CHAPTER 13

REINFORCED CONCRETE PAVEMENTS

13-1. Application

Under certain conditions, concrete pavement slabs may be reinforced with welded wire fabric or formed bar mats arranged in a square or rectangular grid. The advantages of using steel reinforcement include a reduction in the required slab thickness, greater spacing between joints, and reduced differential settlement due to nonuniform support or frost heave.

a. Subgrade conditions. Reinforcement may reduce the damage resulting from cracked slabs. Cracking may occur in rigid pavements founded on subgrades where differential vertical movement is a definite potential. An example is a foundation with definite or borderline frost susceptibility that cannot feasibly be made to conform to conventional frost design requirements.

b. Economic considerations. In general, reinforced concrete pavements will not be economically competitive with plain concrete pavements of equal load-carrying capacity, even though a reduction in pavement thickness is possible. Alternate bids, however, should be invited if reasonable doubt exists on this point.

c. Plain concrete pavements. In otherwise plain concrete pavements, steel reinforcement should be used for the following conditions:

(1) *Odd-shaped slabs.* Odd-shaped slabs should be reinforced in two directions normal to each other using a minimum of 0.05 percent of steel in both directions. The entire area of the slab should be reinforced. An odd-shaped slab is considered to be one in which the longer dimension exceeds the shorter dimension by more than 25 percent or a slab which essentially is neither square nor rectangular. Figure 13-1 includes examples of reinforcement required in odd-shaped slabs.

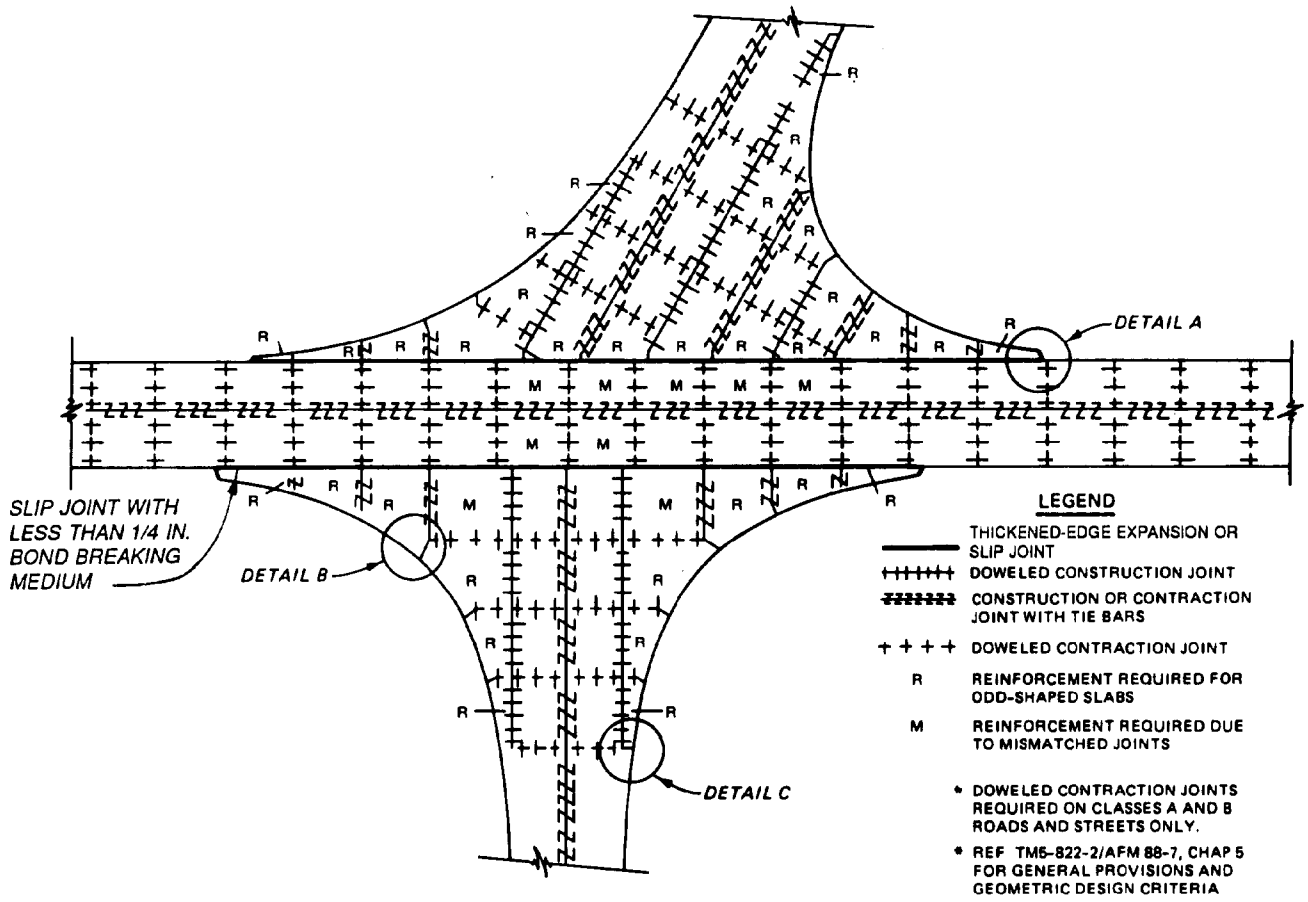

Figure 13-1. Typical Layout of Joints at Intersection. (Sheet 1 of 2)

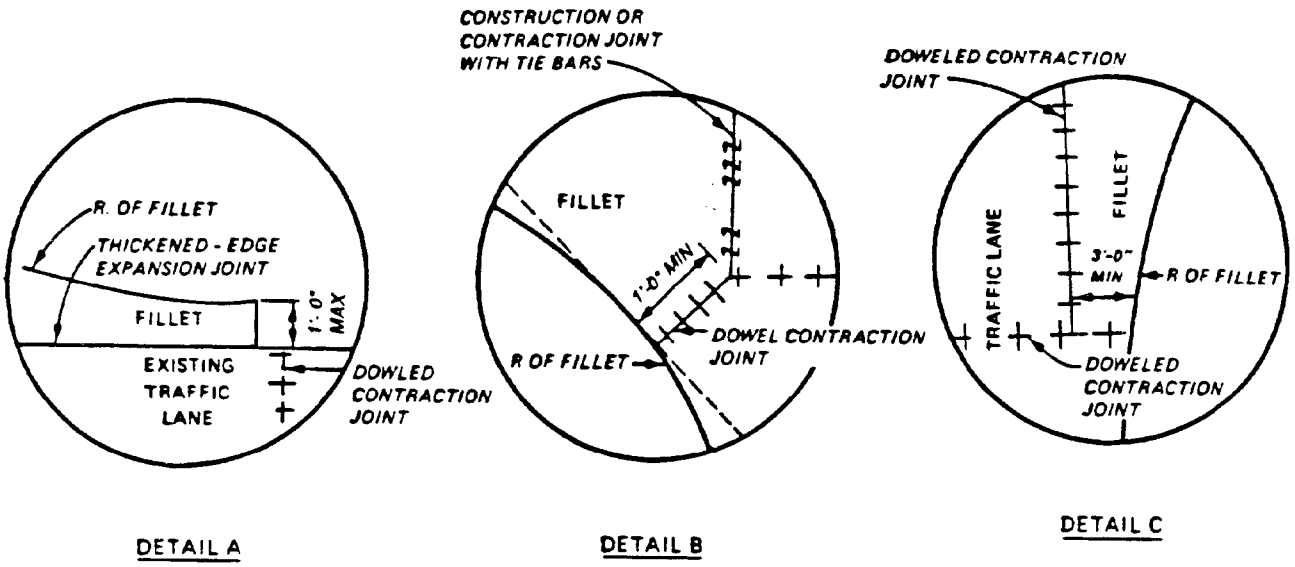

Figure 13-1. Typical Layout of Joints at Intersection. (Sheet 2 of 2)

(2) *Mismatched joints. A partial* reinforcement or slab *is* required where the joint patterns of abutting pavements or adjacent *paving lanes* do Dot match, unless the pavements are positively separated by *an* expansion joint or slip-type joint having Dot less than ¼-inch bond-breaking medium. The pavement slab directly opposite the mismatched joint should be reinforced with a minimum of 0.05 percent of steel in directions normal to each other for a distance of 3 feet back from the juncture and for the full width or length of the slab in 8 direction normal to the mismatched joint. Mismatched joints normally will occur at intersections of pavements or between pavement and fillet areas as shown in figure 13-1.

d. Other uses. Reinforced concrete pavements may be considered for reasons other than those described above provided that a report containing a justification of the need for reinforcement is prepared and submitted for approval to HQUSACE (CEMP-ET) or the appropriate Air Force Major Command.

13-2. Design Procedure.

a. Thickness design on unbound base or subbase. The design procedure for reinforced concrete pavements uses the principle of allowing a reduction in the required thickness of plain concrete pavement due to the presence of the steel reinforcing. The design procedure has been developed empirically from a limited Dumber of prototype test pavements subjected to accelerated traffic testing. Although some cracking will occur in the pavement under the design traffic loadings, the steel rein-forcing will hold the cracks tightly closed. The reinforcing will prevent spalling or faulting at the cracks and provide a serviceable pavement during the anticipated design life. Essentially, the design method consists of determining the percentage of steel required, the thickness of the reinforced concrete pavement, and the minimum allowable length of the slabs. Figure 13-2 presents a graphic solution for the design of reinforced concrete pavements. Since the thickness of a reinforced concrete pavement is a function of the percentage of steel reinforcing, the designer may determine either the required percentage of steel for a predetermined thickness of pavement or the required thickness of pavement for a predetermined percentage of steel. In either case, it is necessary first to determine the required thickness of plain concrete pavement by the method outlined previously in chapter 12. The plain concrete pavement thickness h_d (to the nearest 0.1 inch) is used to enter the nomograph in figure 13-2. A straight line is then drawn from the value of h_d to the value selected for either the reinforced concrete pavement thickness h_r or the percentage of reinforcing steel S. It should be noted that the S value indicated by figure 13-2 is the percentage to be used in the longitudinal direction only. For normal designs, the percentage of steel used in the transverse direction will be one- half of that to be used in the longitudinal direction. In fillets, the percent steel will be the same in both directions.

Once the h_r and S values have been determined, the maximum allowable slab length L is obtained from the intersection of the straight line and the scale or L. Difficulties may be encountered in sealing joints between very long slabs because of large volumetric changes caused by temperature changes.

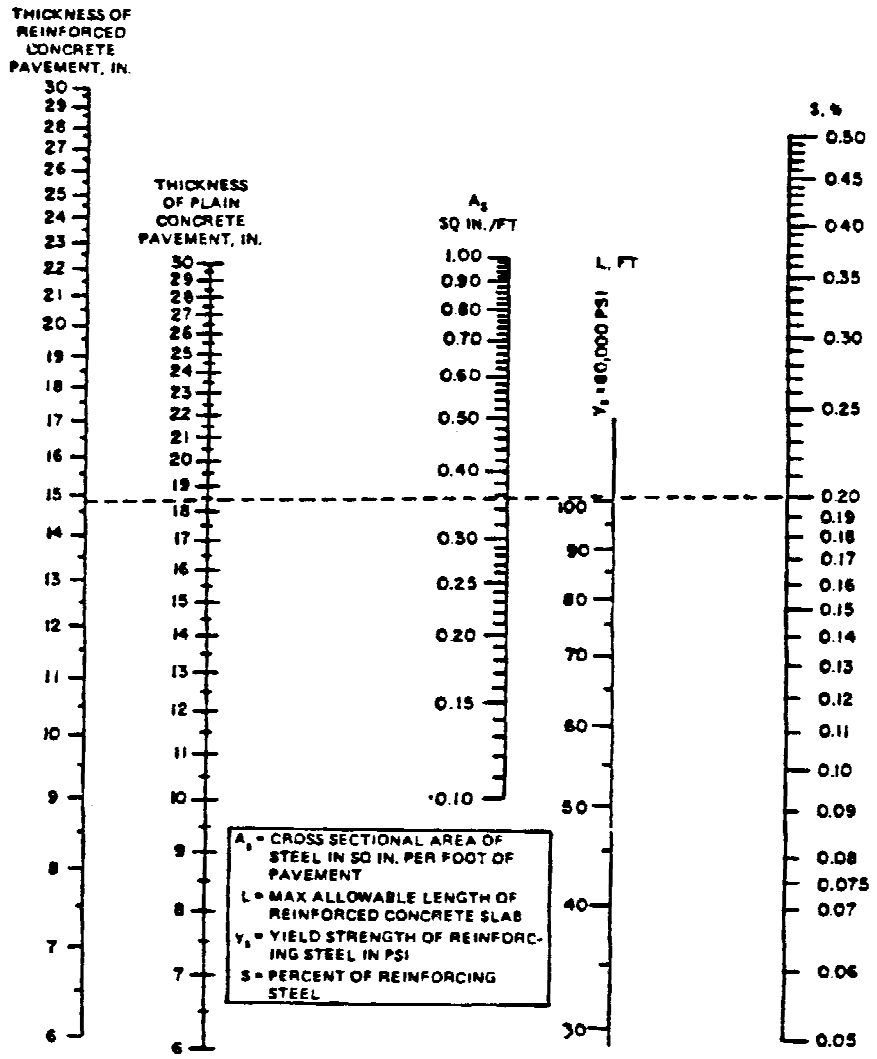

Figure 13-2. Reinforced Rigid Pavement Design

b. Thickness design on stabilized base or subgrade. Ta determine the thickness requirements for reinforced concrete pavement on a stabilized foundation, it is first necessary to determine the thickness of plain concrete pavement required over the stabilized layer using procedures set forth in chapter 12. This thickness of plain concrete is then used with figure 13-2 to design the reinforced concrete pavement in the same manner discussed above for nonstabilized foundations.

*U.S. G.P.O.:1993-300-723:80080

13-3. Limitations.

The design criteria for reinforced concrete pavement for military roads and streets are subject to the following limitations.

a. No reduction in the required thickness of plain concrete pavement should be allowed for percentages of longitudinal steel less than 0.05 percent.

b. No further reduction in the required thickness of plain concrete pavement should be allowed over that indicated in figure 13-2 for 0.5 percent longitudinal steel, regardless of the percentage of steel used.

c. The maximum length L of reinforced concrete pavement slabs should not exceed 75 feet regardless of the percentage of longitudinal steel, yield strength of the steel, or thickness of the pavement. When long slabs are used, special consideration must be given to joint design and sealant requirements.

d. The minimum thickness of reinforced concrete pavements should be 6 inches, except that the minimum thickness for driveways will be 5 inches and the minimum thickness for reinforced overlays over rigid pavements will be 4 inches.

13-4. Reinforcing Steel.

a. Type of reinforcing steel. The reinforcing steel may be either deformed bars or welded wire fabric. Deformed bars should conform to the requirements of ASTM A 615, A 616, or A 617. In general, grade 60 deformed bars should be specified, but other grades may be used if warranted. Fabricated steel bar mats should conform to ASTM A 184. Cold drawn wire for fabric reinforcement should conform to the requirements of ASTM A 82, and welded steel wire fabric to ASTM A 185. The use of epoxy coated steel may be considered in areas where corrosion of the steel may be a problem.

b. Placement of reinforcing steel. The reinforcing steel will be placed at a depth of $\frac{1}{4}h_d$ + 1 inch from the surface of the reinforced slab. This will place the steel above the neutral axis of the slab and will allow clearance for dowel bars. The wire or bar sizes and spacing should be selected to give, as nearly as possible, the required percentage of steel per foot of pavement width or length. In no case should the percent steel used be less than that required by figure 13-2. Two layers of wire fabric or bar mat, one placed directly on top of the other, may be used to obtain the required percent of steel; however, this should only be done when it is impracticable to provide the required steel in one layer. If two layers of steel are used, the layers must be fastened together (either wired or clipped) to prevent excessive separation during concrete placement. When the reinforcement is installed and concrete is to be placed through the mat or fabric, the minimum clear spacing between bars or wires will be 1½ times the maximum size of aggregate. If the strike-off method is used to place the reinforcement (layer of concrete placed and struck off at the desired depth, the reinforcement placed on the plastic concrete, and the remaining concrete placed on top of the reinforcement), the minimum spacing of wires or bars will not be less than the maximum size of aggregate. Maximum bar or wire spacing or slab thickness shall not exceed 12 inches. The bar mat or wire fabric will be securely anchored to prevent forward creep of the steel mats during concrete placement and finishing operations. The reinforcement shall be fabricated and placed in such a manner that the spacing between the longitudinal wire or bar and the longitudinal joint, or between the transverse wire or bar and the transverse joint, will not exceed 3 inches or one-half of the wire or bar spacing in the fabric or mat. The wires or bars will be lapped as follows.

(1) Deformed steel bars will be overlapped for a distance of at least 24 bar diameters measured from the tip of one bar to the tip of the other bar. The lapped bars will be wired or otherwise securely fastened to prevent separation during concrete placement.

(2) Wire fabric will be overlapped for a distance equal to at least one spacing of the wire in the fabric or 32 wire diameters, whichever is greater. The length of lap is measured from the tip of one wire to the tip of the other wire normal to the lap. The wires in the lap will be wired or otherwise securely fastened to prevent separation during concrete placement.

13-5. Design Examples.

As an example, let it be required to design a reinforced concrete pavement for the same set of conditions used in the initial design example given previously in paragraph 12-4. Using Tthevalue of h_d of 7.9 inches, the percentage of longitudinal reinforcing steel S required to reduce the pavement thickness to 7 inches is obtained from figure 13-2 as 0.10 percent. Similarly, the percentage of longitudinal reinforcing steel required to reduce the pavement thickness to 6 inches is 0.30 percent. The percentage of transverse reinforcing steel would be either 0.05 for a design thickness of 7 inches or 0.15 for a design thickness of 6 inches. The choice of which percentage of steel reinforcement to use should be based on economic considerations as well as on foundation and climatic conditions peculiar to

the project area. If the yield strength of the steel is assumed to be 60,000 psi, the maximum allowable spacing of the transverse contraction joints would be 49 feet for 0.10 percent longitudinal steel, and 97 feet would be indicated as the maximum spacing for 0.30 percent longitudinal steel. In the latter case, the maximum permissible spacing of 75 feet would be used.

13-6. Design Details.

Typical details for the design and construction of reinforced concrete pavements for military roads and streets are shown in figures 13-3, 13-4, 13-5, and 13-6.

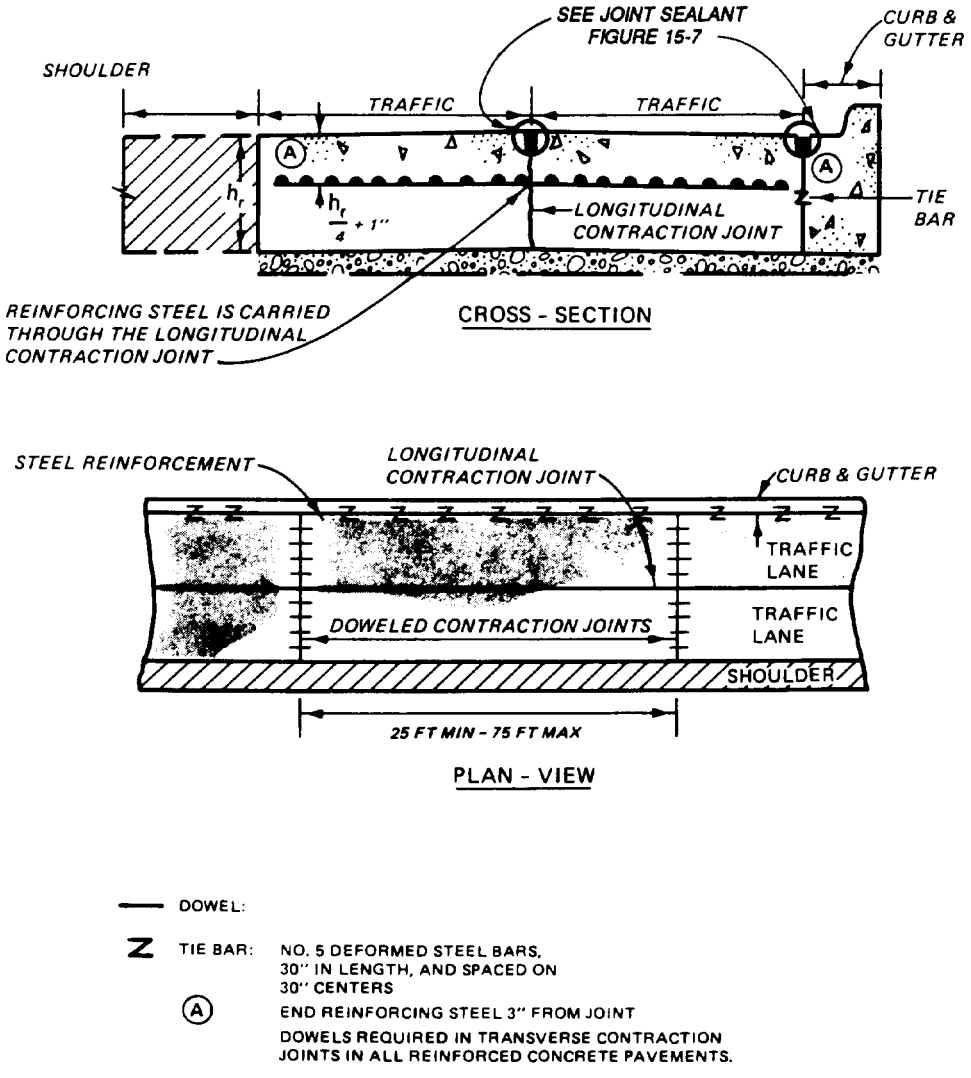

Figure 13-3. Design Details of Reinforced Rigid Pavement with Two Traffic Lanes. (Sheet 1 of 2)

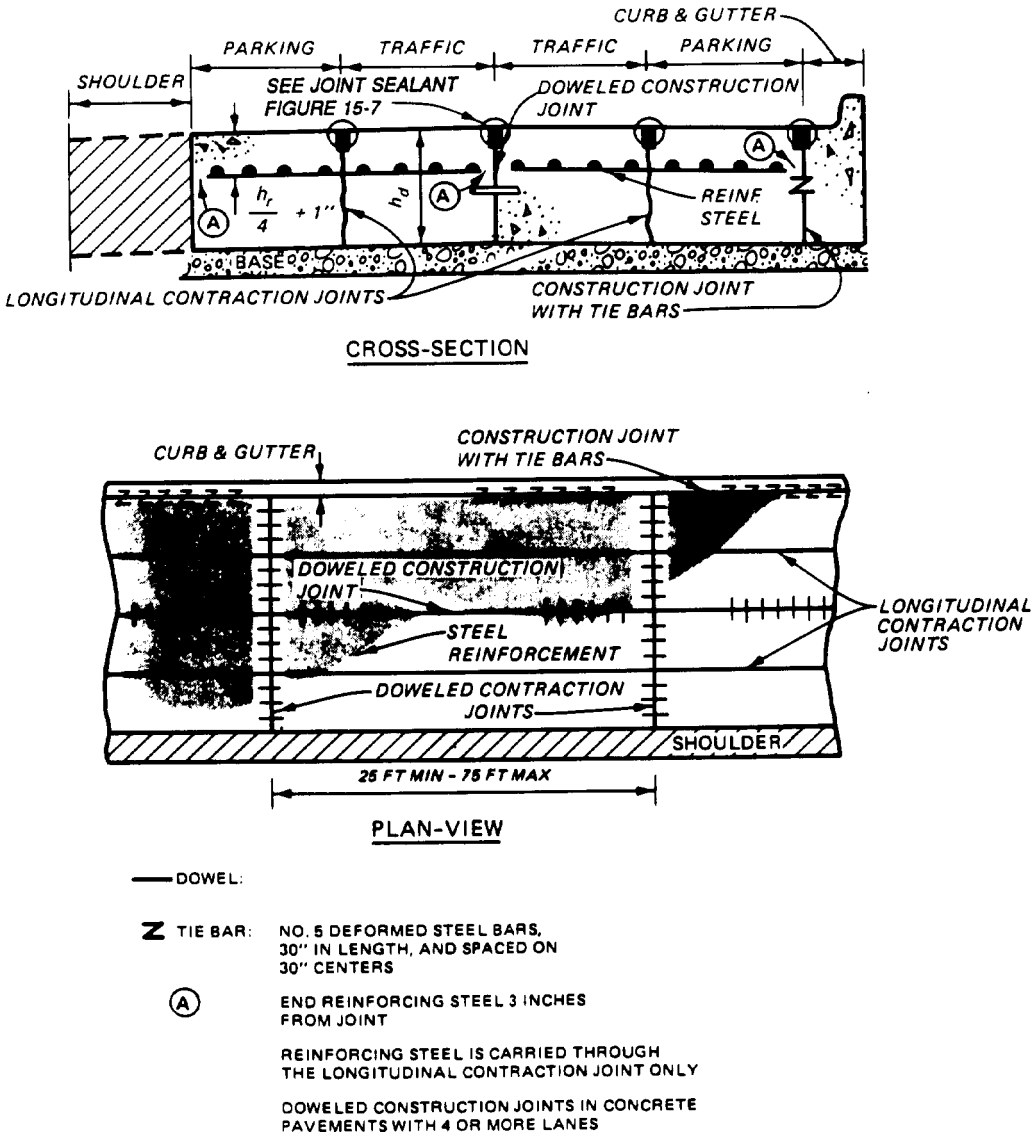

Figure 13-3. Design Details of Reinforced Rigid Pavement with Two Traffic Lanes. (Sheet 2 of 2)

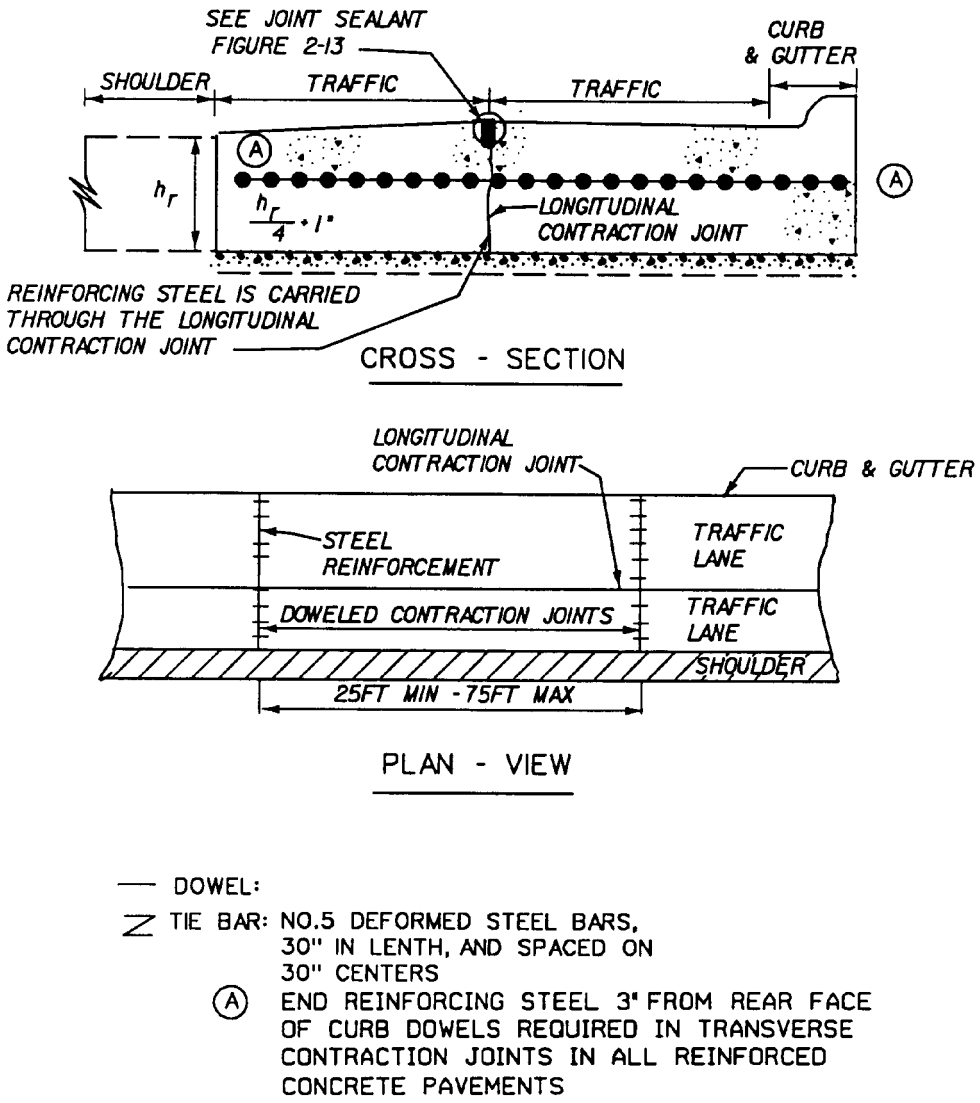

Figure 13-4. Design Details of Reinforced Rigid Pavement with Traffic and Parking Lanes.

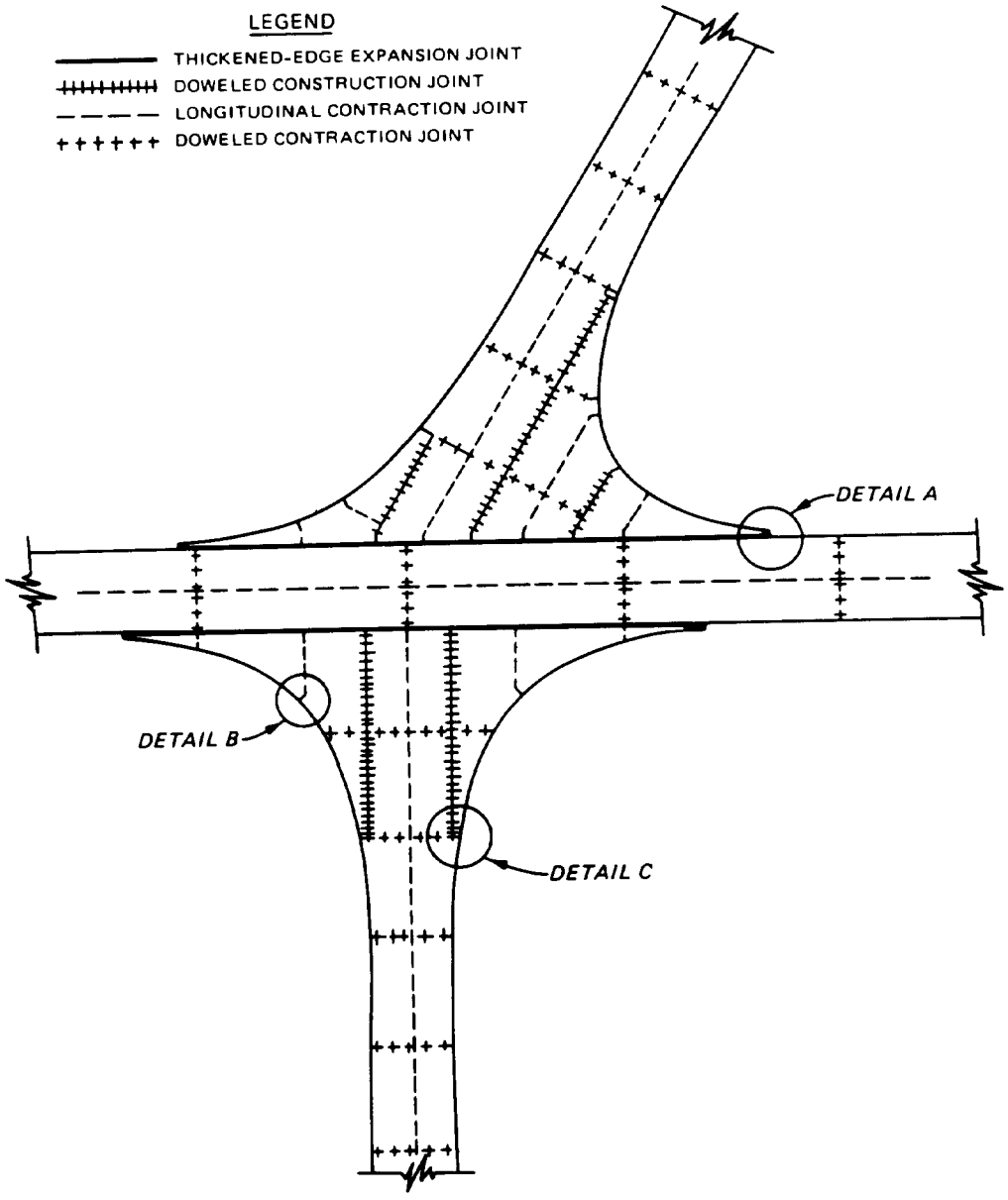

Figure 13–5. Design Details of Reinforced Rigid Pavement with Integral Curb. (Sheet 1 of 2)

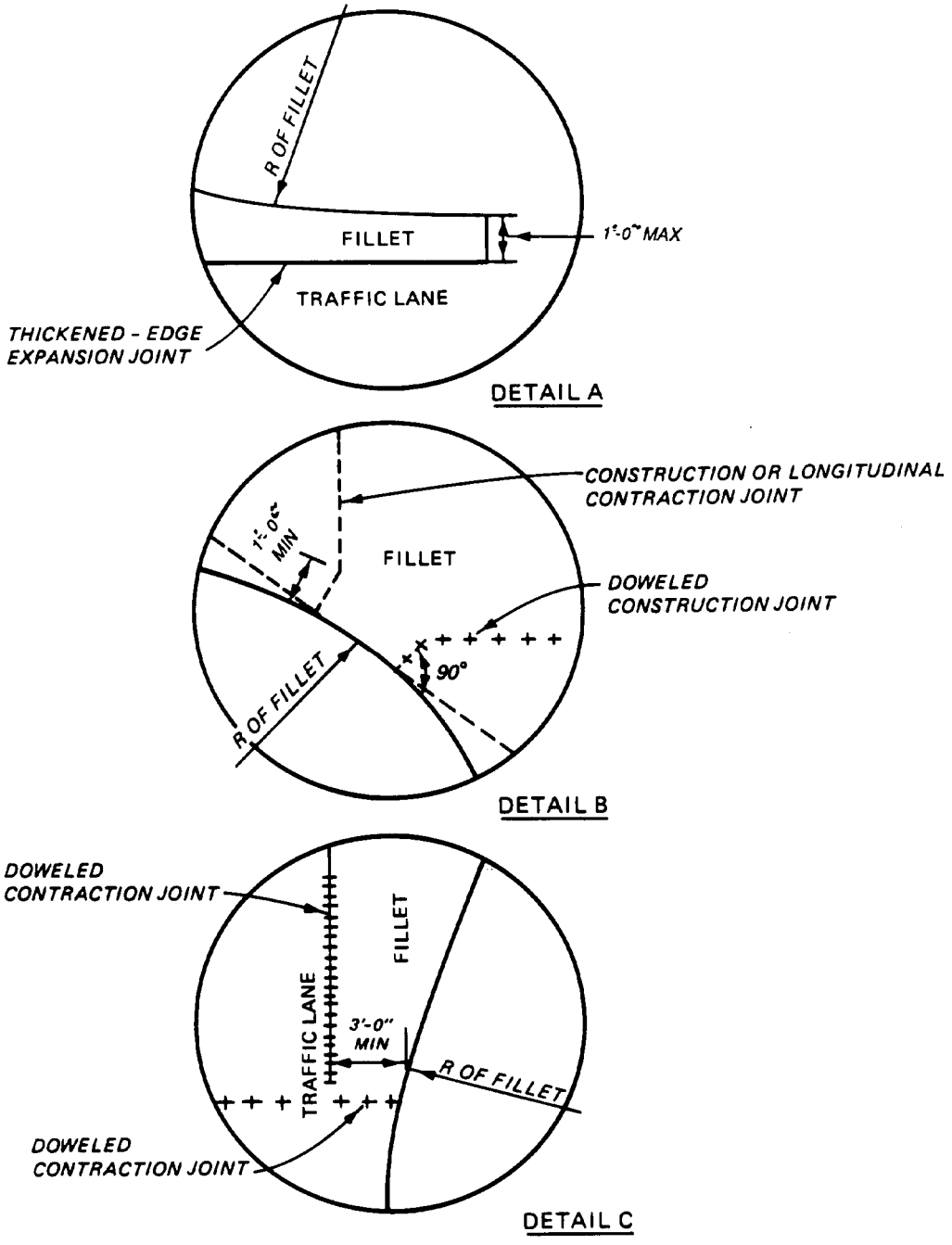

Figure 13-5. Design Details of Reinforced Rigid Pavement with Integral Curb. (Sheet 2 of 2)

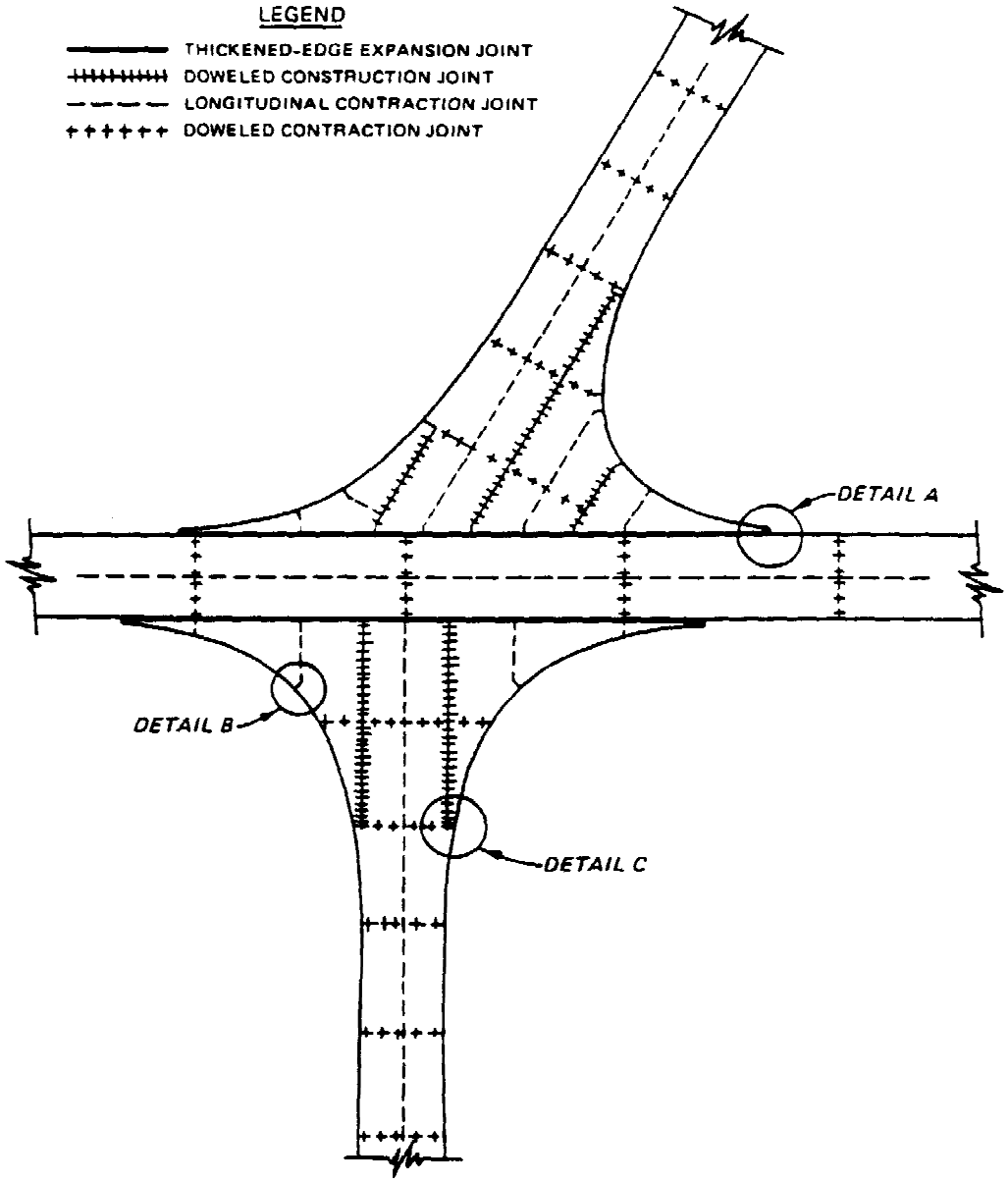

Figure 13-6. Typical Layout of Joints at the Intersection of Reinforced Rigid Pavement. (Sheet 1 of 2)

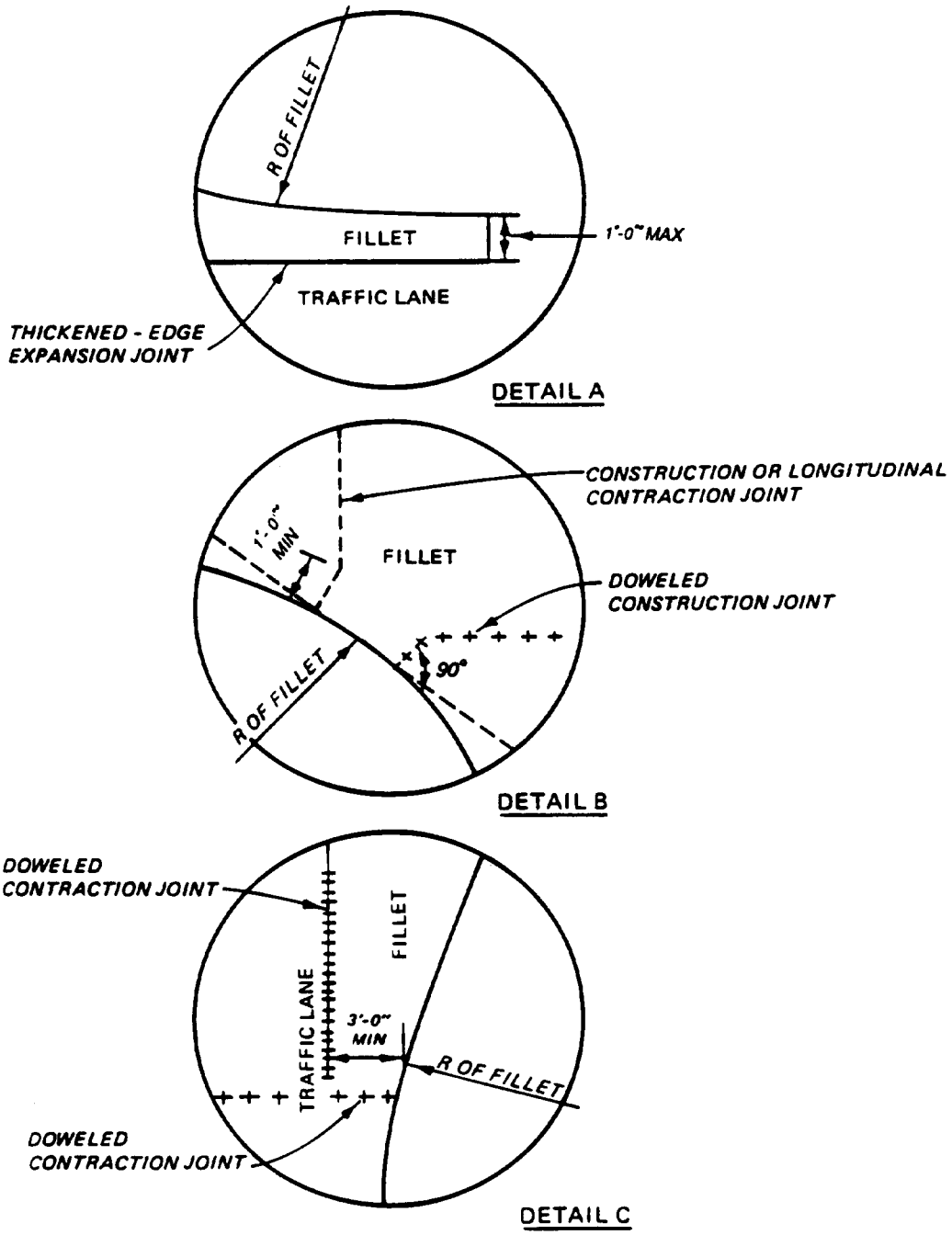

Figure 13-6. Typical Layout of Joints at the Intersection of Reinforced Rigid Pavement. (Sheet 2 of 2)