NONRESIDENT
TRAINING
COURSE

November 1996

Steelworker, Volume 2

NAVEDTRA 14251

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Although the words "he," "him," and "his" are used sparingly in this course to enhance communication, they are not intended to be gender driven or to affront or discriminate against anyone.

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ERRATA #1 29 May 2001

Specific Instructions and Errata for
Nonresident Training Course

STEELWORKER, VOLUME 2, NAVEDTRA 14251

1. This errata supersedes all previous errata. No attempt has been made to issue corrections for errors in typing, punctuation, etc., that do not affect your ability to answer the question or questions.

2. To receive credit for deleted questions, show this errata to your local course administrator (ESO/scorer). The local course administrator is directed to correct the course and the answer key by indicating the questions deleted.

3. <u>Assignment Booklet, NAVEDTRA 14251.</u>

Delete the following questions, and leave the corresponding spaces blank on the answer sheets:

Questions	Questions
2-44	5-12
3-16	6-31
3-17	7-23
3-18	7-55
4-45	8-51
4-52	8-52
4-55	

PREFACE

By enrolling in this self-study course, you have demonstrated a desire to improve yourself and the Navy. Remember, however, this self-study course is only one part of the total Navy training program. Practical experience, schools, selected reading, and your desire to succeed are also necessary to successfully round out a fully meaningful training program.

COURSE OVERVIEW: In completing this nonresident training course, you will demonstrate a knowledge of the subject matter by correctly answering questions on the following subjects:

Technical Administration
Layout and Fabrication of Sheet Metal and Fiberglass Duct
Structural Terms/Layout and Fabrication of Structural Steel and Pipe
Fiber Line
Wire Rope
Rigging
Reinforcing Steel
Pre-engineered Structures: Buildings, K-Spans, Towers, and Antennas
Pre-engineered Storage Tanks
Pontoons
Pre-engineered Structures: Short Airfield for Tactical Support
Steelworker Tools and Equipment

THE COURSE: This self-study course is organized into subject matter areas, each containing learning objectives to help you determine what you should learn along with text and illustrations to help you understand the information. The subject matter reflects day-to-day requirements and experiences of personnel in the rating or skill area. It also reflects guidance provided by Enlisted Community Managers (ECMs) and other senior personnel, technical references, instructions, etc., and either the occupational or naval standards, which are listed in the *Manual of Navy Enlisted Manpower Personnel Classifications and Occupational Standards*, NAVPERS 18068.

THE QUESTIONS: The questions that appear in this course are designed to help you understand the material in the text.

VALUE: In completing this course, you will improve your military and professional knowledge. Importantly, it can also help you study for the Navy-wide advancement in rate examination. If you are studying and discover a reference in the text to another publication for further information, look it up.

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Sailor's Creed

"I am a United States Sailor.

I will support and defend the Constitution of the United States of America and I will obey the orders of those appointed over me.

I represent the fighting spirit of the Navy and those who have gone before me to defend freedom and democracy around the world.

I proudly serve my country's Navy combat team with honor, courage and commitment.

I am committed to excellence and the fair treatment of all."

CONTENTS

CHAPTER PAGE

1. Technical Administration 1-1
2. Layout and Fabrication of Sheet Metal and Fiber-glass Duct 2-1
3. Structural Steel Terms/Layout and Fabrication of Structural Steel and Pipe 3-1
4. Fiber Line, ...4-1
5. Wire Rope 5-1
6. Rigging 6-1
7. Reinforcing Steel 7-1
8. Pre-engineered Structures: Buildings, K-Spans, Towers, and Antennas 8-1
9. Pre-engineered Storage Tanks 9-1
10. Pontoons 10-1
11. Pre-engineered Structures: Short Airfield for Tactical support 11-1
12. Steelworker Tools and Equipment 12-1

APPENDIX

I. Glossary AI-1
II. Mathematics AII-1
III. Metric Conversion Tables. AIII-1
IV.HandSignals AIV-1
V. References Used to Develop This TRAMAN AV-1

INDEX INDEX-1

CHAPTER 7

REINFORCING STEEL

As a Steelworker, you must be able to cut, bend, place, and tie reinforcing steel. This chapter describes the purpose of reinforcing steel in concrete construction, the types and shapes of reinforcing steel commonly used, and the techniques and tools used by Steelworkers in rebar (reinforcing steel) work. This chapter begins with a presentation of fundamental information about concrete to help you understand rebar work fully.

REINFORCED CONCRETE

As a Steelworker you will be primarily concerned with reinforcing steel placement but you should to some extent, be concerned with concrete as well. Concrete with reinforcing steel added becomes reinforced concrete. Structures built of reinforced concrete, such as retaining walls, buildings, bridges, highway surfaces, and numerous other structures, are referred to as reinforced concrete structures or reinforced concrete construction.

CONCRETE MATERIALS

Concrete is a synthetic construction material made by mixing cement, fine aggregate (usually sand), coarse aggregate (usually gravel or crushed stone), and water in proper proportions. This mixture hardens into a rocklike mass as the result of a chemical reaction between the cement and water. Concrete will continue to harden and gain strength as long as it is kept moist and warm. This condition allows the chemical reaction to continue and the process is known as curing. Durable, strong concrete is made by the correct proportioning and mixing of the various materials and by proper curing after the concrete is placed.

The correct proportioning of the concrete ingredients is often referred to as the mix. The quality of the concrete is largely determined by the quality of the cement-water paste that bonds the aggregates together. The strength of concrete will be reduced if this paste has water added to it. The proportion of water to cement is referred as the water-cement ratio. The water-cement ratio is the number of gallons of water per pounds of cement. High-quality concrete is produced by using the lowest water-cement mixture possible without sacrificing workability.

Because concrete is plastic when it is placed forms are built to contain and form the concrete until it has hardened In short forms and formwork are described as molds that hold freshly placed concrete in the desired shape until it hardens. All the ingredients of the mix are placed in a concrete mixer, and after a thorough mixing, the concrete is transferred by numerous methods, such as by bucket, by wheelbarrow, and so forth, into the formwork in which the reinforcing steel has already been placed.

Concrete reaches its initial set in approximately 1 hour under normal conditions and hardens to its final set in approximately 6 to 12 hours. Before the initial set, concrete must be placed in the forms and vibrated to consolidate it into the formwork and ensure complete coverage of all reinforcing bars. Finish operations, such as smooth troweled finishes, must be performed between initial and final set. After the final set, concrete must be protected from shock, extreme temperature changes, and premature drying until it cures to sufficient hardness. Concrete will be self-supportive in a few days and attain most of its potential strength in 28 days of moist curing. For further information on concrete, refer to *Builder 3 & 2,* Volume 1, NAVEDTRA 12520.

CONCRETE STRENGTH

As stated previously, the strength of concrete is determined by the water-cement ratio. The strength of ready-mixed concrete ranges from 1,500 to about 5,000 pounds per square inch (psi); and, with further attention paid to proportioning, it can go even higher. Under usual construction processes, lower strength concrete will be used in footers and walls and higher strength in beams, columns, and floors. The required strength of concrete on a given project can be found in the project plans and specifications for a specific project.

NOTE: Quality control is important to ensure specific design requirements are met. If the design specifications do not meet minimum standards, structural integrity is compromised and the structure is considered unsafe. For this reason, the compressive strength of concrete is checked on all projects.

The strength of the concrete is checked by the use of cylindrical molds that are 6 inches in diameter and 12 inches in height. Concrete samples must be taken on the jobsite from the concrete that is being placed. After being cured for a time period that ranges between 7 to 28 days, the cylinders are "broken to failure" by a laboratory crushing machine that measures the force required for the concrete to fail. For further information on concrete strength and testing, refer to *Engineering Aid 3,* NAVEDTRA 10696, and NAVFAC MO 330. (The MO 330 should be maintained in a battalion's tech library.)

PURPOSES AND TYPES OF REINFORCING STEEL

Reinforced concrete was designed on the principle that steel and concrete act together in resisting force.

Concrete is strong in compression but weak in tension. The tensile strength is generally rated about 10 percent of the compression strength. For this reason, concrete works well for columns and posts that are compression members in a structure. But, when it is used for tension members, such as beams, girders, foundation walls, or floors, concrete must be reinforced to attain the necessary tension strength.

Steel is the best material for reinforcing concrete because the properties of expansion for both steel and concrete are considered to be approximate] y the same; that is, under normal conditions, they will expand and contract at an almost equal rate.

NOTE: At very high temperatures, steel expands more rapidly than concrete and the two materials will separate.

Another reason steel works well as a reinforcement for concrete is because it bonds well with concrete. This bond strength is proportional to the contact surface of the steel to the concrete. In other words, the greater the surface of steel exposed to the adherence of concrete, the stronger the bond. A deformed reinforcing bar adheres better than a plain, round, or square one because it has a greater bearing surface. In fact, when plain bars of the same diameter are used instead of deformed bars, approximately 40 percent more bars must be used.

The rougher the surface of the steel, the better it adheres to concrete. Thus steel with a light, firm layer of rust is superior to clean steel; however, steel with loose or scaly rust is inferior. Loose or scaly rust can be removed from the steel by rubbing the steel with burlap or similar material. This action leaves only the firm layer of rust on the steel to adhere to the concrete.

NOTE: Reinforcing steel must be strong in tension and, at the same time, be ductile enough to be shaped or bent cold.

Reinforcing steel can be used in the form of bars or rods that are either plain or deformed or in the form of expanded metal, wire, wire fabric, or sheet metal. Each type is useful for different purposes, and engineers design structures with those purposes in mind.

Plain bars are round in cross section. They are used in concrete for special purposes, such as dowels at expansion joints, where bars must slide in a metal or paper sleeve, for contraction joints in roads and runways, and for column spirals. They are the least used of the rod type of reinforcement because they offer only smooth, even surfaces for bonding with concrete.

Deformed bars differ from the plain bars in that they have either indentations in them or ridges on them, or both, in a regular pattern. The twisted bar, for example, is made by twisting a plain, square bar cold. The spiral ridges, along the surface of the deformed bar, increase its bond strength with concrete. Other forms used are the round and square corrugated bars. These bars are formed with projections around the surface that extend into the surrounding concrete and prevent slippage. Another type is formed with longitudinal fins projecting from the surface to prevent twisting. Figure 7-1 shows a few of the types of deformed bars available. In the United States, deformed bars are used almost exclusively; while in Europe, both deformed and plain bars are used.

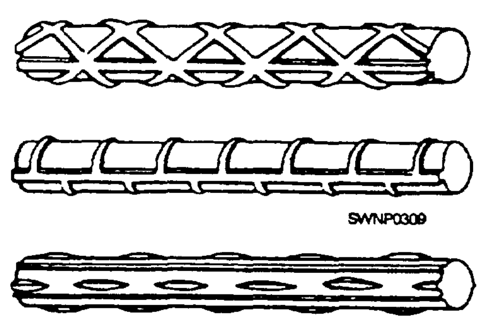

Figure 7-1.—Various types of deformed bars.

Eleven standard sizes of reinforcing bars are in use today. Table 7-1 lists the bar number, area in square inches, weight, and nominal diameter of the 11 standard sizes. Bars No. 3 through 11 and 14 and 18 are all deformed bars. Table 7-2 lists the bar number, area in square inches and millimeters, weight in pounds per foot as well as kilograms per meter, and nominal diameter of the 8 standard metric sizes. At various sites overseas, rebar could be procured locally and could be metric. Table 7-3 is given for comparison. Remember that bar numbers are based on the nearest number of one-eighth inch included in the nominal diameter of the bar. To measure rebar, you must measure across the round/square portion where there is no deformation. The raised portion of the deformation is not measured when measuring the rebar diameter.

Table 7-1.—U.S. Standard Reinforcing Bars

U.S. Standard Reinforcing Steel Bars				
Bar Size Designation	Area Square Inches	Weight lb Per Foot	Diameter	
			inches	mm
#3	.11	.376	.375	9.53
#4	.20	.668	.500	12.7
#5	.31	1.043	.625	15.88
#6	.44	1.502	.750	19.05
#7	.60	2.044	.875	22.23
#8	.79	2.670	1.000	25.40
#9	1.00	3.400	1.128	28.58
#10	1.27	4.303	1.270	31.75
#11	1.56	5.313	1.410	34.93
#14	2.25	7.650	1.693	43.00
#18	4.00	13.600	2.257	57.33

Table 7-2.—Metric Reinforcing Bars

METRIC REINFORCING STEEL BARS						
BAR SIZE DESIGNATION	AREA		WEIGHT		DIAMETER	
	Sq. Inches	Sq. mm	Lb Per Ft	KG/M	Inches	mm
10m	.16	100	.527	.785	.445	11.3
15m	.31	200	1.054	2.355	.630	16.0
20m	.47	300	1.563	2..355	.768	19.5
25m	.78	500	2.606	3.925	.992	25.2
30m	1.09	700	3.649	5.495	1.177	29.9
35m	1.55	1000	5.213	7.850	1.406	35.7
45m	2.33	1500	7.820	11.775	1.710	43.7
55m	3.88	2500	13.034	19.625	2.220	56.4

Table 7-3.—Comparison of U.S. Customary and Metric Rebar

U.S. Standard Bar		Metric Bar		Metric Bar is:
Bar Size	Area Sq. Inches	Bar Size	Area Sq. Inches	
#3	.11	10m	.16	45% larger*
#4	.20	10m	.16	20% smaller
#4	.20	15m	.31	55% larger
#5	.31	15m	.31	Same
#6	.44	20m	.47	6.8% larger
#7	.60	20m	.47	22% smaller
#7	.60	.25m	.78	30% larger
#8	.79	25m	.78	1.3% smaller
#9	1.00	30m	1.09	9% larger
#10	1.27	30m	1.09	14% smaller
#10	1.27	35m	1.55	22% larger
#11	1.56	35m	1.55	0.6% smaller
#14	2.25	45m	2.33	3.5% larger
#18	4.00	55m	3.88	3.0% smaller

***NOTE: % Difference is based upon area of rebar in square inches.**

Reinforcing Bars

Reinforcing bars are hot-rolled from a variety of steels in several different strength grades. Most reinforcing bars are rolled from new steel billets, but some are rolled from used railroad-car axles or railroad rails that have been cut into rollable shapes. An assortment of strengths are available.

The American Society for Testing Materials (ASTM) has established a standard branding for deformed reinforcing bars. There are two general systems of bar branding. Both systems serve the basic purpose of identifying the marker size, type of steel, and grade of each bar. In both systems an identity mark denoting the type of steel used is branded on every bar by engraving the final roll used to produce the bars so as to leave raised symbols between the deformations. The manufacturer's identity mark that signifies the mill that rolled the bar is usually a single letter or, in some cases, a symbol. The bar size follows the manufacturer's mark and is followed by a symbol indicating new billet steel (-N-), rolled rail steel (-I-), or rolled axle steel (-A-). Figure 7-2 shows the two-grade marking system.

The lower strength reinforcing bars show only three marks: an initial representing the producing mill, bar size, and type of steel. The high strength reinforcing bars use either the continuous line system or the number system to show grade marks. In the line system, one continuous line is rolled into the 60,000 psi bars, and two continuous lines are rolled into the 75,000 psi bars. The lines must run at least five deformation spaces, as shown in figure 7-2. In the number system, a "60" is rolled into the bar following the steel type of mark to denote 60,000 psi bars, and a "75" is rolled into the 75,000 psi bars.

Expanded Metal and Wire Mesh Reinforcement

Expanded metal or wire mesh is also used for reinforcing concrete. Expanded metal is made by partly shearing a sheet of steel, as shown in view A figure 7-3. The sheet steel has been sheared in parallel

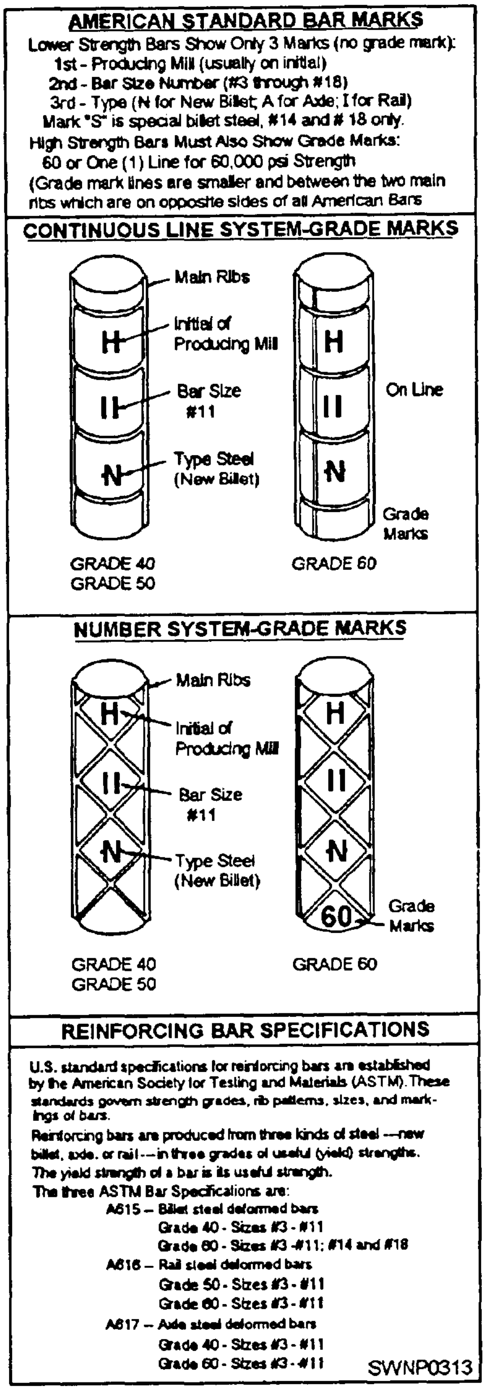

Figure 7-2.—American standard reinforcing bar marks.

lines and then pulled out or expanded to form a diamond shape between each parallel cut. Another type is square, rather than diamond shaped, as shown in view B, figure 7-3. Expanded metal is customarily y used during plastering operations and light reinforcing concrete construction, such as sidewalks and small

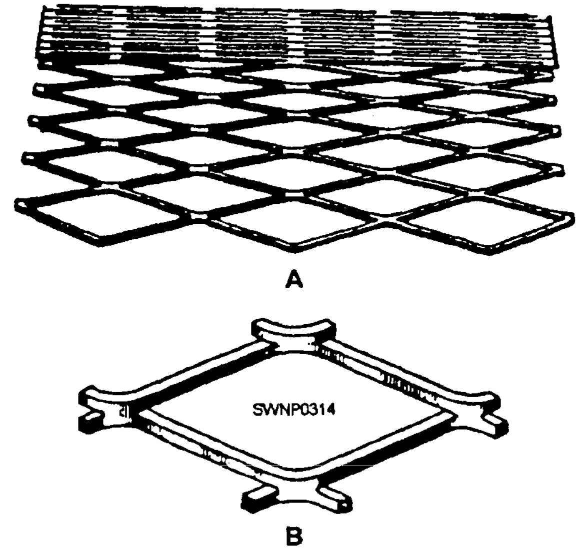

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Figure 7-3.—Expanded or diamond mesh steel reinforcement.

concrete pads that do not have to bear substantial weight, such as transformer and air-conditioner pads.

Welded Wire Fabric

Welded wire fabric is fabricated from a series of wires arranged at right angles to each other and electrically welded at all intersections. Welded wire fabric, referred to as WWF within the NCF. has various uses in reinforced concrete construction. In building construction, it is most often used for floor slabs on well-compacted ground. Heavier fabric, supplied mainly in flat sheets, is often used in walls and for the primary reinforcement in structural floor slabs. Additional examples of its use include road and runway pavements, box culverts, and small canal linings.

Four numbers are use-d to designate the style of wire mesh; for example, 6 by 6-8 by 8 (sometimes written 6 x 6 x 8 x 8 or 6 x 6 - W 2.1 x W 2.1). The first number (in this case, 6) indicates the lengthwise spacing of the wire in inches; the second number (in this case, 6) indicates the crosswise spacing of the wire in inches; the last two numbers (8 by 8) indicate the size of the wire on the Washburn and Moen gauge. More recently the last two numbers are a W number that indicates the size of the cross-sectional area in the wire in hundredths of an inch. (See table 7-4.) WWF is currently available within the Navy stock system using the four-digit system, 6 by 6-8 by 8, as of this writing, but if procured through civilian sources, the W system is used.

Table 7-4—Common Stock Sizes of Welded Wire Fabric

STYLE DESIGNATION		Weight Approximate lb per 100 sq. ft.
Current Designation (by W—Number)	Previous Designation (By Steel Wire Gauge)	
PANELS / SHEETS		
6x6—W1.4xW1.4	6x6—10x10	21
6x6—W2.1xW2.1	6 x 6 — 8 x 8	29
6x6—W2.9xW2.9	6 x 6 — 6 x 6	42
6x6—W4.0xW4.0	6 x 6 — 4 x 4	58
4x4—W1.4xW1.4	4x4—10x10	31
4x4—W2.1xW2.1	4 x 4 — 8 x 8	43
4x4—W2.9xW2.9	4 x 4 — 6 x 6	62
4x4—W4.0xW4.0	4 x 4 — 4 x 4	86
ROLLS		
6x6—W1.4xW1.4	6x6—10x10	21
6x6—W2,9xW2.9	6 x 6 — 6 x 6	42
6x6—W4.0xW4.0	6 x 6 — 4 x 4	58
6x6—W5.5xW5.5	6 x 6 — 2 x 2	80
4x4—W4.0xW4.0	4 x 4 — 4 x 4	86

Light fabric can be supplied in either rolls or flat sheets. Fabric made of wire heavier than W4 should always be furnished in flat sheets. Where WWF must be uniformly flat when placed, fabric furnished in rolls should not be fabricated of wire heavier than W 2.9. Fabricators furnish rolled fabric in complete rolls only. Stock rolls will contain between 700 to 1,500 square feet of fabric determined by the fabric and the producing location. The unit weight of WWF is designated in pounds per one hundred square feet of fabric (table 7-4). Five feet, six feet, seven feet, and seven feet six inches are the standard widths available for rolls, while the standard panel widths and lengths are seven feet by twenty feet and seven feet six inches by twenty feet.

Sheet-Metal Reinforcemat

Sheet-metal reinforcement is used mainly in floor slabs and in stair and roof construction. It consists of annealed sheet steel bent into grooves or corrugations about one-sixteenth inch (1.59 mm) in depth with holes punched at regular intends.

Tension in Steel

Steel bars are strong in tension. Structural grade is capable of safely carrying up to 18,000 psi and intermediate, hard, and rail steel, 20,000 psi. This is the SAFE or WORKING STRESS; the BREAKING STRESS is about triple this.

When a mild steel bar is pulled in a testing machine, it stretches a very small amount with each increment of load. In the lighter loadings, this stretch is directly proportional to the amount of load (fig. 7-4, view A). The amount is too small to be visible and can be measured only with sensitive gauges.

At some pull (known as the YIELD POINT), such as 33,000 psi for mild steel, the bar begins to neck down (fig. 7-4, view B) and continues to stretch perceptibly with no additional load.

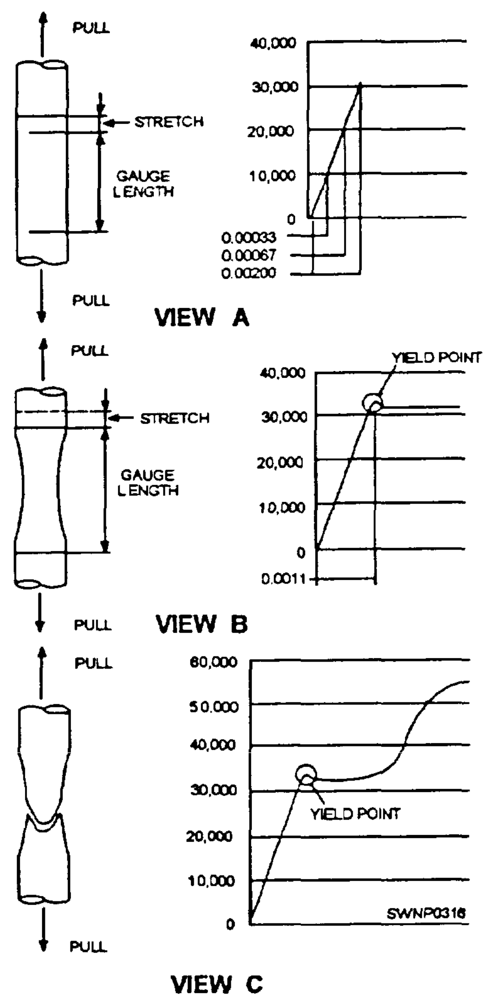

Figure 7-4.—Tension in steel bars.

Then, when it seems the bar will snap like a rubber band it recovers strength (due to work hardening). Additional pull is required (fig. 7-4, view C) to produce additional stretch and final failure (known as the ULTIMATE STRENGTH) at about 55,000 psi for mild steel.

BENDING REINFORCING BARS

The job of bending reinforcing bars is interesting if you understand why bending is necessary. There are several masons. Let us go back to the reason for using reinforcing steel in concrete—the tensile strength and compressive strength of concrete. You might compare the hidden action within a beam from live and dead loads to the breaking of a piece of wood with your knee. You have seen how the splinters next to your knee push toward the middle of the piece of wood when you apply force, while the splinters from the middle to the opposite side pull away from the middle. This is similar to what happens inside the beam.

For instance, take a simple beam (a beam resting freely on two supports near its ends). The dead load (weight of the beam) causes the beam to bend or sag. Now, from the center of the beam to the bottom, the forces tend to stretch or lengthen the bottom portion of the beam. This pad is said to be in tension, and that is where the steel reinforcing bars are needed. As a result of the combination of the concrete and steel, the tensile strength in the beam resists the force of the load and keeps the beam from breaking apart. At the exact center of the beam, between the compressive stress and the tensile stress, there is no stress at all-it is neutral.

In the case of a continuous beam, it is a little different. The top of the beam maybe in compression along part of its length and in tension along another part. This is because a continuous beam rests on more than two supports. Thus the bending of the beam is not all in one direction. It is reversed as it goes over intermediate supports.

To help the concrete resist these stresses, engineers design the bends of reinforcing steel so that the steel will set into the concrete just where the tensile stresses take place. That is the reason you may have to bend some reinforcing rods in almost a zigzag pattern. The joining of each bar with the next, the anchoring of the bar ends within concrete, and the anchoring by overlapping two bar ends together are some of the important ways to increase and keep bond strength. Some of the bends you will be required to make in reinforcing bars are shown in figure 7-5.

The drawings for a job provide all the information necessary for cutting and bending reinforcing bars. Reinforcing steel can be cut to size with shears or with an oxygas cutting torch. The cutting torch can be used in the field.

Before bending the reinforcing bars, you should check and sort them at the jobsite. Only after you check the bars can you be sure that you have all you need for the job. Follow the construction drawings when you sort the bars so that they will be in the proper order to be bent and placed in the concrete forms. After you have divided the different sizes into piles, label each pile so that you and your crew can find them easily.

For the job of bending, a number of types of benders can be used. Stirrups and column ties are normally less than No. 4 bar, and you can bend them

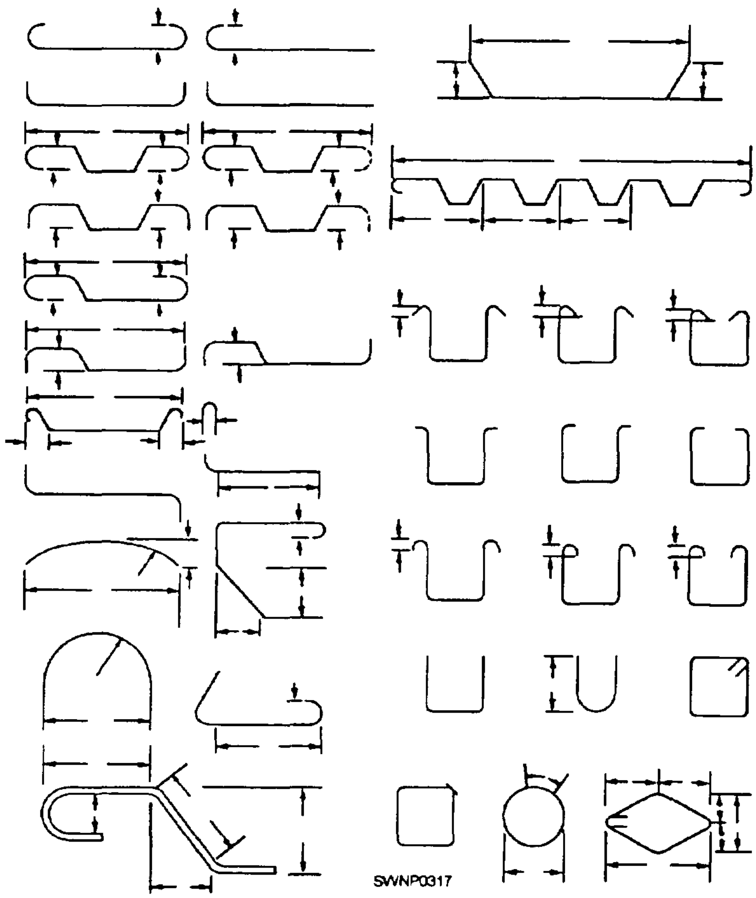

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Figure 7-5.—Typical reinforcement bends.

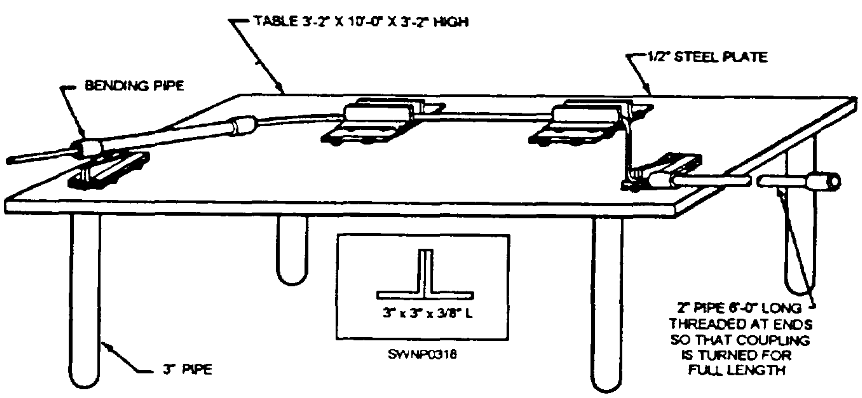

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Figure 7-6.—Bar-bending table.

cold by means of the bending table, as shown in figure 7-6. Typical stirrup tie shapes are shown in figure 7-7. Stirrups are used in beams; as shown in figure 7-8. Column ties are shown in position in figure 7-9.

When the bars have to be bent in place, a bending tool, like the one shown in figure 7-10, is effective. By placing the jaws of the hickey on one side of the center of the bend and pulling on the handle, you can produce a smooth, circular bend through almost any angle that is desired.

Bending Guidelines and Techniques

Make bends, except those for hooks, around pins with a diameter of not less than six times the bar diameter for No. 3 through No. 8 bar. If the bar is larger

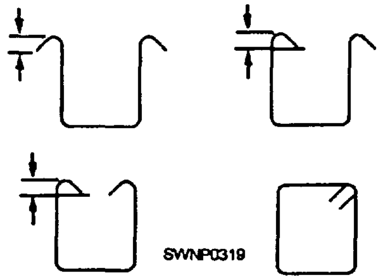

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Figure 7-7.—Stirrup and column ties.

45.481

Figure 7-8.—Steel in place in a beam

than 1 inch (25.4 mm) (No. 9, No. 10, and No. 11 bar), the minimum pin diameter should be eight times the bar size. For No. 14 through No. 18, the pin diameter should be ten times the diameter of the bar.

To get smooth, sharp bends when bending large rods, slip a pipe cheater over the rod. This piece of pipe gives you a better hold on the rod itself and makes the whole operation smoother. You can heat No. 9 bars and larger to a cherry red before bending them, but make sure you do not get them any hotter. If the steel becomes too hot, it will lose strength, become brittle, and can even crack.

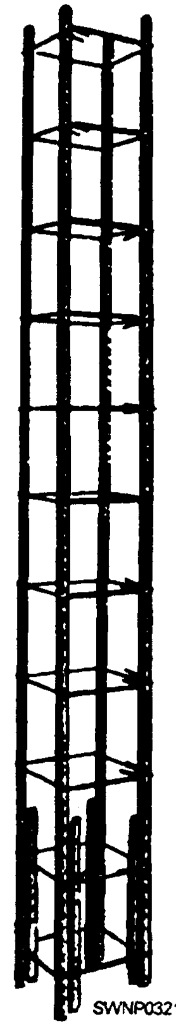

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Figure 7-9.—Column steel in place.

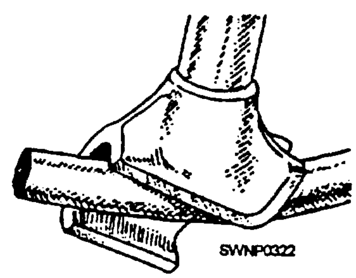

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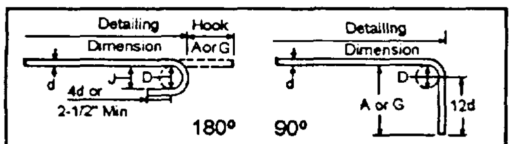
Figure 7-10.—Bending tool.

Bend Diameters

If you do not want your rod to crack while it is being bent, bend it gradually, not with a jerk. Also, do not make your bends too sharp. Bends made on a bar-bending table or block are usually too sharp, and the bar is somewhat weakened. Therefore, certain minimum bend diameters have been established for the different bar sizes and for the various types of hooks. These bending details are shown in figure 7-11. You can use many different types of bends. The one you select depends on where you are to place the rods. For example, there are bends on heavy beam and girder bars, bends for reinforcement of vertical columns at or near floor levels, bends for stirrups and column ties, bends for slab reinforcement, and bends for bars or wire for column spiral reinforcement. To save yourself some time and extra work, try to make all bends of one kind at one time instead of remeasuring and resetting the templates on your bending block for different bends.



SIZES OF 180-DEG HOOKS
D = 6d for #3 through #8
D = 8d for #9, #10, and #11
D = 10d for #14 and #18

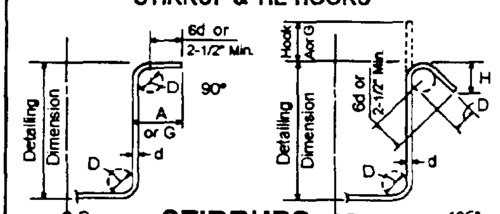
SIZES OF 90-DEG HOOKS
D = 6d for #3 through #8
D = 8d for #9, #10, and #11
D = 10d for #14 and #18

RECOMMENDED END HOOK DIMENSIONS

Bar Size	180° HOOKS All Grades		90° HOOKS All Grades
	A or G	J	A or G
#3	5	3	6
#4	6	4	8
#5	7	5	10
#6	8	6	1-0
#7*	10	7	1-2
#8*	11	8	1-4
#9*	1-3	11-1/4	1-7
#10*	1-5	10-1/4	1-10
#11	1-7	1-2-1/4	2-0
#14	2-2	1-8-1/2	2-7
#18	2-11	2-3	3-5

*These sizes - Grade 40 - check availability. Sizes #14 - #18, check availability; no Grade 40 under ASTM.

STIRRUP & TIE HOOKS



STIRRUPS
(TIES SIMILAR)

RECOMMENDED STIRRUP & TIE HOOK DIMENSIONS
Grades 40-50-60 ksi

Bar Size	D (in.)	90° HOOK	135° HOOK	
		Hook A or G	Hook A or G	Approx. H
#3	1-1/2	4	4	2-1/2
#4	2	4-1/2	4-1/2	3
#5	2-1/2	6	5-1/2	3-3/4

SWNP0323

Figure 7-11.—Standard hook details

The Iron master Portable Hydraulic Rod Bender and Shear

The Ironmaster portable hydraulic rod bender and shear (fig. 7-12) can cold-work reinforcing bars into various shapes for use in concrete construction work. The machine is capable of working reinforcing bars up to and including No. 11 bars, which is equivalent in a cross-sectional area to 1 1/4-inch (31.75 mm)-square or 1 1/2-inch (38.1 mm)-round bar.

In addition to all sizes of reinforcing bars, the Ironmaster will also work bars of higher carbon content desired in the fabrication of anchor bolts, and so forth. However, limitations must be imposed when considering bar of 1-inch (25.4 mm) diameter or greater that have a carbon content of greater than 0.18 percent, such as SAE 1020 cold-finished steel. Bars under 1 inch (25.4 mm) in diameter should have a carbon content of no greater than 0.37 percent, such as SAE 1040 C. F. steel.

Although the Ironmaster is powered to work steels of heavier sections than 1 1/2-inch (38.1 mm) reinforcing bar, the manufacturer must place safety limitations on it when considering various alloys and shapes of steel. Users will undoubtedly adapt this versatile machine to perform work other than common bar bending, such as bending flats and angles. However, the primary intention of the manufacturer was to produce a machine for bending concrete reinforcing steel. The manufacturer recommends that the Ironmaster not be used on steels heavier than 1 1/4-inch (31.75 mm)-square or 1 1/2-inch (38.1 mm)-round reinforcing bar.

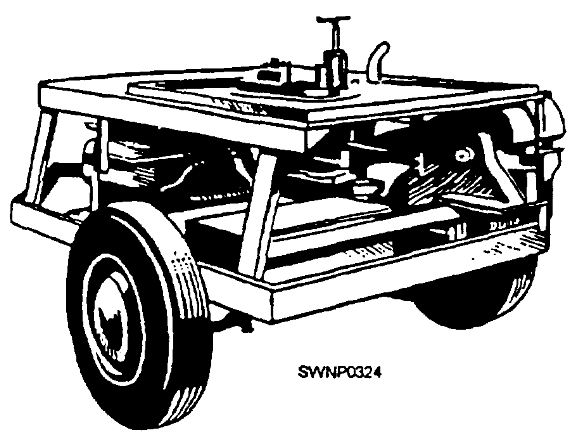


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Figure 7-12.—Ironmaster portable hydraulic bender and shear.

Standard Hook Bending

Standard hook bending (fig. 7-13) is accomplished on the turntable section located on top of the machine. Before you start any bending procedure, the turntable must be at the START position as shown in figure 7-14. As an example, when you desire to bend a 180-degree hook in apiece of No. 11 reinforcing bar, setup the machine as shown, using the following: bending cleat with cleat slide and drive pin, main center pin, and No. 11 radius roll. As a safeguard, the radius rolls have been designed to accept only the number of bars specified, suti as No. 7 roll for No. 7 bar (fig. 7-15).

1. Plain the rebar between the cleat slide upright and the radius roll, which is placed over the center pin,

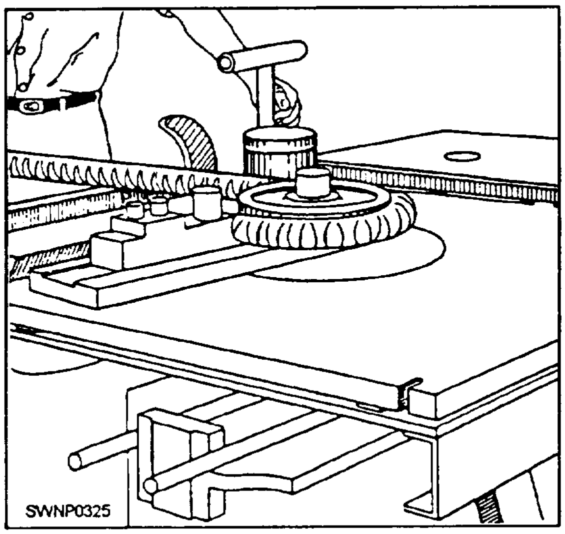

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Figure 7-13.—Ironmaster bar-bending unit.

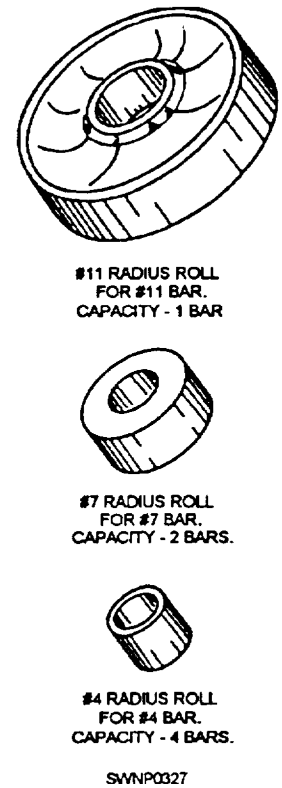

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Figure 7-15.—Radius rolls for bending rebar on an Ironmaster.

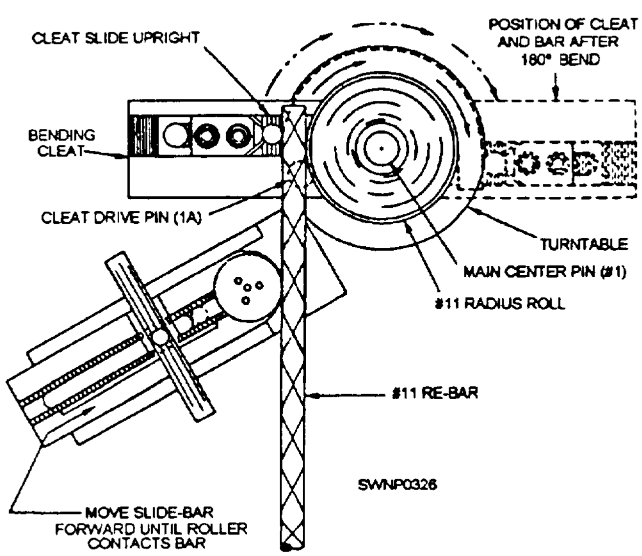

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Figure 7-14.—Example of bending a 180-degree hook with No. 11 rebar.

with the end of the rebar protruding a sufficient distance for the cleat slide to be upright to engage it where you want the bend to commence.

2. Move the cleat slide to contact the rebar and tighten the locking screws.

3. Move the positioner slide bar until the roller contacts the rebar and tightens the T handle.

4. Set the desired angle ‘of bend on the graduated control rod which is under the right side of the working table. This is done by placing the trigger pin of the rear adjustable stop (toward the rear of the machine) in the hole corresponding to the angle of bend, in this case, 180 degrees. This rod is graduated from 5 degrees to 190 degrees at 5-degree intervals.

NOTE: ENSURE THE FRONT ADJUSTABLE STOP TRIGGER PIN IS IN THE “O’ HOLE, so the turntable will return to and stop in the START position when retracted after the bend.

5. Advance the engine throttle to operating speed, and move either the rear bending control lever or slide bending control lever to the bend position. This actuates the bend cylinder. The lever will stay in the bending position until the bend is completed, the rack movement disengaging the cylinder, and the levers returning to neutral automatically.

6. To remove the rebar from the machine after the bend is completed, apply light intermittent reverse pressure to the lever until the bar releases from the radius roll. After removal of the hook from the machine, move the lever to the position shown on “retract” to return the turntable to the START position.

Multiple Bending

Multiple bending is accomplished the same way as standard hook bending for bars up to No. 8 simply by placing the bars in the machine one on top of the other.

Table 7-5 shows the bars that may be bent by the Ironmaster and the number of bars it will bend in one operation.

On the side of the machine next to the shear is the shearing support (fig. 7-16). This support holds the bars square between the shear blades and prevents them from “kicking up” during shearing. The upper jaw of the shearing support is adjustable. For bars three-fourths inch and smaller, place this jaw in the LOWER position. For larger bars, use the UPPER position. NEVER SHEAR WITHOUT USING THIS SUPPORT.

To operate, insert the bar to be cut to the farthest point possible toward the inside of the blades (fig. 7-15), making sure that the blades are in the fully OPEN or RETRACT position. With light downward pressure on the shear control lever, hold the bar in this position until the shear grips. Continue applying pressure downward to the full limit of the lever until the bar is sheared To retract the shear, pull the lever up.

The same-size bar that can be bent can be sheared Multiple shearing, however, can be accomplished only on bars of less than 0.44-square-inch area. When shearing more than one bar at a time, always place the bars side by side in the shear, as shearing with bars piled on top of each other may cause blade failure.

Table 7-5.—Single Operation Multibending

Bar #	Bar Size in Inches	Number of Bars that can be Bent in One Operation
3	3/8rd	6
4	1/2rd	4
5	5/8rd	3
6	3/4rd	3
7	7/8rd	2
8	1 rd	2
9	1 rd	1
10	1 1/8 sq	1
11	1 1/4 sq	1

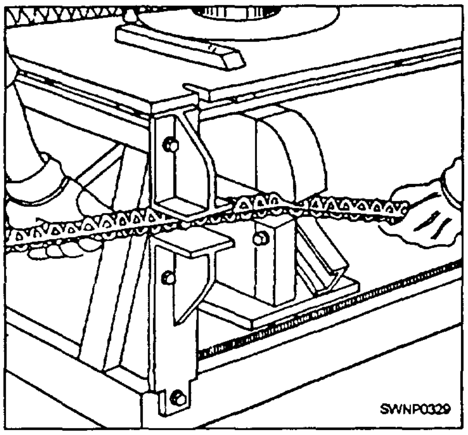

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Figure 7-16.—Ironmaster bar-cutting unit.

Table 7-6 shows the number of bars that can be sheared at one time.

The care and maintenance of the Ironmaster portable hydraulic rod bender and shear consist primarily of lubrication and cleaning. There are grease fittings on the machine. Keep these points well lubricated with a good grade of grease, but do not overlubricate, as the surplus grease will collect dirt and rust scale from the rebars. When greasing the shear pin, work the shear arm up and down until grease appears between the arm and the side ears. When using the stirrup bending attachment, keep the center pin clean and well lubricated.

Rust scale from the rebar will accumulate in the holes in the turntable and worktable and in the serrations in the bending cleat and roller slide. Keep these cleaned out, particular] y when changing over to or from the stirrup bending attachment or changing a center pin by means of a solvent-soaked rag or brush. Keep the worktable as clean as possible to minimize the amount of rust scale dropping through to the rack and gear.

PLACING AND TYING REINFORCING STEEL

Before you place reinforcing steel in forms, all form oiling should be completed. Oil on reinforcing bars should be avoided because it reduces the bond between the bars and the concrete. Use a piece of burlap to remove rust, mill scale, grease, mud, or other foreign matter from the bars. A light film of rust or mill scale is not objectionable.

Bars are marked to show where they will fit. You may work according to either one of the two most-used systems for marking bars; however, the system you use should agree with the marking system which appears on the engineering or assembly drawings. The two marking systems used are as follows:

1. All bars in one type of member are given the mark of that member. This system is used for column bars, beam bars, footing bars, and so on.

2. The bars are marked in greater detail. These marks show exactly where the bar is to be placed. In addition to the type member (that is, beam (B), wall (W), column (C), and so on), the marks show the floor on which the bars are to be placed and the size and individual number of each particular bar. Instead of showing the bar size by its diameter measurement, the mark shows the bar size in code by eighths. The examples shown below show the second type of marking system.

2B805 2 = second floor
B = beam member
8 = 8/8- or 1 -inch (2.5 cm)-square bar
05 = part of the second floor plan designated by the number 5

2B0605 2 = second floor
B = beam member
06 = 6/8- or 3/4-inch (1.9 cm)-round bar
05 = part of second floor plan designated by the number 5

Tie wire is used to hold rebar in place to ensure that when concrete is placed the bars do not shift out of position. Sixteen gauge wire is used to tie

Table 7-6.—Multishearing

Bar Size	Quantity
3,4,5,6	4
7	3
8	2
9, 10, 11	1

reinforcing bars. About 12 pounds (5.4 kg) of wire is required to tie an average ton (0.9 tome) of bars.

NOTE: Tie wire adds nothing to the strength of the steel.

A number of different types of ties can be used with reinforcing bars; some are more effective than others. Figure 7-17 shows six types of ties that are identified below according to the letters of the alphabet used to show individual ties.

A. SNAP TIE or SIMPLE TIE. The wire is simply wrapped once around the two crossing bars in a diagonal manner with the two ends on top. These are twisted together with a pair of sidecutters until they are very tight against the bars. Then the loose ends of the wire are cut off. This tie is used mostly on floor slabs.

B. WALL TIE. This tie is made by going about 1 1/2 times around the vertical bar, then diagonally around the intersection, twisting the two ends together until the connection is tight, but without breaking the tie wire, then cutting off the excess. The wall tie is used on light vertical mats of steel.

C. DOUBLE-STRAND SINGLE TIE. This tie is a variation of the simple tie. It is especially favored for heavy work

D. SADDLE TIE. The wires pass halfway around one of the ban on either side of the crossing bar and are brought squarely or diagonally around the crossing bar with the ends twisted together and cut off. This tie is used on special locations, such as on walls.

E. SADDLE TIE WITH TWIST. This tie is a variation of the saddle tie. The tie wire is carried completely around one of the bars, then squarely across and halfway around the other, either side of the crossing bars, and finally brought together and twisted either squarely or diagonally across. The saddle tie with twist is used for heavy mats that are to be lifted by a crane.

F. CROSS TIE or FIGURE-EIGHT TIE. This type of tie has the advantage of causing little or no twist in the bars.

The proper location for the reinforcing bars is usually given on drawings (table 7-7). In order for the structure to withstand the loads it must carry, place the steel in the position shown. Secure the bars in position in such a way that concrete-placing operations will not move them. This can be accomplished by the use of the reinforcing bar supports shown in figures 7-18, 7-19, and 7-20.

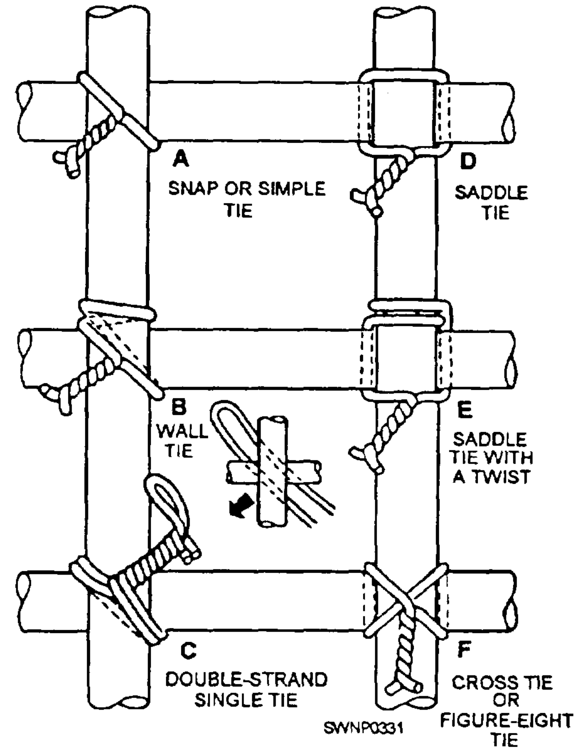

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Figure 7-17.—Six types of ties.

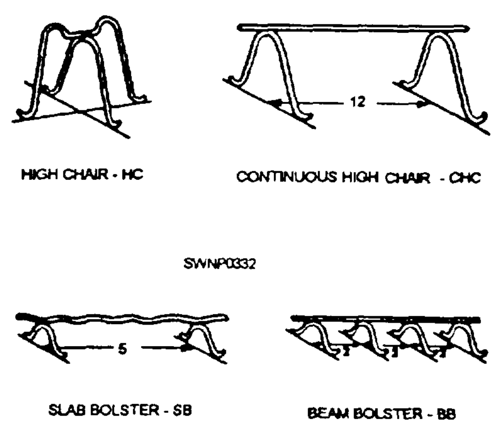

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Figure 7-18.—Reinforcement bar accessories.

The proper coverage of bars in the concrete is very important to protect the bars from fire hazards, possibility of corrosion, and exposure to weather. When not specified, minimum standards given below and in figure 7-21 should be observed.

FOOTINGS-3 inches at the sides where concrete is cast against the earth and on the bottoms of footings or other principal structural members where concrete is deposited on the ground.

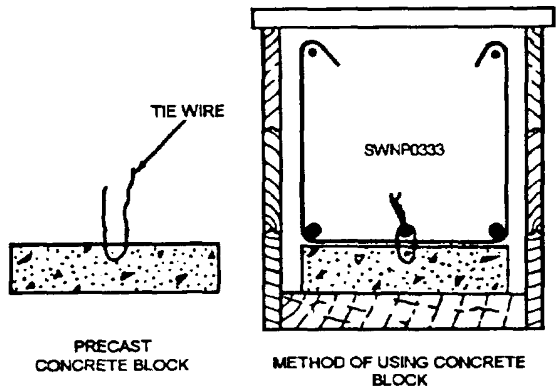

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Figure 7-19.—Precast concrete block used for rebar support.

WALLS-2 inches for bars larger than No. 5, where concrete surfaces, after removal of forms, would be exposed to the weather or be in contact with the ground; 1 1/2 inches for No. 5 bars and smaller; 3/4 inch from the faces of all walls not exposed directly to the ground or the weather.

COLUMNS—1 1/2 inches over spirals and ties.

BEAMS AND GIRDERS—1 1/2 inches to the nearest bars on the top, bottom, and sides.

JOISTS AND SLABS—3/4 inch on the top, bottom, and sides of joists and on the top and the bottom of slabs where concrete surfaces are not exposed directly to the ground or the weather.

NOTE: All measurements are from the outside of the bar to the face of the concrete, NOT from the main steel, unless otherwise specified.

Footings and other principal structural members that are against the ground should have at least 3 inches (76.2 mm) of concrete between the steel and the ground. If the concrete surface is to be in contact with the ground or exposed to the weather after removal of the forms, the protective covering of concrete over the steel should be 2 inches (50.8 mm). It maybe reduced to 1 1/2inches (38.1 mm) for beams and columns and 3/4 inch (19.5 mm) for slabs and interior wall surfaces, but it should be 2 inches (50.8 mm) for all exterior wall surfaces. This measurement is taken from the main rebar, not the stirrups or the ties.

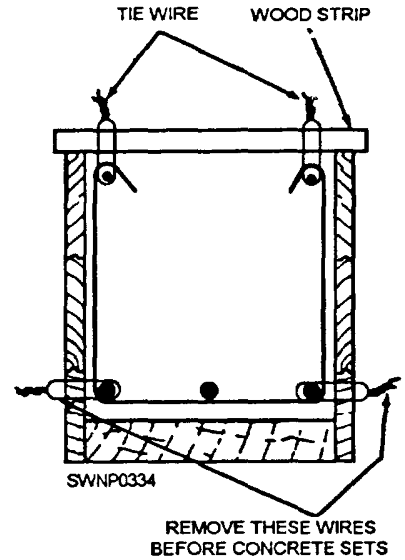

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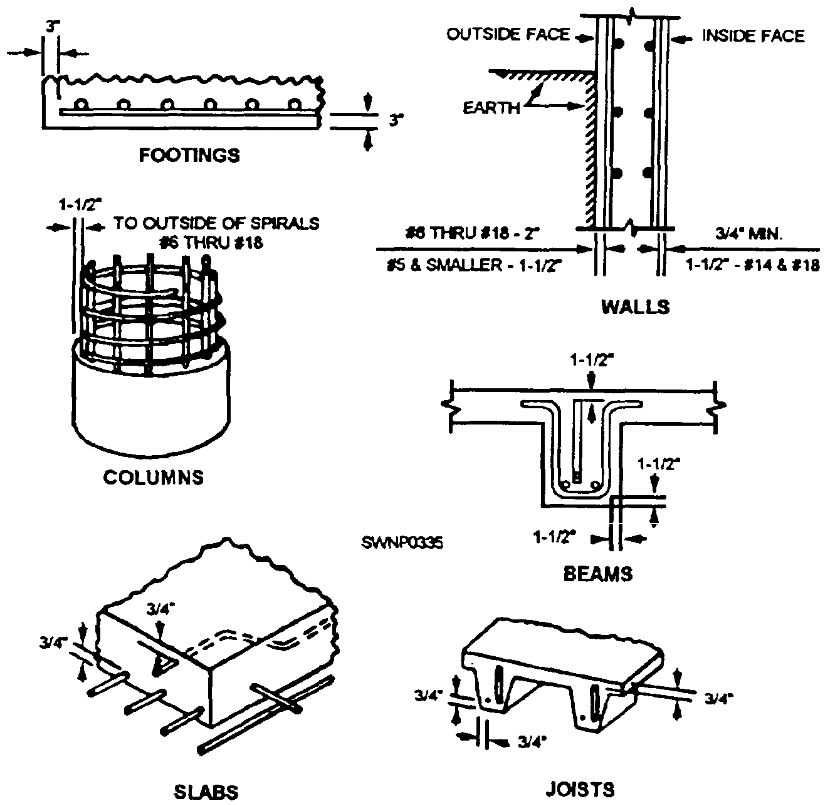
Figure 7-20.—Rebar hung in place.

NOTE: Where splices in reinforcing steel are not dimensioned on the drawings, the bars should be lapped not less than 30 times the bar diameter nor less than 12 inches (table 7-7). The stress in a tension bar

Table 7-7.—Length of Lap Splices in Reinforcing Steel

INCHES OF LAP CORRESPONDING TO NUMBER OF BAR DIAMETERS*											
Number of Diameters	Size of Bars										
	#3	#4	#5	#6	#7	#8	#9	#10	#11	#14	#18
30	12	15	19	23	27	30	34	39	43	51	68
32	12	16	20	24	28	32	36	41	45	55	73
34	13	17	22	26	30	34	39	44	48	58	77
36	14	18	23	27	32	36	41	46	51	61	82
38	15	19	24	29	34	38	43	49	54	65	86
40	15	20	25	30	35	40	46	51	57	68	91
Minimum lap equals 12 inches!											
*Figured to the next larger whole inch											



127.286

Figure 7-21.—Minimum coverage of rebar in concrete.

can be transmitted through the concrete and into another adjoining bar by a lap splice of proper length.

To lap-weld wire fabric/wire mesh, you can use a number of methods, two of which are the end lap and the side lap. In the end lap method, the wire mesh is lapped by overlapping one full mesh, measured from the ends of the longitudinal wires in one piece to the ends of the longitudinal wires in the adjacent piece, and then tying the two pieces at 1-foot 6-inch (45.0 cm) centers with a snap tie. In the side lap method, the two longitudinal side wires are placed one alongside and overlapping the other and then are tied with a snap tie every 3 feet (.9 m).

Reinforcing bars are in tension and therefore should never be bent around an inside corner beams. They can pull straight through the concrete cover. Instead, they should overlap and extend to the far face for anchorage with 180-degree hooks and proper concrete coverage (fig. 7-23).

The bars can also be spliced by metal arc welding but only if called for in the plans and specifications. For bars which are placed in a vertical position, a butt weld is preferred. The end of the bottom bar is cut square, and the end of the top bar resting on it is cut in a bevel fashion, thus permitting a butt weld. For bars which will bear a load in a horizontal position, a fillet weld is preferred. Usually, the two bars are placed end to end (rather than overlapping), and pieces of flat bar (or angle iron) are placed on either side. Fillet welds are then made where the metals join. The welds are

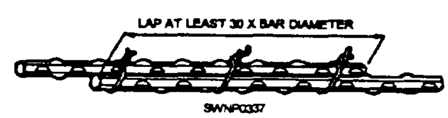


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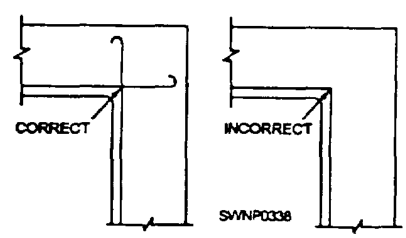
Figure 7-22.—Bars spliced by lapping.



145.66X

Figure 7-23.—Correct and Incorrect placement of reinforcement for an inside corner.

made to a depth of one half of the bar diameter and for a length eight times the bar diameter.

The minimum clear distance between parallel bars in beams, footings, walls, and floor slabs should either be 1 inch (25.4 mm) or 1 1/3 times the largest size aggregate particle in the concrete, whichever distance is greater. In columns, the clear distance between parallel bars should be not less than 1 1/2 times the bar diameter or 1 1/2 times the maximum size of the coarse aggregate. Always use the larger of the two.

The support for reinforcing steel in floor slabs is shown in figure 7-24. The height of the slab bolster is determined by the required concrete protective cover. Concrete blocks made of sand-cement mortar can be used in place of the slab bolster. Wood blocks should never be used for this purpose. Highchairs (fig. 7-18) can be obtained in heights up to 6 inches (15 cm). When a height greater than 6 inches is required, make the chair out of No. 0, soft, annealed iron wire. To hold the bars firmly in position, you should tie the bars together at frequent intervals where they cross with a snapat.

Steel for column ties may be assembled with the verticals into cages by laying the vertical bars for one side of the column horizontally across a couple of sawhorses. The proper number of ties are slipped over the bars, the remaining vertical bars are added, and then the ties are spaced out as required by the placing plans. All intersections are wired together to make the assembly rigid so that it may be hoisted and set as a unit. Figure 7-25 shows atypical column tie assembly.

After the column is raised, it is tied to the dowels or reinforcing steel carried up from below. This holds it firmly in position at the base. The column form is erected and the reinforcing steel is tied to the column form at 5-foot (4.5-m) intervals, as shown in figure 7-26.

The use of metal supports to hold beam reinforcing steel in position is shown in figure 7-8. Note the position of the beam bolster. The stirrups are tied to the main reinforcing steel with a snap tie. Wherever possible you should assemble the stirrups and main reinforcing steel outside the form and then place the assembled unit in position. Precast concrete blocks, as shown in figure 7-27, maybe substituted for metal supports.

The horizontal and vertical bars are wired securely to each other at sufficiently frequent intervals to make a rigid mat. Tying is required at every second or third intersection, depending upon the size and spacing of bars, but with not less than three ties to any one bar, and, in any case, not more than 4 to 6 feet apart in either direction.

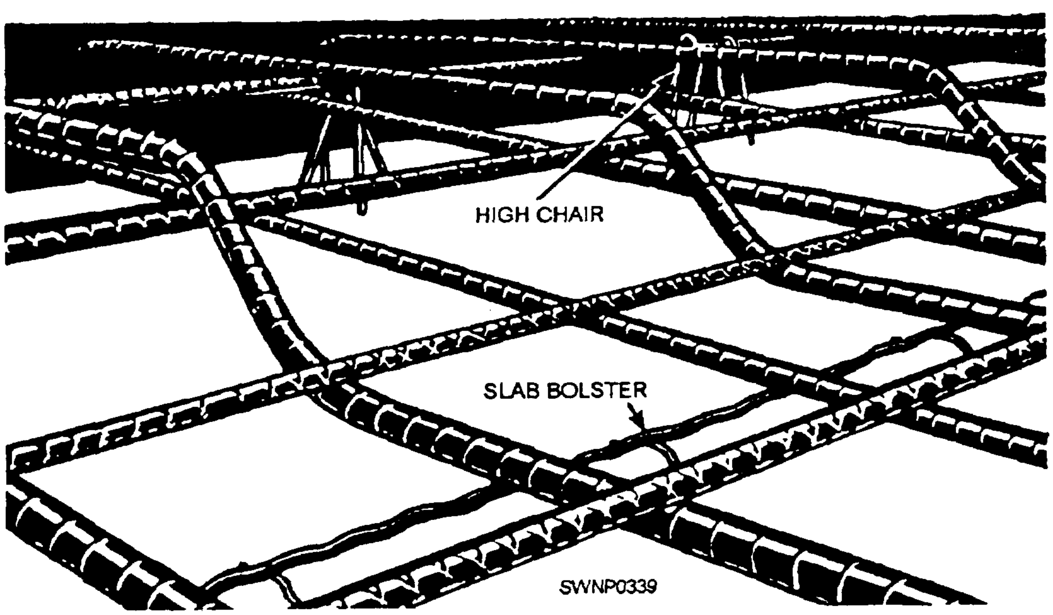


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Figure 7-24.—Steel in place in a floor slab.

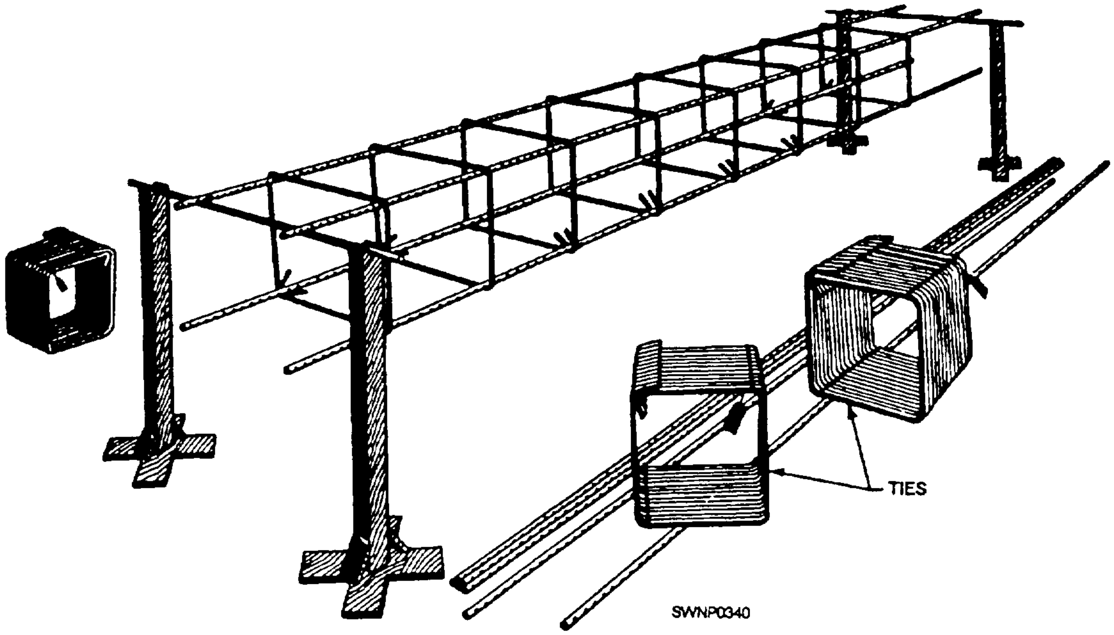

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Figure 7-25.—Column assembly.

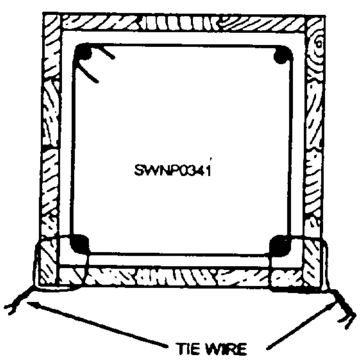

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Figure 7-26.—Method of holding column steel in plain in formwork.

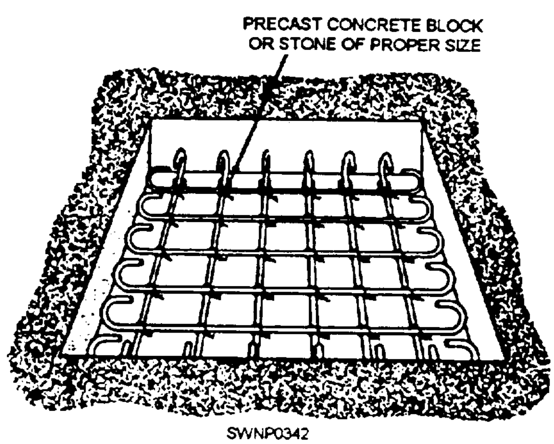

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Figure 7-27.—Steel in place in a footing.

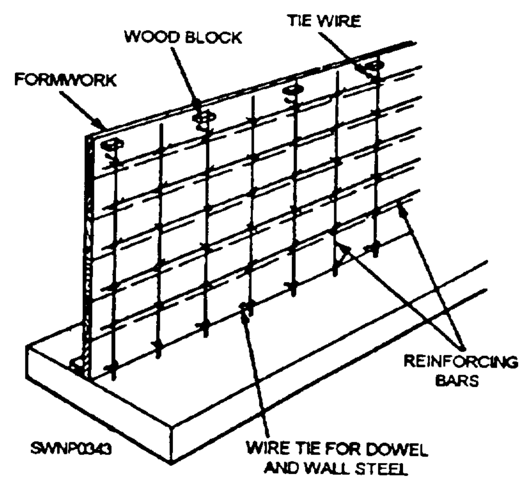

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Figure 7-28.—Steel in place on a wall form

Steel in place in a wall is shown in figure 7-28. The wood block is removed when the form has been filled up to the level of the block For high walls, ties in between the top and bottom should be used.

Steel is placed in footings very much as it is placed in floor slabs. Stones, rather than steel supports, may be used to support the steel at the proper distance above the subgrade. Steel mats in small footings are generally preassembled and placed after the forms have been set. A typical arrangement is shown in figure 7-27. Steel mats in large footings are constructed in place.