5000. Concrete Structures and Construction

- 5100 • Reinforced Concrete
- 5200 • Prestressed Concrete
- 5300 • Reinforcing Bars, Reinforcing Details & Tolerances
- 5400 • Concrete Containments, Modular Construction& Mass Concrete
- 5500 • Durability, NDE & Masonry

5300. Reinforcing Bars, Reinforcing Details & Tolerances

- Objective and Scope
  - Provide introductory level review of Reinforcing Bars, Reinforcing Details & Tolerances
  - Present and discuss
    - Reinforcing Bar Specifications
    - Mechanical Splices
    - Specifications for Tolerances

5300. Reinforcing Bars, Reinforcing Details & Tolerances

- 5310 • 5310 - Reinforcing Bars
- 5320 • 5320 - Mechanical Splices
- 5330 • 5330 - Tolerances & Construction Details

5300. Reinforcing Bars, Reinforcing Details & Tolerances

- 5310 • 5310 - Reinforcing Bars
- 5320 • 5320 - Mechanical Splices
- 5330 • 5330 - Tolerances & Construction Details

5310 - Reinforcing Bars Delivery

Fabrication of Reinforcing Bars Inventory

Fabrication of Reinforcing Bars Shear Line

Fabrication of Reinforcing Bars Bender

Fabrication of Reinforcing Bars
Automatic Bender

Reinforcing Steel Specifications

- Bar Specifications
  - A615 – Plain carbon steel
  - A706 – Low alloy steel
  - A1035 – Low carbon/chromium steel
- Coated & Corrosion Resistant Steel
  - A775 – Epoxy coated rebar
  - A767 – Galvanized rebar
  - A1055 – Galvanized & Epoxy coated
  - A955 – Stainless steel

Reinforcing Steel Specifications
Bar Sizes

- Inch-pound bar size designations represent 1/8 inch fractions

Inch-Pound Units		SI Units	
Bar Designation	Nominal Diameter	Bar Designation	Nominal Diameter
#3	3/8"	#10	9.5 mm
#4	4/8"	#13	12.7 mm
#5	5/8"	#16	15.9 mm
#6	6/8"	#19	19.1 mm
#7	7/8"	#22	22.2 mm
#8	8/8"	#25	25.4 mm
..... #9, 10, 11, 14, 18			

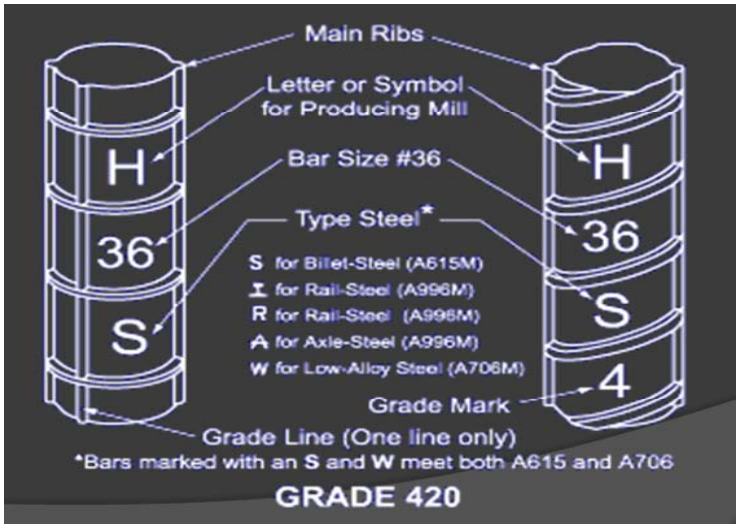
Reinforcing Steel Specifications

ASTM A706		Grade 60 (Grade 420)	Grade 80 (Grade 555)
Minimum Yield Strength, psi (MPa)		60,000 (420)	80,000 (555)
Maximum Yield Strength, psi (MPa)		78,000 (540)	100,000 (690)
Minimum Tensile Strength, psi (MPa)		80,000* (550)	105,000* (725)
* Tensile strength shall not be less than 1.25 times the actual yield strength			
Bar Designation	**Minimum Percent Elongation in 8"**		
#3, #4, #5, #6		14	12
#7, #8, #9, #10, #11		12	12
#14, #18		10	10

Reinforcing Steel Specifications

- Tensile Requirements
- Bending Requirements
  - Withstand bending without cracking
- Permissible Variation in Weight
  - At least 94% of nominal weight
- Deformations
  - Orientation, size, spacing, height
- Marking
  - Mill, bar size, type, grade

Reinforcing Bar Markings



Reinforcing Steel Surface Conditions

CRSI Manual of Standard Practice - Section 8.3

- *At the time of placement, all reinforcing bars shall be free of mud, oil, or other deleterious materials*
- *Reinforcing bars with rust, mill scale, or a combination of both should be considered as satisfactory, provided that the minimum dimensions, weight, and height of deformations of a hand-wire-brushed specimen are not less than the applicable ASTM specification requirements*

Field Bending of Reinforcing Steel

- To correct bars partially embedded in concrete due to incorrect fabrication, incorrect placement, accidental misalignment or design change
- In-situ bending is prohibited unless shown on drawings or specifically authorized by the engineer
- Limited to bar size #11 and smaller

Field Bending of Reinforcing Steel

- Bend diameters must conform to ACI 318
- Bar sizes #3 through #5 and if were previously unbent, can be bent cold
- Bar sizes #3 through #5 and if were previously bent, must be heated prior to straightening and re-bending
- Bar sizes #6 through #11 must be heated prior to straightening and/or bending

Field Bending of Reinforcing Steel

Bending Condition	Bar Size	Reduction in Yield Strength	Reduction in Ultimate Tensile Strength	Reduction in Elongation
Cold	#3 & #4	-	-	20%
	#5	5%	-	30%
Hot	All Sizes	10%	10%	20%

Field Bending of Reinforcing Steel

Bar Size	Minimum Temperature	Maximum Temperature
#3 & #4	1,200 F	1,250 F
#5 & #6	1,350 F	1,400 F
#7, #8 & #9	1,400 F	1,450 F
#10 & #11	1,450 F	1,500 F

Field Cutting of Reinforcing Steel

- Bolt cutters for bar sizes #10 to #16
- Abrasive saw on any bar size
- Cutting torch on any bar size
  - Tests indicate no more than 3/8” from end of bar is effected by heat
- Flame cutting of epoxy-coated bars will damage the coating, proper repair is necessary

Epoxy Coated Reinforcing Bars

- Nylon slings or other padded material to lift bars
- Lift and set bars into place
  - Bars are not to be dragged into place
- Minimize walking on bars
  - Set up a walkway
- Bars to be visually inspected for damage after placement

Epoxy Coated Reinforcing Bars

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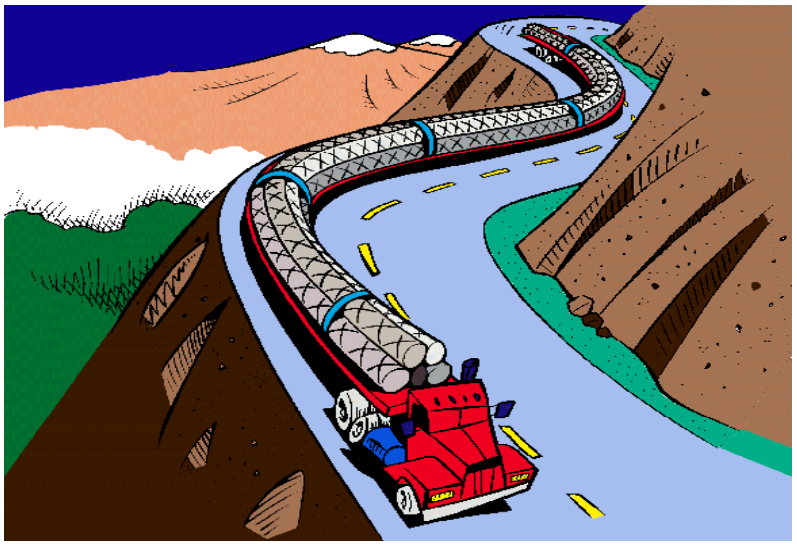
5300. Reinforcing Bars, Reinforcing Details & Tolerances

- 5310 - Reinforcing Bars
- 5320 - Mechanical Splices
- 5330 - Tolerances & Construction Details

5320 - Mechanical Splices Splicing Reinforcing Steel



Reinforcing Steel Splicing Options

- Lap Splices
- Welded Splices
- Mechanical Splices
  - Compression only splices
  - Tension-compression splices
  - Tension compression lap splices

Type 1 and Type 2 mechanical splices

- Type 1 splices are used in elements where there is little concern for inelastic deformations and elevated tensile stresses from seismic events
- Type 2 splices have proven, through accepted industry testing, the ability to develop the specified tensile strength of the spliced bars for resistance to elevated tensile stresses
- In ACI 318, Chapter 21, Type 2 mechanical splices are required to develop the specified tensile strength of the bars being spliced

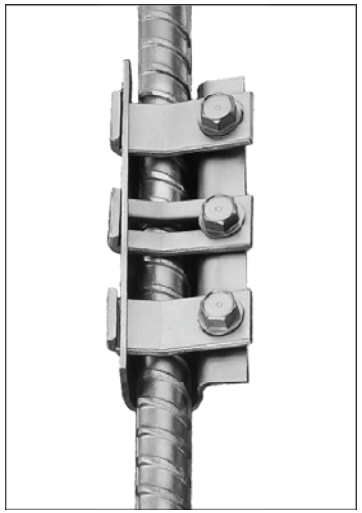
Reinforcing Steel Splicing Options

- Compression-only mechanical splices
  - Engineer should confirm that the splice will not be subjected to stress reversal
  - Temporary stress reversals might be brought about by a dynamic condition
  - When loading is less certain, tension-compression splices are recommended

Reinforcing Steel Splicing Options

- Compression-only mechanical splices (Cont'd)
  - Except for a steel-filled coupling sleeve, ACI 318 requires that the ends of the bars be sawcut, or cut by some other means, within 1-1/2 degrees of square to the bar longitudinal axis. ACI 318 also requires that an end-bearing splice device be capable of holding the bars in concentric bearing contact

Reinforcing Steel Splicing Options
Strap-type Steel Coupling Sleeve

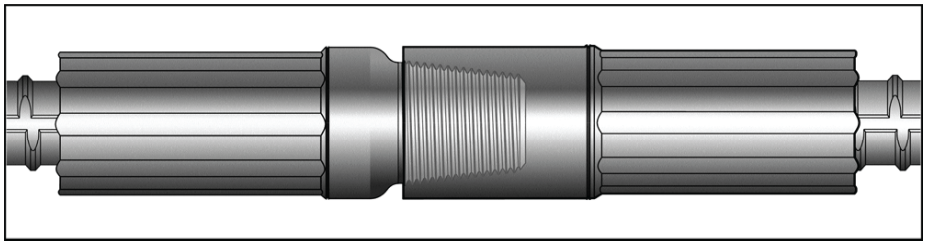


- Compression-only mechanical splice

Reinforcing Steel Splicing Options
Steel-filled Coupling Sleeve

- By means of an exothermic process, molten filler solidifies around the deformations on the bar and internal grooves of the sleeve, creating a mechanical interlock; good also in tension

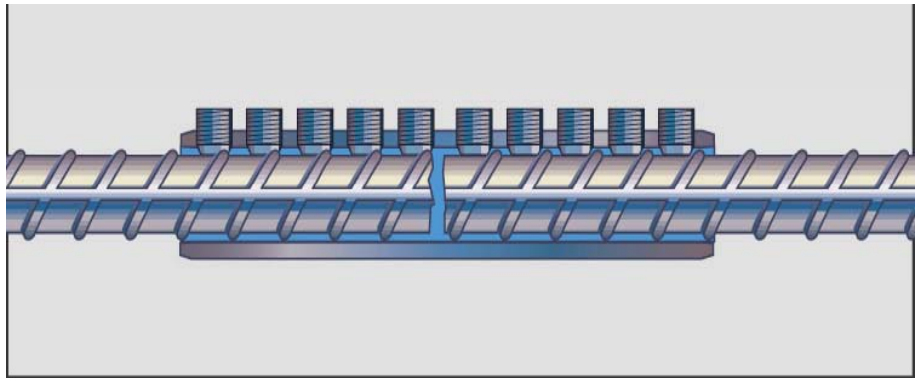
Reinforcing Steel Splicing Options
Tension-compression Mechanical Splice



- Cold-swaged steel coupler with taper-threaded ends

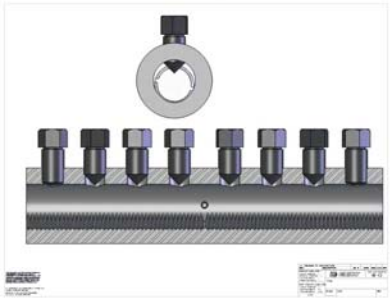
Reinforcing Steel Splicing Options
Tension-compression Mechanical Splice

- Bolted



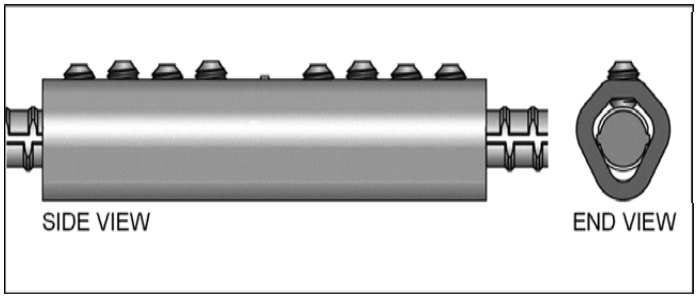
Reinforcing Steel Splicing Options
Tension-compression Mechanical Splice

- **Bolt heads shear off when proper values are reached**



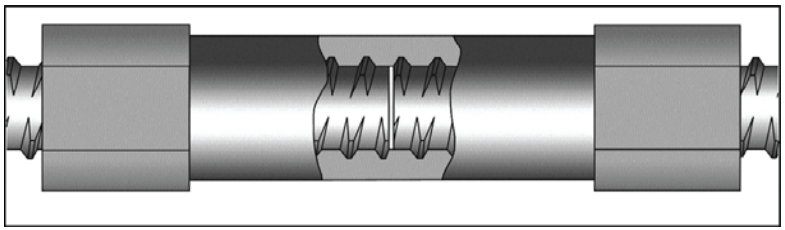
Reinforcing Steel Splicing Options
Tension-compression Mechanical Splice

- Shear screw and wedge coupling sleeve



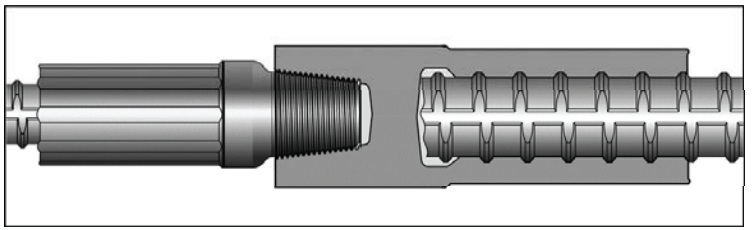
Reinforcing Steel Splicing Options
Tension-compression Mechanical Splice

- Coupler for thread-like deformed reinforcing bars



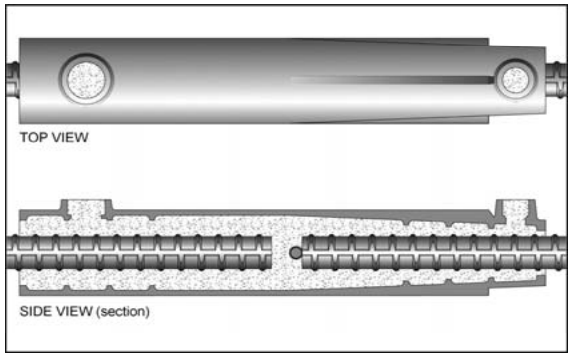
Reinforcing Steel Splicing Options
Tension-compression Mechanical Splice

- Transition cold-swaged coupler with taper-threaded ends



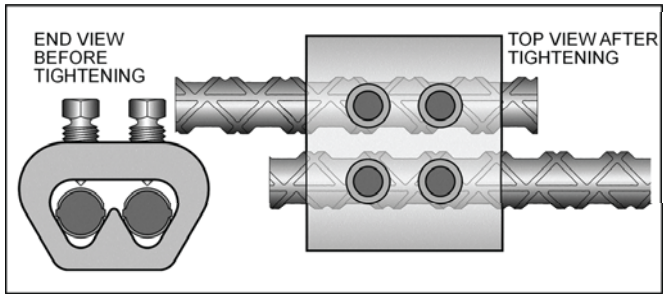
Reinforcing Steel Splicing Options
Tension-compression Mechanical Splice

- Grout-filled coupling sleeve



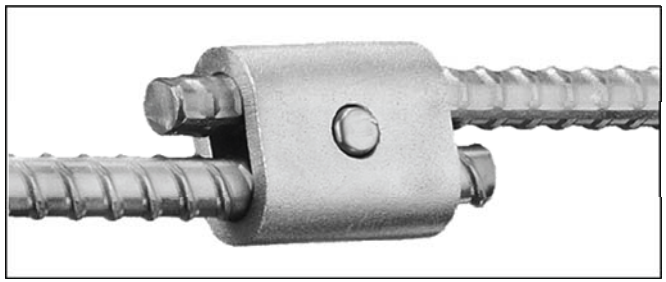
Reinforcing Steel Splicing Options
Mechanical Lap Splice

- Shear screw and double-wedge coupling sleeve



Reinforcing Steel Splicing Options
Mechanical Lap Splice

- Steel coupling sleeve with wedge



Mechanical Splices - Summary

- It may be necessary to determine whether particular mechanical splices are acceptable to local code or building officials. The mechanical splice manufacturer should normally be the principal party to obtain the necessary recognition or approval of the splicing products it manufactures
- The engineer should approve all splices on the project that are appropriate for certain conditions of inelastic behavior or repeated reverse loading, which should be considered in seismic design

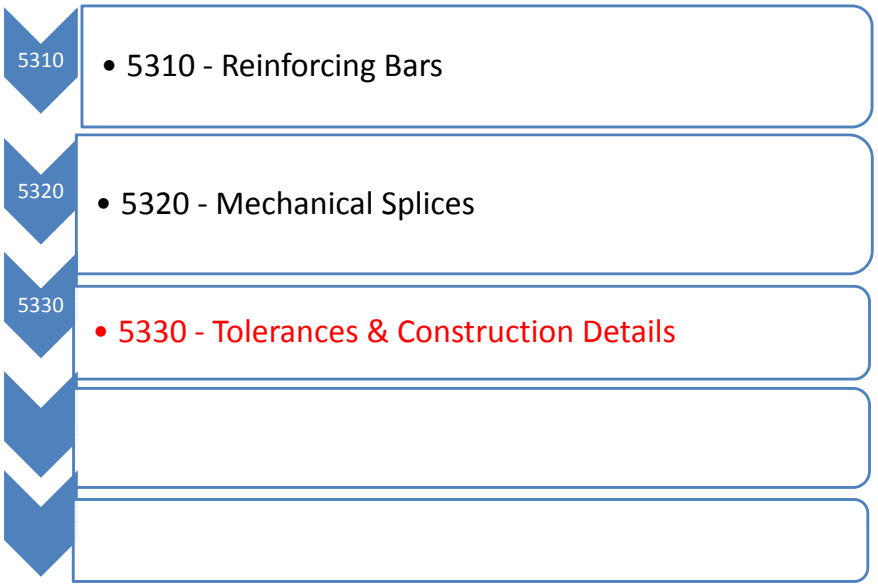
Mechanical Splices – Summary (Cont'd)

- Where no special requirements or job conditions exist that either favor or preclude the use of a particular mechanical splice, as in certain Type 1 splice applications, project specifications should be left open
- Installation instructions and performance data should be secured directly from the manufacturers of the mechanical splices. Manufacturer's requirements should be referenced in design drawings and specifications to provide greater assurance that the devices will be installed properly

Mechanical Splices – Summary (Cont'd)

- Inspection or quality assurance is needed to ensure satisfactory performance. Splice manufacturers can provide installation acceptance criteria for field inspection
- Testing can be performed to verify that a particular splice type will meet specified performance requirements, particularly in critical locations where Type 2 splices are used

5300. Reinforcing Bars, Reinforcing Details & Tolerances

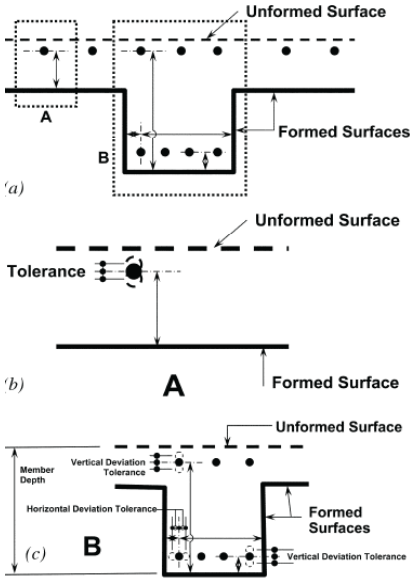


5330 - Tolerances & Construction Details

Specifications for Tolerances - Examples ACI 117

- Placement of nonprestressed reinforcement, measured from form surface
  - When member depth (or thickness) is 4 in. or less.....±1/4 in.
  - When member depth (or thickness) is over 4 in. and not over 12 in.....±3/8 in.
  - When member depth (or thickness) is over 12 in.....±1/2 in.

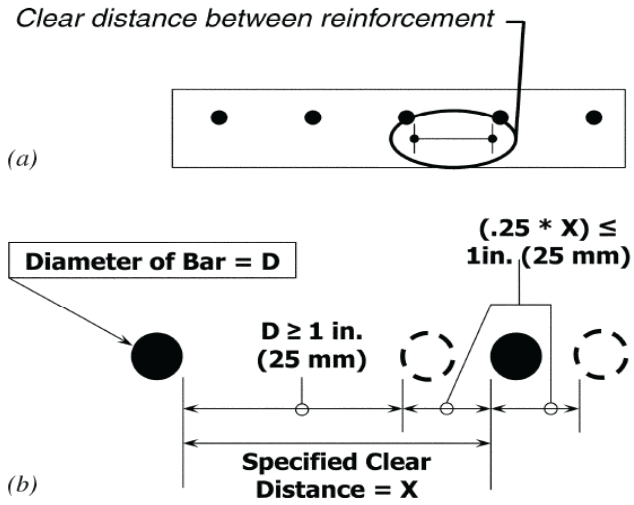
Specifications for Tolerances - Examples ACI 117 (Cont'd)



Specifications for Tolerances - Examples ACI 117 (Cont'd)

- Concrete cover measured perpendicular to concrete surface
  - When member depth (or thickness) is 12 in. or less.....-3/48in.
  - When member depth (or thickness) is over 12 in.....-1/2in.
  - Reduction in cover shall not exceed 1/3 the specified concrete cover

Specifications for Tolerances - Examples ACI 117 (Cont'd)



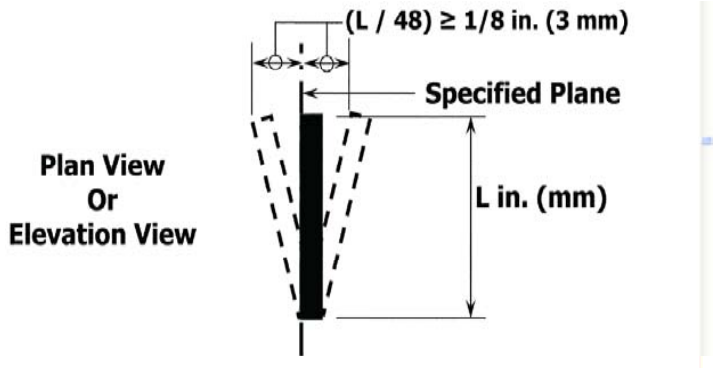
Specifications for Tolerances - Examples ACI 117 (Cont'd)

Placement of prestressing reinforcement or prestressing ducts

- Horizontal deviation
  - Element depth (or thickness) 24 in. or less..... ±1/2 in
  - Element depth (or thickness) over 24 in. ..... ±1 in.
- Vertical deviation
  - Element depth (or thickness) 8 in. or less..... ±1/4 in
  - Element depth (or thickness) > 8 in. but ≤24 in..... ±3/8in
  - Element depth (or thickness) over 24 in. ..... ±1 /2in

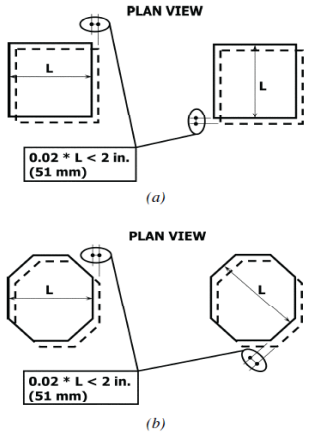
Specifications for Tolerances - Examples ACI 117 (Cont'd)

- Bearing plate for prestressing tendons



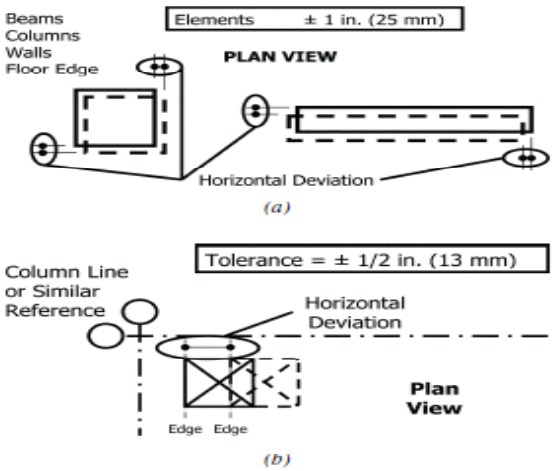
Specifications for Tolerances - Examples ACI 117 (Cont'd)

- Deviation from location - Foundations



Specifications for Tolerances - Examples ACI 117 (Cont'd)

- Horizontal deviation

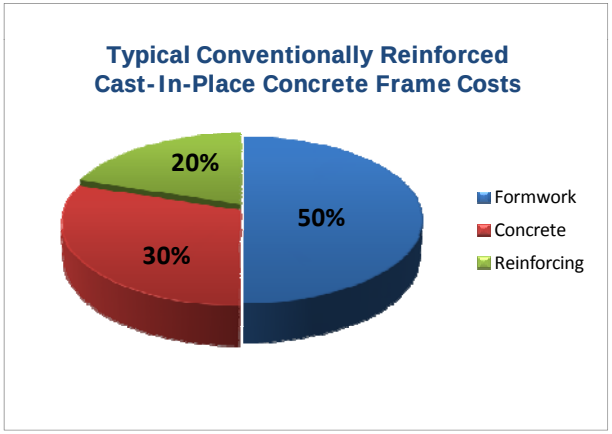


Economical Concrete Construction

- Formwork
- Concrete
- Reinforcement

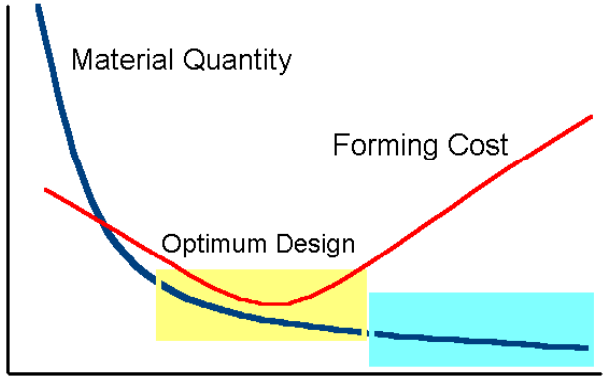
Economical Concrete Construction

Formwork 50%; Concrete 30%; Reinforcing 20%



Economical Concrete Construction

- Minimizing material quantities can lead to "inefficient" designs

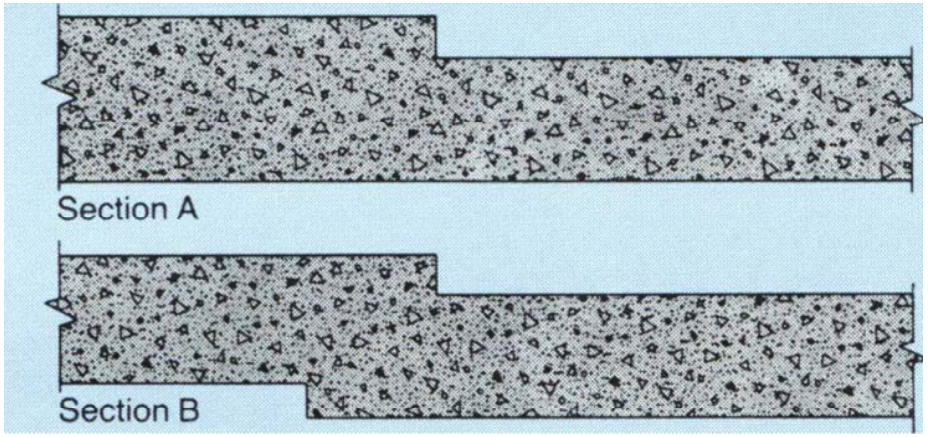


Economical Concrete Construction

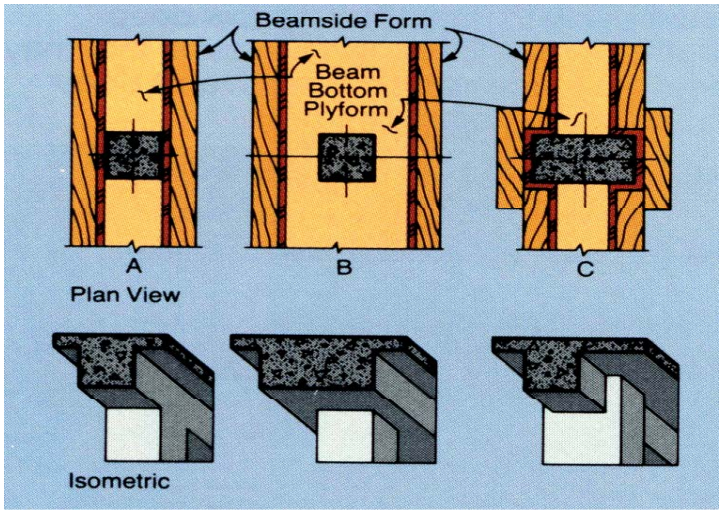
- Keep Formwork
  - Simple
  - Repetitious
  - Standard
    - Form sizes
    - Lumber dimensions

Economical Concrete Construction

- Material savings does not offset forming costs



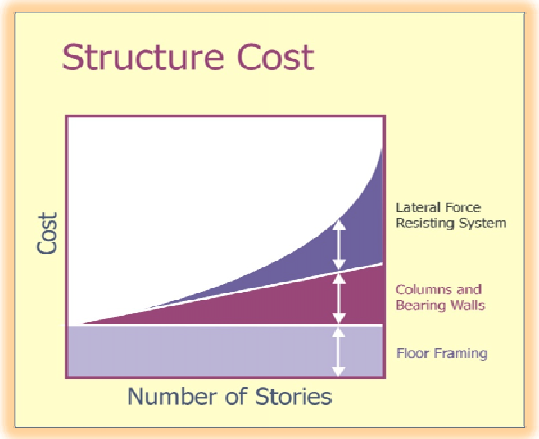
Beam - Column Intersections



Floor Framing Systems

- Size beams and joists the same depth

Floor Framing Systems



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