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DATA REPORT
NUMBER 44

COMMONLY-ASKED TECHNICAL QUESTIONS CONCERNING CAST-IN-PLACE REINFORCED CONCRETE CONSTRUCTION

A SERVICE OF THE CONCRETE REINFORCING STEEL INSTITUTE
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INTRODUCTION

CRSI's technical Staff regularly receives numerous inquiries from the public concerning cast-in-place reinforced concrete construction. Most of the inquiries are received by phone. The majority of the callers are design professionals, in other words, practicing engineers and architects. Inquiries are also received from contractors, inspectors at construction projects, and building officials.

Let's discuss the most frequently asked questions or issues concerning cast-in-place reinforced concrete construction that the technical Staff has dealt with during the past year. A list of the most popular issues or subjects would include:

1. Field bending of reinforcing bars
2. Welded splices of reinforcing bars
3. Metrication
4. ACI 318 Building Code
5. Tensile properties of old reinforcing bars
6. Field cutting of reinforcing bars
7. New steel reinforcement materials

FIELD BENDING OF REINFORCING BARS

Q: **Since CRSI discourages field fabrication of reinforcement, what is or why is this subject at the top of the list of popular issues?**

A: Questions concerning this subject are by far the most frequent. This subject is not related to fabrication of reinforcement.* The issue here is concerned with bending and straightening or rebending of reinforcing bars that are partially embedded in hardened concrete. Perhaps, at least for the unplanned cases, the terminology "field corrections of reinforcing bars" would be appropriate.

* Fabrication of reinforcing bars is the cutting-to-length of straight bars, and cutting-to-length and bending to shape of bent bars.

Q: **What are some examples of conditions or situations which would require "field corrections"?**

A: Incidents occur at a construction site whereby reinforcing bars, partially embedded in hardened concrete, are accidentally bent. For example, dowels projecting from a footing might be run over by a vehicle. In another scenario, bars may need to be field bent to allow for openings or embedments. In any case, adjustments or "corrections" must be made.

Q: **"Unplanned" situations requiring "field corrections" were cited above. Is an attempt being made to distinguish such cases from "planned" field adjustments?**

A: Yes, that is correct. The "planned" scenarios would be when construction activities or procedures require reinforcing bars to be rebent or intentionally straightened. The recommendations and cautions in the technical literature are also applicable to the planned events.

Q: **What information does a caller, say a contractor, seek about straightening or rebending bars?**

A: There are probably some extenuating circumstances or influences that prompted the call, such as an inspector expressing reservations about the proposed procedure for making the corrections. Often the conversations with a contractor start at square one. The caller is informed about Section 7.3.2 in the ACI 318 Building Code, and that the companion Commentary Section R7.3.2 presents guidelines on carrying out the corrective operations. If the caller does not have a copy of the ACI Building Code, the Commentary guidelines are then paraphrased. The Staff also emphasizes that close control of the work is essential. If bars are kinked, there is not much that can be done. The Staff comments that successful rebending or straightening is not guaranteed. There is risk involved. A bar or bars might fracture. The Staff also points out that safety of the construction personnel should be paramount.

Table 1 Possible Reduction in Mechanical Properties of Bent and Straightened Reinforcing Bars

Bending Condition	Bar Size	Reduction in Yield Strength	Reduction in Tensile Strength	Reduction in Percentage of Elongation
Cold	#10, #13	–	–	Approx. 20%
	#16	Approx. 5%	–	Approx. 30%
Hot	All sizes	Approx. 10%	Approx. 10%	Approx. 20%

Q: Since the majority of recipients of these reports are design professionals, what would or should be their interest or stake in these field corrections?

A: ACI 318 Code Section 7.3.2 prohibits such field bending except as shown on the design drawings or permitted by the engineer. Commentary Section R7.3.2 states such field bending should not be done without authorization of the engineer, and that the engineer must determine whether the bars should be bent cold or if heating should be used. Thus, the Code and Commentary explicitly require the engineer to be an involved party.

Q: Are inquiries received from design professionals, and if so, what information are they seeking?

A: Most of the time, the design professionals want to discuss the effect of the rebending or straightening on the mechanical properties of the bar. In other words, presuming a bar is successfully rebent or straightened, is there any detrimental effect on the strength or ductility of the bar? The best response the Staff can muster is to cite test results (see Table 1) which were published in “Field Bending and Straightening of Reinforcing Steel” by K. Babei and N. M. Hawkins in the January 1992 issue of *Concrete International* by the American Concrete Institute.

WELDED SPLICES OF REINFORCING BARS

Q: Since welding or welded splices of reinforcing bars is apparently a broad subject, should the discussion begin with some background as to what the issues are or what information do the callers seek?

A: Welding of reinforcing bars is indeed a broad subject. There are, for example, many rebar welding applications in the precast concrete industry such as welding bars to steel embedments. To keep this discussion focused, the following remarks will be limited to the welding concerned with splicing of reinforcing bars — the welded splices prescribed by the ACI Building Code. These remarks should not be interpreted as encouraging or promoting the use of welded splices of reinforcing bars.

In responding to an inquiry, the caller is first asked whether they are familiar with the ANSI/AWS Welding Code for reinforcing bars. If their answer is negative, the caller is informed that for many years, the American Welding Society has published a consensus standard for welding reinforcing bars. The current standard’s title and designation is “Structural Welding Code — Reinforcing Steel (ANSI/AWS D1.4–98).” Copies of the welding code can be obtained from the American Welding Society in Miami, Florida, telephone 1-800-334-9353. Anyone dealing with the welding of reinforcing bars should have a copy of the Welding Code.

Q: Having a copy of the Welding Code is essential — a starting point. Then what?

A: The Staff suggests to the caller that Section R3.5.2 of the Commentary to the ACI Building Code is an informative and up-to-date discussion of welding and includes several of the steps the design professional should take in specifying welded splices. Weldability, carbon equivalent, and the main requirements in the Welding Code are then discussed.

From interaction with design professionals, the Staff has observed that mis-information is widespread when it comes to welded splices. An example . . . . . Some suggested standard contract documents, e.g., project specifications, which can be adopted by reference for a specific construction project, direct the design professional to specify the welding procedure to be used and concurrently direct the design professional to require the welding of reinforcing bars to conform to the Welding Code. These instructions are in conflict. The Welding Code requires the contractor to prepare a WPS (Welding Procedure Specification) for each welded splice. The designer is not obliged to specify procedures.

Q: What is the relation of the terms “weldability” and “carbon equivalent” with the Welding Code?

A: The “weldability” of steel, which is established by its chemical analysis, sets the minimum preheat and interpass temperatures, and limits the applicable welding procedures. For example, low-alloy steel reinforcing bars, conforming to the ASTM A706/A706M Specification, are intended for welding. Weldability is accomplished in the A706/A706M Specification by limits or controls on chemical composition. One limit is on individual chemical elements, for example, carbon is limited to 0.30% and manganese to 1.50%. Another limit is on “carbon equivalent.” Carbon equivalent, abbreviated as C.E., accounts for those chemical elements affecting weldability. The ASTM A706/A706M Specification and the Welding Code have the same formula for C.E.:

$$\text{C.E.} = \%C + \%Mn/6 + \%Cu/40 + \%Ni/20 + \%Cr/10 - \%Mo/50 - \%V/10$$

On the other hand, included in the scope of the ASTM A615/A615M Specification for billet-steel reinforcing bars, is a statement concerning welding:

> “. . . Welding of the material in this specification should be approached with caution since no specific provisions have been included to enhance its weldability. When steel is to be welded, a welding procedure suitable for the chemical composition and intended use or service should be used . . .”

The scope of the A615/A615M Specification then recommends use of ANSI/AWS D1.4 for welding of reinforcing bars. The C.E. formula in the Welding Code for bars other than low-alloy steel is:

$$\text{C.E.} = \%C + \%Mn/6$$

Table 2 illustrates the relation between bar sizes, range of carbon equivalent, and the required minimum preheat and interpass temperatures. These data have been excerpted from the Welding Code.

Table 2 Minimum Preheat and Interpass Temperatures, °F

C.E. Range, %	BAR SIZES		
	#10 to #19	#22 to #36	#43 to #57
0.40 Max	None	None	50
0.41 to 0.45	None	None	100
0.46 to 0.55	None	50	200
0.56 to 0.65	100	200	300
0.66 to 0.75	300	400	400
Above 0.75	500	500	500

Q: If a design professional decides to specify welded splices for a construction project, what criteria should be included in the contract documents?

A: The Architect/Engineer should indicate on the project drawings or in the project specifications:

- The welding of reinforcing bars shall conform to the ANSI/AWS D1.4 Welding Code.
- The type and location of welded splices of reinforcing bars.

The latter item is a requirement of the ACI 318 Building Code.

As mentioned earlier, the ANSI/AWS D1.4 Welding Code requires the contractor to prepare written welding procedure specifications (WPS’s) conforming to the requirements of the Welding Code. The ASTM A706/A706M Specification for Low-Alloy Steel Reinforcing Bars requires the producer of the reinforcing bars to report the chemical composition and carbon equivalent of the steel. For billet-steel reinforcing bars, the ASTM A615/A615M Specification requires the producer to determine the percentages of certain chemical elements including carbon and manganese. Reporting these material properties should be required in the project specifications so that the contractor will have the carbon equivalent available for the bars to be welded.

Q: Any final comments on welded splices?

A: CRSI’s recommendations for welding reinforcing bars are included in the *Manual of Standard Practice*. Perhaps it would be beneficial to paraphrase the recommendations here to serve as the closure to the discussion of welded splices.

1. Minimize manual arc welding in the field, where ever possible. Consider mechanical splices as an alternative to welded splices.
2. Where arc welded splices are used, welding should conform to requirements of ANSI/AWS D1.4 “Structural Welding Code — Reinforcing Steel”; require reporting of mill test analysis of the reinforcing bars for calculating carbon equivalent (C.E.); and require continuous supervision of all welding operations.
3. Chemical analyses are not ordinarily meaningful for rail-steel and axle-steel reinforcing bars. Welding of these types of bars is not recommended.
4. Never permit field welding of crossing bars (“tack” welding or “spot” welding) for the assembly of reinforcement. Such welding can be detrimental to bars. Tie wire should be used for assembly and securing of reinforcement.

METRICATION

Q: Please give some background information on this subject.

A: Since early 1997, many of the manufacturers of reinforcing bars (the "mills") began to phase in the production of soft metric bars. The shift in production to soft metric bars resulted in soft metric reinforcing bars being furnished to non-metric construction projects as well as, naturally, to metric projects. In many areas of the country, the transition to soft metric bars has been achieved — soft metric bars have replaced inch-pound bars.

Q: Briefly discuss "soft metric" reinforcing bars and their relation to inch-pound bars.

A: The term "soft metric" can be described in the context of bar designations and bar sizes. "Soft metric conversion" means describing the dimensions of inch-pound reinforcing bars in terms of metric units, but not physically changing the bar sizes. Table 3 shows the relation between the soft metric bar sizes and the inch-pound bar sizes. The metric bar designations are simply a re-labeling of the inch-pound bar designations. More detailed data showing the relation of soft metric bars to inch-pound bars are given in Table 4.

Q: Has the industry's shift to soft metric reinforcing bars created problems?

A: From all indications, it appears the shift to soft metric reinforcing bars has proceeded very smoothly. The Staff is unaware of any problems. CRSI's technical committees meet periodically, most recently in March 1999. Producers, fabricators and placers of reinforcing bars from various regions of the nation serve on the technical committees.
Several of them commented they were not aware of any problems associated with soft metric bars. The consensus was: It appears metrication in the rebar industry, including the furnishing of soft-metric bars to non-metric construction projects, is a non-issue.

Table 3 Soft Metric Bar Sizes vs. Inch-Pound Bar Sizes

Soft Metric	Inch-Pound
#10	#3
#13	#4
#16	#5
#19	#6
#22	#7
#25	#8
#29	#9
#32	#10
#36	#11
#43	#14
#57	#18

Q: It seems somewhat of a contradiction. The statement was made that the switch to soft metric reinforcing bars has gone smoothly. On the other hand, metrication is listed as a popular topic. Please explain.

A: The numerous calls received about metrication are not necessarily associated with some sort of a problem. The majority of the callers are seeking basic information about soft metric bars. They might ask about the markings required for soft metric bars. Or they may request confirmation about some aspect of the size designations or grades (minimum yield strengths).

Table 4 ASTM Standard Soft Metric Reinforcing Bars

Bar Size[a]	Nominal Dimensions[b]		
	Diameter mm [in.]	Cross-Sectional Area, mm² [in.²]	Weight kg/m [lb/ft]
#10 [#3]	9.5 [0.375]	71 [0.11]	0.560 [0.376]
#13 [#4]	12.7 [0.500]	129 [0.20]	0.994 [0.668]
#16 [#5]	15.9 [0.625]	199 [0.31]	1.552 [1.043]
#19 [#6]	19.1 [0.750]	284 [0.44]	2.235 [1.502]
#22 [#7]	22.2 [0.875]	387 [0.60]	3.042 [2.044]
#25 [#8]	25.4 [1.000]	510 [0.79]	3.973 [2.670]
#29 [#9]	28.7 [1.128]	645 [1.00]	5.060 [3.400]
#32 [#10]	32.3 [1.270]	819 [1.27]	6.404 [4.303]
#36 [#11]	35.8 [1.410]	1006 [1.56]	7.907 [5.313]
#43 [#14]	43.0 [1.693]	1452 [2.25]	11.380 [7.65]
#57 [#18]	57.3 [2.257]	2581 [4.00]	20.240 [13.60]

[a] Equivalent inch-pound bar sizes are the designations enclosed within brackets.
[b] The equivalent nominal dimensions of inch-pound bars are the values enclosed within brackets.

Q: Bar markings and strength levels were mentioned. Please elaborate on these aspects.

A: Let's describe briefly the main differences in the ASTM specifications for reinforcing bars — metric vs. inch-pound. The differences are:

· Bar size designations — the metric and inch-pound designations are shown in Tables 3 and 4.

· Minimum yield strengths or grades. The minimum yield strength of 420 MPa is the equivalent of the inch-pound minimum f_y of 60,000 psi, i.e., Grade 420 is the counter-part of Grade 60. A slight rounding was done in the ASTM Specifications as the exact conversion of 420 MPa is 60,900 psi.

· Marking requirements — the bar marking requirements can best be described with a sketch. Figure 1 shows the marks required for Grade 420 MPa bars under the ASTM A615/A615M and A706/A706M Specifications. The most frequently raised ques tion concerns the numeral used for grade marking. Yes, the ASTM specifications require the number "4" to indicate Grade 420.

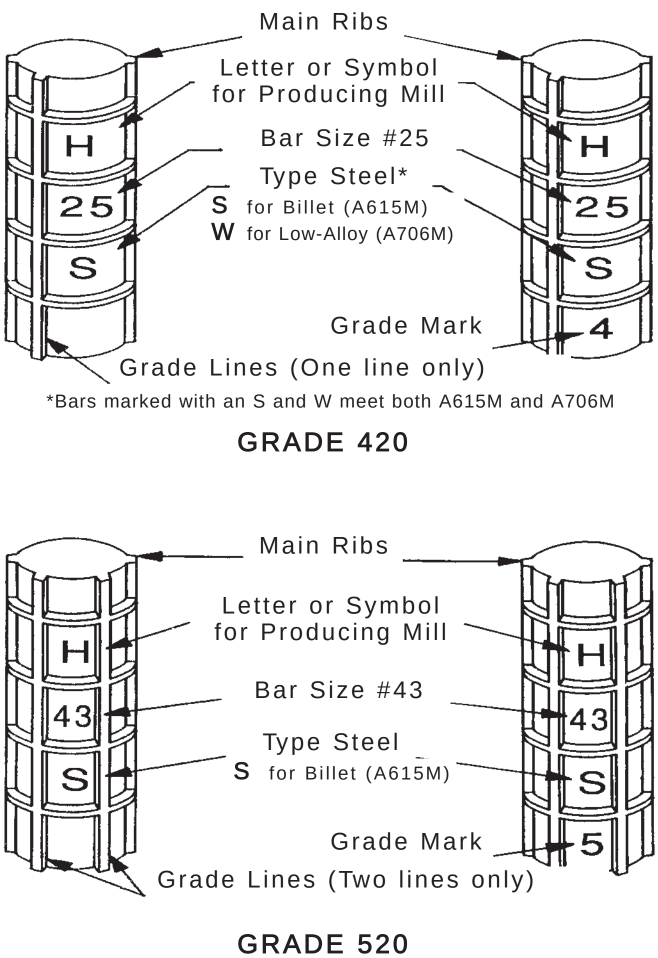

Figure 1 Marking Requirements for Metric Reinforcing Bars

Q: Any final comments on metrication?

A: More detailed information on soft metric reinforcing bars was presented in Engineering Data Report No. 42 which is titled, "Using Soft Metric Reinforcing Bars in Non-Metric Construction Projects."

It appears that metric conversion may be waning, especially among the State Departments of Transportation. At press time (May 1999) nearly half of the fifty DOT's have switched back to inch-pound units, or they are re-evaluating the situation.

ACI 318 BUILDING CODE

Q: What do callers ask about the ACI 318 Building Code?

A: Most of the questions are concerned with provisions in Chapter 7 — Details of Reinforcement and Chapter 12 — Development and Splices of Reinforcement. Since the rules in Chapter 12 for calculating tension development lengths were revised in the 1995 edition of the Code, the number of such inquiries has been reduced.

Q: What kinds of questions or what kind of information do the callers seek?

A: The callers usually want to talk about a particular provision in the code. They often are seeking an explanation of a provision. Callers use different approaches for their requests for an "explanation". For instance, a caller may wish to discuss their interpretation of a code provision, in effect the caller is seeking a reaffirmation of their interpretation. A caller may seek to discuss, essentially a review, of their proposed application of a code provision to particular details of reinforcement. A caller may want to discuss the background or basis of a code provision. An attempt has been made here to describe several of the scenarios because there is no single type of inquiry concerning the ACI Building Code.

The first response to a caller, seeking an explanation or interpretation of a code provision, is: No individual is authorized to offer an official interpretation. ACI has a procedure in place, which is called a "code case," to process requests for official code interpretations. The caller is then informed that the Staff would be willing to give a personal opinion on the intent of a code provision, and further emphasize it will be a personal opinion and not necessarily CRSI's.

Q: **It was stated the streamlining of the provisions for calculating tension development lengths in the 1995 Code has resulted in fewer inquiries concerning Chapter 12. Regarding Chapter 12 of the Code, what types of questions do callers pose?**

A: Despite the improvements made in Chapter 12, there are still some "gray" areas. Perhaps "hybrid" areas would be an appropriate description. With regard to specifics, typically the most challenging questions deal with development and lap splicing of bundled bars.

Q: **Any further comments to complete the discussion of this subject?**

A: On numerous occasions, the Staff has discovered that callers are unaware of some very important requirements in Chapter 1 of the ACI 318 Building Code. Code Section 1.2.1 addresses the items that the design professional must indicate on the design drawings or include in the project specifications. Among the ten items listed in Section 1.2.1 are:

- Anchorage length of reinforcement and location and length of lap splices
- Type and location of mechanical splices and welded splices of reinforcement

For example, it would not be proper to require in the contract documents: "All lap splices shall conform to ACI 318-95." This requirement would conflict with Section 1.2.1 of the Code.

TENSILE PROPERTIES OF OLD REINFORCING BARS

Q: **Can it be presumed the word "Old" in this subject refers to the rehabilitation and retrofitting of older existing reinforced concrete structures? What sort of information do callers seek?**

A: The observation about the word "Old" is correct. Numerous inquiries are received from design professionals who are engaged in evaluating old reinforced concrete structures for repair, rehabilitation or retrofitting. In many cases, the caller has basic information such as approximately when the structure was built. The caller may also have, from the drawings or other records, the ASTM specification number for the reinforcing bars. Sometimes the design professional relates other available information such as size designations for the reinforcement. Since the first step in the evaluation of an older structure is to determine material properties, the caller's typical lead-off question is: What minimum yield strength of the reinforcement should be used in the structural analysis?

Q: **Can some of the specific tensile property data for old reinforcing bars be cited here?**

A: Table 5 relates minimum yield strengths, or grades of steel, to the ASTM specifications for reinforcing bars from the year 1911 to the present. In the late 1970's, when the Staff realized just how many calls were being received about old reinforcing bars, CRSI decided to prepare a publication. A booklet titled *Evaluation of Reinforcing Steel Systems in Old Reinforced Concrete Structures* was published in 1981. The booklet is still in print. Readers can order a copy from the CRSI Publications Center.

Table 5 Reinforcing Bars 1911 to Present; ASTM specifications; Minimum Yield and Tensile Strengths in psi

ASTM Spec.	Years		Steel Type	Grade 33 (Stuctural)		Grade 40 (Intermediate)		Grade 50 (Hard)		Grade 60		Grade 75	
	Start	End		Min. Yield	Min. Tens.	Min. Yield	Min. Tens.	Min. Yield	Min. Tens.	Min. Yield	Min. Tens.	Min. Yield	Min. Tens.
A160	1936	1964	Axle	33,000	55,000	40,000	70,000	50,000	80,000				
A160	1965	1966	Axle	33,000	55,000	40,000	70,000	50,000	80,000	60,000	90,000		
A617	1968	Present	Axle			40,000	70,000			60,000	90,000		
A15	1911	1966	Billet	33,000	55,000	40,000	70,000	50,000	80,000				
A408	1957	1966	Billet	33,000	55,000	40,000	70,000	50,000	80,000				
A432	1959	1966	Billet							60,000	90,000		
A431	1959	1966	Billet									75,000	100,000
A615	1968	1972	Billet			40,000	70,000			60,000	90,000	75,000	100,000
A615	1974	1986	Billet			40,000	70,000			60,000	90,000		
A615	1987	Present	Billet			40,000	70,000			60,000	90,000	75,000	100,000
A706	1974	Present	Low-Alloy							60,000	80,000		
A16	1913	1966	Rail					50,000	80,000				
A61	1963	1966	Rail							60,000	90,000		
A616	1968	Present	Rail					50,000	80,000	60,000	90,000		
A955	1996	Present	Stainless			40,000	70,000			60,000	90,000	75,000	100,000

Q: **Any other comments on old reinforcing bars?**

A: Another ASTM specification should be cited. Specification A305, which only covered the deformation requirements for reinforcing bars, existed from about 1950 to 1968. Those deformation requirements were merged into the 1968 editions of the specifications for reinforcing bars, and Specification A305 was dropped.

FIELD CUTTING OF REINFORCING BARS

Q: **Please give some background information on this subject.**

A: An issue often occurring on construction projects is concerned with the cutting of reinforcing bars. The cutting envisioned in this discussion is unplanned cutting. It is not the kind of cutting associated with field fabrication of reinforcing bars. CRSI discourages field fabrication.* Field cutting of bars would be required, for example, when bars are too long as a result of design changes, or errors were made in detailing, fabrication, or placing. The field cutting could involve overlength bars prior to their placement in the formwork or overlength bars that are partially embedded in hardened concrete.

Q: **What is the issue then about the cutting of overlength bars in the field?**

A: The basic issue or question is: When bars are too long, how should, or how can the excess length be removed? There are essentially two approaches:

- For the smaller size bars, #10, #13 and #16**, it might be possible to perform the cutting with bolt-cutters.
- Bar sizes #19** and larger are usually flame-cut with an oxy-acetylene torch.

Q: **The explanation of field cutting sounds straightforward. Unless something has been overlooked, what is the "issue" associated with such cutting?**

A: A question arises whether flame-cutting is suitable. In other words, will flame-cutting affect the reinforcing bars?

* According to the CRSI *Manual of Standard Practice*, "It is recommended that all reinforcing steel be shop fabricated, and so specified by the Architect/Engineer, as operations can be performed with greater accuracy in the shop."
** Designations of soft metric bar sizes.

Q: **What is the response to the question whether flame-cutting will harm the bar?**

A: The technical Staff is aware of a test conducted some years ago by a manufacturer of mechanical splices. An oxyacetylene torch was used to cut a piece from a #18 Grade 75 reinforcing bar. The cut-off piece of bar was then air cooled to room temperature. Hardness readings of the base metal were taken on a longitudinal section of the piece of bar. Readings were taken at some nine points, including readings in the heat-affected zone (HAZ), and at points located up to 2-1/2 inches [65 mm] from the flame cut end. The HAZ extended back only about 3/8 inches [10 mm] from the cut end. From an evaluation of the hardness test data, it was concluded that any effect of flame-cutting is localized to the end-cut surfaces, and that the use of flame-cut bar ends would have no adverse effect on the performance of either the bar or the mechanical splice.

It is realized that the above test results on one bar size are limited. Recently, a producer of reinforcing bars and a member of CRSI, reported results of a more extensive program to determine the effect of flame-cutting on reinforcing bars. The bar producer's testing program:

- Covered bar sizes #16, #25, #36 and #57 in Grade 420.
- Test bars were billet-steel conforming to ASTM A615/A615M and alloy-steel conforming to ASTM A706/A706M.
- Hardness tests were conducted by an independent laboratory.

The results of the bar producer's more extensive testing program mirrored the results of the previously described test by the mechanical splice manufacturer. In the recent tests by the bar producer, only a very short distance or length of bar at the bar ends were affected by flame-cutting — less than 3/16 inch. From an analysis of the hardness test data, the conclusions were virtually the same as those for the limited testing program. In other words, any effect of flame-cutting is localized to the end-cut surfaces, and such flame-cutting has no adverse effect on the bars.

Q: **Any additional comments?**

A: The preceding discussion is concerned with flame-cutting of uncoated reinforcing bars. Flame-cutting of epoxy-coated bars is not recommended. Coating damage can be reduced by using other means of cutting rather than flame-cutting. After cutting epoxy-coated reinforcing bars, the cut ends should be coated with the patching material that is used for repairing damaged coating. Damaged coating in the vicinity of the cut ends of the bars should also be properly repaired.

NEW STEEL REINFORCEMENT MATERIALS

Q: It is unclear why this subject is included in the list of most popular issues or questions. If materials are "new", how can there be many questions?

A: It might appear to be unusual on the surface. A scenario would be when a design professional, who is undertaking the design of a high-tech research or medical facility, comments that the concrete structure will house equipment which cannot tolerate any magnetic material such as (carbon) steel reinforcement in the walls, floor slab, and so on. The caller usually then asks about the feasibility of non-magnetic steel reinforcement. A suggestion is made to the caller to consider using stainless steel reinforcing bars.

If the caller expresses interest, the Staff then goes on to cite the ASTM A955M Specification for stainless steel reinforcing bars, which was issued in 1996. The main features of the specification are then outlined to the caller:

- ASTM A955M is in metric units.
- Bar sizes are soft metric conversions of the inch-pound bar sizes.
- Minimum yield strengths are 300 MPa, 420 MPa and and 520 MPa, which are equivalent to 40, 60, and 75 ksi, respectively.
- Requirements in ASTM A955M for deformations, tensile properties, and bend tests are the same as those in the ASTM A615M specification for billet-steel bars.
- Use of the ASTM A955M specification to prescribe stainless steel reinforcing bars for a construction project will require the Architect/Engineer to specify the required chemical composition (the stainless steel grade), heat treatment conditions, and the application — corrosion resistance or magnetic permeability — and whether either of the two supplementary requirements, S1 and S2, applies. Special corrosion testing is covered by supplementary requirement S1. Supplementary requirement S2 prescribes magnetic permeability testing.

Q: Are there other new steel reinforcement materials?

A: Discussion here of new materials or products should include headed reinforcing bars.

Q: What is a "headed reinforcing bar"?

A: A headed bar is a reinforcing bar with a head attached to one or both ends. The steel head can be attached or connected to the bar by welding or threading. Another type of headed bar uses an integrally-forged head. In 1997, ASTM issued a specification for headed bars. The specification, whose designation is A970/A970M, prescribes requirements for the head and bar material, the minimum dimensions of the head, connecting the head to the bar, and acceptance testing of a headed bar.

Q: What kind of information do callers seek with regard to headed reinforcing bars?

A: In most cases, the callers wish to talk about headed bars. They may have seen the A970/A970M Specification in the *1999 ASTM Annual Book of Standards*, or they have seen a technical article or heard about headed reinforcing bars at a meeting. They may also inquire about design procedures. Regarding design procedures, the response is to cite published research reports and technical papers.

Q: What are the advantages of using headed reinforcing bars? Or what would be an application?

A: Congestion of reinforcement in cast-in-place construction hampers constructability. An example of possible congestion of reinforcement is a beam-to-column joint in a frame. At an edge joint, the beam top bars would probably require hooked ends embedded into the column. If the frame is part of the lateral-load resisting system for seismic construction, the bottom bars might also have hooked ends. In the same joint, the column longitudinal bars would be present, and for a seismic-resistant structure, transverse reinforcement would be required within the joint — all of which add to the congestion. To relieve the congestion of reinforcement, headed bars can be used in lieu of bars with standard end hooks. The head is very effective in anchoring the bar. The end anchorages, namely, the heads, can be designed so that the headed bar is immediately anchored by the head alone, thereby significantly reducing or even eliminating the need to rely upon any straight bar embedment to develop the yield strength of the bar.

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