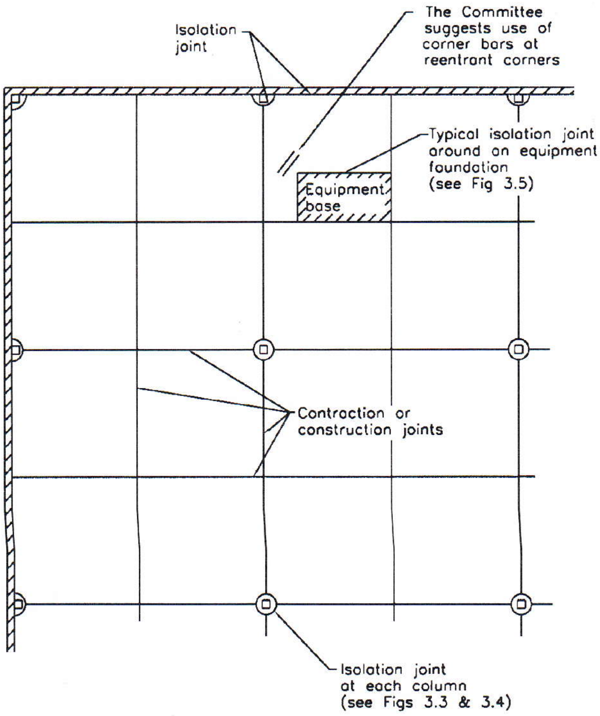

Fig. 3.2—Appropriate locations for joints.

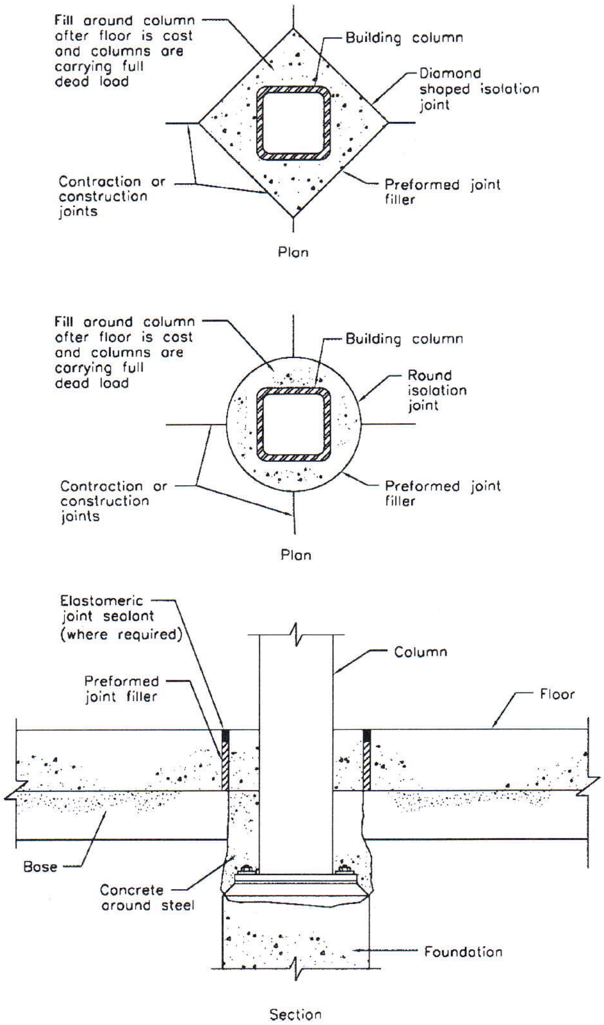

Fig. 3.3—Typical isolation joints at tube columns.

between the floor and the adjacent member. The joint material should extend the full depth of the slab and not protrude above it. The joint filler will be objectionably visible where there are wet conditions, or hygienic or dust-control requirements. Two methods of producing a relatively uniform depth of joint sealant are as follows:

1) Score both sides of the preformed filler at the depth to be removed by using a saw. Insert the scored filler in the proper location and remove the top section after the concrete hardens by using a screwdriver or similar tool.

2) Cut a strip of wood equal to the desired depth of the joint sealant. Nail the wood strip to the preformed filler and install the assembly in the proper location. Remove the wood strip after the concrete has hardened.

Alternatively, a premolded joint filler with a removable top portion can be used. Refer to Fig. 3.3 and 3.4 for typical isolation joints around columns. Figure 3.5 shows an isolation joint at an equipment foundation.

Isolation joints for slabs using shrinkage-compensating concrete should be dealt with as recommended in ACI 223.

3.2.5.2 *Construction joints*—Construction joints are placed in a slab to define the extent of the individual concrete placements, generally in conformity with a predetermined joint layout. If concreting is ever interrupted long enough for the placed concrete to harden, a construction joint should be used. If possible, construction joints should be located 5 ft (1.5 m) or more from any other joint to which they are parallel.

In areas not subjected to traffic, a butt joint is usually adequate. In areas subjected to hard-wheeled traffic, heavy loadings, or both, joints with dowels are recommended (Fig. 3.6). Refer to Section 3.2.7 for a detailed discussion on dowel joints. Keyed joints are not recommended where load transfer is required because the two sides of the keyway lose contact when the joint opens due to drying shrinkage (Section 3.2.7).

3.2.5.3 *Contraction joints*—Contraction joints are usually located on column lines with intermediate joints located at equal spaces between column lines as shown in Fig. 3.2. The following factors are normally considered when selecting spacing of contraction joints:

- Method of slab design (ACI 360R);
- Thickness of slab;
- Type, amount, and location of reinforcement;
- Shrinkage potential of the concrete (cement type and quantity; aggregate size, quantity, and quality; *w/cm*; type of admixtures; and concrete temperature);
- Base friction;
- Floor slab restraints;
- Layout of foundations, racks, pits, equipment pads, trenches, and similar floor discontinuities;
- Environmental factors such as temperature, wind, and humidity; and

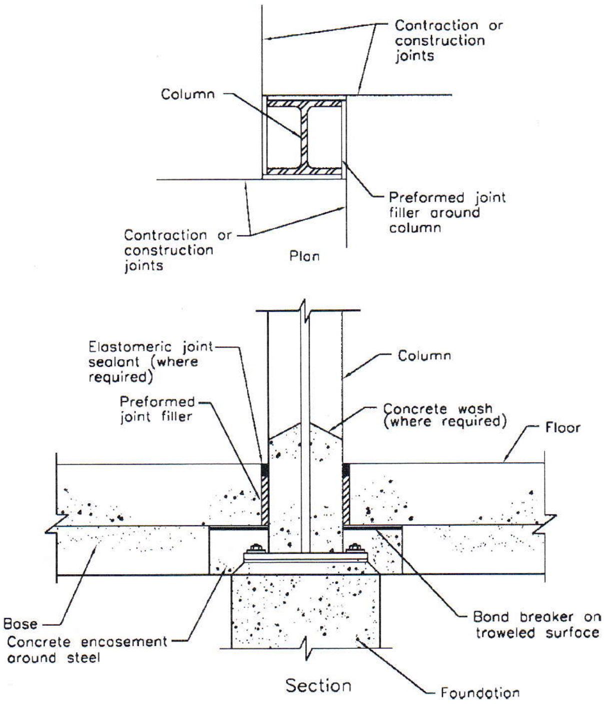

Fig. 3.4—Typical isolation joint at wide flange column.

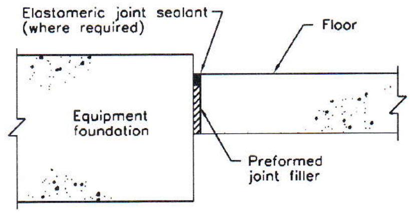

Fig. 3.5—Typical isolation joint around an equipment foundation.

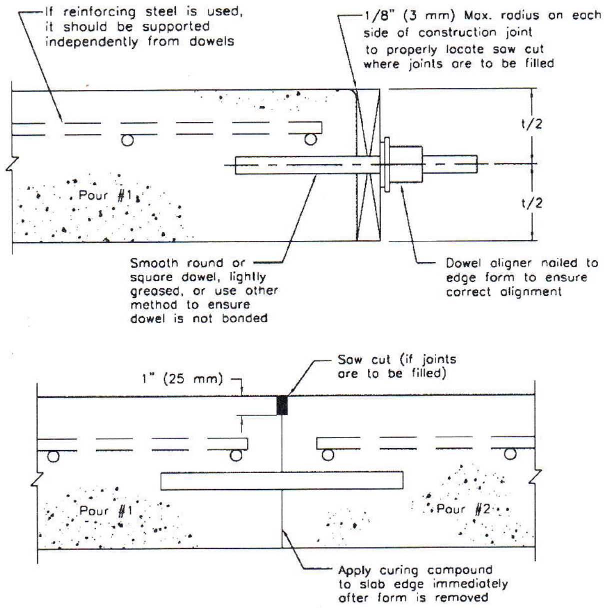

Fig. 3.6—Typical doweled construction joint.

- Methods and quality of concrete curing.

As previously indicated, establishing slab joint spacing, thickness, and reinforcement requirements is the responsibility of the designer. The specified joint spacing will be a principal factor dictating both the amount and the character of random cracking to be experienced, so joint spacing should always be carefully selected.

Curling of the floor surface at joints is a normal consequence of volume change resulting from differential moisture loss from concrete slab to the surrounding environment. This distortion can result in conflict with respect to installation of some floor coverings in the months after concrete placement. Current national standards for ceramic tile and wood flooring, such as gymnasium floors, are two instances that require the concrete slab surface to comply with stringent surface tolerances that cannot be met under typical slab curling behavior. The designer should consider the requirements for successful installation of floor coverings contained in Division 9 of the project specifications when performing the concrete slab design (ACI 360R).

For unreinforced, plain concrete slabs, joint spacings of 24 to 36 times the slab thickness, up to a maximum spacing of 18 ft (5.5 m), have produced acceptable results. Some random cracking should be expected; a reasonable level might be random visible cracks to occur in 0 to 3% of the surface area floor slab panels formed by saw-cutting, construction joints, or a combination of both. If slab curl is of greater concern than usual, joint spacing, mixture proportion, and joint details should be carefully analyzed.

Joint spacing in nominally reinforced slabs (approximately 0.2% steel placed within 2 in. [50 mm] of the top of the slab) can be increased somewhat beyond that recommended for unreinforced, plain concrete slabs, but the incidence of random cracking and curling will increase. Reinforcement will not prevent cracking. If the reinforcement is properly sized and located, cracks that do occur should remain tightly closed.

Contraction joints can be reduced or eliminated in slabs reinforced with at least 0.5% continuous reinforcing steel placed within 2 in. (50 mm) of the top of the slab or upper one-third of slab thickness, whichever is closer to the slab top surface. This will typically produce a larger number of closely spaced fine cracks throughout the slab.

Joints in either direction can be reduced or eliminated by post-tensioning that introduces a net compressive force in the slab after all tensioning losses.

The number of joints can also be reduced with the use of shrinkage-compensating concrete; however, the recommendations of ACI 223 should be carefully followed.

Contraction joints should be continuous, not staggered or offset. The aspect ratio of slab panels that are unreinforced, reinforced only for shrinkage and temperature, or made with shrinkage-compensating concrete should be a maximum of 1.5 to 1; however, a ratio of 1 to 1 is preferred. L- and T-shaped panels should be avoided. Figure 3.7 shows various types of contraction joints. Floors around loading docks have a tendency to crack due to their configuration and restraints.

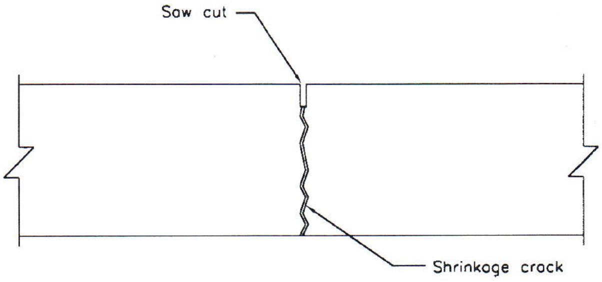

Fig. 3.7—Saw-cut contraction joint.

Figure 3.8 shows two methods that can be used to minimize slab cracking at reentrant corners of loading docks.

Plastic or metal inserts are not recommended for constructing or forming a contraction joint in any exposed floor surface that will be subjected to wheeled traffic.

3.2.5.4 *Saw cutting joints*—Contraction joints in industrial and commercial floors are usually formed by sawing a continuous slot in the slab to result in a weakened plane, below which a crack will form (Fig. 3.7). Further details on saw cutting of joints are given in Section 8.3.12

3.2.6 *Joint filling*—Contraction and construction joints in floor areas subject to the hard wheels of material handling vehicle traffic should be filled with a semirigid filler to minimize wear and damage to joint edges. Construction joints should be saw-cut 1 in. (25 mm) deep before filling. Joints should be as narrow as possible to minimize damage due to wheels loads while still being wide enough to be properly filled.

Where wet conditions or hygienic requirements exist, joints should be sealed with an elastomeric liquid sealant or a preformed elastomeric device. If there is also industrial vehicular traffic in these areas, consideration should be given to strengthening the edge of the joint through alternative means.

Refer to Section 5.12 for a discussion of joint materials, Section 9.10 for installation of joint fillers, and ACI 504R for joint sealants.

3.2.7 *Load-transfer mechanisms*—Doweled construction and contraction joints (Fig. 3.6 and 3.9) are recommended when load transfer is required, unless a sufficient post-tensioning force is provided across the joint to transfer the shear. Dowels force the concrete sections on both sides of a joint to undergo approximately equal vertical displacements subjected to a load and help prevent damage to an exposed edge when the joint is subjected to vehicles with hard-wheels such as forklifts. Table 3.1 provides recommended dowel sizes and spacing for round, square, and rectangular dowels. For dowels to be effective, they should be smooth, aligned, and supported so they will remain parallel in both the horizontal and the vertical planes during the placing and finishing operation. All dowels should be sawn and not sheared. Properly aligned, smooth dowels allow the joint to open as concrete shrinks. Dowel baskets (Fig. 3.9 to 3.11) should be used to maintain alignment of dowels in contraction joints, and alignment devices similar to the one shown in Fig. 3.6 should be used when detailing the doweled construction joints. Dowels should be placed no closer than 12 in. (300 mm) from the intersection of any joints.

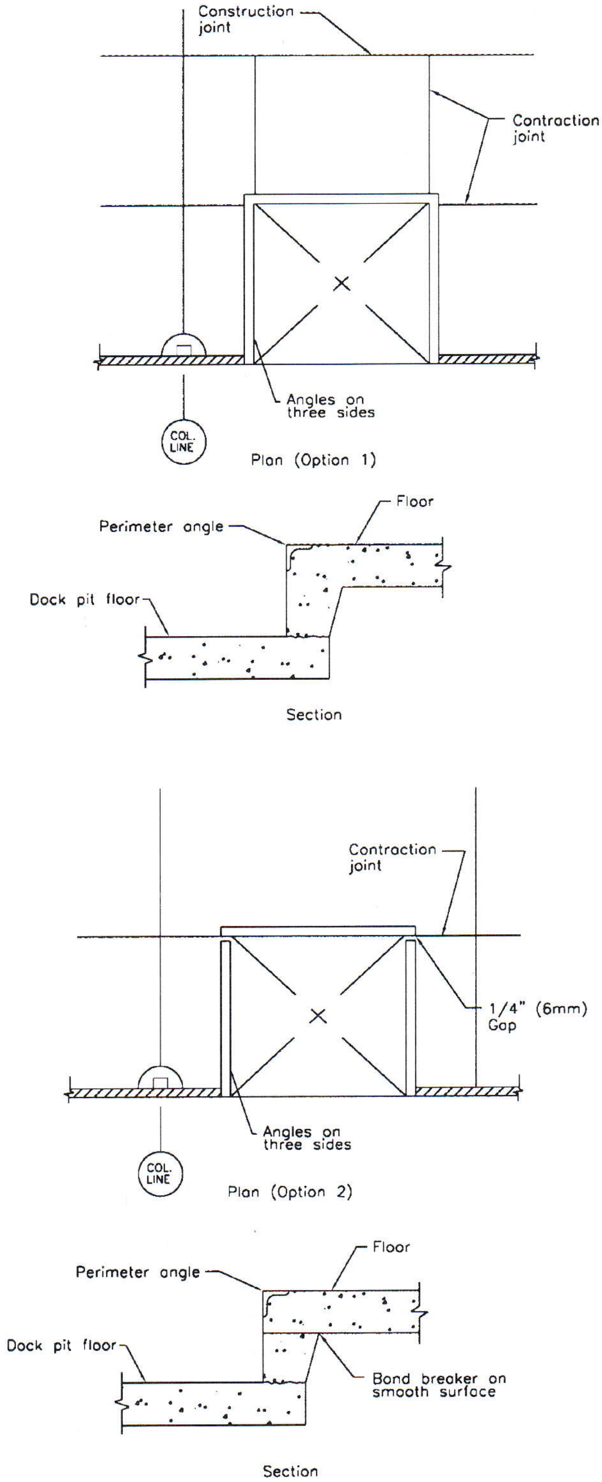

Fig. 3.8—Joint details at loading dock.

Diamond-shaped load plates (a square plate turned so that two corners line up with the joint, Fig. 3.12) can be used to replace dowels in construction joints (Walker and Holland 1998). The diamond shape allows the slab to move horizontally without restraint when the slab shrinkage opens the joint (Fig. 3.13). Table 3.2 provides the recommended size and

Table 3.1—Dowel size and spacing for round, square, and rectangular dowels (ACI Committee 325 1956)

Slab depth, in. (mm)	Dowel dimensions*, in. (mm)			Dowel spacing center-to-center, in. (mm)		
	Round	Square	Rectangular†	Round	Square	Rectangular
5 to 6 (125 to 150)	3/4 x 14 (19 x 350)	3/4 x 14 (19 x 350)	3/8 x 2 x 12 (10 x 50 x 300)	12 (300)	14 (350)	19 (475)
7 to 8 (175 to 200)	1 x 16 (25 x 400)	1 x 16 (25 x 400)	1/2 x 2-1/2 x 12 (12 x 60 x 300)	12 (300)	14 (350)	18 (450)
9 to 11 (225 to 275)	1-1/4 x 18 (30 x 450)	1-1/4 x 18 (30 x 450)	3/4 x 2-1/2 x 12 (19 x 60 x 300)	12 (300)	12 (300)	18 (450)

*Total dowel length includes allowance made for joint opening and minor errors in positioning dowels.
†Rectangular plates are typically used in contraction joints.
Notes: Table values based on a maximum joint opening of 0.20 in. (5 mm). Dowels must be carefully aligned and supported during concrete operations. Misaligned dowels cause cracking.

Table 3.2—Dowel size and spacing for diamond-shaped load plates

Slab depth, in. (mm)	Diamond load plate dimensions, in. (mm)	Diamond load plate spacing center-to-center, in. (mm)
5 to 6 (125 to 150)	1/4 x 4-1/2 x 4-1/2 (6 x 115 x 115)	18 (450)
7 to 8 (175 to 200)	3/8 x 4-1/2 x 4-1/2 (10 x 115 x 115)	18 (450)
9 to 11 (225 to 275)	3/4 x 4-1/2 x 4-1/2 (19 x 115 x 115)	20 (500)

Notes: Table values based on a maximum joint opening of 0.20 in. (5 mm). The construction tolerances required make it impractical to use diamond-shaped load plates in contraction joints.

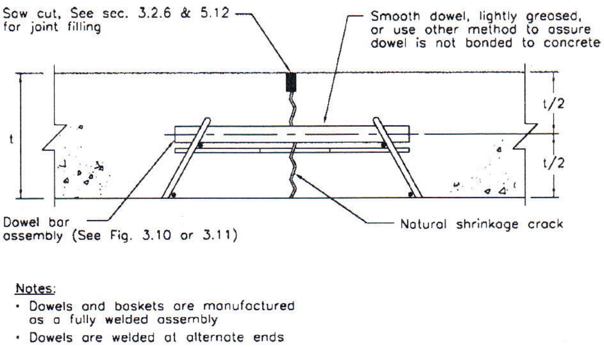

Fig. 3.9—Typical doweled contraction joint.

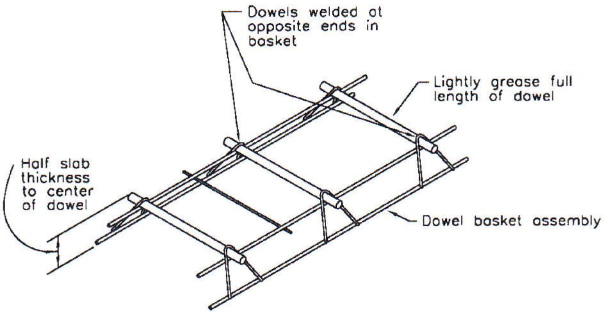

Fig. 3.10—Dowel basket assembly.

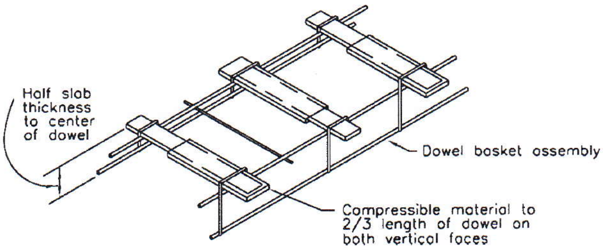

Fig. 3.11—Rectangular load plate basket assembly.

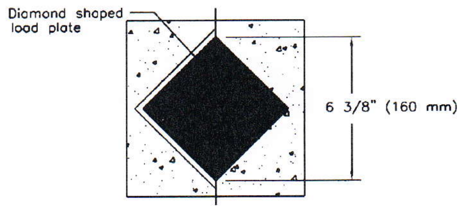

Fig. 3.12—Diamond-shaped load plate at construction joint.

spacing of diamond-shaped load plates. This type of load-transfer device can be placed within 6 in. (150 mm) of an intersection (Fig. 3.13). Square and rectangular dowels cushioned on the vertical sides by a compressible material also permit movement parallel and perpendicular to the joint (Fig. 3.14). These types of load-transfer devices are useful in other slab types where the joint should have load-transfer capability while allowing some differential movement in the direction of the joint, such as might be necessary in post-tensioned and shrinkage-compensating concrete slabs or in slabs with two-directional doweling (Schrader 1987). In saw-cut contraction joints, aggregate interlock should not be relied upon for effective load transfer for wheeled traffic if the expected joint width exceeds 0.035 in. (0.9 mm) (Colley and Humphrey 1967).

Deformed reinforcing bars should not be used across contraction joints or construction joints because they restrain joints from opening as the slab shrinks during drying. Continuation of a part of the slab reinforcing through contraction joints can provide some load-transfer capability without using dowels but significantly increases the probability of out-of-joint random cracking.

Round, square, and rectangular dowels for slab-on-ground installation should meet ASTM A 36. The diameter or cross-sectional area, length, shape, and specific location of dowels as well as the method of support should be specified by the designer. Refer to Table 3.1 and Fig. 3.9 to 3.14.

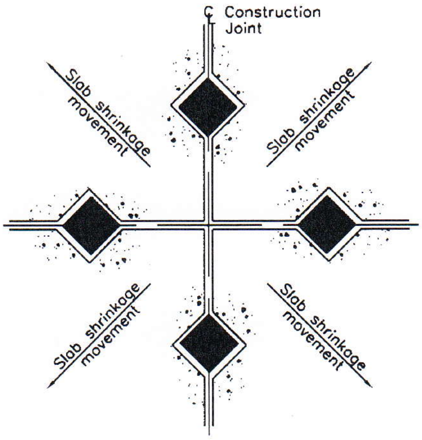

Fig. 3.13—Diamond-shaped load plates at slab corner.

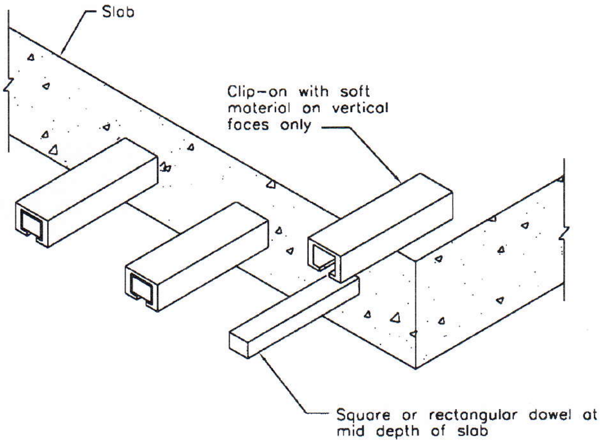

Fig. 3.14—Doweled joint detail for movement parallel and perpendicular to the joint.

Keyed joints are not recommended for load transfer in slabs-on-ground where heavy-wheeled traffic load is anticipated, because they do not provide effective load transfer. When the concrete shrinks, the keys and keyways do not retain contact and do not share the load between panels; this can eventually cause a breakdown of the concrete joint edges. For long post-tensioned floor strips and floors using shrinkage-compensating concrete with long joint spacing, care should be taken to accommodate significant slab movements. In most instances, post-tensioned slab joints are associated with a jacking gap. The filling of jacking gaps should be delayed as long as possible to accommodate shrinkage and creep (PTI 1990; PTI 2000). Where significant slab movement is expected, steel plating of the joint edges is recommended; for strengthening the edges (Fig. 3.15 and 3.16).

A doweled joint detail at a jacking gap in a post-tensioned slab (ASTM 1994; Spears and Panarese 1992) is shown in Fig. 3.16.

3.3—Suspended slabs

3.3.1 *Required design elements*—In addition to many of the items listed in Section 1.1.2, the following items specifically impact the construction of suspended slabs and should

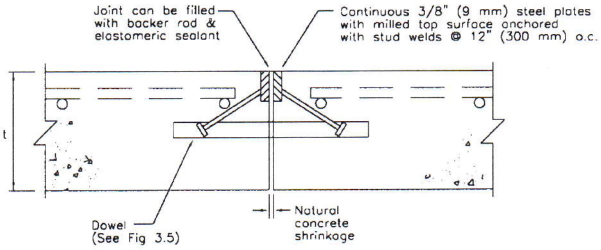

Fig. 3.15—Typical armored construction joint detail.

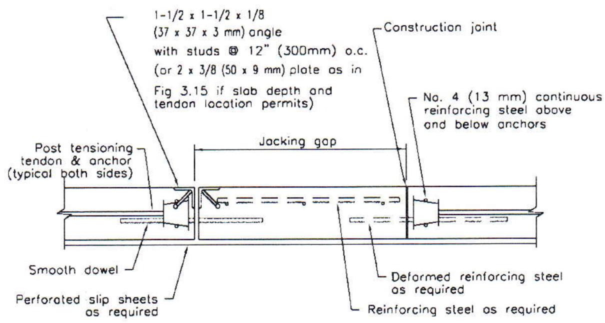

Fig. 3.16—Typical doweled joint detail for post-tensioned slab.

be included in the contract documents prepared by the designer:

- Frame geometry (member size and spacing);
- Reinforcement (type, size, location, and method of support);
- Shear connectors, if required;
- Construction joint location;
- Metal deck (type, depth, and gage), if required;
- Shoring, if required; and
- Tolerances (forms, structural steel, reinforcement, and concrete).

3.3.2 *Suspended slab types*—In general, suspended floor systems fall into four main categories:

1. Cast-in-place suspended floors;
2. Slabs with removable forms;
3. Slabs on metal decking; and
4. Topping slabs on precast concrete.

Design requirements for cast-in-place concrete suspended floor systems are covered by ACI 318 and ACI 421.1R. Refer to these documents to obtain design parameters for various cast-in-place systems. Slabs on metal decking and topping slabs on precast concrete are hybrid systems that involve design requirements established by ANSI, ASCE, The American Institute of Steel Construction, Precast/Prestressed Concrete Institute, and tolerances of ACI 117.

The levelness of suspended slabs depends on the accuracy of formwork and strikeoff but is further influenced (especially in the case of slabs on metal decking) by the behavior of the structural frame during and after completion of construction. Each type of structural frame behaves somewhat differently; it is important for the contractor to recognize these differences and plan accordingly.