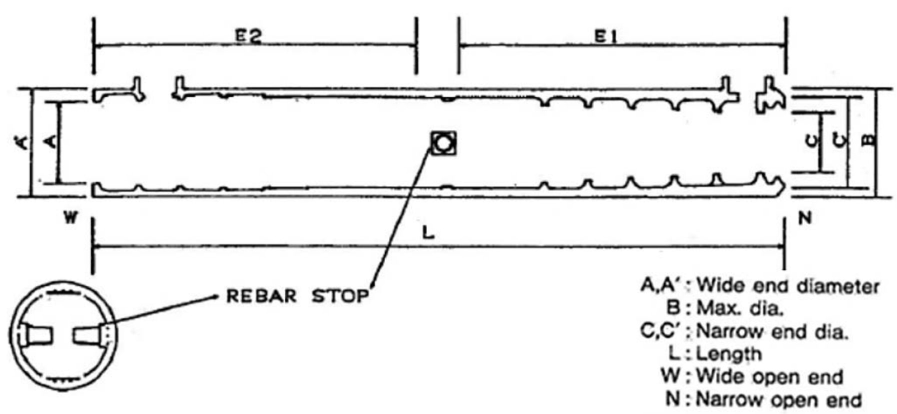


Figure 3. NMB SNX11 Splice Sleeve.
(ICC-ES Report ESR-3433, Splice Sleeve North America, Inc., 2016).

Table 2. Dimensions of NMB Type U-X and A11W Splice-Sleeves (ICC-ES Report ESR-3433, Splice Sleeve North America, Inc., 2016).

DIMENSIONS OF NMB U-X SLEEVES												REQUIRED REBAR EMBEDMENT LENGTH			
Sleeve No.	Bar Diameter (in.) [mm]	Bar Size		Sleeve Length (in.) [mm]	Narrow End Diameter (in.) [mm]		Maximum Diameter (B) (in.) [mm]	Wide End Diameter (in.) [mm]				Dowel (E1) (in.) [mm]		Dowel (E2) (in.) [mm]	
		ASTM	JIS		I.D. (C)	O.D. (C')		I.D. (A)	Total Tolerance [1]	O.D (A')		Min.	Max.	Min.	Max.
5U-X	0.625 [16]	#5	D16	9.65 [245]	0.87 [22]	1.50 [38]	1.89 [48.0]	1.26 [32.0]	0.63 [16.0]	1.89 [48.0]		4.13 [105]	4.33 [110]	4.13 [105]	4.92 [125]
6U-X	0.750 [19]	#6	D19	11.22 [285]	1.02 [26]	1.65 [42]	2.05 [52.0]	1.42 [36.0]	0.67 [17.0]	2.05 [52.0]		4.92 [125]	5.12 [130]	4.92 [125]	5.71 [145]
7U-X	0.875 [22]	#7	D22	12.80 [325]	1.14 [29]	1.77 [45]	2.36 [60.0]	1.73 [44.0]	0.86 [21.8]	2.36 [60.0]		5.71 [145]	5.91 [150]	5.71 [145]	6.50 [165]
8U-X	1.000 [25]	#8	D25	14.57 [370]	1.30 [33]	1.93 [49]	2.52 [64.0]	1.89 [48.0]	0.89 [22.6]	2.52 [64.0]		6.50 [165]	6.69 [170]	6.50 [165]	7.48 [190]
9U-X	1.128 [29]	#9	D29	16.34 [415]	1.42 [36]	2.06 [52.4]	2.67 [67.9]	2.01 [51.0]	0.89 [22.6]	2.67 [67.9]		7.40 [188]	7.56 [192]	7.40 [188]	8.35 [212]
10U-X	1.270 [32]	#10	D32	17.91 [455]	1.57 [40]	2.28 [58]	2.87 [73.0]	2.17 [55.0]	0.89 [22.6]	2.87 [73.0]		8.19 [208]	8.35 [212]	8.19 [208]	9.13 [232]
11U-X	1.410 [36]	#11	D36	19.49 [495]	1.73 [44]	2.40 [61]	3.03 [77.0]	2.32 [59.0]	0.91 [23.1]	3.03 [77.0]		8.98 [228]	9.13 [232]	8.98 [228]	9.92 [252]
14U-X	1.693 [43]	#14	D43	24.41 [620]	2.01 [51]	2.80 [71]	3.46 [88.0]	2.60 [66.0]	0.91 [23.1]	3.46 [88.0]		11.42 [290]	11.61 [295]	11.42 [290]	12.40 [315]
A11W	1.410 [36]	#11	D36	19.49 [495]	1.73 [44]	3.31 [84]	3.31 [84.0]	2.60 [66.0]	1.19 [30.2]	3.31 [84.0]		8.86 [225]	9.69 [246]	8.27 [210]	9.50 [241]

[1]Total tolerance is determined by subtracting bar diameter from the wide end inside diameter (A).

Table 3. Dimensions of NMB SNX11 Splice-Sleeve (ICC-ES Report ESR-3433, Splice Sleeve North America, Inc., 2016).

DIMENSIONS OF NMB SNX SLEEVE											REQUIRED REBAR EMBEDMENT LENGTH			
Sleeve No.	Bar Diameter (in.) [mm]	Bar Size		Sleeve Length (in.) [mm]	Narrow End Diameter (in.) [mm]		Maximum Diameter (B) (in.) [mm]	Wide End Diameter (in.) [mm]			Dowel (E1) (in.) [mm]		Dowel (E2) (in.) [mm]	
		ASTM	JIS		I.D. (C)	O.D. (C')		I.D. (A)	Total Tolerance[1]	O.D (A')	Min.	Max.	Min.	Max.
SNX11	1.410 [36]	#11	D36	19.09 [485]	1.69 [43]	3.03 [77]	3.03 [77.0]	2.32 [59]	0.91 [23.1]	3.03 [77]	8.86 [225]	9.25 [235]	8.27 [210]	9.45 [240]

[1]Total tolerance is determined by subtracting bar diameter from the wide end inside diameter (A).

Figure 4 shows the connector configuration for Erico's Lenton Interlok couplers and Table 4 shows the dimensions and cut length for reinforcing steel.

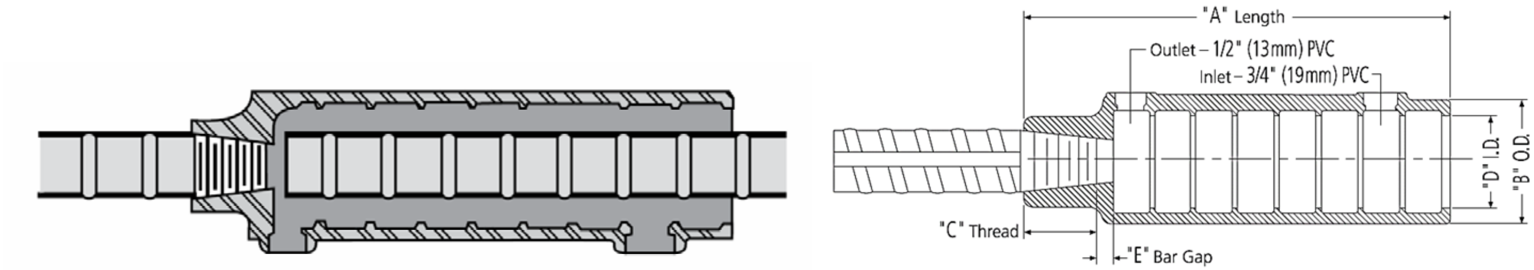


Figure 4. Erico's Lenton Interlok Rebar Splicing System. (Erico, 2013).

Table 4. Coupler Dimensions and Cut Length for Reinforcing Steel for Lenton Interlok Rebar Splicing System. (Erico, 2013).

Rebar Size in-lb	Rebar Size Canadian	Coupler Part No.	"A"	"B"	"C"	"D"	"E" Reference	"X" Max.	"X" Min. Type 1*	"X" Min. Type 2**
#5	15M	LK5	7-13/16"	2-9/16"	7/8"	1-7/8"	13/16"	6-1/8"	5-1/4"	5-1/2"
#6	20M	LK6	7-13/16"	2-9/16"	1-1/8"	1-7/8"	9/16"	6-1/8"	5-1/4"	5-3/8"
#7	---	LK7	7-13/16"	2-9/16"	1-1/4"	1-7/8"	7/16"	6-1/8"	5-1/4"	
#8	25M	LK8	8-5/8"	2-11/16"	1-3/8"	2"	1/4"	7"	6"	
#9	30M	LK9	9-3/4"	2-13/16"	1-1/2"	2-1/8"	1/4"	8"	6-7/8"	
#10	---	LK10	10-13/16"	3"	1-9/16"	2-5/16"	1/4"	9"	7-3/4"	
#11	35M	LK11	11-15/16"	3-1/8"	1-11/16"	2-7/16"	3/8"	9-7/8"	8-1/2"	
#14	45M	LKT14	15-3/16"	3-11/16"	2-1/8"	2-3/4"	5/16"	12-3/4"	11"	
#18	55M	LKT18	20-5/16"	4-1/2"	2-3/4"	3-1/4"	9/16"	17"	14-3/4"	

* "X" Min. Type 1 will develop 125% of the specified yield strength of the rebar in tension and compression (125% f_y).
** "X" Min. Type 2 meets Type 1 and will develop the specified tensile strength of the rebar in tension (f_u).

Reference: Idaho Transportation Department Research Report, Report No. FHWA-ID-16-246: *“Seismic Performance of Columns with Grouted Couplers in Idaho Accelerated Bridge Construction Applications”* (Authors: Arya Ebrahimpour, Barbara E. Earles, Supreme Maskey, Maria Tangarife, Andrew D. Sorensen, Idaho State University Department of Civil and Environmental Engineering)

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