



WIDE-MODULE JOIST SYSTEMS — REVISITED

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INTRODUCTION

Standard joist construction, as defined in ACI 8.11*, includes a limit of 30 in. on the maximum clear spacing between ribs. According to the accompanying Commentary for ACI 8.11, the rationale for the limit on rib spacing is that ACI 8.11 includes special provisions for higher design shear strengths of the concrete and less concrete cover over the reinforcement. Dimensions of removable standard size forms for modules of 2'-0" and 3'-0" are given in Table 1.

An increasingly popular type of joist construction is the wide-module joist system. Wide-module joist systems may be defined as joist systems with clear spacings of

ribs exceeding 30 in. Since the rib spacings for wide-modules are greater than the ACI 318 Code limit for standard joist construction, wide-module joists must be designed as T-beams. In other words, the design shear strength of concrete and minimum concrete cover requirements for beams are applicable to the T-beams of wide-module joist systems. Economy in construction is achieved through the use of combinations of commonly available, re-usable standard joist forms. Standard form dimensions for modules of 4'-0", 5'-0" and 6'-0" are given in Table 1.

* References in this report to "Building Code Requirements for Structural Concrete (ACI 318-99)" are given as "ACI" followed by the appropriate section number.

Table 1 Dimensions of Forms for One-Way Joist Construction ⁽¹⁾

Module	Standard Forms		Special Filler Forms ⁽⁴⁾	
	Width ⁽²⁾	Depth ⁽³⁾	Width ⁽²⁾	Depth ⁽³⁾
Standard Joist Construction				
2'-0"	20	8, 10, 12	10, 15	8, 10, 12
3'-0" ⁽⁵⁾	30	8, 10, 12, 14, 16, 20	10, 15, 20	8, 10, 12, 14, 16, 20
Wide-Module Joist Construction				
4'-0" ⁽⁶⁾	40	12, 14, 16, 18, 20, 22, 24	20, 30	12, 14, 16, 18, 20, 22, 24
5'-0"	53	16, 20, 24	—	—
6'-0"	66	14, 16, 20, 24	—	—

NOTES

- All dimensions are in inches, except the module designations.
- Width is the horizontal clear distance, between two consecutive joists, measured at the bottom of the joists.
- Depth is the vertical distance, measured between two consecutive joists, from the underside of the concrete slab to the bottom of the joists.
- Special filler forms may be available only in limited quantities. Availability should be investigated before specifying these forms.
- Tapered endforms are available for the one-way 3'-0" module. These forms are 30 in. wide at one end and 25 in. wide at the other end, and they are 36 in. long. Standard depths of these forms are 8, 10, 12, 14, 16, and 20 in.
- Tapered endforms are available for the one-way 4'-0" module. These forms are 40 in. wide at one end and 34 inches wide at the other end, and they are 36 in. long. Standard depths of these forms are 12, 14, 16, 18, 20, 22, and 24 in. These forms are generally available only on the West Coast.

TYPICAL WIDE-MODULE JOIST DIMENSIONS

Figure 1 shows typical cross-sectional dimensions for 5'-0" and 6'-0" wide modules. As noted in the figure, the modules are formed with single size forms in widths of 53-in. and 66-in.

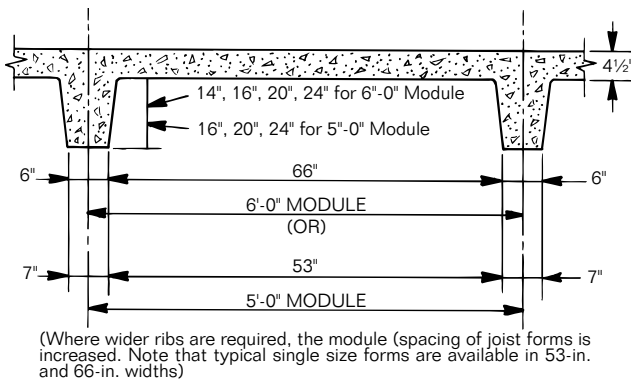


Figure 1 – Typical Wide-Module Joist Dimensions

The wide-module joist system can easily adapt to wider modules where required for architectural purposes, or to provide wider ribs where structural considerations require the use of larger reinforcing bars and higher shear capacity. Where single full-width forms are not readily available, combinations of smaller standard forms may be used with covers over the omitted ribs. See Figure 2 for an example of a 66-in. clear spacing of ribs resulting from using 30-in. standard joist forms.

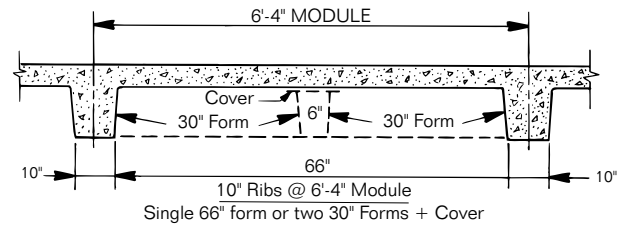


Figure 2 – 66-in. Module Using 30-in. Standard Forms

TWO-WAY JOIST CONSTRUCTION

Two-way joist construction, meeting the requirements of ACI 8.11, is commonly called waffle slab construction. Waffle slabs are designed as two-way flat slab systems under Chapter 13 of the ACI 318 Building Code. The dimensions of forms for standard two-way joist construction, i.e., waffle slabs, with modules of 2'-0", 2'-6" and 3'-0", are given in Table 2.

Table 2 also includes the standard dimensions of forms for two-way joist construction with 4'-0" and 5'-0" modules.

GENERAL STRUCTURAL CONSIDERATIONS

Top Slab. To meet the fire ratings of the statutory building codes, the required thickness of the top slab is usually about 4½-in. In standard joist construction (ACI 8.11), which limits the maximum clear spacing of the ribs to 30-in., the flexural capacity of a 4½-in. top slab is underutilized. In contrast, the wide-module joist system takes advantage of the structural value of the slab thickness. A 4½-in. thick top slab is utilized more fully as a structural element.

Table 2 Dimensions of Forms for Two-Way Joist Construction ⁽¹⁾

System	Standard Forms		Special Filler Forms ⁽⁴⁾	
	Width ⁽²⁾	Depth ⁽³⁾	Width ⁽²⁾	Depth ⁽³⁾
2'-0" Module 19" x 19" Square with 2½" Flanges	19 x 19	8, 10, 12, 14, 16	—	—
2'-6" Module 24" x 24" Square with 3" Flanges	24 x 24	8, 10, 12, 14, 16, 20	—	—
3'-0" Module 30" x 30" Square with 3" Flanges	30 x 30	8, 10, 12, 14, 16, 20	20 x 20 20 x 30	8, 10, 12, 14, 16, 20 8, 10, 12, 14, 16, 20
4'-0" Module 41" x 41" Square with 3½" Flanges	41 x 41	12, 14, 16, 18, 20, 24	—	—
5'-0" Module 52" x 52" Square with 4" Flanges	52 x 52	14, 16, 20, 24	40 x 40	14, 16, 20, 24

Notes 1 through 4 under Table 1 are also applicable to this Table 2.

Ribs. Since the wide-module “joists” are technically classified as beams, their design must conform to the requirements for T-beams (ACI 8.10). Principal design requirements are:

1. **Minimum concrete cover.** 1½ in. to stirrups and main flexural bars (top, bottom, and sides) instead of ¾ in. (ACI 7.7.1).

2. **Design shear strength of concrete.**
 $\phi V_c = \phi 2 \sqrt{c} b_w d$ instead of $\phi V_c = \phi 2.2 b_w d$
 (ACI 11.3.1.1 and 8.11.8).

3. **Minimum area of shear reinforcement.**
 $A_v = 50(b_w s)/f_y$ where factored shear $V_u > 0.5 \phi V_c$
 (ACI 11.5.5.3 and 11.5.5.1).

4. **Reinforcing steel requirements and recommended details.** Alternative arrangements to provide required shear reinforcement include the common open U-stirrup. With minimum rib widths, the maximum size of the main tensile reinforcement becomes limited by concrete cover requirements. And with minimum rib widths, fabricating constraints may require wider U-stirrups. These conditions may require that the U-stirrups be angled to fit. For minimum rib widths, the use of single leg stirrups simplifies placing. A special note should be included on the design drawings and placing drawings to require alternating of the stirrup positions. See Figure 3.

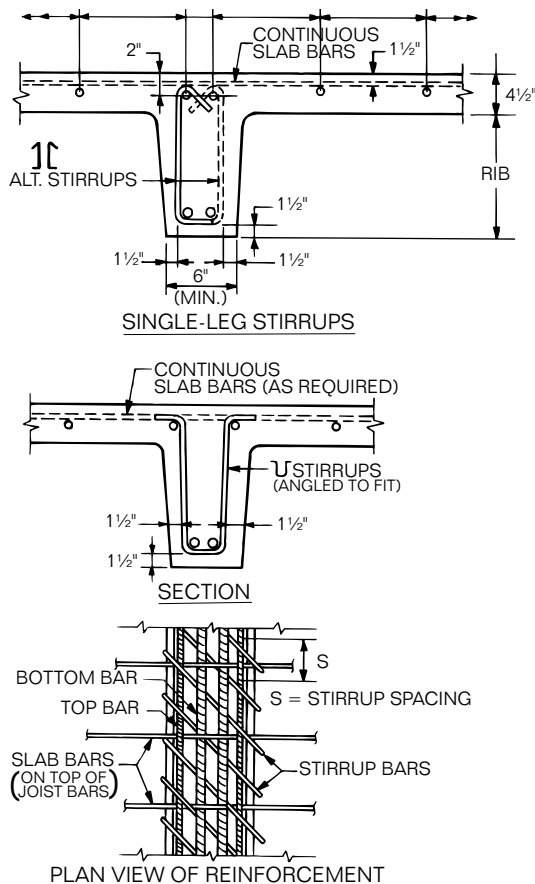


Figure 3 – Details for Single Leg and Common U-Stirrup Applications for Shear Reinforcement in Wide-Module Joist

Welded wire fabric (plain or deformed) can also be used as shear reinforcement. The vertical wires are developed by two horizontal wires spaced at 2 in. maximum at the top and at the bottom (Figure 4).

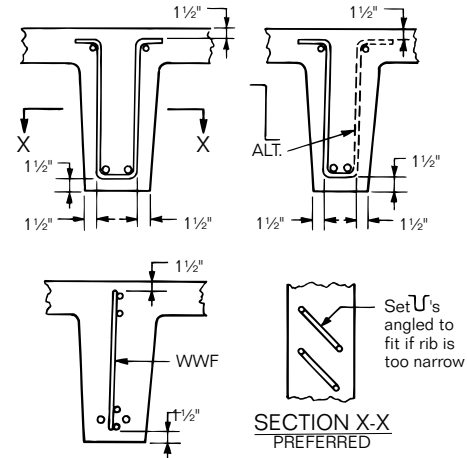


Figure 4 – Alternative Stirrup Arrangements

Live-load reduction. A typical wide-module joist system can often be laid out to take maximum live-load reductions as permitted by most national and local building codes. For rectangular bays, where the joists' capacity permits the layout of joists parallel to the longer span, the longer span wide module width provides a larger area to qualify for the reduction.

Formwork economy. If conditions permit, further formwork economy will result from the use of a uniform depth. See Section A-A in Figure 5. The entire procedure of formwork utilizes the same height shores and provides a solid level work platform and the simplest formwork. Placing of reinforcement is facilitated and minimum time is achieved for completion of each floor level. The supporting beam will usually be wide enough to reduce shear reinforcement, often with the use of the higher two-way design shear strength immediately around the column. See layout of typical wide-module joist system in Figure 5.

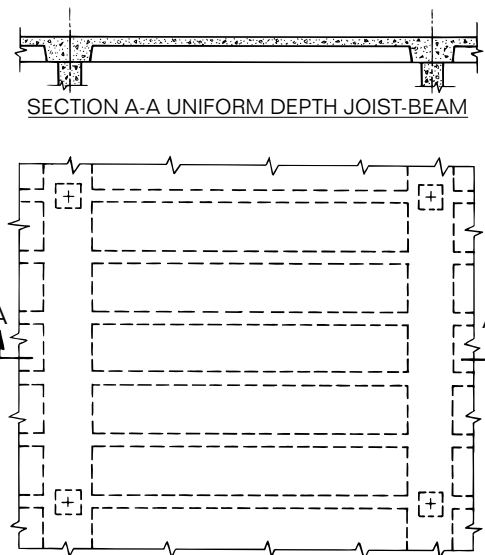


Figure 5 – Typical Wide-Module Joist Layout

SUPPORTING REINFORCEMENT

Chapter 3 in the CRSI *Manual of Standard Practice* contains information on the various types of bar supports used in reinforced concrete construction. Industry practices for the placing of bar supports are presented in the chapter. Recommendations for supporting reinforcing bars in standard one-way and two-way (waffle slabs) joist construction are also included in Chapter 3.

Recently, the CRSI technical committees have prepared recommendations for supporting the shrinkage and temperature reinforcement in the top slabs of wide-module joist construction:

For wide-module joist systems, it is recommended that the shrinkage and temperature reinforcement be supported by placing rows of slab bolsters at right angles to the shrinkage and temperature bars and spaced at 4'-0" on center maximum, unless otherwise shown in the Contract Documents.

Placing practices in certain geographical areas of the country may prefer to substitute individual bar supports (steel wire, all-plastic, or precast concrete) in lieu of continuous bar supports. If individual bar supports are used, they should be placed at a maximum spacing of 4'-0" on center each way.

DESIGN AND DETAILING AIDS

The following publications provide guidance in designing and detailing reinforced concrete standard joist and wide-module joist systems.

1. *CRSI Design Handbook*, Concrete Reinforcing Steel Institute, 8th Edition, 1996.
2. *Reinforcing Bar Detailing*, Concrete Reinforcing Steel Institute, 4th Edition, 2000.
3. *ACI Detailing Manual*, American Concrete Institute, SP-66, 1994.
4. "HB1JOIST and HB2JOIST, Handbook Computer Programs", Concrete Reinforcing Steel Institute, 1997.
5. "Effective Width of One-Way Monolithic Joist Construction as a Two-Way System", Structural Bulletin No. 8, Concrete Reinforcing Steel Institute, 1983.
6. *Workbook for Evaluating Concrete Building Designs*, Concrete Reinforcing Steel Institute, 2nd Edition, 1997.

CLOSING COMMENTS

Potential savings in both materials and construction with the use of wide-module joist systems include:

- Utilization of the top slab required for fire rating,
- Elimination of 50 % of the ribs,
- Uniform height of the deck form with the wide beam,
- Easy adjustments to fit the common range of modular column layouts,
- Less field labor time for construction.

The five preceding items are *direct* potential savings. *Indirect* benefits are:

- Elimination of half the ribs reduces dead load and reinforcement, and
- The wider rib spacing creates a larger supported area per rib, thereby increasing the allowable live load reductions and further reducing reinforcement.

CRSI

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