Rebar 101

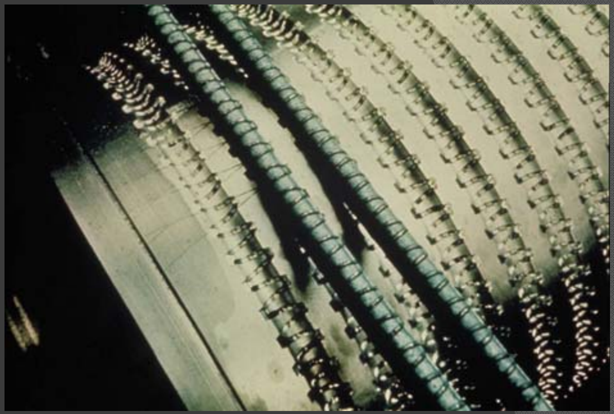
A presentation of the
Concrete Reinforcing Steel Institute

What are the basic questions?

- What “materials” are used to make rebar?
- How is rebar made?
- How is rebar used?
  - ASTM Specs
  - Typical framing systems

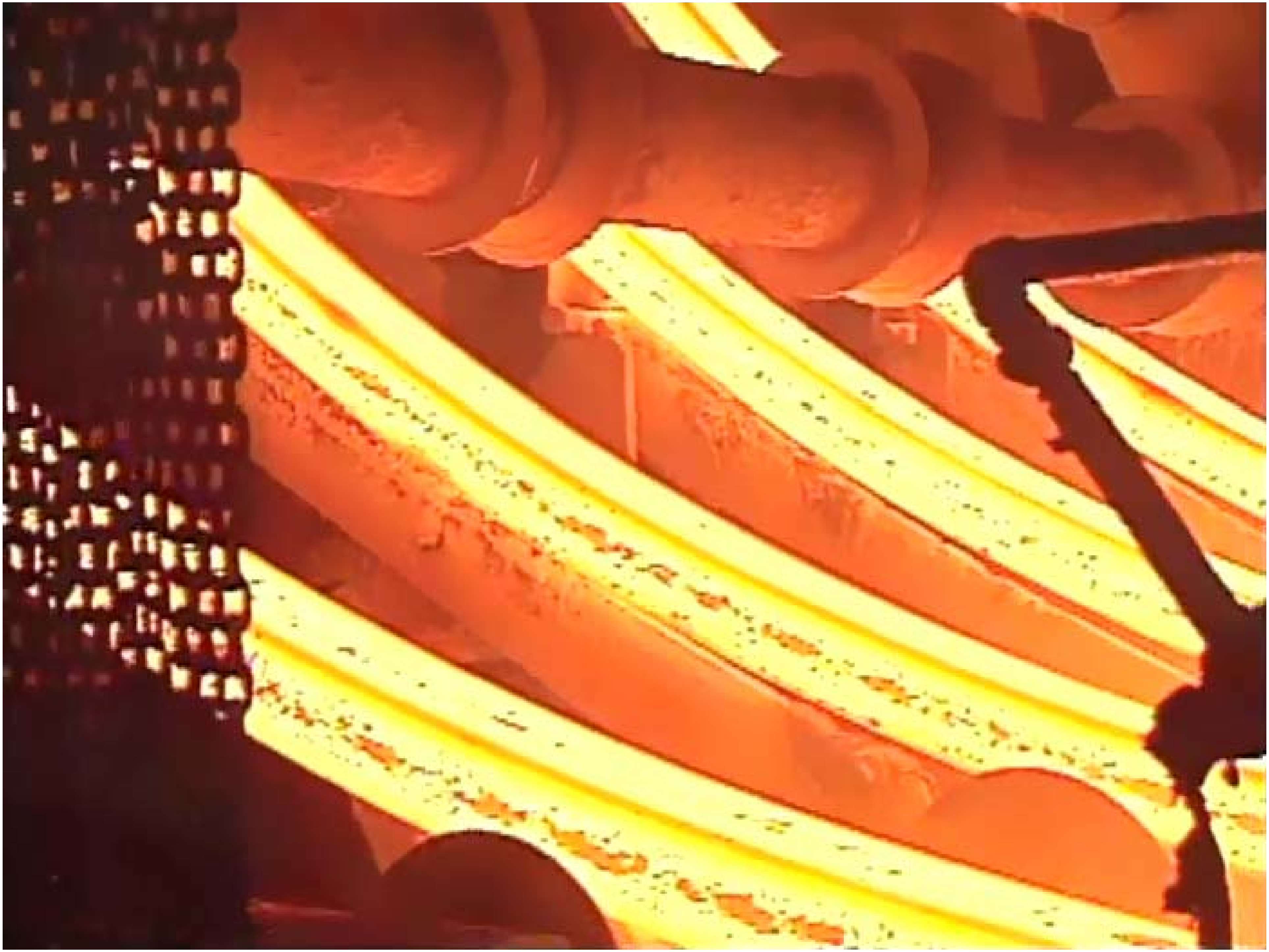
The following presentation has been aired on Public Television stations nationwide.

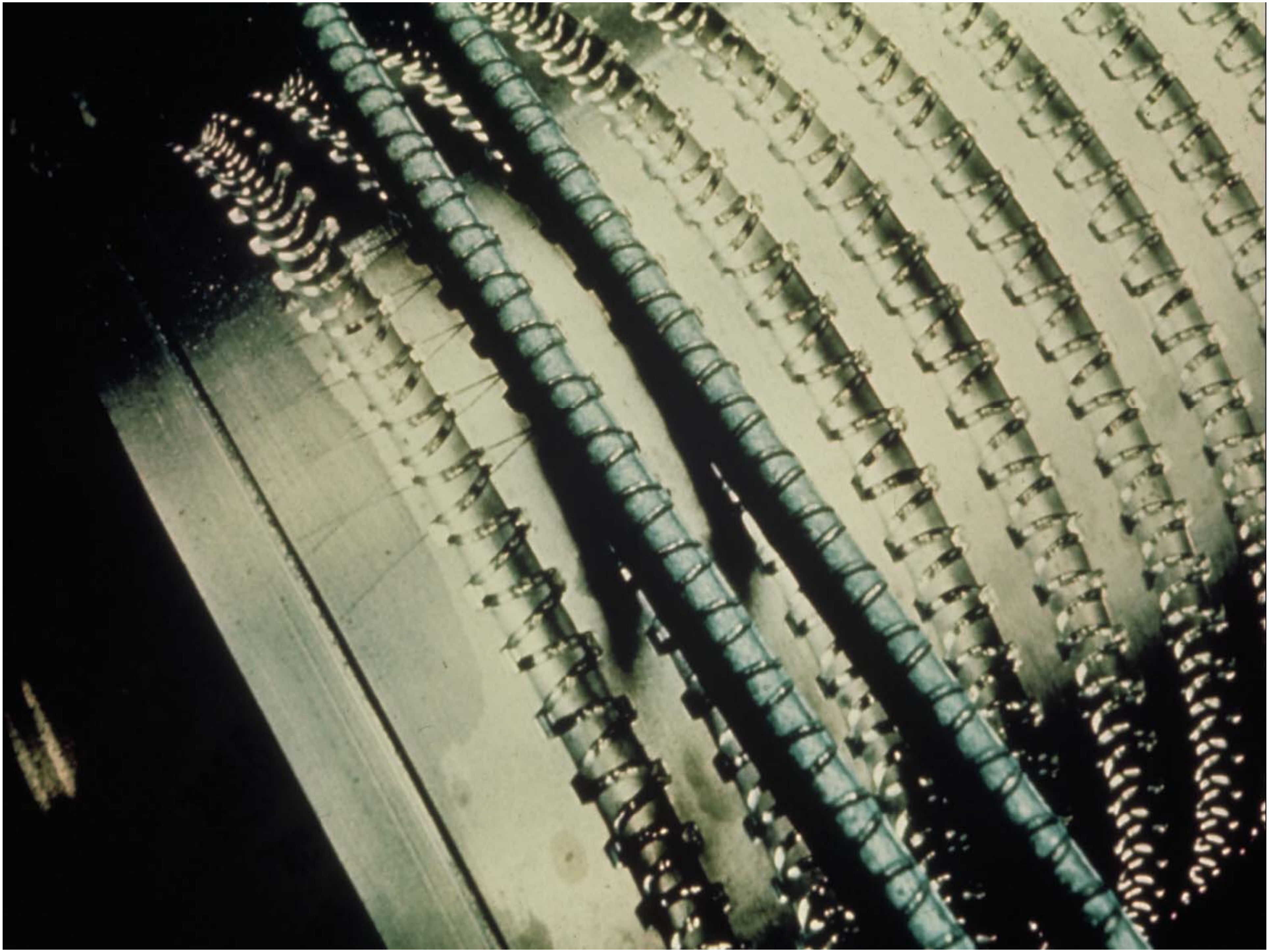
Production of Reinforcing Bars



Today's Reinforcing Steel is 100 % Recycled


NUCOR
NUCOR
BAR MILL GROUP
NUCOR STEEL KANKAKEE, INC.





Fabrication


Delivery
EOC-10
M-921B
60 IN CPLR
7 12:38PM

Inventory


Shear Line
P&H
7 12:27PM


LA CALIDAD


EXIT

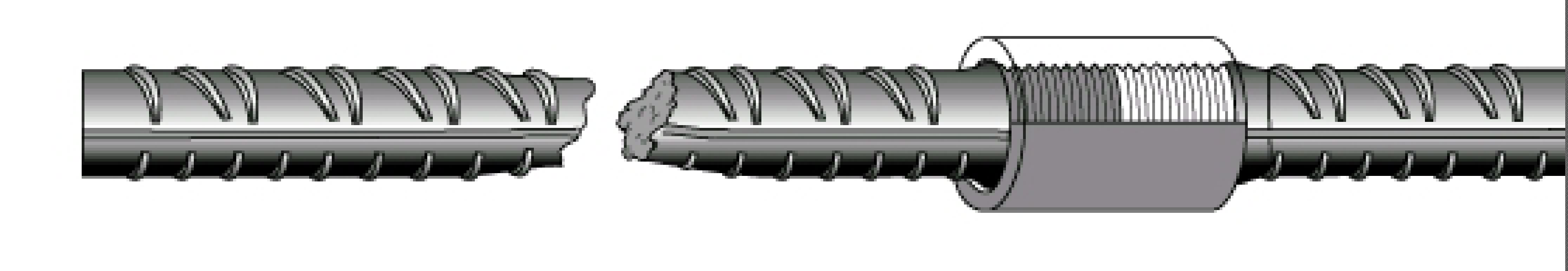

3W

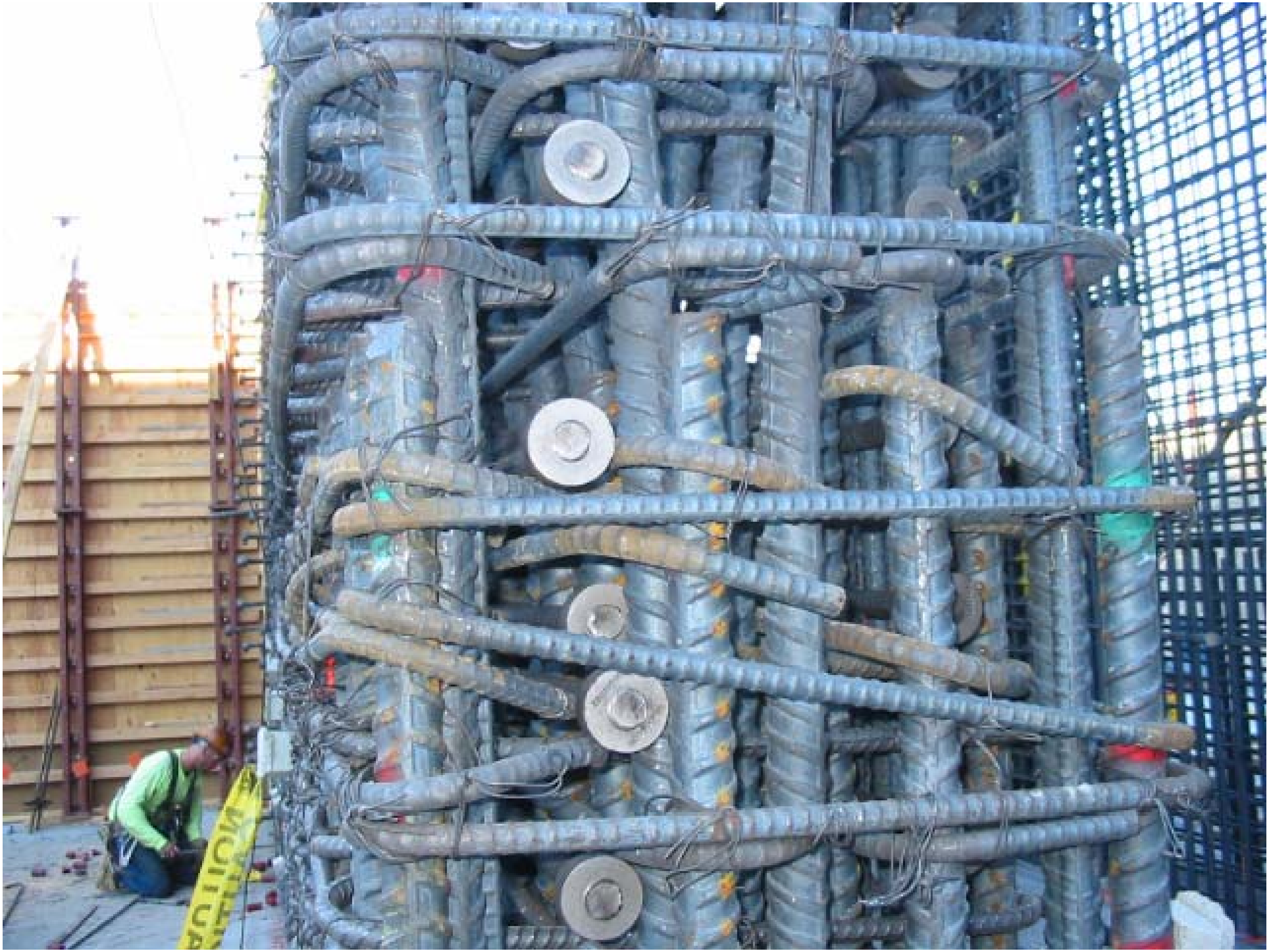
Bender

Automatic Bender

New Techniques and Materials

- Couplers
- End Anchors
- Corrosion Protection
- High Strength Reinforcing Grade 100 & 120





Specifications

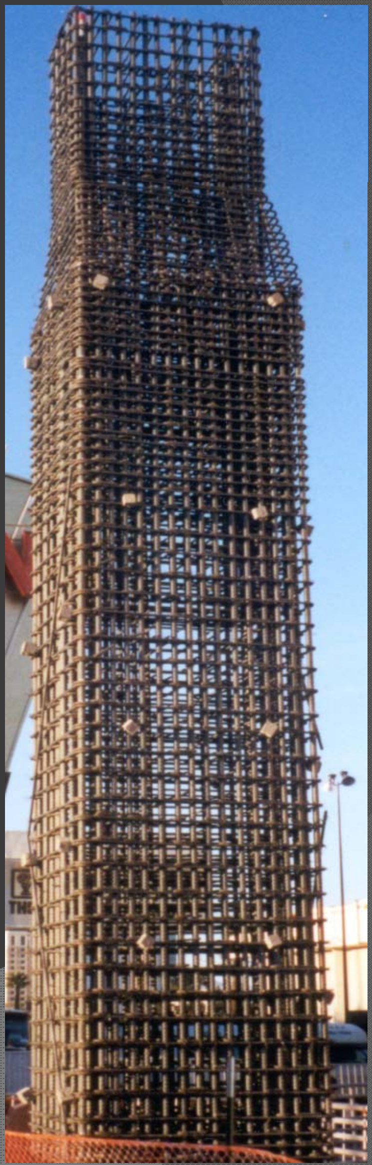
Reinforcing Steel Specifications

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

Metrification .... or not ?

- ASTM Specifications in inch-pound units
  - Soft SI conversations are shown for reference
- Majority of reinforcing steel marked in soft SI
- Industry talks in inch-pound units
- Design community works in inch-pound units
- Construction is performed in inch-pound units

Reinforcing Steel Specifications

What is bar size?

- 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 A615	Grade 40 (Grade 280)	Grade 60 (Grade 420)	Grade 75 (Grade 520)
Minimum Yield Strength, psi (MPa)	40,000 (280)	60,000 (420)	75,000 (520)
Minimum Tensile Strength, psi (MPa)	60,000 (420)	90,000 (620)	100,000 (690)
Bar Designation	**Minimum Percent Elongation in 8”**		
#3	11	9	7
#4, #5	12	9	7
#6	12	9	7
#7, #8	-	8	7
#9, #10, #11	-	7	6
#14, #18	-	7	6

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

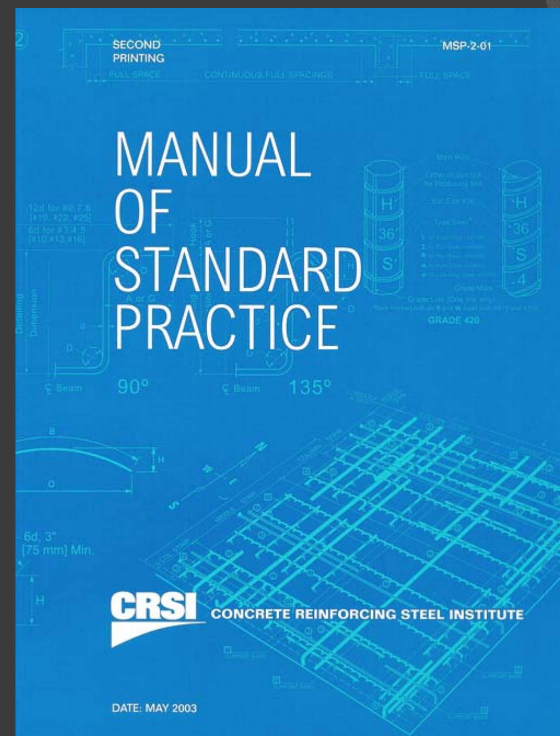
Reinforcing Steel Specifications

- 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
- Finish

Time for a Field Trip !

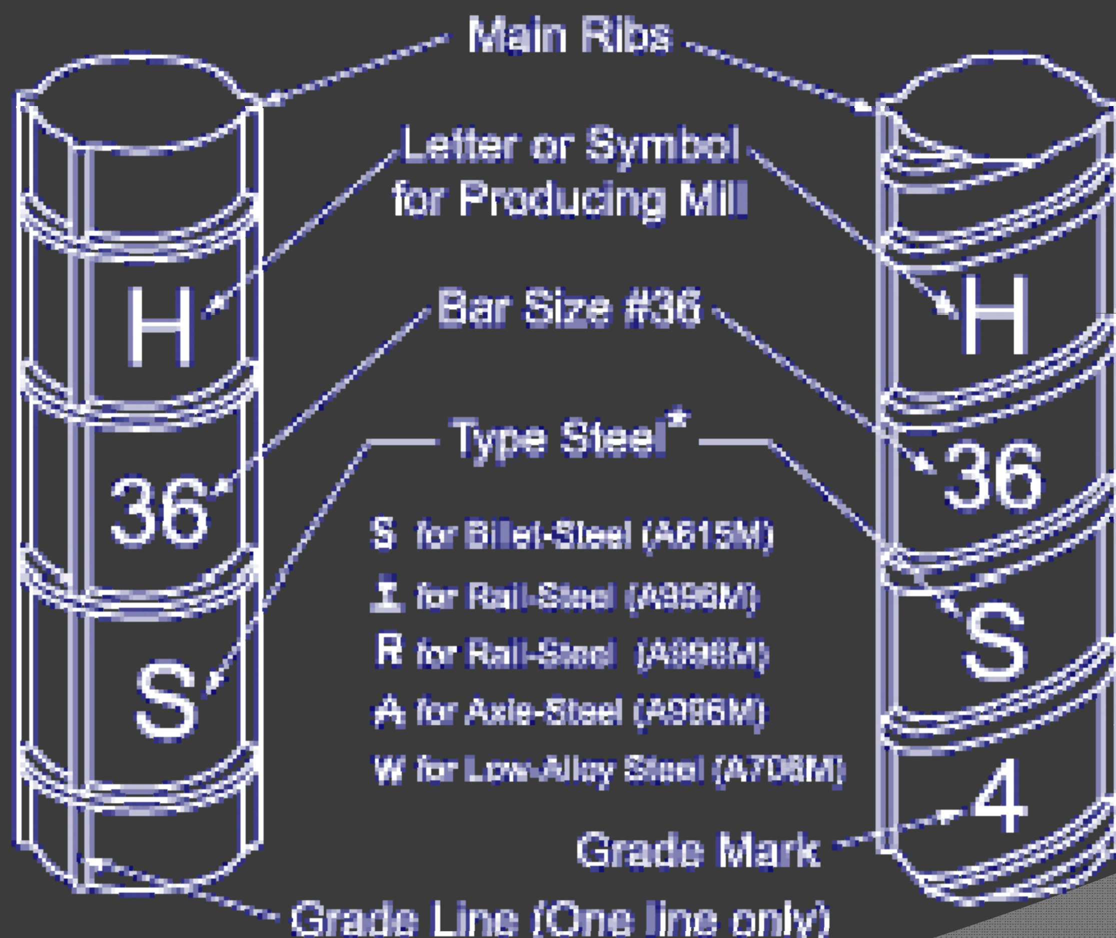
Manual of Standard Practice

- Material Specifications for Reinforcing Bars
- Welded Wire Fabric (WWF)
- Bar Supports
- Notes to Architects/Engineers
- Estimating Reinforcing Materials
- Detailing Reinforcing Materials
- Fabrication of Reinforcing Materials
- Placing Reinforcing Bars
- Contract Components
- Concrete Joist Construction
- APPENDICES



First published - 1927

Reinforcing Bar Markings



*Bars marked with an S and W meet both A615 and A706

GRADE 420


Pressure
ASTM
INTERNATIONAL
Standards Worldwide

Tying Reinforcing Steel

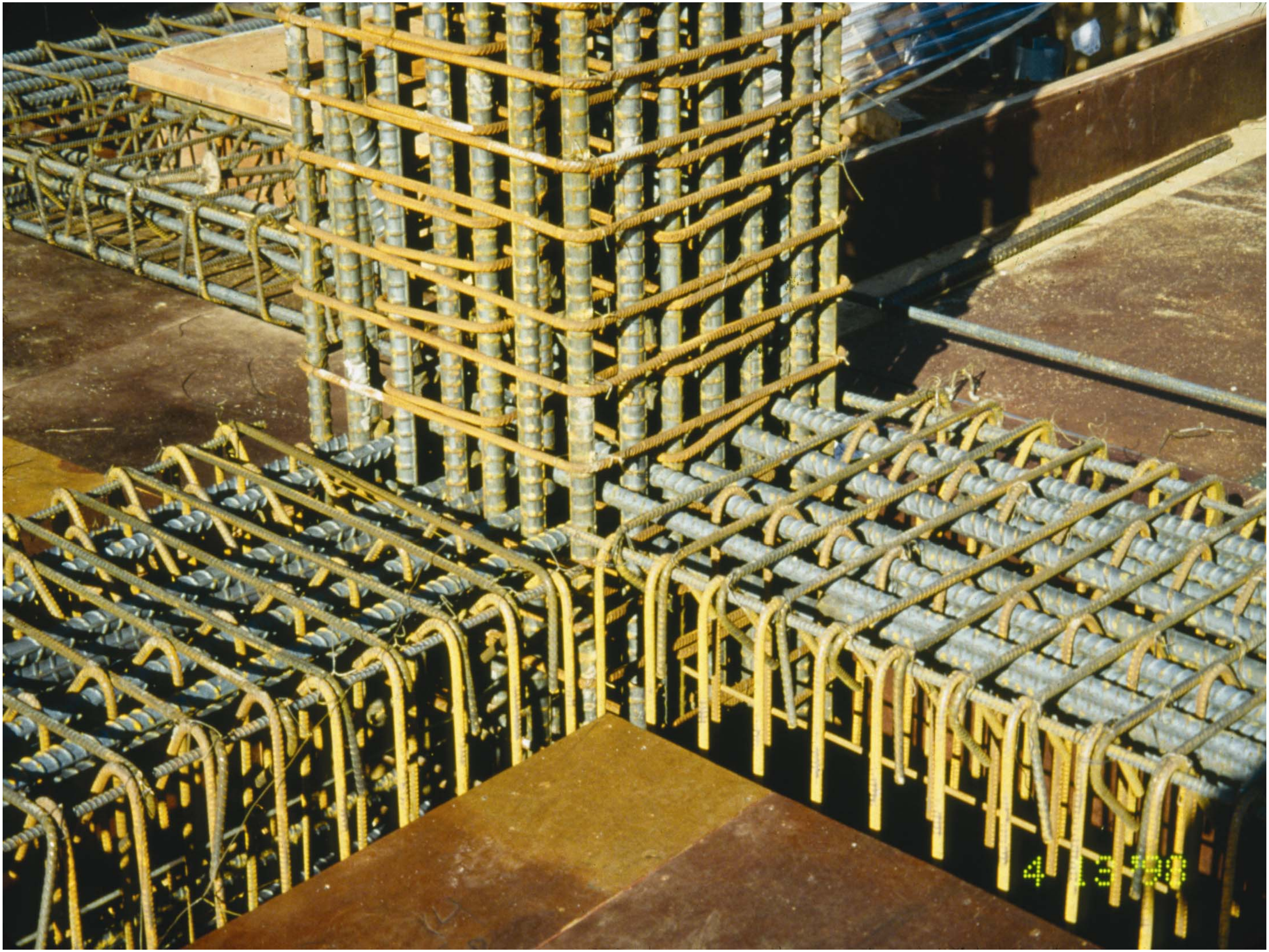
- Tying does not add to the strength of the finished structure
- Specifications typically require that a specified number of intersections by tied
- Criteria for tying:

“The mats, cages, or bars will not displace during casting, screeding, and finishing operations”

Surface Condition

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."



Surface Condition - Rust

CRSI Manual of Standard Practice

- Section 8.3

"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
- Not field fabrication
- In-situ bending is prohibited unless shown on drawings or specifically authorized by the engineer

Field Bending of Reinforcing Steel

- Limited to bar size #11 and smaller
- 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%

Source: Concrete International January 1992 - Khossrow Babaei and Neil M. Hawkins

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

Source: Concrete International January 1992 - Khossrow Babaei and Neil M. Hawkins

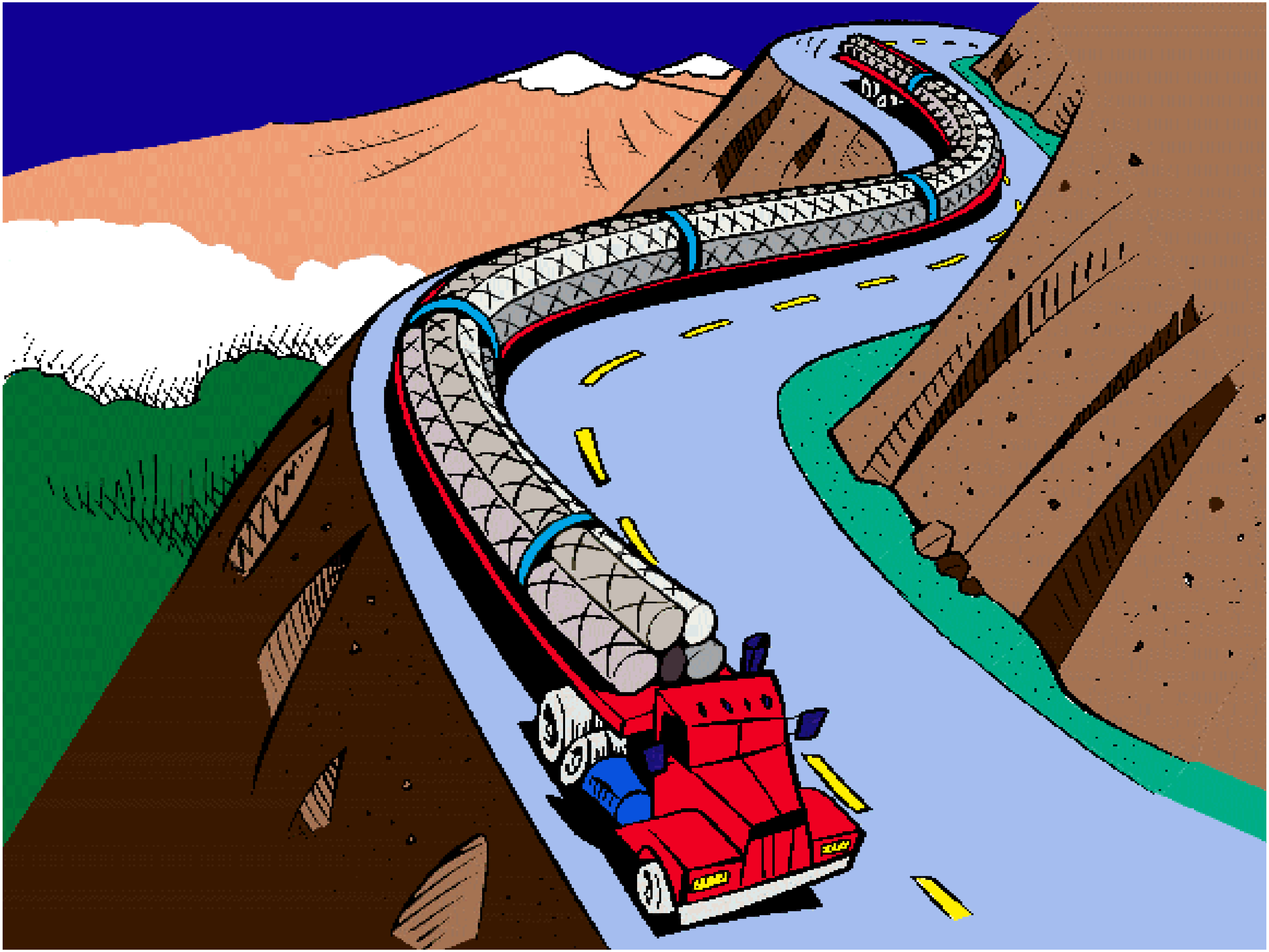
Field Cutting of Reinforcing Steel

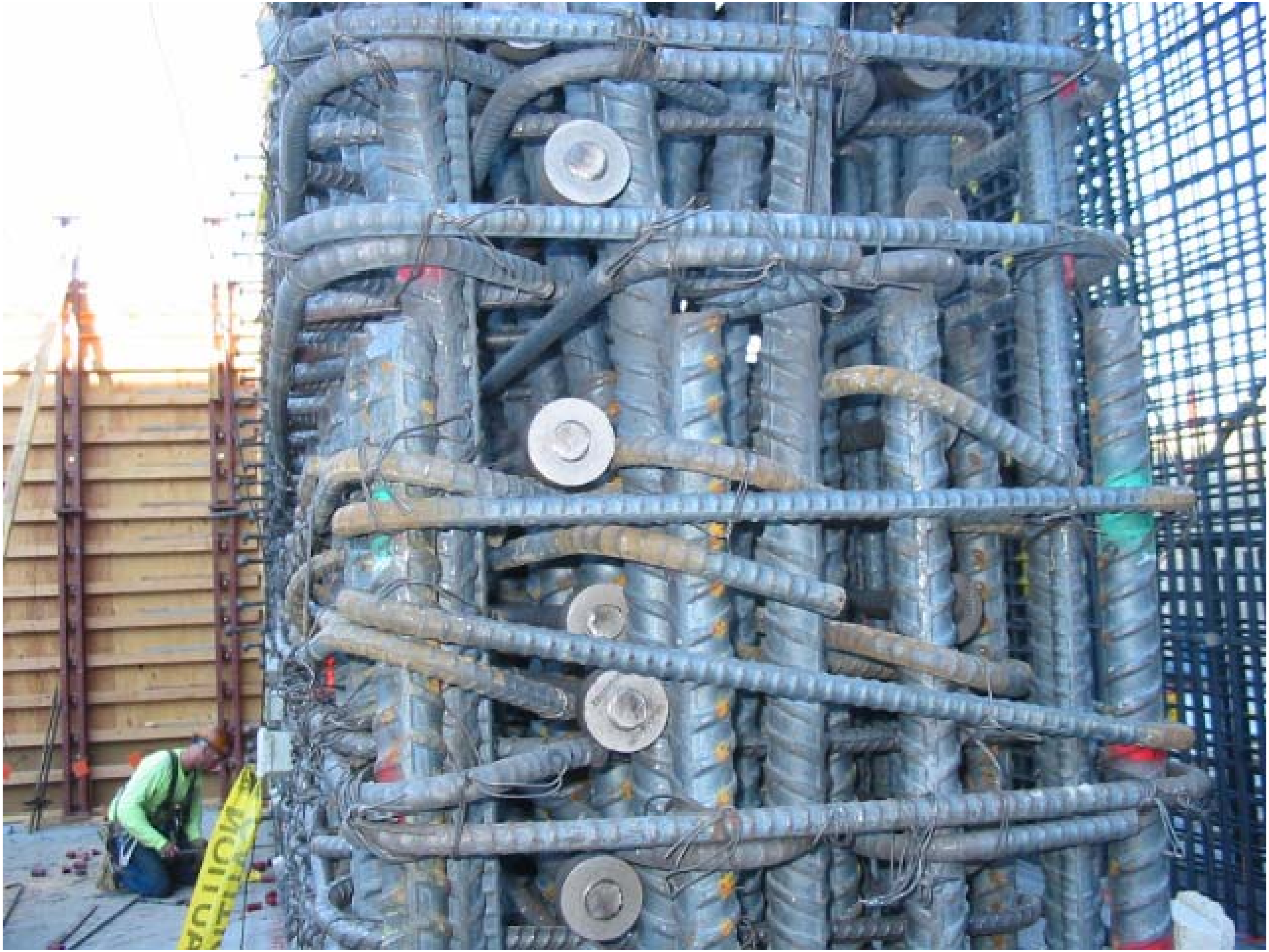
- Bolt cutters for bar sizes #10 to #16
- Abrasive saw on any bar size
- Cutting torch on any bar size
  - Tests indicate no more than 3/8” from end of bar is effected by heat
- Flame cutting of epoxy-coated bars will damage the coating, proper repair is necessary

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

Splicing Reinforcing Steel



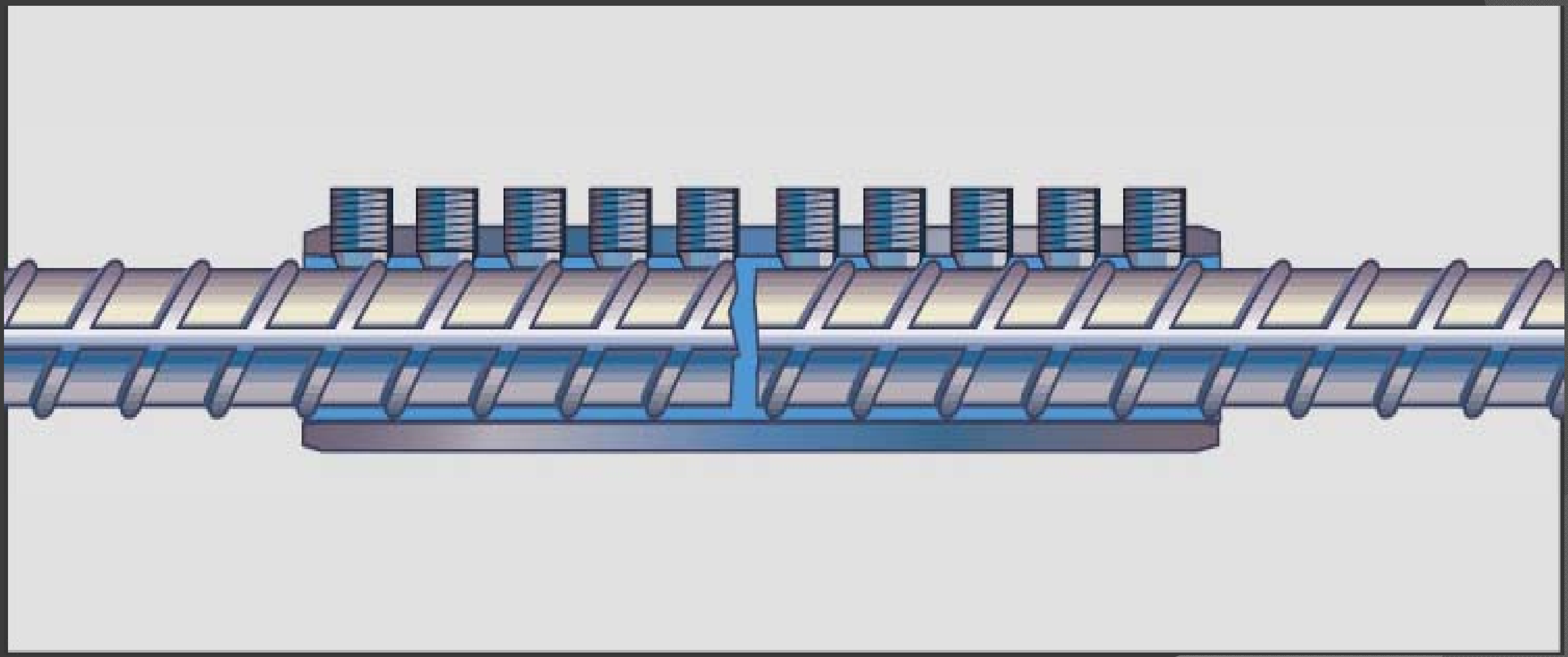


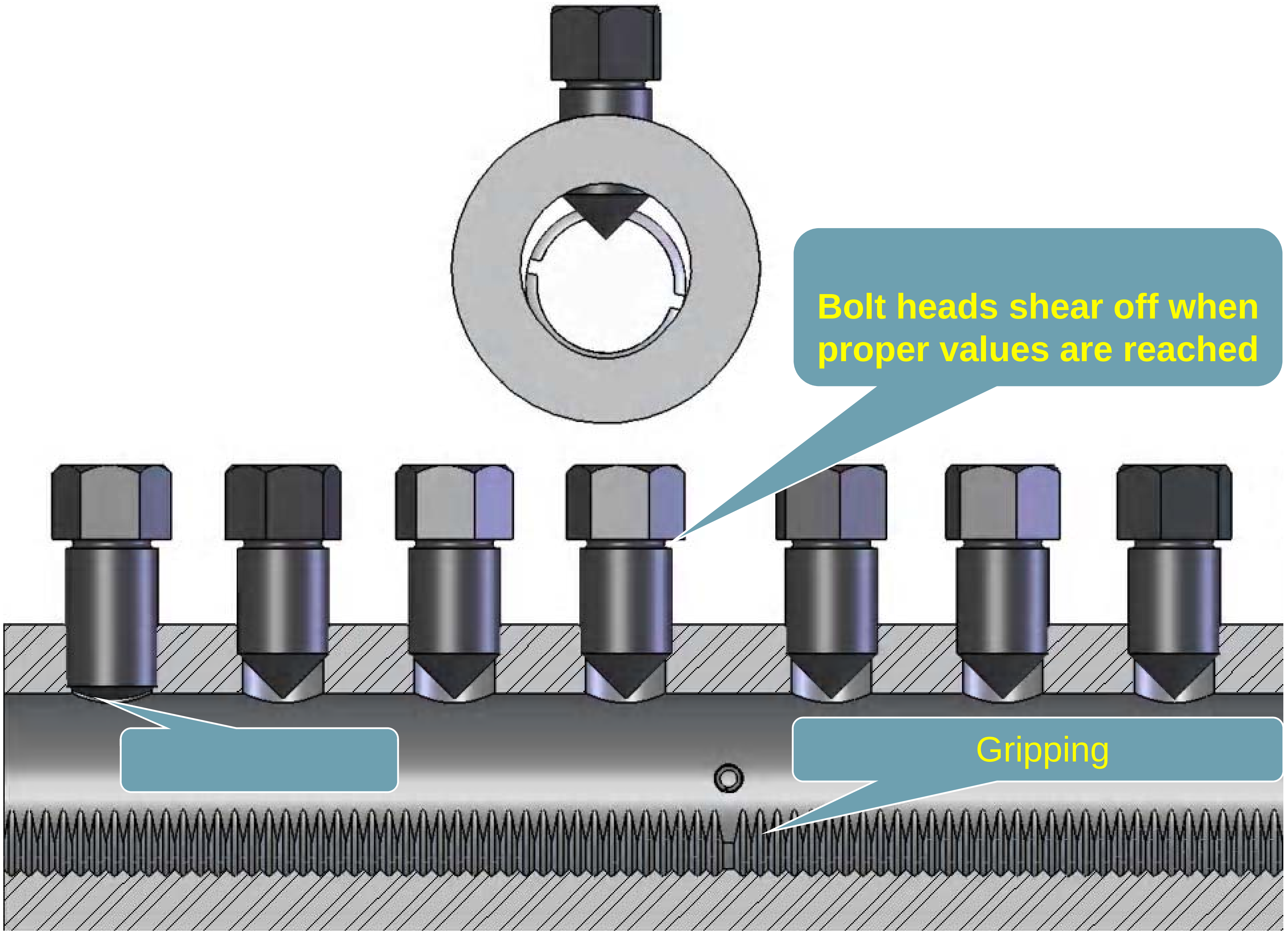
Reinforcing Steel Splicing Options

- Lap Splices
- Welded Splices
- Mechanical Splices
  - Deformation Dependent
  - Non-Deformation Dependent

Deformation Dependent

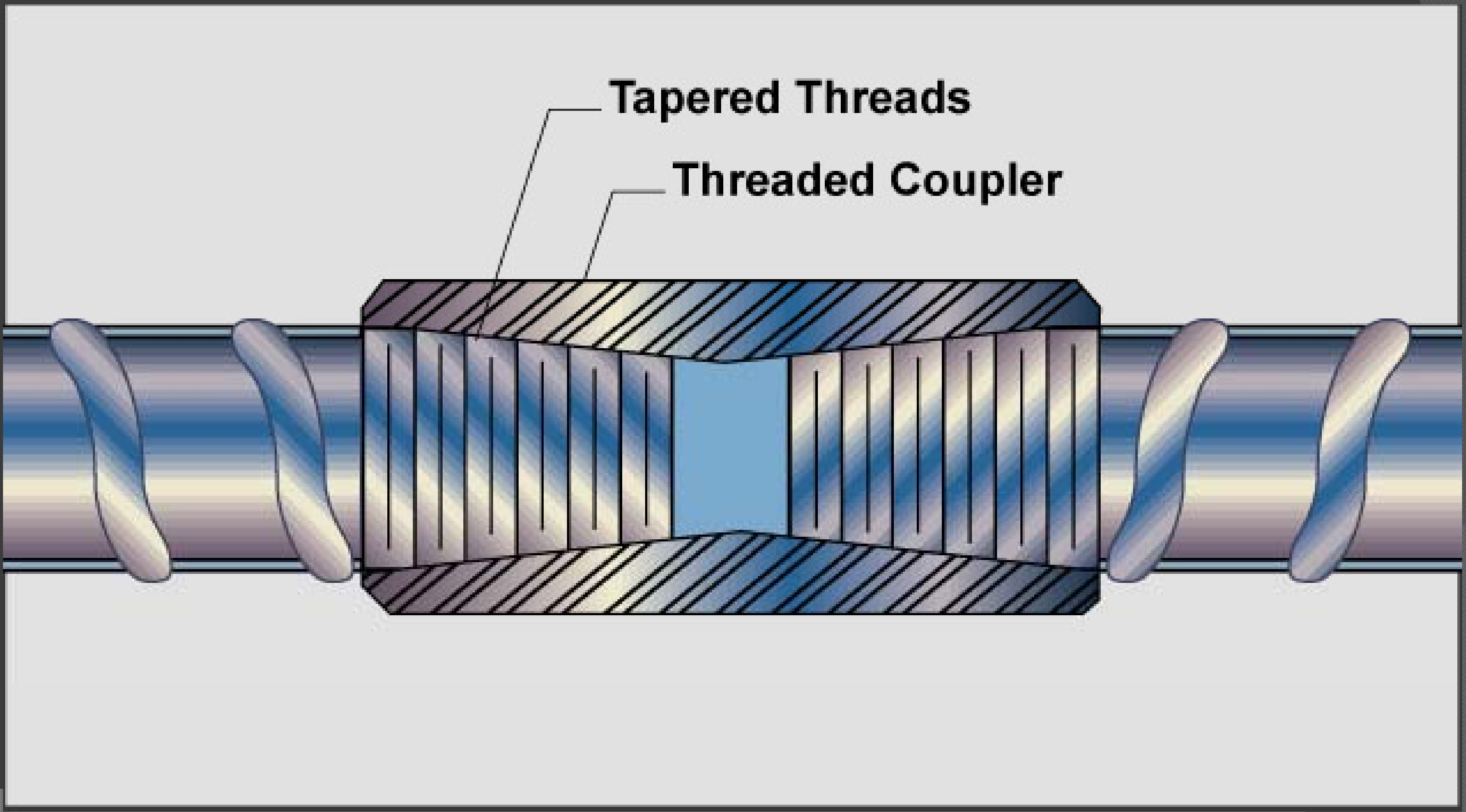
- Bolted




Bolt heads shear off when proper values are reached
Gripping

Non-Deformation Dependent

- Tapered Thread



Framing System

Constructability

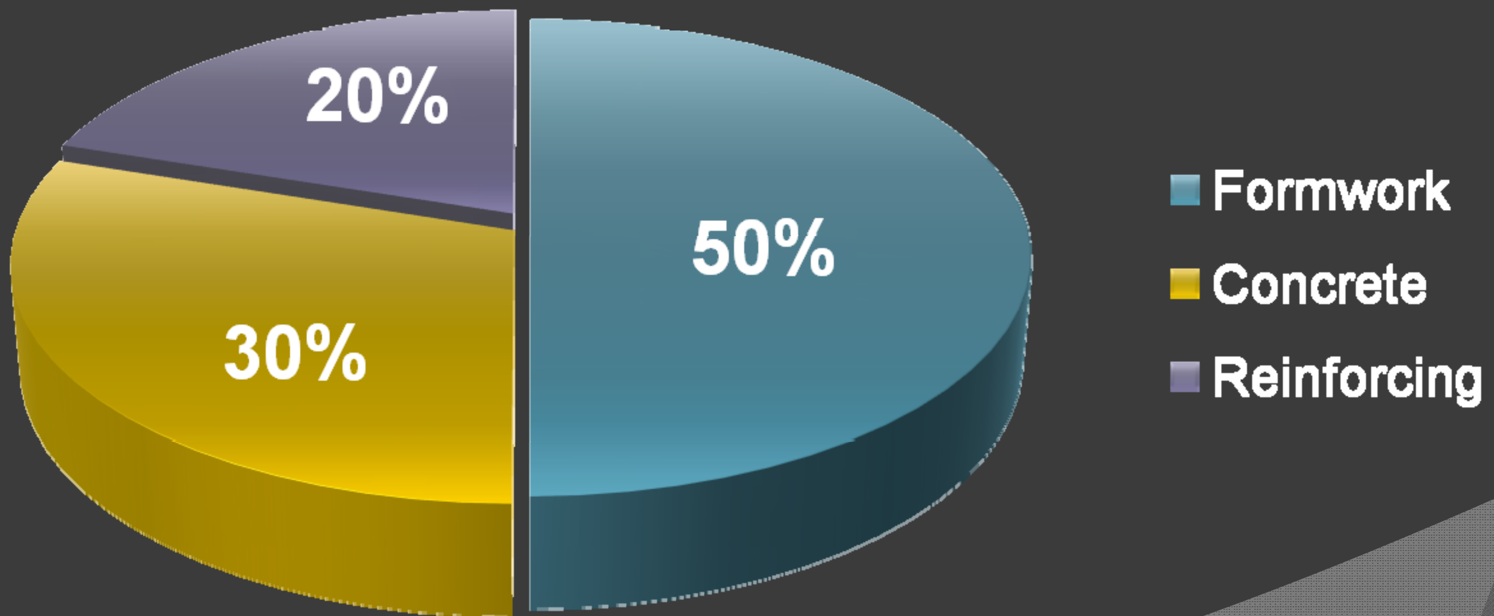
- Efficiency in design and construction
- New tools and techniques

Economical Concrete Construction

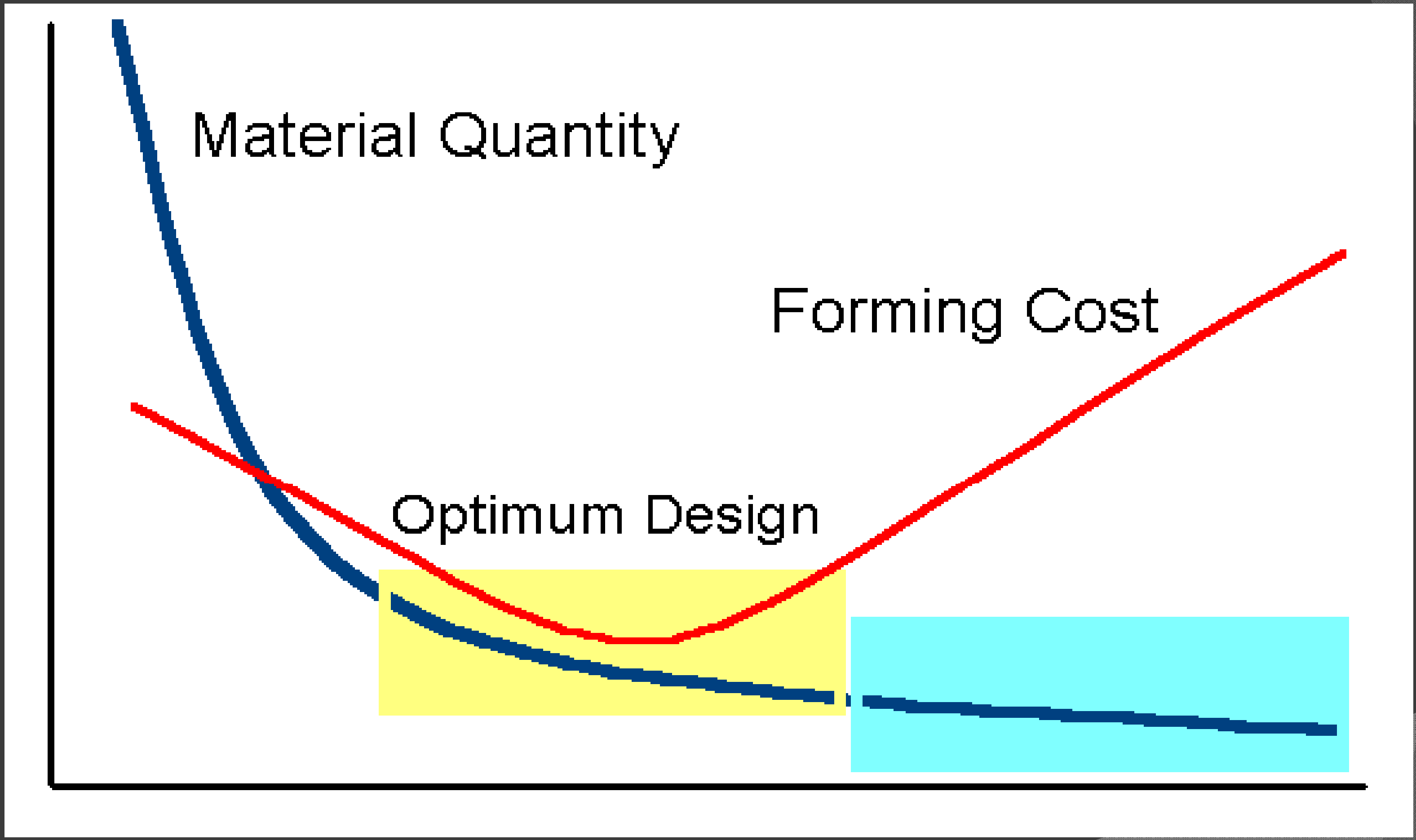
- Formwork
- Concrete
- Reinforcement

Economical Concrete Construction

Typical Conventionally Reinforced Cast-In-Place Concrete Frame Costs



Economical Concrete Construction



Minimizing material quantities can lead to "inefficient" designs

Economical Concrete Construction

Designing to minimize quantities of concrete and reinforcement leads to false economy

Economical Concrete Construction

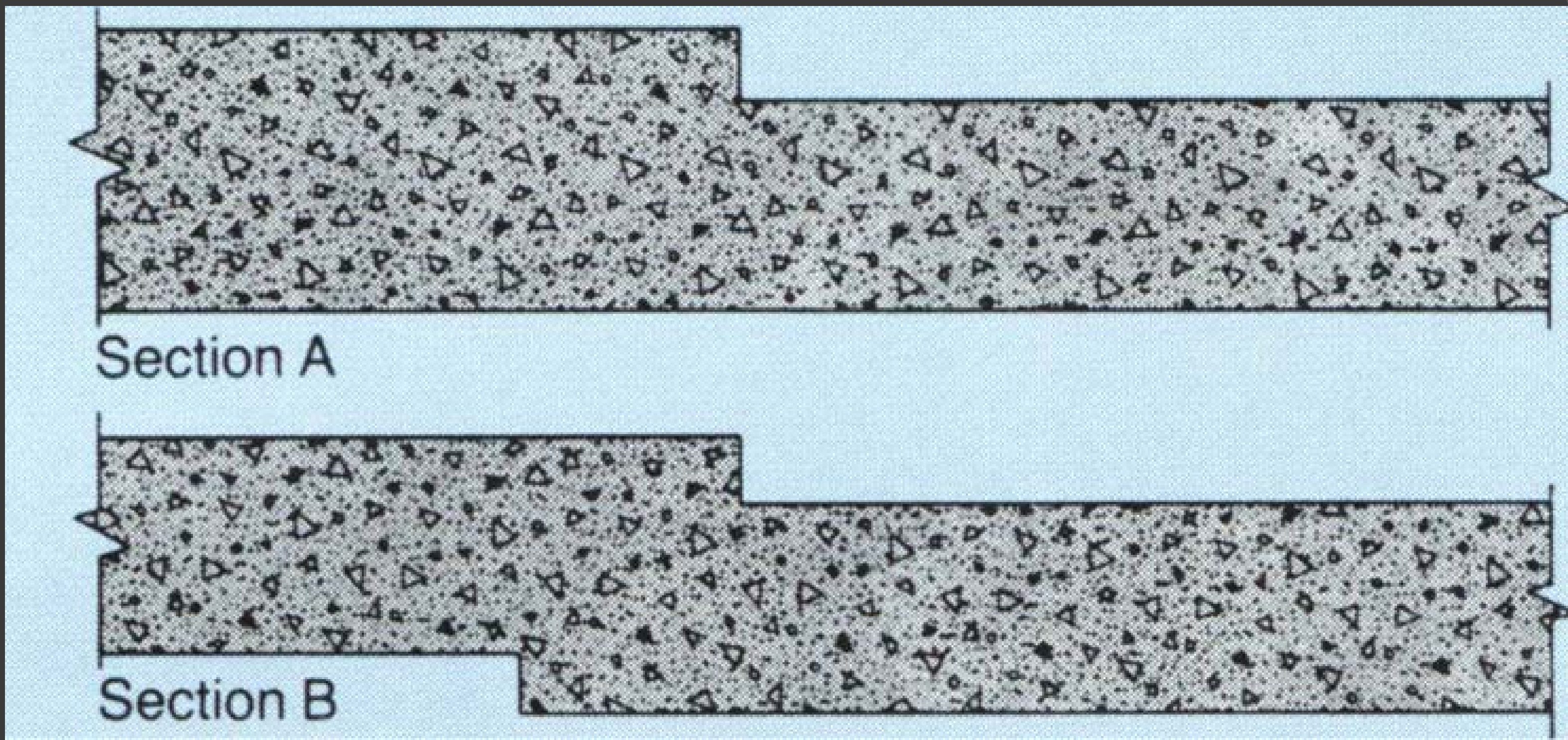
Optimizing design and utilization of formwork holds the key to true economy

Economical Concrete Construction

Keep Formwork

1. Simple
2. Repetitious
3. Standard
    - Form sizes
    - Lumber dimensions

Economical Concrete Construction



Material savings does not offset forming costs

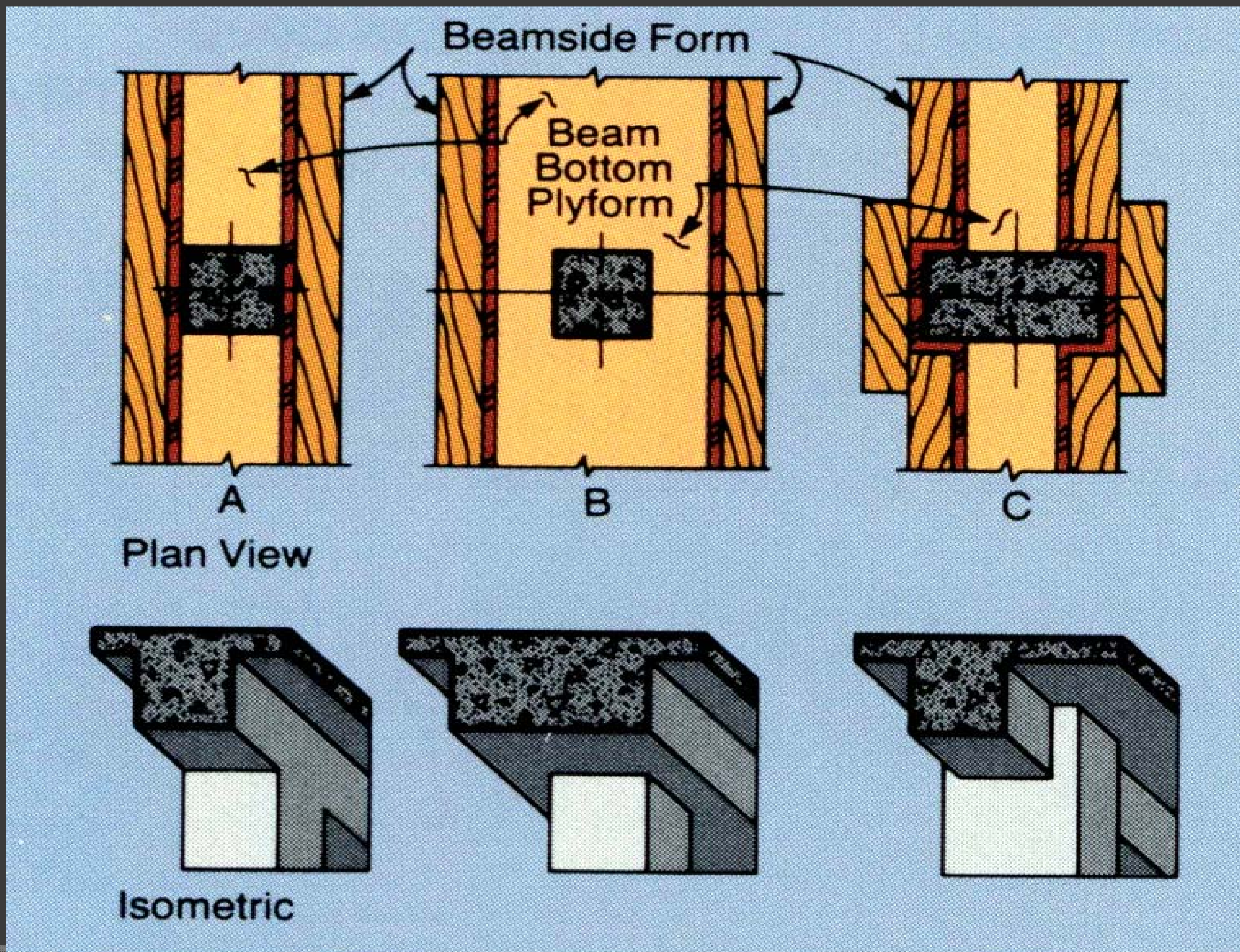
Column Considerations

- Make column same size throughout
  - Vary concrete strength
  - Vary percentage of reinforcement
- Use fewer, larger bars
- Utilize mechanical couplers
- Consider Grade 75 (Grade 80) reinforcement

Column Considerations

- Space columns uniformly
- Use fewest column sizes
- When column size must change, reduce one dimension at a time

Beam - Column Intersections



Floor Framing Systems

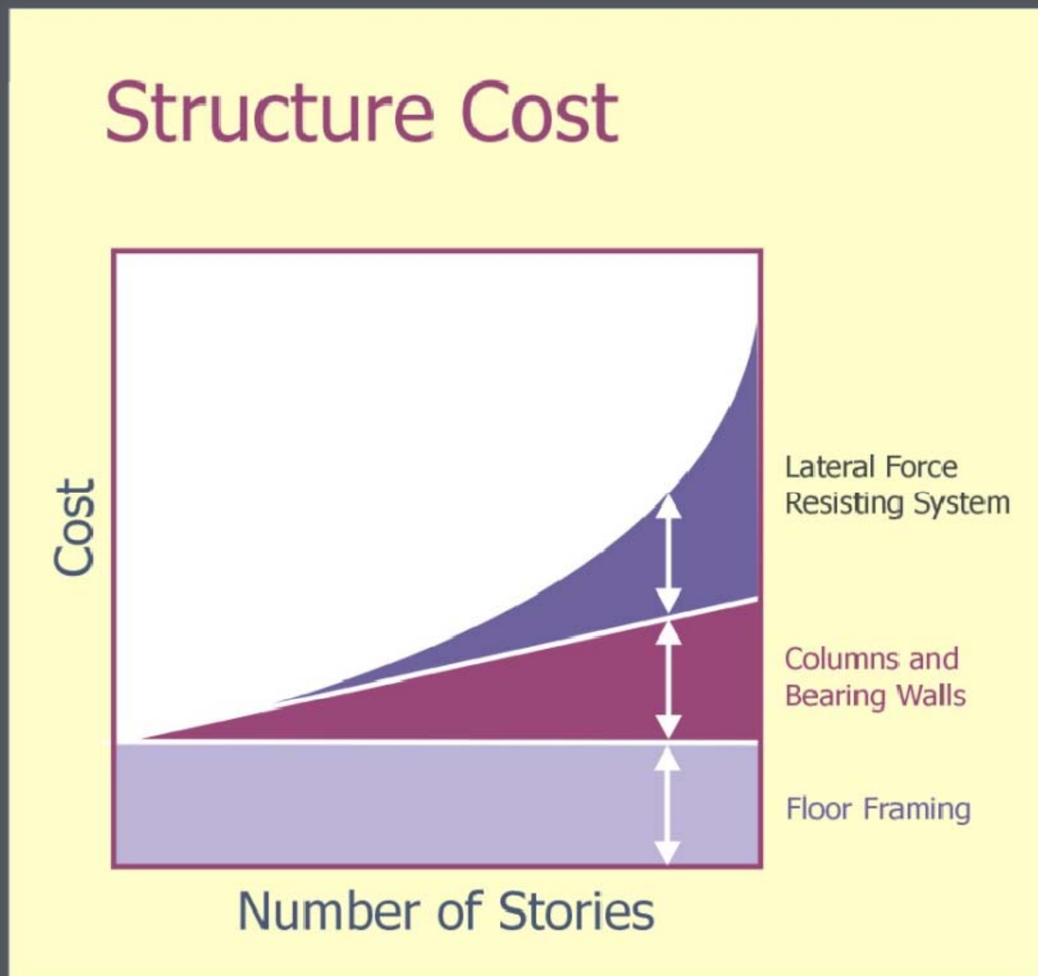
Make beams wider than columns

Size beams and joists the same depth

Floor Framing Systems

- Select one floor framing system
- Use shallowest system
- For most buildings floor framing costs dominate
- Vertical element costs become more significant in taller buildings or in moderate to strong seismic zones

Floor Framing Systems



Two-Way Flat Plate

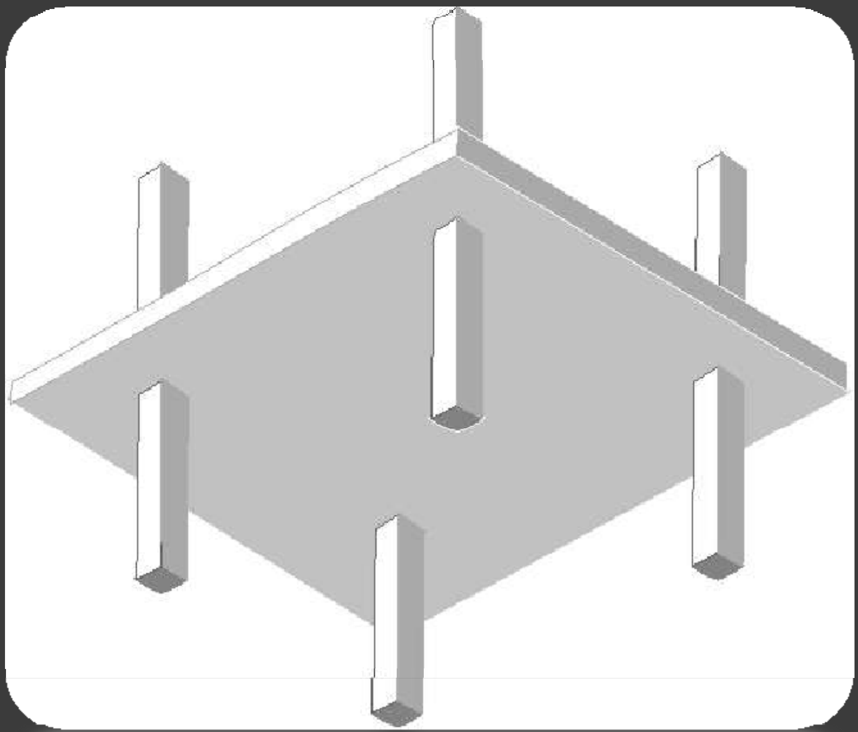


Plate Range:

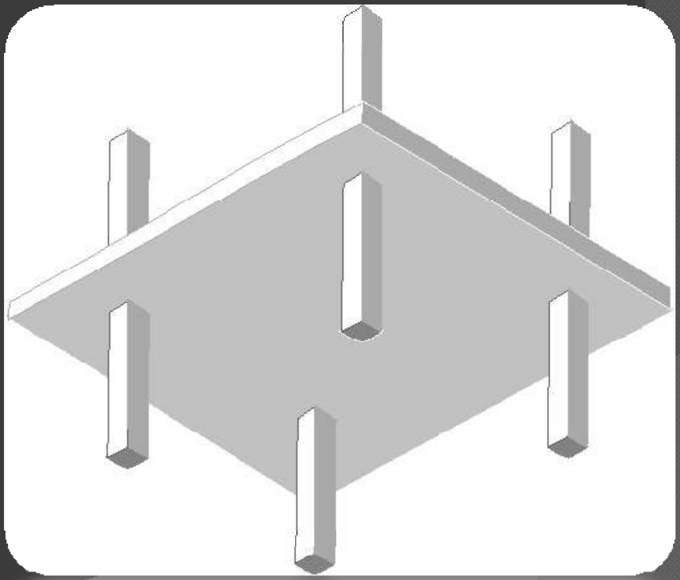
12 to 25 ft.

Plate Depth:

6 to 9 in.

Two-Way Flat Plate

- Most economical short span structural system
- Minimizes floor-to-floor height
- Shortest construction time with least field labor
- Simplest formwork and reinforcing steel layout
- Greatest flexibility in layout of columns, partitions



Two-Way Flat Plate with Drop Panels

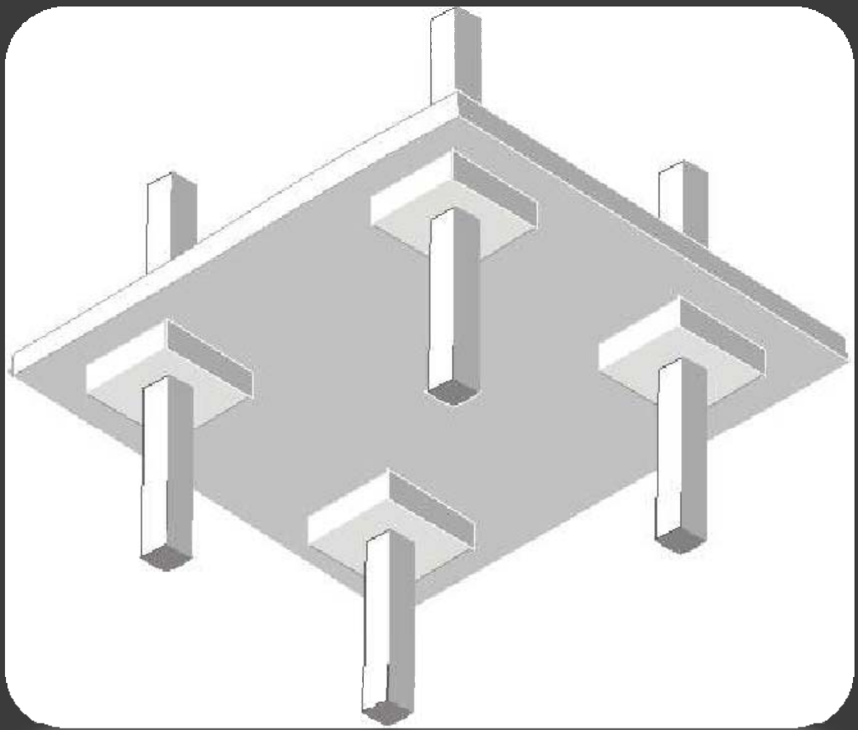


Plate Range:

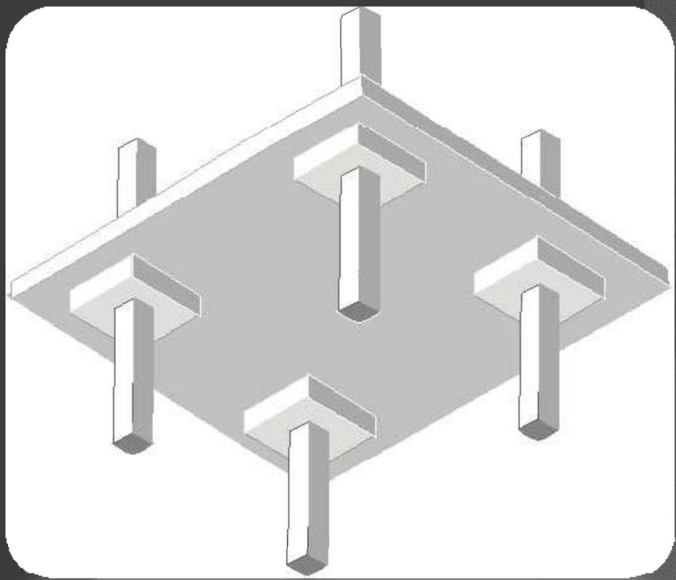
20 to 35 ft.

Plate Depth:

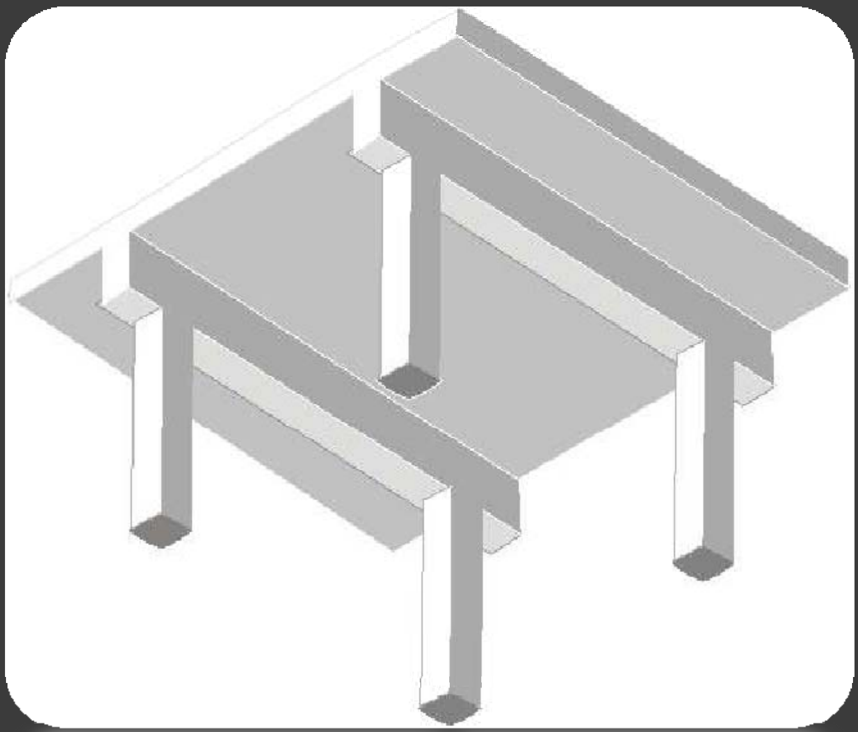
7 to 12 in.

Two-Way Flat Plate with Drop Panels

- Very economical system for relatively square bays and multiple bays in each direction
- Uses smaller columns than Two-Way Flat Plate with longer spans
- Provides uniform clear space below slab
- Provides flexibility in layout of columns, partitions



One-Way Slab and Beam



Beam Range:

60 to 65 ft.

Slab Spans:

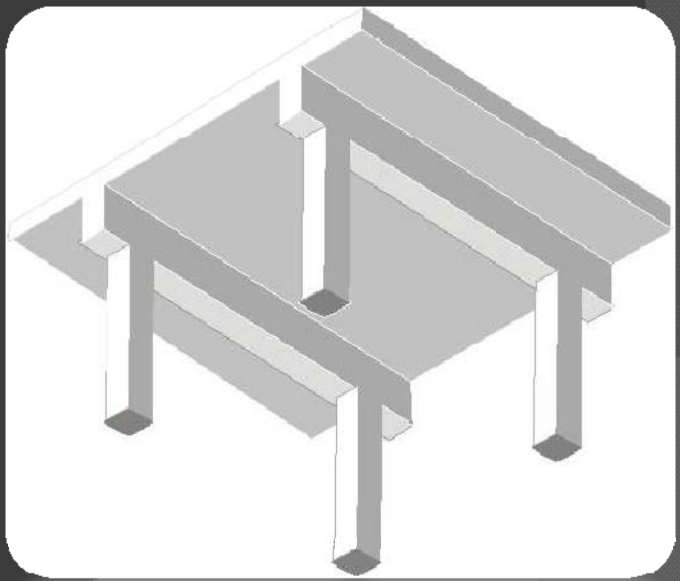
18 to 22 ft.

Construction Depth:

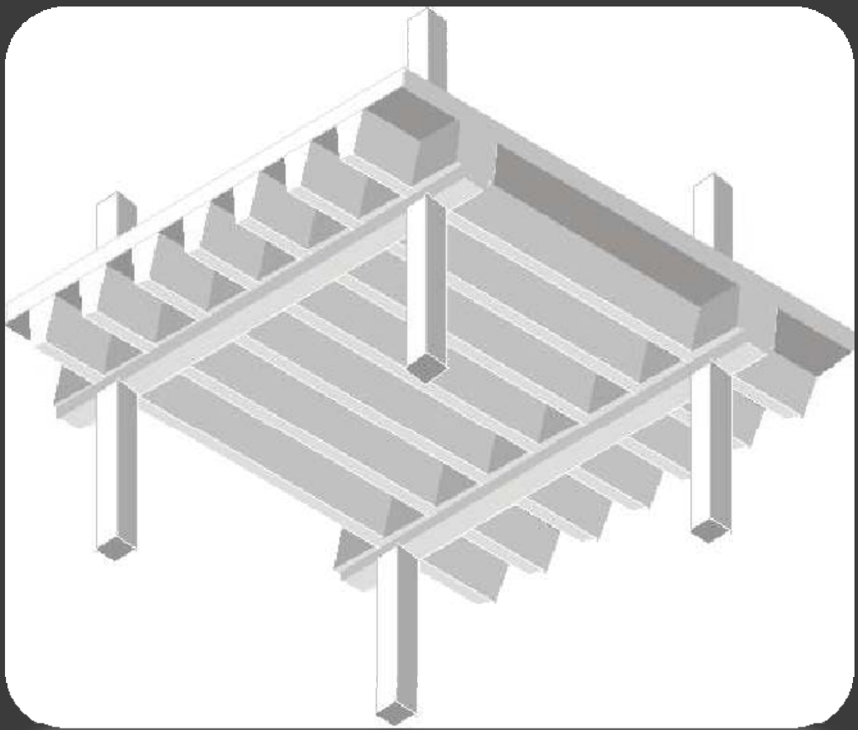
30 to 36 in.

One-Way Slab and Beam

- Good for concentrated and heavy load areas
- Basis for more complex framing systems
- Commonly used for parking structures and elevator and stair areas
- Excellent vibration characteristics
- Popular for use in commercial buildings
- Adaptable to custom forming situations



Standard Beams and Joist



Beam Range:

Up to 30 ft.

Joist Spacing:

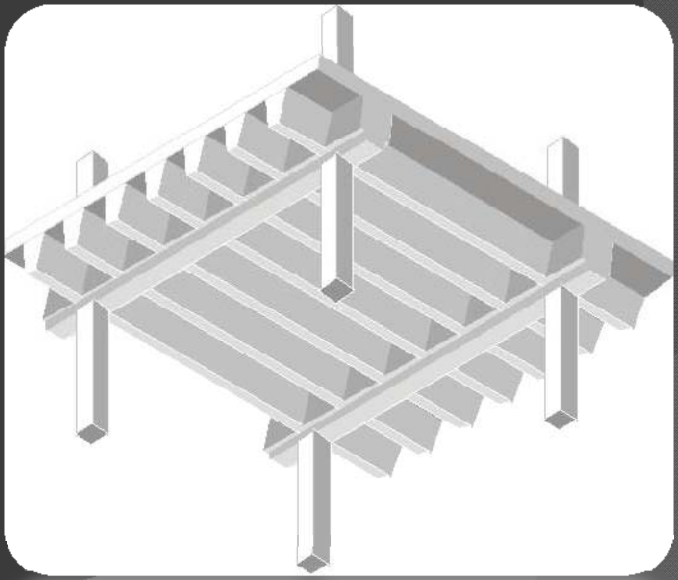
24 to 36 in.

Pan Depth:

8 to 20 in.

Standard Beams and Joist

- Provides depth for stiffness and increased load bearing capacity
- Efficient use of concrete and reinforcing materials
- Standard reusable forms readily removed and re-erected
- Accommodates floor penetrations and mechanical systems



cobiax®

In-situ Application

Building Value and Efficiency

Building Value and Efficiency

- Life cycle cost, not project or initial cost
- Contribution of concrete to other systems
- Sustainability and concrete construction
- Scalable, adaptable and expandable to accommodate future needs

Schedule

Accelerated Start

- Readily available materials
- Local materials
- Staging and transportation logistics are minimal

Schedule

Early Completion

- On-site adaptability
- Multi-track construction
- Concrete inherencies

Schedule

Multi-Track Construction

- Concurrent work due to concrete inherencies
- Multiple trades working off the critical path
- Jobsite safety is the key

Cash Flow

Low Upfront Cost

- Cash flow is back-end loaded
- Local materials
- Reduced lead times
- Minimal staging

Cash Flow

Floor-to-Floor

- Building for space, not volume
- Height restrictions
- Urban footprint
- Reduction in vertical material utilization and costs

Cash Flow

Operating Costs

- Reduced HVAC costs
- Low maintenance costs
- Lower insurance premiums

Inherent Systems

Unique Properties

- More than just initial frame cost
- Elimination of material and labor expenses
- Cost and time savings

Inherent Systems

Thermal Mass

- Limited fluctuations in temperature
- Savings in energy and cost

Inherent Systems

Fire Resistance

- Concrete is non combustible
- No fireproofing required
- Connections are protected
- Reduced insurance premiums

Inherent Systems

Sensitive Structure

- Vibration and heat sensitive equipment
  - Research Labs
  - Hospitals
  - Computer data facilities

Flexibility

Design

- Long open spans
- Shear wall options
- Hybrid systems with post tensioning for additional span length

Flexibility

Future Growth

- Built-in or expandable
- Large increases in initial capacity for very minimal cost

Flexibility

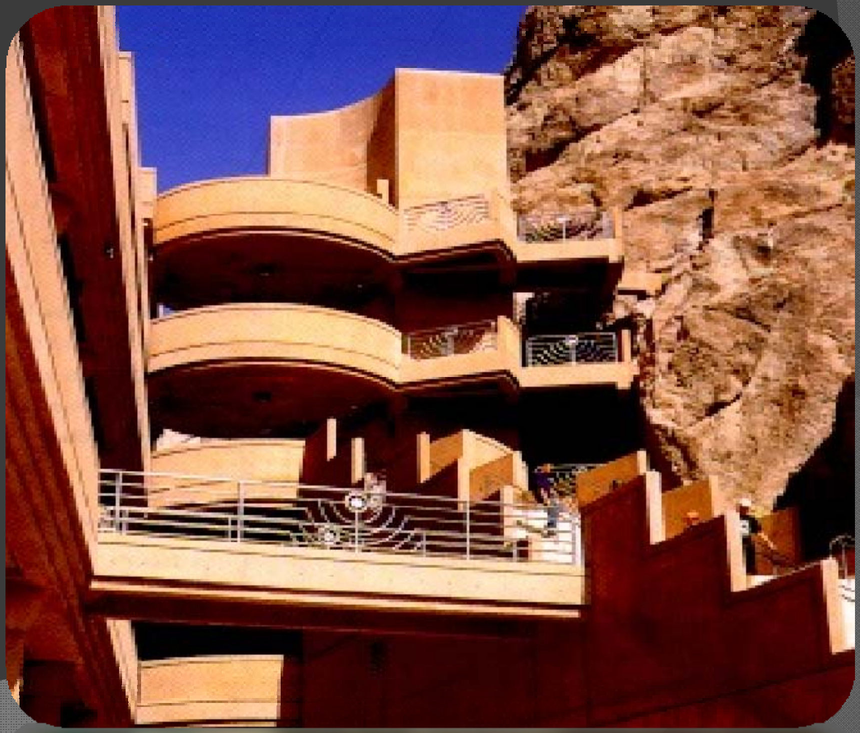
Adaptability

- Changes happen
- Conflicts
- Form and pour

Aesthetics

Visual Statement

- Innovation
- Freeform
- Creativity
- Color & texture



Reinforced Concrete Construction

- Cost effective
- Durable
- Safe
- Sustainable
- Adaptable
- Aesthetic

Assessment of Learning

(Question 1)

What materials are used for producing Reinforcing Bars”?

- Metal scrap from automobiles, washers, refrigerators, dryers

Assessment of Learning

(Question 1)

What is the minimum head size for “Headed Reinforcing Bars”?

- The gross area of the head shall be a minimum of 5 times the nominal bar diameter
- i.e. 4 times of nominal bar diameter of net embedment surface area

Assessment of Learning

(Question 2)

What is the minimum yield strength requirement for Grade 60 reinforcing steel?

- “60” refers to the minimum yield strength, so a Grade 60 reinforcing bar has a minimum yield strength of 60,000 PSI (60 KSI)

Assessment of Learning

(Question 3)

Is it permissible to re-bend a #8 bar partially embedded in concrete?

- Yes
- Must be heated to between 1,400 F and 1,450 F
- Doing so will lower both the yield and UTS by 10% and result in a 20% reduction in elongation

Assessment of Learning

(Question 4)

Which component of cast-in-place concrete makes the largest contribution to onsite construction costs?

- Formwork. An optimized design will minimize formwork costs.