CONCRETE PAVEMENT DESIGN AND CONSTRUCTION PRACTICES BY THE TEXAS DOT

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INTRODUCTION

The Texas Department of Transportation (Texas DOT) is a decentralized organization consisting of twenty-four geographical Districts (Figure 1). Each District makes its own decision as to what pavement type will be designed and constructed. However, the Department's use of concrete pavement in highway projects has increased significantly over the past decade, especially in urban areas and in high truck traffic corridors. A paper presented at the Fourth International Conference on Concrete Pavement Design and Rehabilitation described and analyzed the use of the 1986 AASHTO Guide for Design of Pavement Structures procedure in determining concrete pavement thicknesses for Texas DOT highway projects (Ref. 1). This paper will discuss the other concrete pavement design and construction practices by the Texas DOT.

The paper will present and describe the background behind the various Texas DOT concrete pavement design standard plan sheets included in highway construction plans. Currently, the Texas DOT has standards for continuously reinforced concrete pavement (CRCP) , plain dowelled jointed concrete pavement (CPCD), skewed plain jointed concrete pavement (CPSJ), and jointed reinforced concrete pavement (JRCP). In conjunction with these standards, the Texas DOT terminal anchorage standards, wide flange terminal joint standards, and joint sealing standards will be presented and discussed. The background behind the CRCP standard will be of particular interest, since the current longitudinal steel requirements were developed using a design procedure generated by a research project with the University of Texas. Examples of interstate highway projects built recently with the various standards will also be briefly presented.

After the standards are presented, a summary of concrete pavement usage in Texas since 1983 will be presented. Finally, the paper will briefly describe ongoing efforts and findings in the research area that will affect concrete pavement design and construction procedures in the future.

The overall objective of this paper is to generally summarize the experience the Texas DOT has had with concrete pavement design and construction since the beginning of the U.S. Interstate program. As a result, the paper will indicate the current state of the practice concerning concrete pavement design and construction by this transportation agency.

BACKGROUND

In order to understand how concrete pavement design has developed in Texas, a brief discussion of the past history and experiences with concrete pavements in Texas will need to be presented. This section is mainly derived from construction plans investigations and discussions the author has had with present and past Texas DOT personnel, most notably Dr. B. Frank McCullough, P.E, Director of the Center for Transportation Research (CTR) at the University of Texas (who worked at the Texas DOT, then known as the Texas Highway Department, in the late fifties to the late sixties); Mr. James L. Brown, P.E., (former Engineer of Pavement Design at the Texas DOT); Mr. Bill Ward, P.E., (former Engineer-Manager of the Texas Highway Department Houston Urban Office); and Mr. Larry Buttler, P.E. (current Acting Engineer of Pavement Design at the Texas DOT).

Jointed Concrete Pavement

In the early days of the Texas Department of Transportation (from the 1920's to the 1940's) many of the concrete pavements constructed in Texas consisted of 9"-6"-9" jointed concrete pavement placed directly on the subgrade. Figure 2 presents one typical cross-section of such a pavement type. Some of these early pavements are still in service, as either part of the pavement structure (where several successive overlays have been placed over the concrete pavement) or as the actual riding surface.

During the time of the Interstate program, however, several concrete pavement types were used. A 10 inch thick, 15 foot plain jointed concrete pavement design, using wrinkled tin at the joints, were used in many areas, especially in the cities of Houston, Dallas, and Fort Worth. Figure 3 shows a typical joint detail of this pavement type. The wrinkled tin was supposed to help provide load transfer across the joints. However, the long term joint performance was poor due to the use of the wrinkled tin – the joints tended to spall and break up badly.

Jointed reinforced concrete pavements, usually 10 inches thick, with active joint spacings ranging from 30 feet to 60 feet, were also used at this time. The active joints were usually formed using redwood boards, were preformed using plastic insert strips, or were sawed. These joints did contain load transfer in the form of dowels. Cracks were either allowed to form within the slabs, or control joints were placed within the slabs to force cracking at certain locations within the slabs - the internal transverse steel kept such joints or cracks closed. This pavement type has been extensively used (even up to the present day) in the Houston District. However, as it is to be expected, asphalt overlays over the 60 foot jointed reinforced pavement have generally not performed well due to the JRCP active joint reflection cracks occurring in the overlays. Fabric joint underseals, which are placed and secured on the concrete pavement joints before the concrete pavement is overlaid with ACP, have been used statewide to try to counter this problem, but the performance of such underseals has been variable. According the Mr. William T. Wycoff (a Texas DOT Houston District employee), the Houston District has not used fabric joint underseals in the past five years because they were not found to be cost effective.

Continuously Reinforced Concrete Pavement

The most innovative pavement that was used during this time on the Interstate system (and is extensively used up to the present day in Texas) is continuously reinforced concrete pavement (CRCP). During the 1950's and 1960's, the Texas Highway Department constructed literally thousands of miles of this pavement type on the Interstate system. The design usually consisted of 8" thick CRCP, placed over a stabilized or unstabilized base material, with flexible pavement for shoulders (usually a thin wearing surface over a flexible base). The longitudinal steel percentage was either

0.5 percent or 0.6 percent, depending on the project. The majority of the sections were built using deformed reinforcing bars. Some sections were built with welded wire fabric – however, these sections did not perform well, and the practice was stopped (the cracks in such pavements tended to open too widely, letting water and incompressible material within the cracks and causing distress).

However, in rural areas, several sections of this pavement type initially performed badly. The rural sections usually consisted of four lane divided highways (two lanes in each direction). Truck traffic tended to travel very close to the edge of the CRCP on the outside lane, and since these sections did not have tied concrete shoulders, the edge stresses were very high. In addition, warping and curling action tended to be quite significant on such a relatively thin pavement. This situation usually led to excessive distress in the form of punchouts. Such cases were especially severe when siliceous river gravel was used (which usually resulted in close crack spacing), the subbase support was poor due to the lack of stabilization, or the subbase consisted of cement stabilized subbase, which usually bonded to the CRCP and caused excessive transverse cracking in some cases.

What "saved the day" for CRCP during this time were asphalt overlays. The Highway Design Division Research Section of the Texas Highway Department (where Dr. McCullough, Mr. Brown, and Mr. Buttler worked during this time) found that 4-inch to 6-inch asphalt overlays, combined with the repair of significant distresses in the CRCP, virtually eliminated the propagation of distresses in the CRCP (one example referenced by Mr. Buttler was IH45 in Huntsville, Walker County, Bryan District). In addition, it has been found that the transverse cracks in CRCP do not reflect through the overlay, since the steel in the CRCP keeps the cracks tightly closed. So, in other words, CRCP has been relatively easy to rehabilitate since ACP overlays tend to work very well on such a pavement type. This has also been noted in research conducted by Dr. Yoder on CRC pavements constructed in Indiana (Ref. 2).

The performance of CRCP has also varied due to the aggregate type used in the concrete and, to a lesser degree, the subbase type used underneath the pavement. Table 1, which is the result of an analysis using the Rigid Pavement Database maintained by CTR, shows the variance of CRCP transverse crack spacing as a function of aggregate and subbase type (Ref. 3). As it can be seen, the crack spacing tends to be closer for CRCP using siliceous river gravel. This means that punchouts usually occur earlier in CRCP using siliceous river gravel than in CRCP using limestone. Many of the CRCP sections built in the 1950's and 1960's used such gravel as the coarse aggregate. Dr. McCullough has conducted many research projects in this area (one of these studies, funded by the Texas DOT and the FHWA, are currently ongoing), some of which resulted in significant revisions to steel design requirements for CRCP, which will be discussed in the next section (Ref. 4).

Subbases

Many of the concrete pavements built during the Interstate program were built directly on cement stabilized subbases. As was discussed earlier, this subbase tended to adhere to the concrete pavement, which caused excessive cracking in CRCP and jointed pavements on some projects. As a result of this experience, the Texas DOT requires that any concrete pavement built on a cement stabilized subbase must have a bondbreaker (usually a 1 inch thick ACP layer) between the subbase and the pavement. One research study conducted by the Center for Transportation Research (CTR) was able to quantify this effect (Ref. 3 & 13). At this time, the Houston and Beaumont Districts are the only Districts that use cement stabilized subbases with ACP bondbreakers- the other Districts generally use asphalt stabilized subbases from 4 to 6 inches thick.

It is also required that all concrete pavements constructed and maintained by the Texas DOT use non-erosive, dense graded, stabilized subbases, which are either asphalt-stabilized or cement-stabilized subbases. Lime-treated subgrade and flexible (or granular) bases have not been found to be an effective subbase for concrete pavements in Texas under high traffic areas. However, some exceptions have been made. As was discussed in a paper presented at this conference in 1989 (Ref. 1), the Atlanta and Childress Districts have constructed plain jointed concrete pavements placed directly on the subgrade in areas where the subgrade is relatively free-draining and low truck traffic loading is expected.

Shoulders

During the past ten years, almost all concrete pavements constructed on high traffic roadways in rural areas have some sort of tied concrete shoulders. In addition, the joint between the shoulder and the outside lane is usually a sawed longitudinal warping joint, not a construction joint. The concrete pavement shoulder is also the same thickness as the mainlane pavement.

The concrete shoulder is usually a full width shoulder in most Texas DOT highway projects. However, the Dallas and Fort Worth Districts have used a design where the shoulder consists of three feet of concrete pavement and nine feet of asphaltic concrete pavement. This is done by paving the outer concrete pavement mainlane 15 feet wide instead of 12 feet wide. Then, the concrete pavement is striped so that the outer three feet of the concrete pavement is part of the shoulder. In this design, a longitudinal joint is **not** placed at the shoulder stripe.

Joints

Finally, almost all of the concrete pavements currently constructed in the state use sawed joints (rather than preformed joints) for longitudinal and transverse joints (the Houston District, however, uses redwood board expansions joints for their 60 foot, 6 inch jointed reinforced concrete pavement).

It was also mentioned that the Texas DOT requires the joint between the outside lane and a concrete shoulder be a longitudinal warping joint instead of a construction joint. Both joint types have the same transverse tiebar requirements. However, since the tiebar requirements are designed so that they preserve load transfer through aggregate interlock, and since construction joints basically have no aggregate interlock, it is assumed warping joints would perform better over the long term than construction joints, especially if truck traffic tends to ride close to the pavement-shoulder edge.

The Texas DOT also requires that transverse contraction joints and longitudinal warping joints should be sawed within 24 hours of the placement of the concrete. Ideally, the joints should be sawed at night; however, this is usually not practical.

In addition, the Texas DOT requires that the sawcut depths for such joints be one third of the concrete pavement thickness for concrete pavement using siliceous river gravel. Otherwise, the sawcut depth is one fourth of the concrete pavement thickness. This was based on research conducted by CTR for the Houston District and on the engineering judgment of Texas DOT personnel (Ref. 5). It was found that in those cases where uncontrolled cracks occured, the cracks did not form at the sawed joints for concrete pavement containing siliceous river gravel. Therefore, sawcuts are deeper in siliceous river gravel pavements in order to insure that the crack forms under the sawed joint.

CONCRETE PAVEMENT STANDARDS

The Texas DOT currently has the following statewide standards related to concrete pavement design and construction:

(1) Joint Seal Details for Concrete Pavement (JS-75 Standard, Figure 4),
(2) Plain, 15-foot jointed concrete pavement with sawed contraction joints (the CPCD-91(1) Standard, Figure 5),
(3) Continuously Reinforced Concrete Pavement (the CRCP(B)-89C Standard, Figure 6),
(4) Jointed Reinforced Concrete Pavement with 30 foot joint spacing (the CPJR(30B)-75 Standard, Figure 7),
(5) Plain, skewed jointed concrete pavement with random joint spacing between 12 and 18 feet (the CPSJ-75 Standard, Figure 8),
(6) Terminal Anchorage for Continuously Reinforced Concrete Pavement (the TA(CPCR)-83 Standard, Figure 9), and
(7) Terminal Anchorage for Jointed Concrete Pavement (the TA(CPJ)-83 Standard, Figure 10).

In addition, the Texas DOT Houston District has the following concrete pavement design standards.:

(1) Continuously Reinforced Concrete Pavement Details (Figure 11),
(2) Jointed Reinforced Concrete Pavement Details with 60 foot joint spacing (Figure 12), and
(3) Wide Flange Terminal Joint Details (Figure 13).

The statewide and Houston District standards are similar in their concepts, so the following descriptions apply to both sets of standards.

Joint Seal Details

Presently, the Texas DOT uses Method B (Joint Sealing Compounds) almost exclusively. Several Districts have had problems with the preformed compressions seals in the past (the seals tended to dislodge from the joint), so such seals have not been used very much. In addition, most joints are now sawed instead of formed, since several Districts (such as the Houston and Dallas Districts) have had problems with spalling when the joints were formed. This standard is currently under revision, since the joint seal dimensions are not desirable (ideally, the sealant width should be equal to or twice the sealant depth). However, the performance of joints with these sealants has generally been good.

Plain Jointed Concrete Pavement with 15 foot Joint Spacing (CPCD)

This latest version of the standard was developed by the author with advice and input from Texas DOT personnel, and was put into effect in September, 1991. This pavement type is used extensively by the Dallas District, where it is in place (among other roadways) on Interstate IH 45 southeast of Dallas in Navarro County. The pavement structure on that project is 14 inches of CPCD over 4 inches of asphalt stabilized base and 6 inches of salvaged base material.

Several details from this standard are of particular interest:

(1) Transverse steel (or tiebar) requirements are determined using the subgrade drag equation found in the 1986 AASHTO Guide for Design of Pavement Structures and in the text by Yoder and Witczak (Ref. 6 and 7). The table in the standard titled "Grade 60 Transverse Tiebar Requirements For Each 15' Long Slab" base the requirements on the slab thickness and the distance from the joint to the nearest longitudinal free edge. The requirements are the same for all longitudinal joints, whether they are longitudinal construction joints or warping joints.
(2) Only Grade 60 tiebars are allowed by the standard, and bending of tiebars is not allowed (see General Note 12 of the standard). At one time, Grade 40 tiebars were allowed by the Texas DOT, and such tiebars were allowed to be bent to facilitate construction because it was assumed they were more ductile than Grade 60 tiebars. The Texas DOT found out , however, that many Grade 40 tiebars were actually "rejected" Grade 60 tiebars that were "downgraded" to Grade 40, and they were just as susceptible to damage as Grade 60 tiebars if they were bent. In addition, it was found by construction personnel that an unacceptable amount of tiebars were damaged when bent. Multiple piece tiebars are now used in lieu of bending tiebars (see General Note 9 of the standard).
(3) If the pavement width is greater than 100 feet, a free longitudinal joint (i.e., a joint with no tiebars) is recommended at the pavement centerline, as shown in Figure 14 (see General Note 8 of the standard). The general experience of the Texas DOT is that if such wide pavement widths are tied together, the chances of uncontrolled longitudinal cracking increase. In addition, significant savings in transverse steel can be realized with the use of such free joints, since it divides the pavement into two shorter-width pavements (i.e., a 100-foot width is separated into two 50-foot widths for calculating transverse steel requirements).
(4) If siliceous river gravel is used as a coarse aggregate, the sawcut depth for all joints except construction joints shall be one third of the concrete pavement thickness. Otherwise, the sawcut depth is one-fourth of the concrete pavement thickness (see General Note 17 of the standard). The reasoning behind this requirement was discussed earlier.
(5) Finally, General Note 6 of the standard states, "The joint between the outside lane and the shoulder shall be a longitudinal warping joint unless otherwise shown on the plans." The reasoning behind this requirement was discussed earlier.

The dowels for CPCD have been usually placed and secured using bar chairs. However, the Dallas District has used mechanical placement of dowels on IH 45. It was found that the mechanical placement equipment was successful and placed the dowels within the tolerances specified in the standard (Ref. 8).

Continuously Reinforced Concrete Pavement (CRCP)

Continuously Reinforced Concrete Pavement is the most widely used concrete pavement type in Texas. The use of CRCP has increased significantly in recent years, mainly due to the fact that there are no transverse joints (except expansion joints at bridge ends), only closed cracks that are forced at a desirable crack spacing. Thus, joint or crack maintenance is essentially nonexistent if CRCP is designed and constructed properly. In addition, as discussed earlier, ACP overlays of CRCP have performed superbly on a statewide basis. Finally, many Districts have had much experience with this pavement type and are satisfied with its performance. However, the Beaumont District does not use this pavement type at all because of their poor experience with CRCP in their area.

The Houston District has used this pavement type on IH 45 in Montgomery County (north of Houston, at the Hardly Toll Road Connection). The pavement structure on that project is 15 inches of CRCP over 0.75 inches of an asphaltic concrete pavement (ACP) bondbreaker, 6 inches of a cement stabilized flexible (or granular) base, and 6 inches of lime treated subgrade.

The Houston District also used this pavement structure on IH 10 in Fort Bend County (west of Houston). The project was an overlay project, where the pavement structure was 14 inches of CRCP over a 1 inch ACP bondbreaker, 10 inches of an existing in-place JRCP, 6 inches of a cement treated base material, and 8 inches of a lime treated subgrade.

The author helped develop the latest version of the statewide CRCP standard, which went into effect in May, 1989. The author also helped to revise the Houston District CRCP standards at that time. Several details are of particular interest in the statewide standard (Figure 6):

(1) The longitudinal steel requirement for CRCP used to be 0.6% for many years (at one time, both 0.5% and 0.6% longitudinal steel requirements for CRCP were allowed by past versions of the Texas DOT CRCP standards). Now, as shown in Table 2 (which is based on the statewide standard requirements), the longitudinal steel requirement increases with increasing pavement thickness. The new requirements were based on a design methodology developed by CTR under a research project funded by the Texas DOT and the FHWA (Ref. 4). This project used a CRCP analysis program developed at CTR.

    It was found that, under the old 0.6% longitudinal steel requirement, highway projects with CRCP using siliceous river gravel aggregate developed closer and less desirable crack spacing than CRCP using limestone aggregate. According to the design methodology developed by CTR, the new requirements should provide more acceptable crack spacing for CRCP with siliceous river gravel. Ideally, the longitudinal steel requirements should be determined when the concrete mix properties are known for the specific highway project. Unfortunately, this is not practically possible.
(2) Footnote Number 4 and Section X-X (Transverse Construction Joint) on the statewide CRCP standard indicate that additional steel would be required at transverse construction joints placed at twice the spacing of the regular longitudinal steel. This situation is shown in Figure 15. The reasoning behind this detail is that excessive distress were found on some highway projects at such joints. The force exerted by concrete shrinkage on both sides of such joints were so high that they caused the steel to yield and possibly rupture. Therefore, to decrease the steel stress, additional steel is placed to insure that steel stress remains within acceptable values.

(3) Footnote Number 2 of the statewide CRCP standard requires that two layers of longitudinal and transverse steel should be used for CRC pavements that are 13 inches or greater in thickness. It was found that the longitudinal steel spacing should not be less than 6 inches, or else problems with concrete vibration and consolidation could occur, especially since most Texas DOT paving projects could have aggregate 1 1/2 inches in size in the concrete mix. The Houston District CRCP standard have the same requirements – however, that standard does allow double mats of steel in 11-inch and 12-inch-thick CRC pavements.

(4) The standard currently allows the use of Grade 40 steel. However, the standard will be modified in the near future to not allow Grade 40 steel. In addition, the author has not seen the use of Grade 40 steel in recent Texas DOT highway projects, mainly because there is no advantage in using it. Most Districts now use multiple piece tiebars instead of bent bars at CRCP longitudinal construction joints.

(5) General Note 5 of the CRCP standard requires that longitudinal steel splices must be staggered (i.e., only one-third of the steel splices can be at one location).

(6) The comments concerning transverse steel spacing and sawcut depths for the CPCD standard apply for the statewide CRCP standard as well. The Houston District CRCP standard is similar in many respects - however, there are minor differences. For example, the Houston District details indicate how to construct CRCP at intersections. The District has many projects where CRCP intersects with CRCP at intersections.

The longitudinal and transverse steel for CRCP have been usually placed using bar chairs. However, the Fort Worth District used mechanical placement of the steel on a project on IH 20 in that District. The equipment was successful in placing the steel within the tolerances required by the standard (Ref. 9). This was confirmed by Mr. Carl Utley, who is the District Construction Engineer in the Fort Worth District.

Jointed Reinforced Concrete Pavement (JRCP)

As was mentioned earlier in this paper, the Houston District is currently the only District that is still using JRCP extensively. The main differences between the statewide and Houston District standards are (1) the joint spacing (30 feet for the statewide standard; 60 feet, 6 inches for the Houston District standard), and (2) the type of joint (sawed joints for the statewide standard, redwood board expansion joints for the Houston District standard).

In general, JRCP has been difficult to rehabilitate because of the large joint movements. Reflection cracking occurs in any ACP overlays of this pavement type, but the severity of the cracking depends on how much the joint expands and contracts (which is mainly a function of the concrete thermal coefficient, temperature ranges, and joint spacing). The Pavement Design Section of the Texas DOT has generally recommended that JRCP should only be used in cases where differential settlement is expected or when midslab cracks are expected to occur.

Skewed Jointed Concrete Pavement (CPSJ)

This pavement type is extensively and successfully used by the Beaumont District. As shown on the standard, the design contains no dowels, the joint spacing is randomly staggered, and the joints are skewed at a 1 to 6 slope. The joints are sawed.

The Beaumont District recently used this pavement type on IH-10 in Chambers County . This pavement, which is 14 inches thick, was constructed under an overlay and added capacity project (the project is a six lane freeway with tied concrete shoulders). The concrete pavement lies directly on 2" of ACP. This 2" ACP "bondbreaker" layer covers the old roadway (12" of a shell concrete pavement and 4 1/2" of a sand-shell flexible base) that remained in place and 16 1/2" of a cement treated material that was placed adjacent to the old roadway. The whole pavement structure lies on 9 inches of treated subgrade.

Terminal Treatment

Figures 9 and 10, which show terminal anchorage details for continuously reinforced concrete pavement and jointed concrete pavement, respectively, are mainly used near bridge ends to restrain the movement at the joints between the bridge approach slabs and the end of the pavement. It is hoped that the restraint of slab movements would result in better-performing joints between the approach slabs and the pavement and in reducing the chances of damaging adjacent structures. Terminal anchors have been used extensively on CRCP projects. Terminal anchors have also been used on jointed concrete pavement projects where joint maintenance is not expected (a situation which could cause debris infiltration, resulting in the expansion of the pavement due to the inability of the joints to close), and in cases where the slabs are expected to push against a structure (such as a pavement sloping down at a significant grade to a bridge structure). The number of anchors used varies based on the District's experience - many interstate projects use three to four anchors.

Some Districts, however, have had poor experiences with terminal anchorage for CRCP (this includes the Houston and Yoakum Districts). Those Districts have found that the anchorage does not restrain movement where subgrade and subbase conditions are poor (i.e., poor subbase and subgrade bearing strength due to moisture infiltration).

As an alternative to terminal anchorage, the Houston District has been recently using a wide flange terminal joint instead, as shown in Figure 13. This design, which has been used in other parts of the country, is essentially an expansion joint that is encapsulated by a steel I-beam. As it can be seen, this joint does not restrain movement; instead, it allows movement while protecting the expansion joint from water and debris infiltration.

CONCRETE PAVEMENT USAGE

From April, 1983, to September, 1992, 1,075 Texas DOT highway projects involving concrete pavement have either been completed or are under construction. These projects represent approximately 64 million square yards of concrete pavement, which is equivalent to approximately 9,100 lane-miles. CRCP is the predominant pavement type, making up 71 percent of the total quantity (approximately 45 million square yards, or 6,400 lane-miles, in 518 projects).

The Houston District (District 12) is the largest user of concrete pavement in Texas. That District is responsible for 45 percent of the total statewide concrete pavement quantity (29 million square yards, or 4,100 lane-miles, in 406 projects). CRCP comprises 86 percent of the total concrete pavement quantity in that District (approximately 25 million square yards, or 3,500 lane-miles, in 249 projects).

Finally, Table 3 shows a summary of the predominant concrete pavement types by District. Almost every District in the state has used concrete pavement. It is interesting to note that the Houston District used CRCP almost exclusively, while the Beaumont District has not used CRCP for many years (the Beaumont District has not had very good experience with CRCP).

A list of these concrete pavement projects by District is available from the author at the Texas DOT, D-8PD, 125 East 11th Street, Austin, Texas, 78701.

FUTURE DEVELOPMENTS

Recent research by Dr. Dan Zollinger at the Texas A&M University's Texas Transportation Institute (TTI) shows that a new method of joint sawing, which allows much earlier sawing and much shallower sawcut depths, has been effective on projects in the Atlanta, Houston , and Bryan Districts (in the cities of Texarkana, Houston, and Caldwell, respectively). This sawing method may be in widespread use by the Texas DOT in the near future. Dr. Zollinger has not published the findings of his work at the time of the writing of this paper. Dr. Zollinger's research is being conducted under a study funded by the Texas DOT and the FHWA and involves CTR and TTI. The study is titled "Evaluation of the Performance of Texas Pavements Made with Different Coarse Aggregates", and the principal researchers are Dr. Zollinger of TTI and Dr. McCullough of CTR (Study No. 2/3-12D-90/2-1244).

The researchers in the research project mentioned above have also designed and evaluated several in place research test sections (mainly in the Houston District) using various coarse aggregates and steel design requirements (Ref. 10). New research test sections are also currently being placed to evaluate blending of aggregates in the CRC pavement mix design.

A proposed new standard specification book, which includes a new specification for concrete pavement, will be issued in 1993. This new concrete pavement specification, which has been used as a special specification on several Texas DOT projects (including IH 10, Chambers County, Beaumont District), contains smoothness specifications for concrete pavement ride quality. It is expected that this specification will positively impact the long-term performance of concrete pavements in Texas.

A new computer program for analysis of CRCP has also been developed by CTR that should more accurately model the performance of CRCP in the field. This model is currently being evaluated and is being calibrated. It is expected that future CRCP design requirements will be significantly affected by this computer program (Ref. 11).

The Rigid Pavement Database, currently managed and maintained by CTR, has been extensively used on many research projects to help update and revise concrete pavement design procedures (Ref. 12). The database mainly consists of 8 inch thick CRCP projects located statewide located on a variety of subbases and subgrade. However, this database is currently being expanded to include pavement sections consisting of jointed concrete pavement and concrete pavements of varying thicknesses. The database is also being used by a CTR study to help develop the initial performance prediction models for the Texas Pavement Management Information System.

Finally, the Department is currently in the process of developing and implementing a Pavement Management Information System for Texas. This system, which has involved Texas DOT personnel from all areas (as well as researchers from TTI and CTR) will help track the long term performance of pavement projects, and thus will help the Texas DOT help revise and update its concrete pavement design and construction procedures.

CONCLUSION

This paper presented the state of the practice in concrete pavement design and construction in Texas. It is hoped that the information provided in this paper will give the reader a perspective on how the Texas DOT is using past experience and research projects to improve concrete pavement performance.

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TABLE 1 - CRACK SPACING FOR EIGHT-INCH-THICK CRCP HIGHWAY PROJECTS IN TEXAS (REF 3)

Subbase Type	Coarse Aggregate Type	Average Mean Crack Spacing, Ft.	Number of Projects Measured
Lime Treated Subgrade	Limestone	6.10	15
	Siliceous River Gravel	3.72	14
Asphalt Stabilized	Limestone	7.31	16
	Siliceous River Gravel	3.56	20
Flexible (Granular)	Limestone	7.79	3
	Siliceous River Gravel	3.39	2
Cement Stabilized	Limestone	6.52	31
	Siliceous River Gravel	3.93	58

TABLE 2 - PERCENT STEEL REQUIREMENTS FOR LONGITUDINAL BARS IN STATEWIDE TEXAS DOT STANDARD CRCP(B)-89C CONTINUOUSLY REINFORCED CONCRETE PAVEMENT

Concrete Pavement Thickness, Inches	Bar Size Number	Bar Spacing, Inches	Percent Steel	Single or Double Mat of Steel
8	5	9	0.43%	Single
9	5	7.5	0.46%	Single
10	6	8.5	0.52%	Single
11	6	7	0.57%	Single
12	6	6	0.61%	Single
13	6	10.5	0.65%	Double
14	6	9.5	0.66%	Double
15	6	8.5	0.69%	Double

TABLE 3 - PREDOMINANT CONCRETE PAVEMENT TYPES USED BY TEXAS DOT DISTRICTS SINCE 1983

District	Headquarters	Concrete Pavement Types
1	Paris	CPCD, CRCP
2	Fort Worth	CRCP, JRCP
3	Wichita Falls	CRCP, CPCD
4	Amarillo	CRCP
5	Lubbock	CRCP, CPCD
6	Odessa	CRCP
8	Abilene	CRCP
9	Waco	CRCP
10	Tyler	CPCD, CRCP
11	Lufkin	JRCP
12	Houston	CRCP, JRCP
13	Yoakum	CRCP, JRCP
14	Austin	CRCP, JRCP
15	San Antonio	CRCP, JRCP
17	Bryan	CRCP
18	Dallas	CPCD, CRCP, JRCP
19	Atlanta	CPCD (no dowels), CRCP
20	Beaumont	CPSJ, JRCP, CPCD
21	Pharr	CPCD
24	El Paso	CRCP
25	Childress	CPCD (no dowels)

Legend:

CRCP:	Continuously Reinforced Concrete Pavement
CPCD:	Plain Jointed Concrete Pavement (15-foot joint spacing)
CPSJ:	Plain Skewed Jointed Concrete Pavement
JRCP:	Jointed Reinforced Concrete Pavement (30 foot or 60 foot joint spacing)

TEXAS DOT DISTRICT ORGANIZATION

DISTRICT NO.	HEADQUARTERS	DISTRICT NO.	HEADQUARTERS
1	Paris	13	Yoakum
2	Ft. Worth	14	Austin
3	Wichita Falls	15	San Antonio
4	Amarillo	16	Corpus Christi
5	Lubbock	17	Bryan
6	Odessa	18	Dallas
7	San Angelo	19	Atlanta
8	Abilene	20	Beaumont
9	Waco	21	Pharr
10	Tyler	23	Brownwood
11	Lufkin	24	El Paso
12	Houston	25	Childress

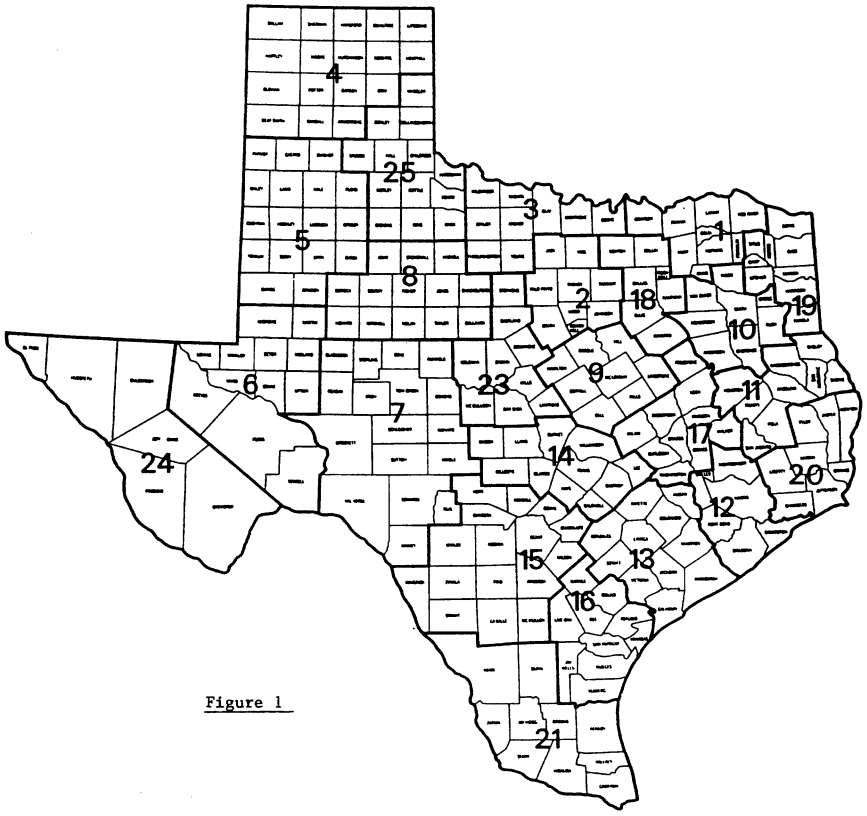
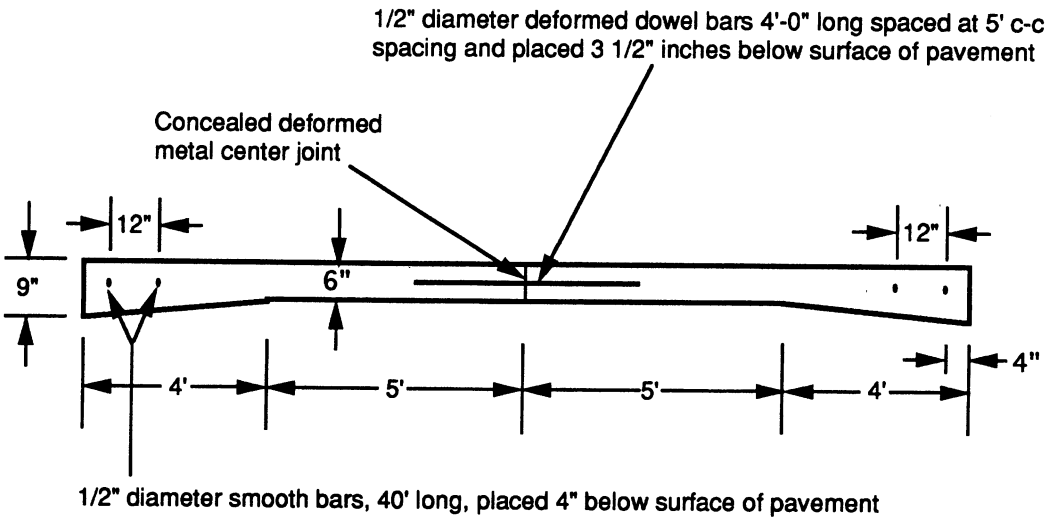


Figure 1

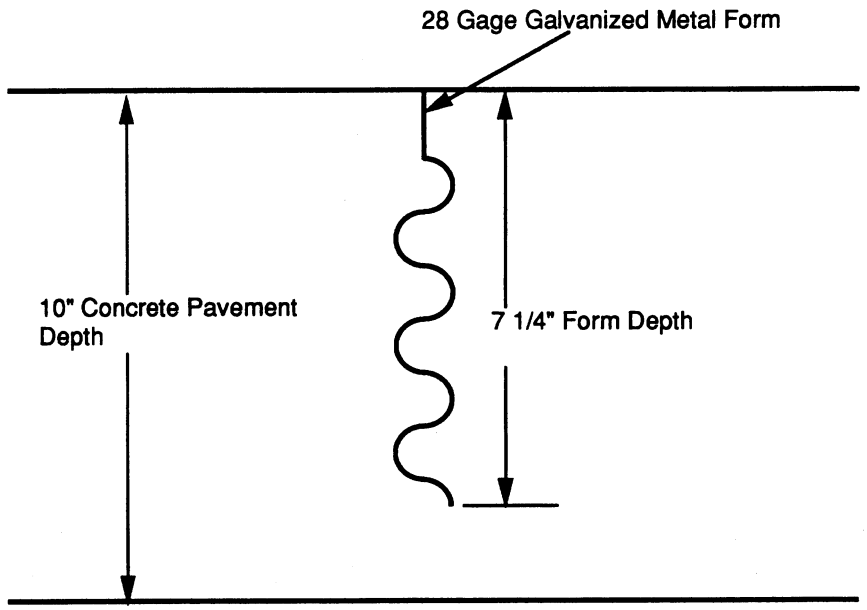
Figure 1



Note: Transverse joint spacings range from 40 feet to 100 feet.
The transverse joints contain 3' long,3/8" diameter smooth dowels at 2'-4" spacing.

TYPICAL 9"-6"-9" CONCRETE PAVEMENT CROSS SECTION

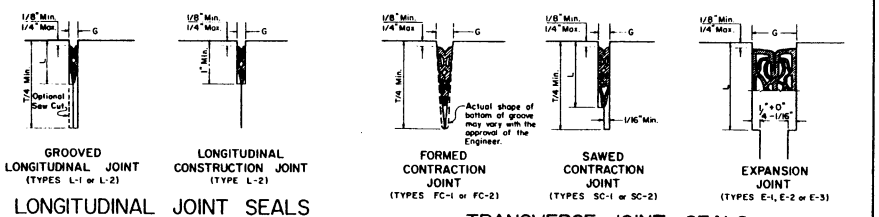
Figure 2

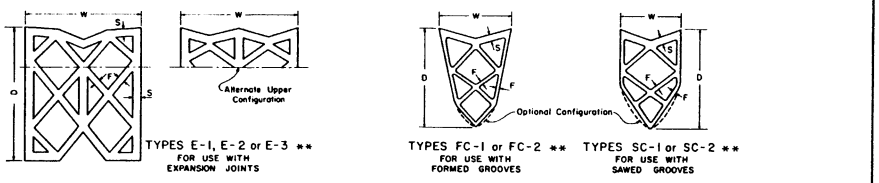


Note: Transverse joint spacing is 15 feet. For longitudinal joints,1/2" diameter deformed tiebars, 3' long, are placed at 30" spacing.

WRINKLED TIN TRANSVERSE JOINT DETAIL

Figure 3





METHOD A: PREFORMED COMPRESSION SEALS

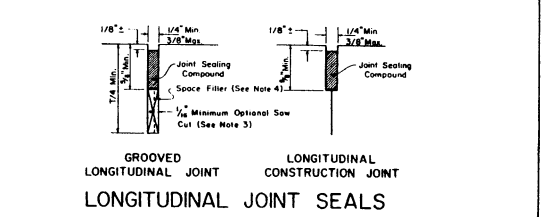
JOINT TYPE	JOINT GROOVE		MINIMUM JOINT SEAL SIZE TO BE USED [2]							SEAL DESIGNATION & TYPE
	WIDTH G (In.)	DEPTH L (In.)	WIDTH W (In.)	DEPTH D (In.)	SEAL 50% COMP	THICK. S (In.)	TOLER. S (In.)	THICK. F (In.)	TOLER. F (In.)	
LONGITUDINAL JOINT	1/8 +0 -1/16	7/8	5/16	5/8	1/8	0.040	-0.005	0.040	-0.005	L-1
	1/4 +0 -1/16	1	7/16	23/32	7/32	0.062	-0.005	0.040	-0.005	L-2
SAWED TRANSVERSE CONTRACTION JOINT	1/4 +0 -1/16	1-1/2	11/16	1-1/8	1/4	0.080	-0.012	0.040	-0.009	SC-1
	1/4 +0 -1/16	+3/4	13/16	1-1/8	5/16	0.080	-0.012	0.040	-0.009	SC-2
FORMED TRANSVERSE CONTRACTION JOINT	3/8	N/A	13/16	1-1/8	5/16	0.080	-0.012	0.040	-0.009	FC-1
	5/8	N/A	1-1/4	1-1/2	5/8	0.080	-0.012	0.080	-0.012	FC-2
EXPANSION JOINTS	1 *	2-1/8	1-5/8	1-5/8	7/8	0.094	-0.016	0.080	-0.012	E-1
	1-1/4 *	2-3/4	2	2	1	0.125	-0.016	0.110	-0.016	E-2
	1-5/8 *	3-3/8	2-1/2	2-3/4	1-1/4	0.187	-0.016	0.125	-0.016	E-3

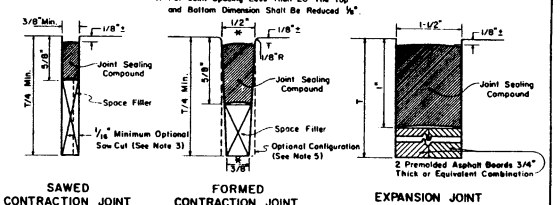
* THIS GROOVE WIDTH IS FOR SUMMER CONCRETE PLACEMENT. WHEN CONCRETE IS PLACED DURING THE WINTER SEASON, THIS GROOVE SHALL BE INCREASED 1/8".

1. DUE TO SMALL VARIATIONS IN SEAL SIZES, THIS DIMENSION MAY HAVE TO BE MODIFIED SLIGHTLY TO INSURE PROPER INSTALLATION. THIS DIMENSION IS APPLICABLE ONLY WHEN A STEPPED GROOVE IS USED. N/A: NOT APPLICABLE.
2. THESE DIMENSIONS ARE MINIMUM DIMENSIONS. DIMENSIONS GREATER THAN THOSE SHOWN MAY BE USED IF APPROVED BY THE ENGINEER AND IF THEY PERMIT INSTALLATION IN A WORKMANLIKE MANNER AT NO EXTRA EXPENSE TO THE STATE.
3. ONLY MINIMUM TOLERANCES ARE SHOWN. ANY REASONABLE OVERSIZE WILL BE ACCEPTED PROVIDED PROPER INSTALLATION IS POSSIBLE.

GENERAL NOTES FOR METHOD "A"

1. A SAMPLE OF EACH SIZE AND TYPE OF SEAL PROPOSED FOR USE SHALL BE APPROVED BY THE ENGINEER PRIOR TO INSTALLATION.
2. THE SEALS SHOWN AS METHOD "A" OR METHOD "B" MAY BE USED AT ANY JOINT REQUIRING A SEAL, HOWEVER, THE SAME SEAL SHALL BE USED THROUGHOUT THE PROJECT UNLESS OTHERWISE AUTHORIZED BY THE ENGINEER.
3. LONGITUDINAL JOINTS SHALL BE SAWED STRAIGHT AND TRUE TO LINE AS DETAILED IN THE STANDARD SPECIFICATIONS.
4. TRANSVERSE JOINTS MAY BE SAWED OR FORMED AND SHALL BE PLACED AS SHOWN ELSEWHERE IN THE PLANS.
5. THE SEALS DESIGNATED L-1 AND L-2 SHALL HAVE A CONFIGURATION SIMILAR TO THE TYPE FC OR SC.
6. ** OTHER INTERIOR CONFIGURATIONS MAY BE USED PROVIDED THE MATERIAL MEETS ALL OF THE REQUIREMENTS OF THE SPECIFICATIONS AND AS OTHERWISE SHOWN HEREON OR ELSEWHERE IN THE PLANS. THE NUMBER OF INTERIOR CELLS AND/OR THE THICKNESS OF THE EXTERIOR AND INTERIOR WALLS SHALL BE SUCH AS TO PROVIDE AN ADEQUATE COMPRESSIVE FORCE TO MAINTAIN A POSITIVE SEAL.
7. UNLESS OTHERWISE SPECIFIED, THE SIDES OF THE FORMED CONTRACTION JOINT MAY BE FORMED PARALLEL, BUT IF SO FORMED, THE SEAL SHALL BE AN APPROPRIATE TYPE SC SEAL APPROVED BY THE ENGINEER.
8. UNLESS THE GROOVE AND SEAL COMBINATION IS SPECIFICALLY DESIGNATED ELSEWHERE IN THE PLANS, ANY GROOVE AND SEAL COMBINATION SHOWN IN THE TABLE FOR A PARTICULAR TYPE JOINT MAY BE USED, BUT MUST BE APPROVED BY THE ENGINEER.





METHOD B: JOINT SEALING COMPOUND

GENERAL NOTES FOR METHOD "B"

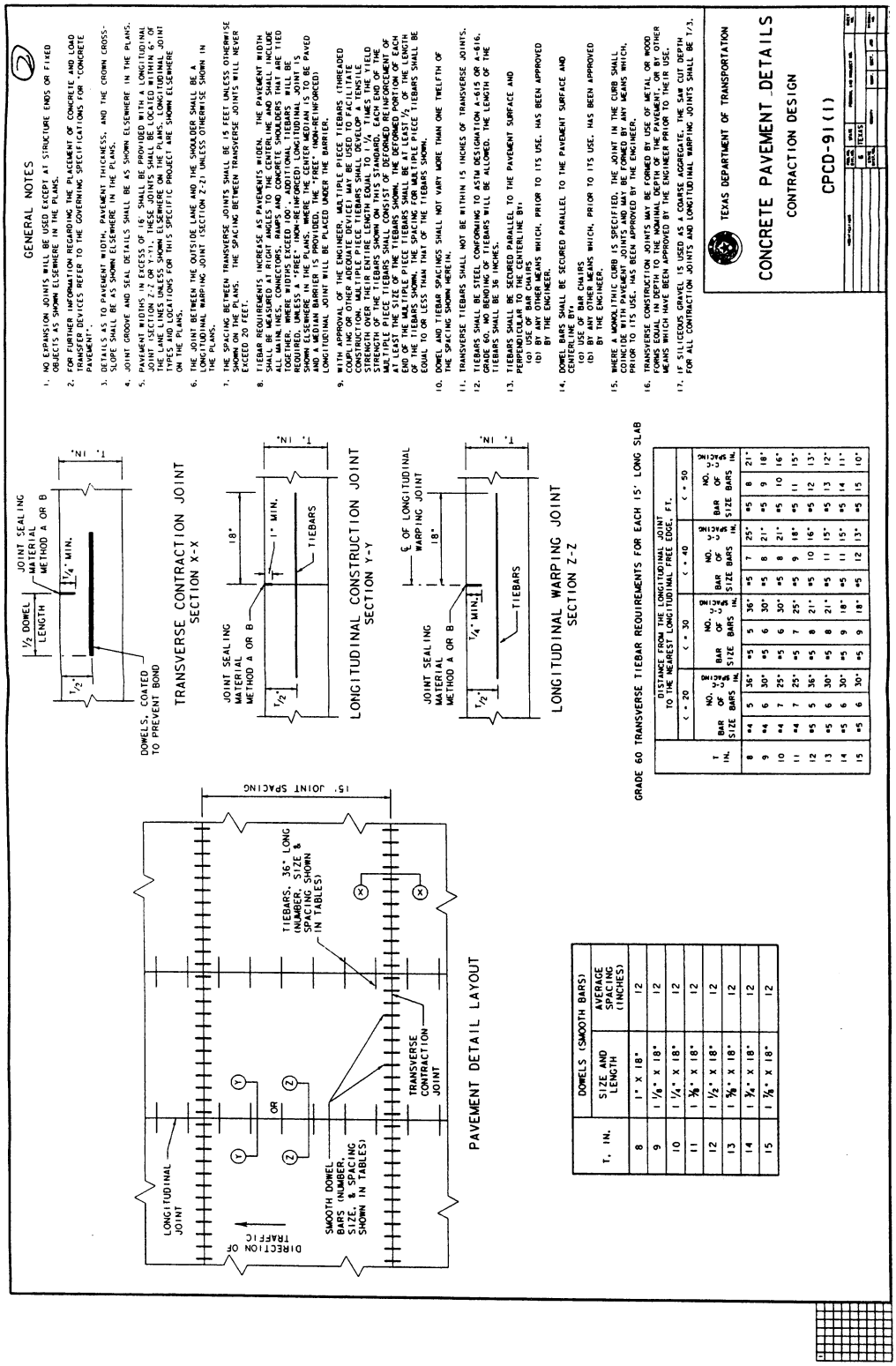
1. LONGITUDINAL JOINTS MAY BE SAWED OR FORMED AS DETAILED IN THE STANDARD SPECIFICATIONS.
2. TRANSVERSE JOINTS MAY BE SAWED OR FORMED AND SHALL BE PLACED AS SHOWN ELSEWHERE IN THE PLANS.
3. A SUITABLE SPACE FILLER SHALL BE USED WHERE SHOWN AND THE JOINT SEAL COMPOUND POURED TO THE DEPTH INDICATED EXCEPT THAT IF THE MINIMUM SAW CUT IS USED, THE SPACE FILLER MAY BE DELETED.
4. AT THE OPTION OF THE CONTRACTOR, THE SPACE FILLER MAY BE OMITTED IN THE LONGITUDINAL JOINT ONLY AND THE JOINT SEALING COMPOUND POURED FULL DEPTH.
5. UNLESS OTHERWISE SPECIFIED, THE SIDES OF THE FORMED CONTRACTION JOINT MAY BE FORMED PARALLEL AT THE OPTION OF THE CONTRACTOR.
6. UNLESS OTHERWISE SHOWN IN THE PLANS, EITHER METHOD "A" OR METHOD "B" MAY BE USED.

STATE DEPARTMENT OF HIGHWAYS AND PUBLIC TRANSPORTATION

CONCRETE PAVING DETAILS
JOINT SEALS
JS-75

DN:	CK:	DW:	CK:	DATE	FED. ROAD DIV. NO.	STATE	FEDERAL PROJECT NO.	SHEET NO.
					6	TEXAS		
					STATE	COUNTY	CONT.	SECT.	JOB	HIGHWAY NO.

Figure 4



T, IN.	DOWELS (SMOOTH BARS) SIZE AND LENGTH	DOWELS (SMOOTH BARS) AVERAGE SPACING (INCHES)
8	1" X 18"	12
9	1 1/8" X 18"	12
10	1 1/4" X 18"	12
11	1 3/8" X 18"	12
12	1 1/2" X 18"	12
13	1 5/8" X 18"	12
14	1 3/4" X 18"	12
15	1 7/8" X 18"	12

T IN.	DISTANCE FROM THE LONGITUDINAL JOINT TO THE NEAREST LONGITUDINAL FREE EDGE, FT.									
	≤ 20			≤ 30			≤ 40			≤ 50		
	BAR SIZE	NO. OF BARS	SPACING IN.	BAR SIZE	NO. OF BARS	SPACING IN.	BAR SIZE	NO. OF BARS	SPACING IN.	BAR SIZE	NO. OF BARS	SPACING IN.
8	#4	5	36"	#5	5	36"	#5	7	25"	#5	8	21"
9	#4	6	30"	#5	6	30"	#5	8	21"	#5	9	18"
10	#4	7	25"	#5	6	30"	#5	8	21"	#5	10	16"
11	#4	7	25"	#5	7	25"	#5	9	18"	#5	11	15"
12	#5	5	36"	#5	8	21"	#5	10	16"	#5	12	13"
13	#5	6	30"	#5	8	21"	#5	11	15"	#5	13	12"
14	#5	6	30"	#5	9	18"	#5	11	15"	#5	14	11"
15	#5	6	30"	#5	9	18"	#5	12	13"	#5	15	10"

Figure 5

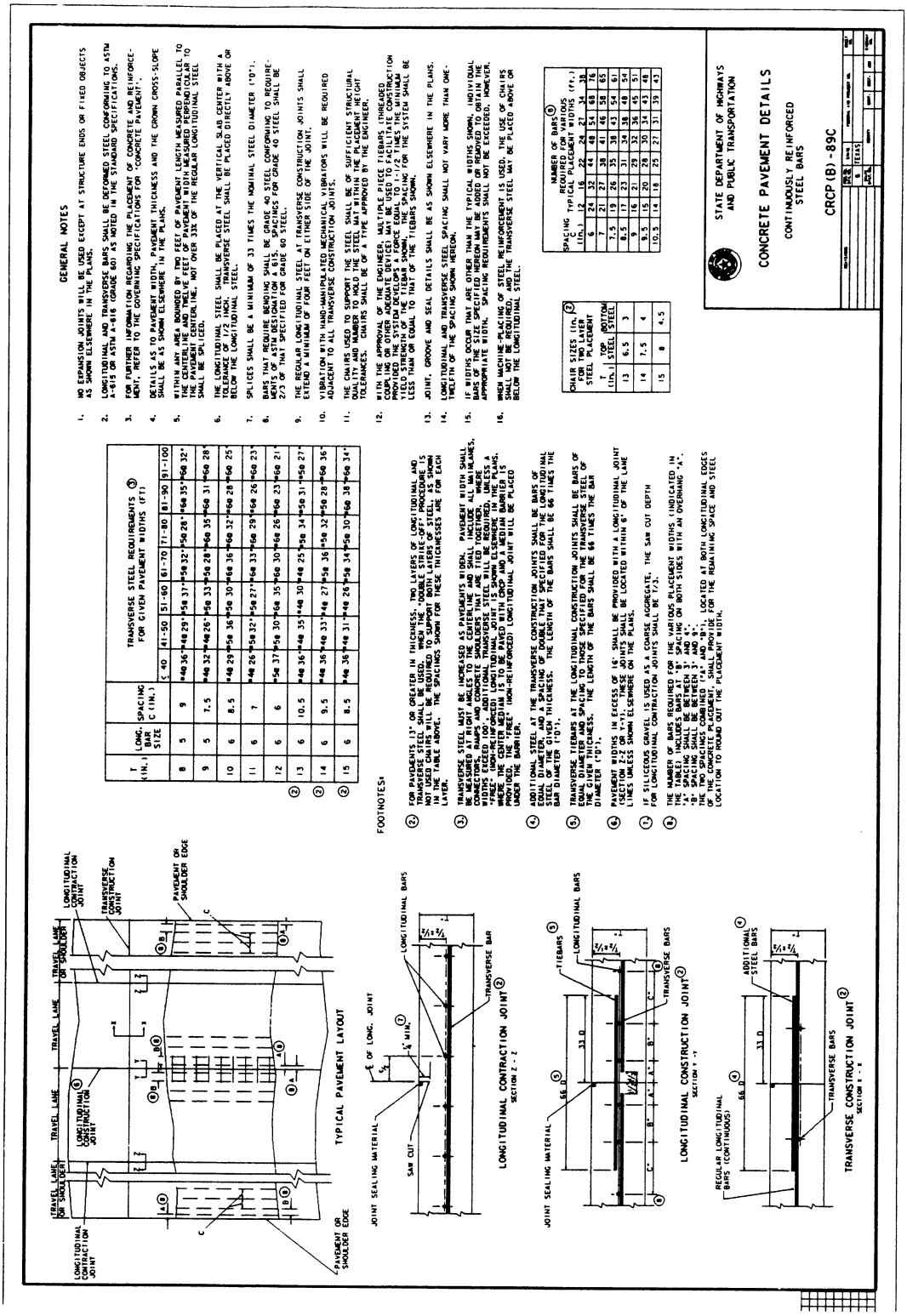

GENERAL NOTES
1. NO EXPANSION JOINTS WILL BE USED EXCEPT AT STRUCTURE ENDS OR FIXED OBJECTS AS SHOWN ELSEWHERE IN THE PLANS.
2. LONGITUDINAL AND TRANSVERSE BARS SHALL BE DEFORMED STEEL CONFORMING TO ASTM A-615 OR ASTM A-616 (GRADE 60) AS NOTED IN THE STANDARD SPECIFICATIONS.
3. FOR FURTHER INFORMATION REGARDING THE PLACEMENT OF CONCRETE AND REINFORCEMENT, REFER TO THE GOVERNING SPECIFICATIONS FOR CONCRETE PAVEMENT.
4. DETAILS AS TO PAVEMENT WIDTH, PAVEMENT THICKNESS AND THE CROWN CROSS-SLOPE SHALL BE AS SHOWN ELSEWHERE IN THE PLANS.
5. WITHIN ANY AREA BOUNDED BY TWO SETS OF PAVEMENT LENGTH-MEASURED PARALLEL TO THE CENTERLINE AND TWELVE FEET APART, WITH ONE SET PARALLEL TO THE PAVEMENT CENTERLINE, NOT OVER 33% OF THE REGULAR LONGITUDINAL STEEL SHALL BE SPLICED.
6. THE LONGITUDINAL STEEL SHALL BE PLACED AT THE VERTICAL SLAB CENTER WITH A TOLERANCE OF ±1/2 INCH. TRANSVERSE STEEL SHALL BE PLACED DIRECTLY ABOVE OR BELOW THE LONGITUDINAL STEEL.
7. SPLICES SHALL BE A MINIMUM OF 33 TIMES THE NOMINAL STEEL DIAMETER ("D").
8. BARS THAT REQUIRE BENDING SHALL BE GRADE 40 STEEL CONFORMING TO REQUIREMENTS OF ASTM DESIGNATION A 615. SPACINGS FOR GRADE 40 STEEL SHALL BE 2/3 OF THAT SPECIFIED FOR GRADE 60 STEEL.
9. THE REGULAR LONGITUDINAL STEEL AT TRANSVERSE CONSTRUCTION JOINTS SHALL EXTEND A MINIMUM OF FOUR FEET ON EITHER SIDE OF THE JOINT.
10. VIBRATION WITH HAND-MANIPULATED MECHANICAL VIBRATORS WILL BE REQUIRED ADJACENT TO ALL TRANSVERSE CONSTRUCTION JOINTS.
11. THE CHAIRS USED TO SUPPORT THE STEEL SHALL BE OF SUFFICIENT STRUCTURAL QUALITY TO HOLD THE STEEL IN THE PROPER POSITION WITHIN THE PLACEMENT TOLERANCES. CHAIRS SHALL BE AS APPROVED BY THE ENGINEER.
12. WITH THE APPROVAL OF THE ENGINEER, MULTI-PIECE FIBERS (THREADED COUPLING OR OTHER ACCEPTABLE DEVICE) MAY BE USED TO FACILITATE CONSTRUCTION PROVIDED THE SYSTEM DEVELOPS A FORCE EQUAL TO 1-1/2 TIMES THE MINIMUM YIELD STRENGTH OF THE BAR AS SHOWN. THE SPACING FOR THE SYSTEM SHALL BE LESS THAN OR EQUAL TO THAT OF THE FIGURES SHOWN.
13. JOINT, GROOVE AND SEAL DETAILS SHALL BE AS SHOWN ELSEWHERE IN THE PLANS.
14. LONGITUDINAL AND TRANSVERSE STEEL SPACING SHALL NOT VARY MORE THAN ONE-TWELFTH OF THE SPACING SHOWN HEREON.
15. IF WIDTHS OCCUR THAT ARE OTHER THAN THE TYPICAL WIDTHS SHOWN, INDIVIDUAL BARS OF THE SIZE SPECIFIED HEREON MAY BE ADDED OR REMOVED TO OBTAIN THE APPROXIMATE WIDTH. SPACING REQUIREMENTS SHALL NOT BE EXCEEDED, HOWEVER.
16. WHEN MACHINE PLACING OF STEEL REINFORCEMENT IS USED, THE USE OF CHAIRS SHALL BE REQUIRED. ADDITIONAL TRANSVERSE STEEL MAY BE PLACED ABOVE OR BELOW THE LONGITUDINAL STEEL.
TRANSVERSE STEEL REQUIREMENTS ③
T (IN.) | LONG. BAR SIZE | SPACING C (IN.) | FOR GIVEN PAVEMENT WIDTHS (FT): ≤ 40 | 41-50 | 51-60 | 61-70 | 71-80 | 81-90 | 91-100
8 | 5 | 9 | #4@36" | #4@29" | #5@37" | #5@32" | #5@28" | #6@35" | #6@32"
9 | 5 | 7.5 | #4@32" | #4@26" | #5@33" | #5@28" | #6@35" | #6@31" | #6@28"
10 | 6 | 8.5 | #4@29" | #5@36" | #5@30" | #6@36" | #6@32" | #6@28" | #6@25"
11 | 6 | 7 | #4@26" | #5@32" | #5@27" | #6@33" | #6@29" | #6@26" | #6@23"
12 | 6 | 6 | #5@37" | #5@30" | #6@35" | #6@30" | #6@26" | #6@23" | #6@21"
② 13 | 6 | 10.5 | #4@36" | #4@35" | #4@30" | #4@25" | #5@34" | #5@31" | #5@27"
② 14 | 6 | 9.5 | #4@36" | #4@33" | #4@27" | #5@36" | #5@32" | #5@28" | #6@36"
② 15 | 6 | 8.5 | #4@36" | #4@31" | #4@26" | #5@34" | #5@30" | #6@38" | #6@34"
FOOTNOTES:
② FOR PAVEMENTS 13" OR GREATER IN THICKNESS, TWO LAYERS OF LONGITUDINAL AND TRANSVERSE STEEL SHALL BE USED. WHEN THE "DOUBLE STRIKE-OFF" PROCEDURE IS NOT USED CHAIRS WILL BE REQUIRED TO SUPPORT BOTH LAYERS OF STEEL. AS SHOWN IN THE TABLE ABOVE, THE SPACINGS SHOWN FOR THESE THICKNESSES ARE FOR EACH LAYER.
① TRANSVERSE STEEL MUST BE INCREASED AS PAVEMENT'S WIDEN. PAVEMENT WIDTH SHALL BE MEASURED AT RIGHT ANGLES TO THE CENTERLINE AND SHALL INCLUDE ALL MAINLANES, CONNECTIONS, RAMPS AND CONCRETE SHOULDERS THAT ARE TIED TOGETHER. WHERE PAVEMENT WIDTHS EXCEED THE TABULATED WIDTHS, THE STEEL WILL BE REQUIRED FOR A "FREE" (NON-REINFORCED) LONGITUDINAL JOINT IS SHOWN ELSEWHERE ON THE PLANS. WHERE THE CENTER MEDIAN IS TO BE PAVED WITH CRCP AND A MEDIAN BARRIER IS PROVIDED, THE ADJACENT (NON-REINFORCED) LONGITUDINAL JOINT WILL BE PLACED UNDER THE BARRIER.
④ ADDITIONAL STEEL AT THE TRANSVERSE CONSTRUCTION JOINTS SHALL BE BARS OF EQUAL DIAMETER, AND A SPACING OF DOUBLE THAT SPECIFIED FOR THE LONGITUDINAL STEEL OF THE GIVEN THICKNESS. THE LENGTH OF THE BARS SHALL BE 66 TIMES THE BAR DIAMETER ("D").
⑤ TRANSVERSE TIEBARS AT THE LONGITUDINAL CONSTRUCTION JOINTS SHALL BE BARS OF EQUAL DIAMETER AND SPACING SPECIFIED FOR THE TRANSVERSE STEEL OF THE GIVEN THICKNESS. THE LENGTH OF THE BARS SHALL BE 66 TIMES THE BAR DIAMETER ("D").
⑥ PAVEMENT WIDTHS IN EXCESS OF 16' SHALL BE PROVIDED WITH A LONGITUDINAL JOINT (SECTION Z-Z OR Y-Y). THESE JOINTS SHALL BE LOCATED WITHIN 6" OF THE LANE LINES UNLESS SHOWN ELSEWHERE ON THE PLANS.
⑦ IF SILICEOUS GRAVEL IS USED AS A COARSE AGGREGATE, THE SAW CUT DEPTH FOR LONGITUDINAL CONTRACTION JOINTS SHALL BE T/3.
⑧ THE NUMBER OF BARS REQUIRED FOR THE VARIOUS PLACEMENT WIDTHS (INDICATED IN THE TABLE) INCLUDES BARS AT: "B": SPACING ON BOTH SIDES WITH AN OVERHANG "A". "A": SPACING SHALL BE BETWEEN 3" AND 9". "B": SPACING SHALL BE BETWEEN 3" AND 9". THE TWO SPACINGS COMBINED ("A" AND "B"). LOCATED AT BOTH LONGITUDINAL EDGES OF THE PAVEMENT. ADJUST SPACING FOR THE REMAINING SPACE AND STEEL LOCATION TO ROUND OUT THE PLACEMENT WIDTH.
CHAIR SIZES (IN.) ② FOR VARIOUS STEEL PLACEMENT
T (IN.) | TOP STEEL | BOTTOM STEEL
13 | 6.5 | 3
14 | 7.5 | 4
15 | 8 | 4.5
NUMBER OF BARS ⑧ REQUIRED FOR VARIOUS TYPICAL PLACEMENT WIDTHS (ft.)
SPACING C (IN.) | 12 | 16 | 22 | 24 | 32 | 34 | 44
6 | 24 | 32 | 44 | 48 | 64 | 68 | 88
7 | 21 | 27 | 38 | 41 | 46 | 58 | 65
7.5 | 19 | 26 | 35 | 38 | 43 | 54 | 61
8.5 | 17 | 23 | 31 | 34 | 38 | 48 | 54
9 | 16 | 21 | 29 | 32 | 36 | 45 | 51
9.5 | 15 | 20 | 28 | 30 | 34 | 43 | 48
10.5 | 14 | 18 | 25 | 27 | 31 | 39 | 43
STATE DEPARTMENT OF HIGHWAYS AND PUBLIC TRANSPORTATION
CONCRETE PAVEMENT DETAILS
CONTINUOUSLY REINFORCED STEEL BARS
CRCP(B)-89C
TYPICAL PAVEMENT LAYOUT
LONGITUDINAL CONTRACTION JOINT
TRAVEL LANE
TRAVEL LANE OR SHOULDER
TRANSVERSE CONSTRUCTION JOINT
PAVEMENT OR SHOULDER EDGE
JOINT SEALING MATERIAL
SAW CUT
LONGITUDINAL BARS
TRANSVERSE BAR
LONGITUDINAL CONTRACTION JOINT
SECTION Z - Z
TIEBARS
66 D
LONGITUDINAL CONSTRUCTION JOINT
SECTION Y - Y
REGULAR LONGITUDINAL BARS (CONTINUOUS)
ADDITIONAL STEEL BARS
TRANSVERSE CONSTRUCTION JOINT
SECTION X - X

Figure 6

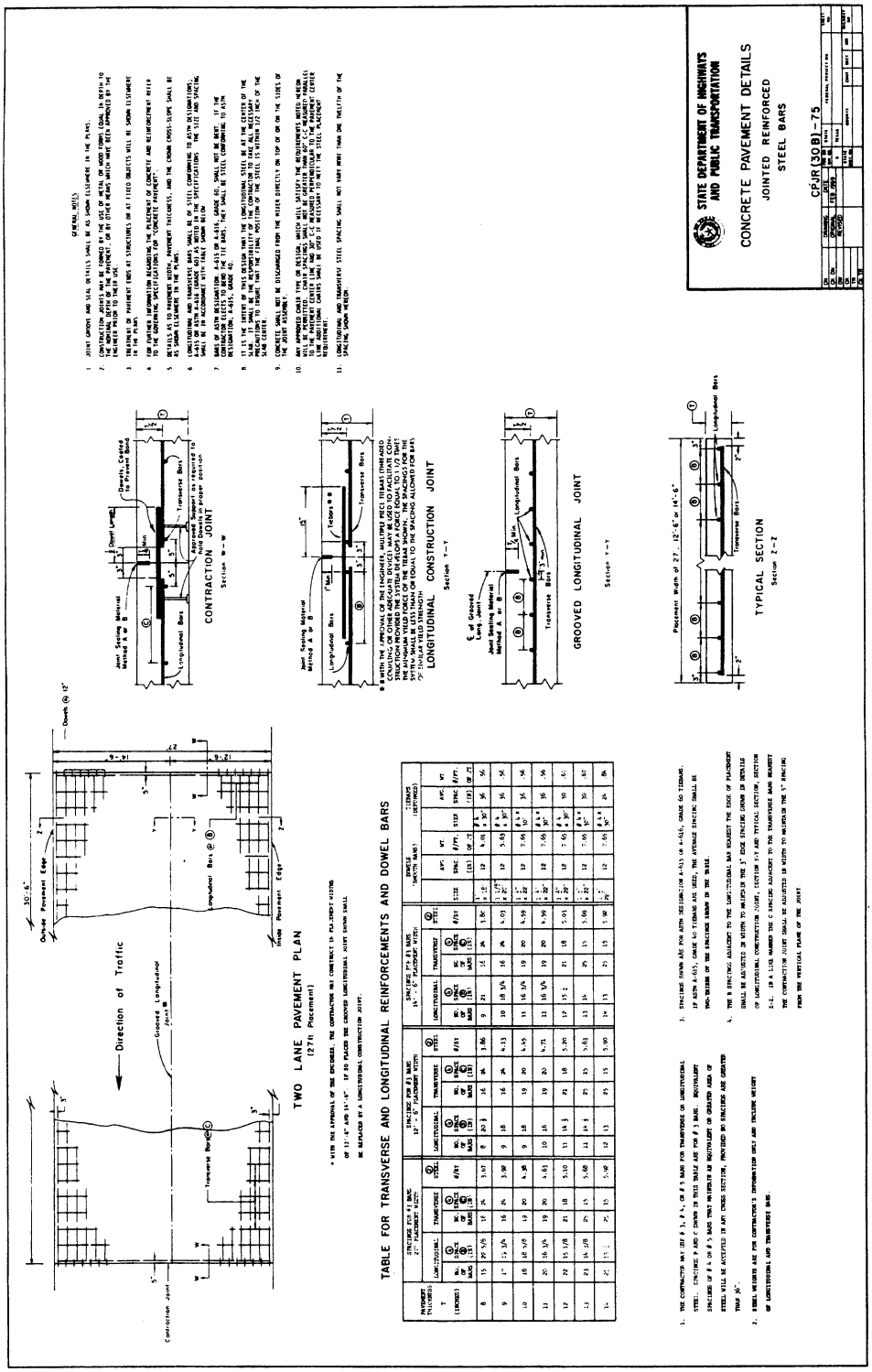

GENERAL NOTES
CONTRACTION JOINT
LONGITUDINAL CONSTRUCTION JOINT
GROOVED LONGITUDINAL JOINT
TYPICAL SECTION
TWO LANE PAVEMENT PLAN
(27ft Pavement)
TABLE FOR TRANSVERSE AND LONGITUDINAL REINFORCEMENTS AND DOWEL BARS
STATE DEPARTMENT OF HIGHWAYS AND PUBLIC TRANSPORTATION
CONCRETE PAVEMENT DETAILS
JOINTED REINFORCED
STEEL BARS
CPJR(30B)-75

Figure 7

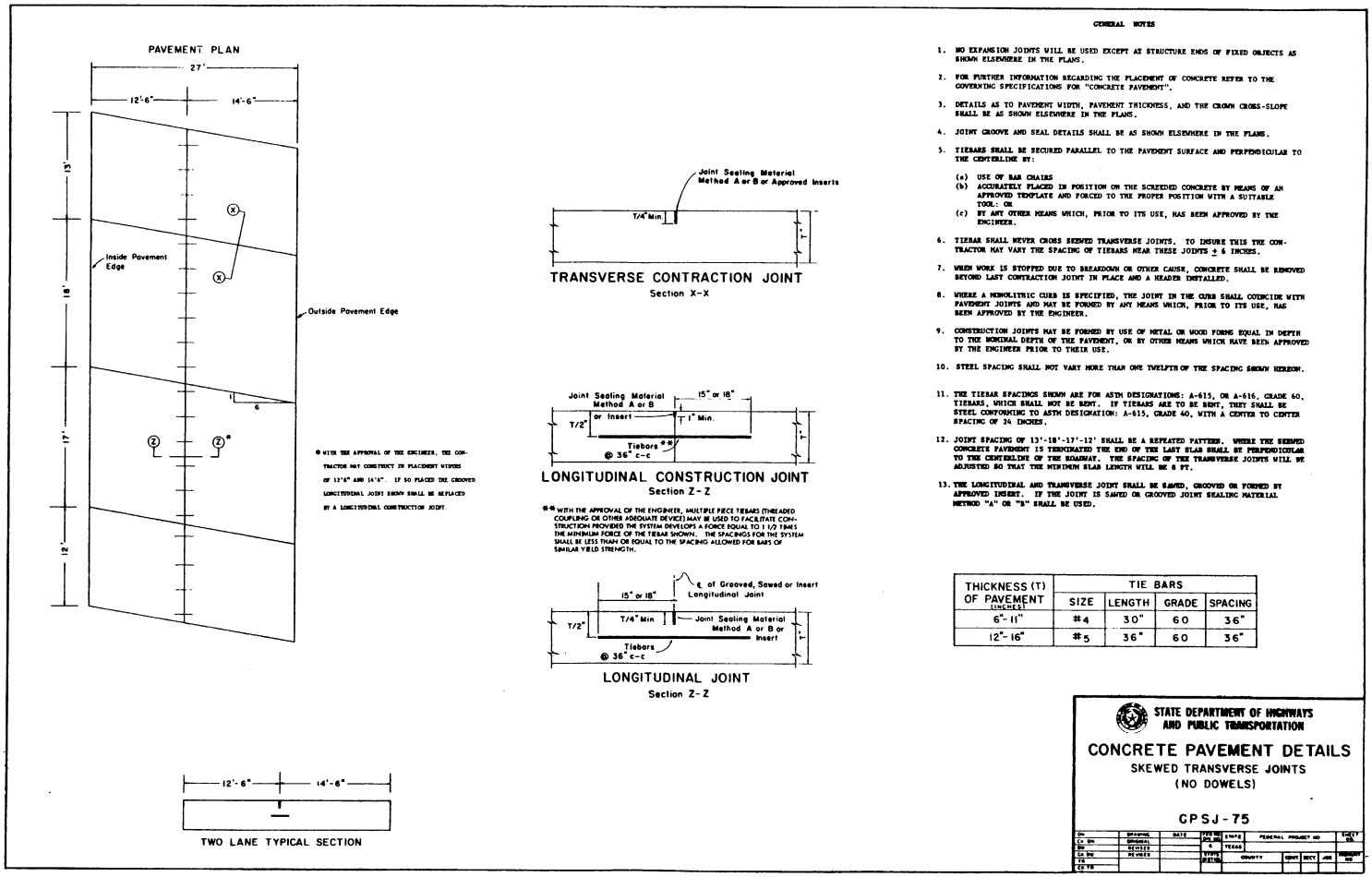

PAVEMENT PLAN
27'
12'-6"
14'-6"
15'
18'
17'
12'
Inside Pavement Edge
Outside Pavement Edge
1
6
* WITH THE APPROVAL OF THE ENGINEER, THE CONTRACTOR MAY CONSTRUCT IN PLACEMENT WIDTHS OF 12'6" AND 14'6". IF SO PLACED THE GROOVED LONGITUDINAL JOINT SHOWN SHALL BE REPLACED BY A LONGITUDINAL CONSTRUCTION JOINT.
Joint Sealing Material Method A or B or Approved Inserts
T/4" Min.
T"
TRANSVERSE CONTRACTION JOINT
Section X-X
Joint Sealing Material Method A or B
15" or 18"
or Insert
T/2"
T" Min.
Tiebars **
@ 36" c-c
LONGITUDINAL CONSTRUCTION JOINT
Section Z-Z
** WITH THE APPROVAL OF THE ENGINEER, MULTIPLE PIECE TIEBARS (THREADED COUPLING OR OTHER ADEQUATE DEVICE) MAY BE USED TO FACILITATE CONSTRUCTION PROVIDED THE SYSTEM DEVELOPS A FORCE EQUAL TO 1 1/2 TIMES THE MINIMUM FORCE OF THE TIEBAR SHOWN. THE SPACINGS FOR THE SYSTEM SHALL BE LESS THAN OR EQUAL TO THE SPACING ALLOWED FOR BARS OF SIMILAR YIELD STRENGTH.
℄ of Grooved, Sawed or Insert Longitudinal Joint
15" or 18"
T/4" Min
T/2"
Joint Sealing Material Method A or B or Insert
Tiebars @ 36" c-c
LONGITUDINAL JOINT
Section Z-Z
12'-6"
14'-6"
TWO LANE TYPICAL SECTION
GENERAL NOTES
1. NO EXPANSION JOINTS WILL BE USED EXCEPT AT STRUCTURE ENDS OF FIXED OBJECTS AS SHOWN ELSEWHERE IN THE PLANS.
2. FOR FURTHER INFORMATION REGARDING THE PLACEMENT OF CONCRETE REFER TO THE GOVERNING SPECIFICATIONS FOR "CONCRETE PAVEMENT".
3. DETAILS AS TO PAVEMENT WIDTH, PAVEMENT THICKNESS, AND THE CROWN CROSS-SLOPE SHALL BE AS SHOWN ELSEWHERE IN THE PLANS.
4. JOINT GROOVE AND SEAL DETAILS SHALL BE AS SHOWN ELSEWHERE IN THE PLANS.
5. TIEBARS SHALL BE SECURED PARALLEL TO THE PAVEMENT SURFACE AND PERPENDICULAR TO THE CENTERLINE BY:
(a) USE OF BAR CHAIRS
(b) ACCURATELY PLACED IN POSITION ON THE SCREEDED CONCRETE BY MEANS OF AN APPROVED TEMPLATE AND FORCED TO THE PROPER POSITION WITH A SUITABLE TOOL: OR
(c) BY ANY OTHER MEANS WHICH, PRIOR TO ITS USE, HAS BEEN APPROVED BY THE ENGINEER.
6. TIEBAR SHALL NEVER CROSS SKEWED TRANSVERSE JOINTS. TO INSURE THIS THE CONTRACTOR MAY VARY THE SPACING OF TIEBARS NEAR THESE JOINTS ± 6 INCHES.
7. WHEN WORK IS STOPPED DUE TO BREAKDOWN OR OTHER CAUSE, CONCRETE SHALL BE REMOVED BEYOND LAST CONTRACTION JOINT IN PLACE AND A HEADER INSTALLED.
8. WHERE A MONOLITHIC CURB IS SPECIFIED, THE JOINT IN THE CURB SHALL COINCIDE WITH PAVEMENT JOINTS AND MAY BE FORMED BY ANY MEANS WHICH, PRIOR TO ITS USE, HAS BEEN APPROVED BY THE ENGINEER.
9. CONSTRUCTION JOINTS MAY BE FORMED BY USE OF METAL OR WOOD FORMS EQUAL IN DEPTH TO THE NOMINAL DEPTH OF THE PAVEMENT, OR BY OTHER MEANS WHICH HAVE BEEN APPROVED BY THE ENGINEER PRIOR TO THEIR USE.
10. STEEL SPACING SHALL NOT VARY MORE THAN ONE TWELFTH OF THE SPACING SHOWN HEREON.
11. THE TIEBAR SPACINGS SHOWN ARE FOR ASTM DESIGNATIONS: A-615, OR A-616, GRADE 60, TIEBARS, WHICH SHALL NOT BE BENT. IF TIEBARS ARE TO BE BENT, THEY SHALL BE STEEL CONFORMING TO ASTM DESIGNATION: A-615, GRADE 40, WITH A CENTER TO CENTER SPACING OF 24 INCHES.
12. JOINT SPACING OF 13'-18'-17'-12' SHALL BE A REPEATED PATTERN. WHERE THE SKEWED CONCRETE PAVEMENT IS TERMINATED THE END OF THE LAST SLAB SHALL BE PERPENDICULAR TO THE CENTERLINE OF THE ROADWAY. THE SPACING OF THE TRANSVERSE JOINTS WILL BE ADJUSTED SO THAT THE MINIMUM SLAB LENGTH WILL BE 6 FT.
13. THE LONGITUDINAL AND TRANSVERSE JOINT SHALL BE SAWED, GROOVED OR FORMED BY APPROVED INSERT. IF THE JOINT IS SAWED OR GROOVED JOINT SEALING MATERIAL METHOD "A" OR "B" SHALL BE USED.
THICKNESS (T) OF PAVEMENT (INCHES)
TIE BARS
SIZE | LENGTH | GRADE | SPACING
6"-11" | #4 | 30" | 60 | 36"
12"-16" | #5 | 36" | 60 | 36"
STATE DEPARTMENT OF HIGHWAYS AND PUBLIC TRANSPORTATION
CONCRETE PAVEMENT DETAILS
SKEWED TRANSVERSE JOINTS
(NO DOWELS)
GPSJ-75
DN
CK. DN
DW
CK. DW
TS
CK. TS
DRAWING ORIGINAL
REVISED
DATE
STATE
TEXAS
FEDERAL PROJECT NO
COUNTY
SHEET NO

Figure 8

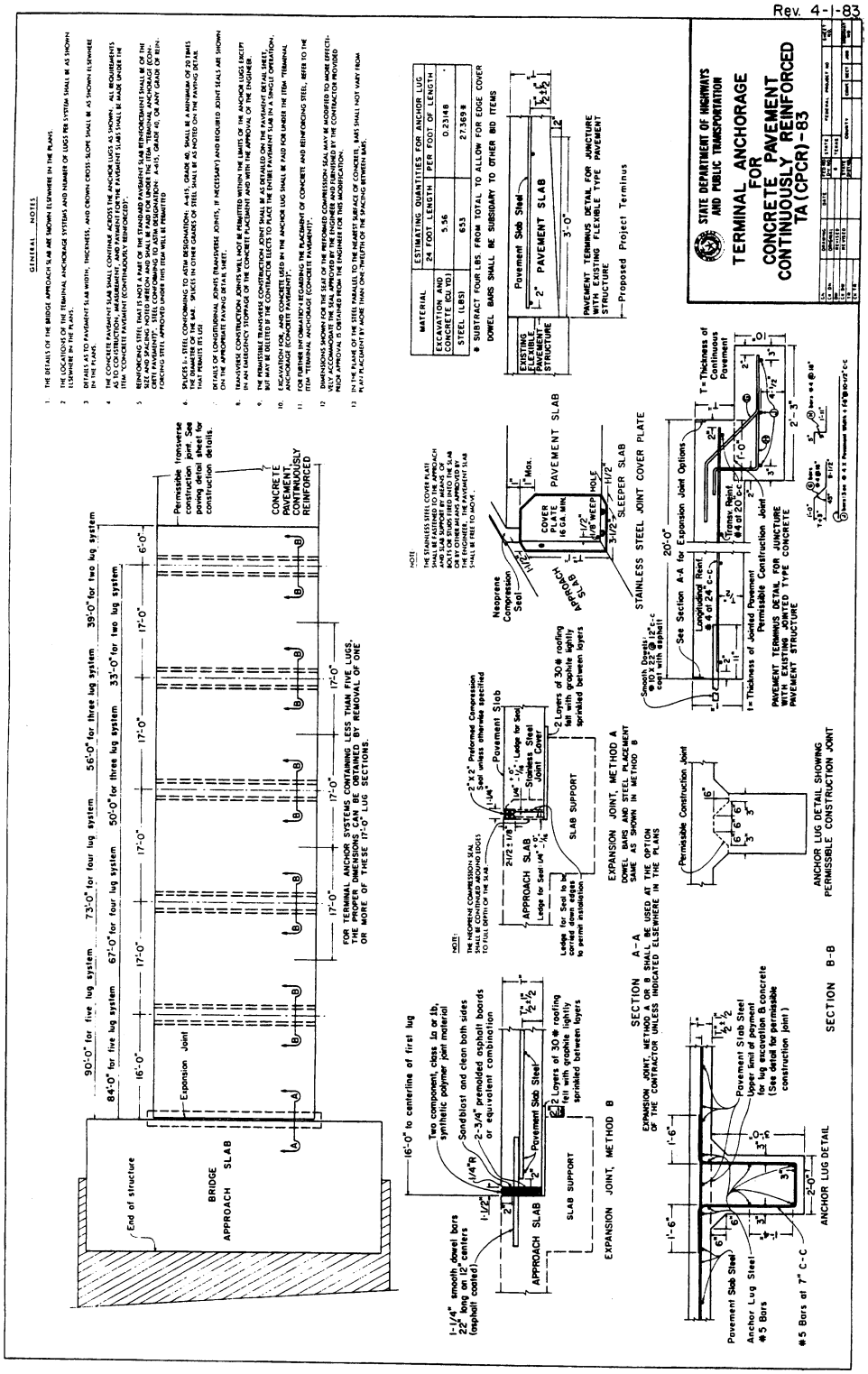

Rev. 4-1-83
STATE DEPARTMENT OF HIGHWAYS AND PUBLIC TRANSPORTATION
TERMINAL ANCHORAGE FOR CONCRETE PAVEMENT CONTINUOUSLY REINFORCED TA (CPCR)-83
GENERAL NOTES
ESTIMATING QUANTITIES FOR ANCHOR LUG
MATERIAL
24 FOOT LENGTH
PER FOOT OF LENGTH
EXCAVATION AND CONCRETE (CU YD)
5.56
0.2314#
STEEL (LBS)
655
27.569#
SUBTRACT FOUR LBS. FROM TOTAL TO ALLOW FOR EDGE COVER
DOWEL BARS SHALL BE SUBSIDIARY TO OTHER BID ITEMS
Pavement Slab Steel
2" PAVEMENT SLAB
3'-0"
EXISTING PAVEMENT STRUCTURE
PAVEMENT TERMINUS DETAIL FOR JUNCTURE WITH EXISTING FLEXIBLE TYPE PAVEMENT STRUCTURE
Proposed Project Terminus
90'-0" for five lug system
73'-0" for four lug system
56'-0" for three lug system
39'-0" for two lug system
84'-0" for five lug system
67'-0" for four lug system
50'-0" for three lug system
33'-0" for two lug system
End of structure
BRIDGE APPROACH SLAB
Expansion Joint
Permissible transverse construction joint. See paving detail sheet for construction details.
CONCRETE PAVEMENT, CONTINUOUSLY REINFORCED
FOR TERMINAL ANCHOR SYSTEMS CONTAINING LESS THAN FIVE LUGS, THE REMOVAL OF ONE OR MORE OF THE 17'-0" LUG SECTIONS, OR MORE OF THESE 17'-0" LUG SECTIONS.
16'-0" to centerline of first lug
Two component, class 1a or 1b, synthetic polymer joint material
Sandblast and clean both sides
2-3/4" premolded asphalt boards or equivalent combination
Pavement Slab Steel
2 Layers of 30# roofing felt with graphite lightly sprinkled between layers
APPROACH SLAB
SLAB SUPPORT
EXPANSION JOINT, METHOD B
1-1/4" smooth dowel bars 22" long on 12" centers (asphalt coated)
Pavement Slab Steel
Anchor Lug Steel
#5 Bars at 7" C-C
Upper limit of payment for lug excavation & concrete (See detail for permissible construction joint)
ANCHOR LUG DETAIL
SECTION B-B
EXPANSION JOINT, METHOD A
DOWEL BARS AND STEEL PLACEMENT SHALL BE USED AT THE OPTION OF THE CONTRACTOR UNLESS INDICATED ELSEWHERE IN THE PLANS
SECTION A-A
Permissible Construction Joint
ANCHOR LUG DETAIL SHOWING PERMISSIBLE CONSTRUCTION JOINT
NOTE
THE NEOPRENE COMPRESSION SEAL SHALL BE CONTINUED AROUND EDGES TO FULL DEPTH OF THE SLAB
2"x2" Preformed Compression Seal unless otherwise specified
Stainless Steel Joint Cover
Ledge for Seal
Ledge for Seal to be constructed of removable form to permit installation
NOTE
THE STAINLESS STEEL COVER PLATE SHALL BE FASTENED TO THE APPROACH SLAB BY MEANS OF 1/2" DIA. STUD BOLTS OR STUDS TIED INTO THE SLAB AS DETAILED ON THE PLANS. AS DIRECTED BY THE ENGINEER, THE PAVEMENT SLAB SHALL BE FREE TO MOVE.
Neoprene Compression Seal
COVER PLATE 16 GA. MIN.
1" Max.
PAVEMENT SLAB
APPROACH SLAB
1/2" dia. WEEP HOLE
SLEEPER SLAB
STAINLESS STEEL JOINT COVER PLATE
Smooth Dowel: #10 X 22" @ 12" C-C coat with asphalt
See Section A-A for Expansion Joint Options
20'-0"
Longitudinal Reinf. #4 at 24" C-C
Transv. Reinf. #4 at 20" C-C
1=Thickness of Jointed Pavement
Permissible Construction Joint
T=Thickness of Continuous Pavement
PAVEMENT TERMINUS DETAIL FOR JUNCTURE WITH EXISTING JOINTED TYPE CONCRETE PAVEMENT STRUCTURE

Figure 9

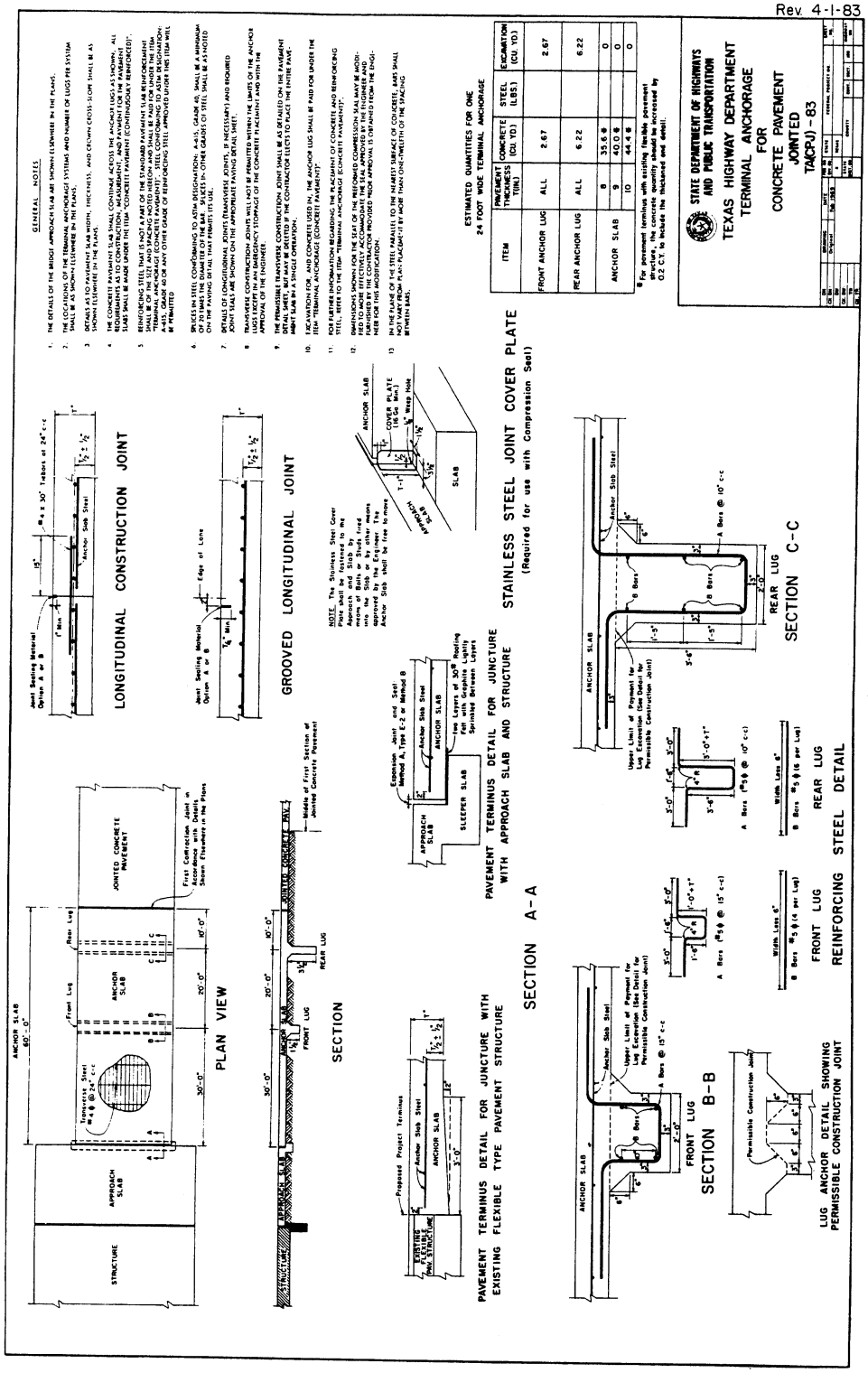

Rev. 4-1-83
GENERAL NOTES
LONGITUDINAL CONSTRUCTION JOINT
GROOVED LONGITUDINAL JOINT
STAINLESS STEEL JOINT COVER PLATE
(Required for use with Compression Seal)
ESTIMATED QUANTITIES FOR ONE
24 FOOT WIDE TERMINAL ANCHORAGE
ITEM | PAVEMENT THICKNESS (IN.) | CONCRETE (CU. YD.) | STEEL (LBS.) | EXCAVATION (CU. YD.)
FRONT ANCHOR LUG | ALL | 2.67 | | 2.67
REAR ANCHOR LUG | ALL | 6.22 | | 6.22
ANCHOR SLAB | 8 | 35.6 | 0 |
9 | 40.0 | 0 |
10 | 44.4 | 0 |
For pavement tie-ins with existing flexible pavement structure, the concrete quantity should be increased by 0.2 C.Y. to include the thickened end detail.
STATE DEPARTMENT OF HIGHWAYS AND PUBLIC TRANSPORTATION
TEXAS HIGHWAY DEPARTMENT
TERMINAL ANCHORAGE FOR CONCRETE PAVEMENT JOINTED
TA(CPJ)-83
PLAN VIEW
SECTION
PAVEMENT TERMINUS DETAIL FOR JUNCTURE WITH EXISTING FLEXIBLE TYPE PAVEMENT STRUCTURE
SECTION A-A
PAVEMENT TERMINUS DETAIL FOR JUNCTURE WITH APPROACH SLAB AND STRUCTURE
SECTION B-B
FRONT LUG
REAR LUG
SECTION C-C
LUG ANCHOR DETAIL SHOWING PERMISSIBLE CONSTRUCTION JOINT
REINFORCING STEEL DETAIL

Figure 10

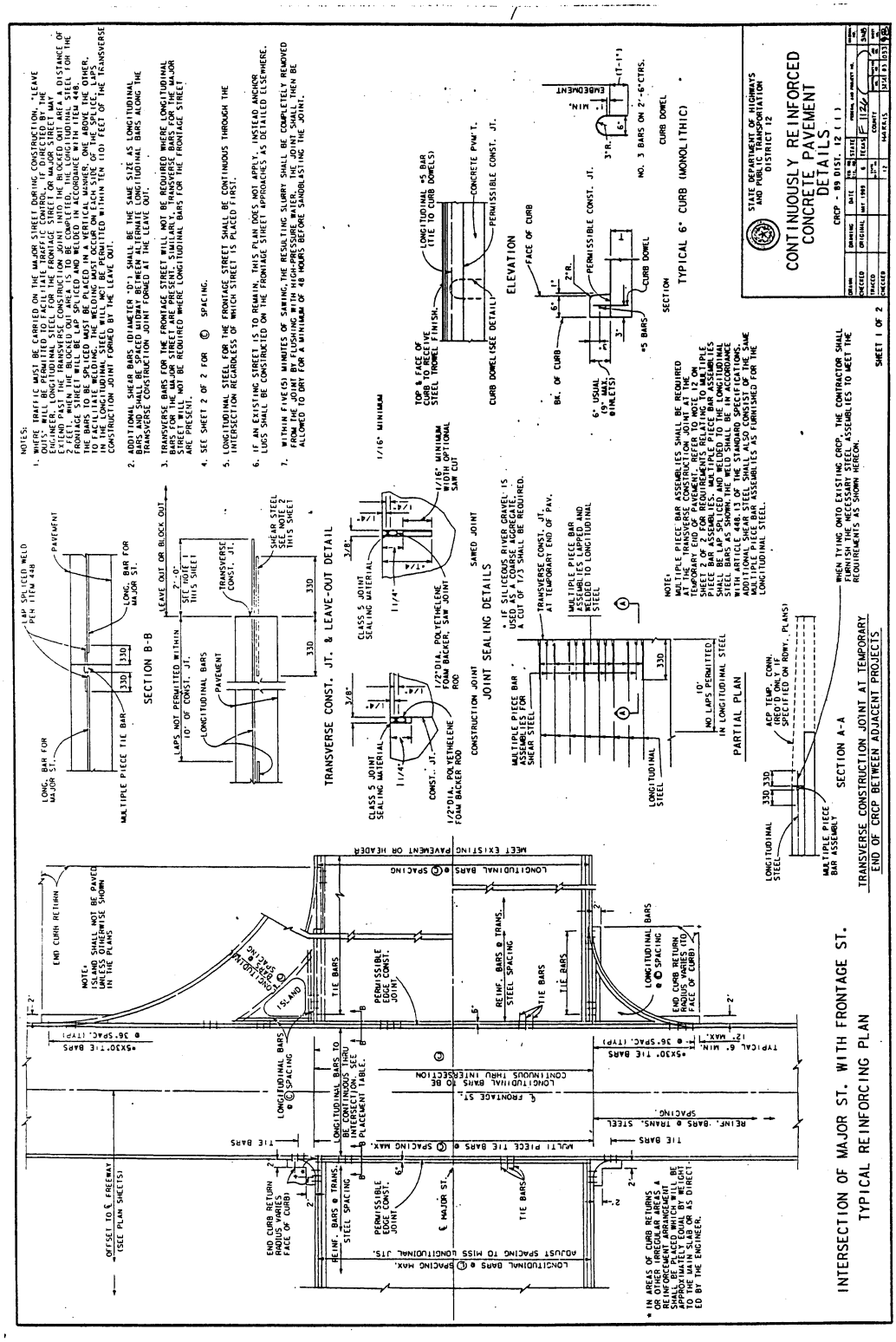

CONTINUOUSLY REINFORCED CONCRETE PAVEMENT DETAILS
CRCP - 89 DIST. 12 (1)
STATE DEPARTMENT OF HIGHWAYS AND PUBLIC TRANSPORTATION DISTRICT 12
NOTES:
SECTION B-B
TRANSVERSE CONST. JT. & LEAVE-OUT DETAIL
JOINT SEALING DETAILS
ELEVATION
SECTION
TYPICAL 6" CURB (MONOLITHIC)
PARTIAL PLAN
SECTION A-A
INTERSECTION OF MAJOR ST. WITH FRONTAGE ST.
TYPICAL REINFORCING PLAN
TRANSVERSE CONSTRUCTION JOINT AT TEMPORARY END OF CRCP BETWEEN ADJACENT PROJECTS
SHEET 1 OF 2

Figure 11

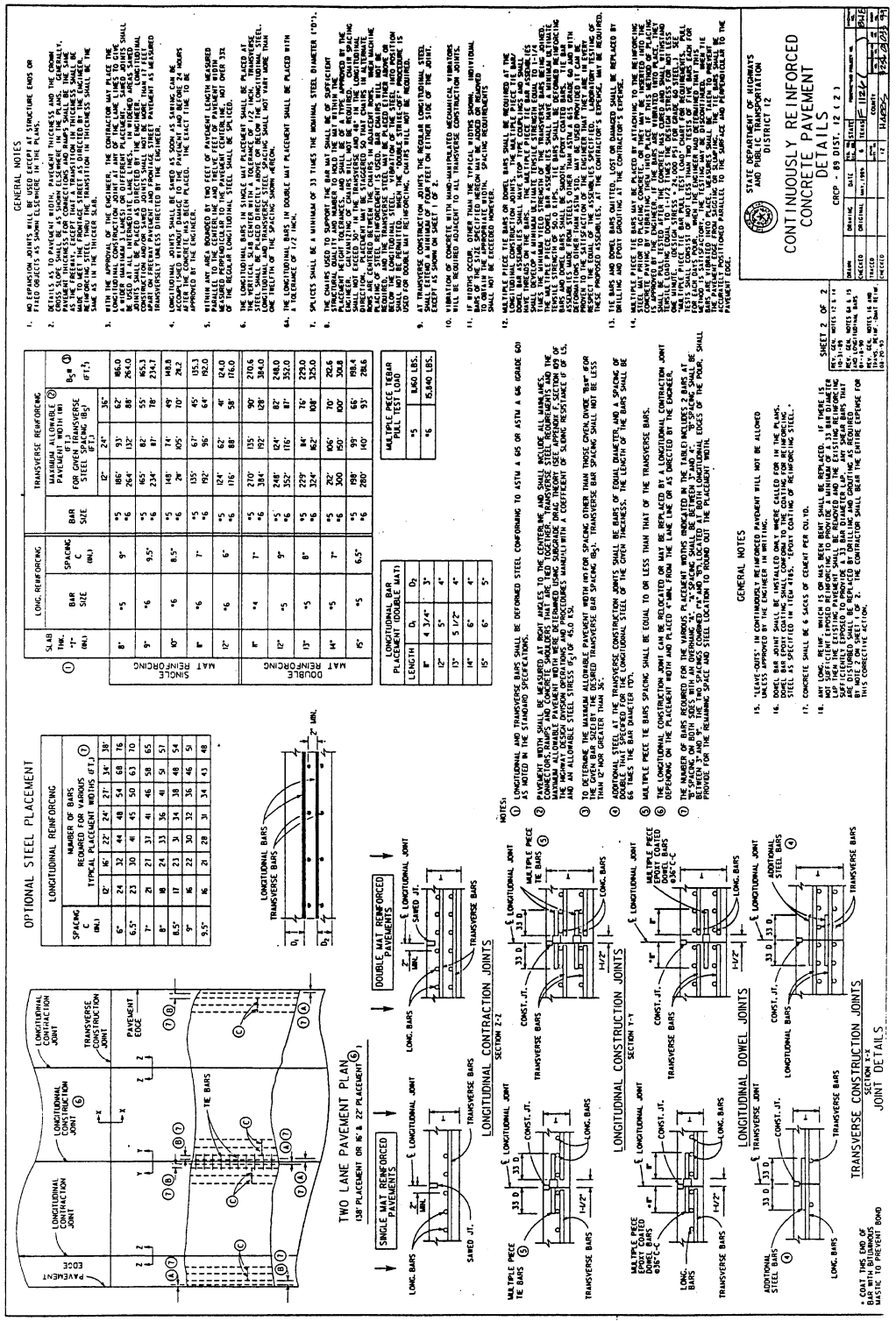


Figure 11 (continued)

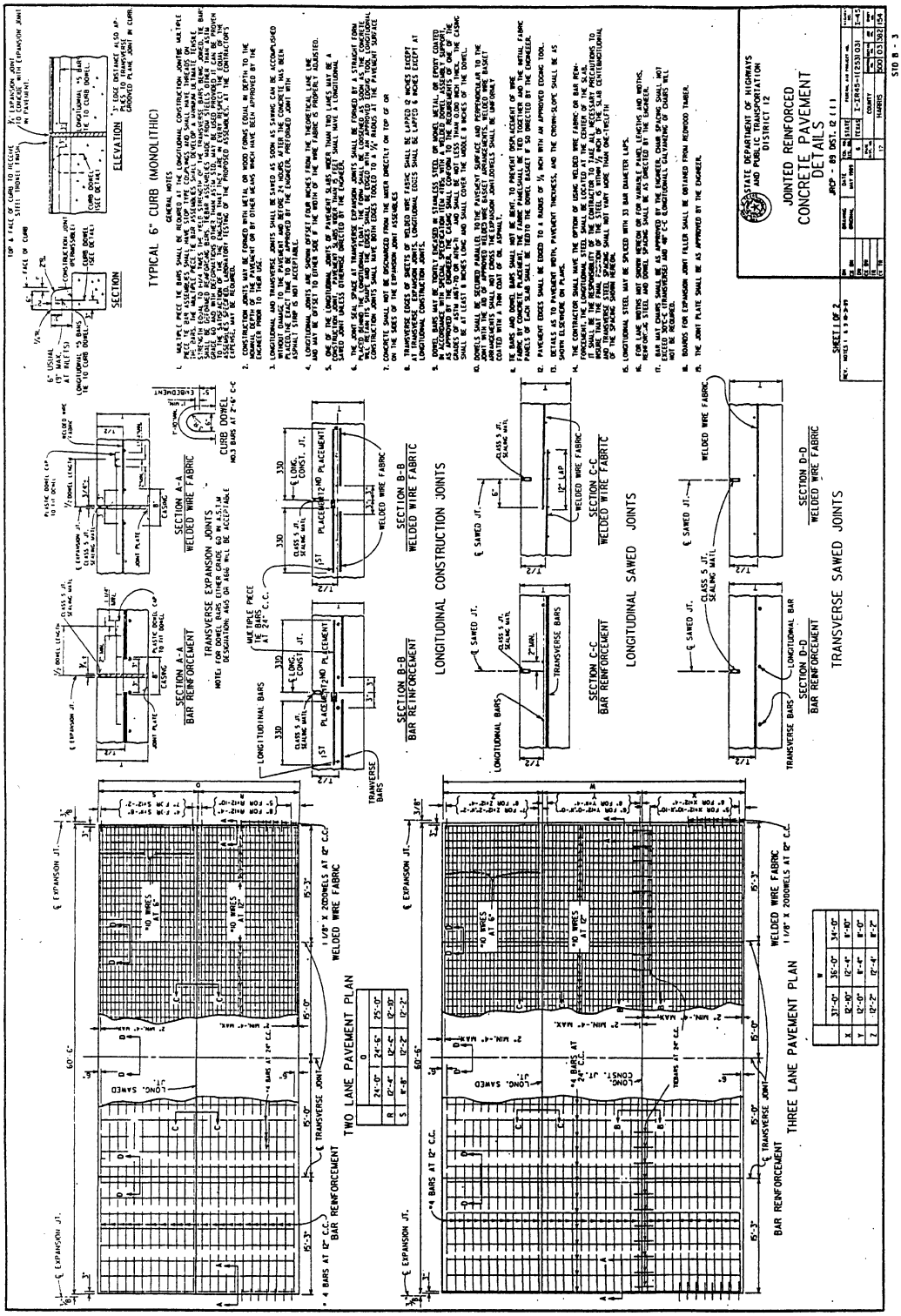

TYPICAL 6" CURB (MONOLITHIC)
GENERAL NOTES
SECTION
ELEVATION
SECTION A-A
BAR REINFORCEMENT
TRANSVERSE EXPANSION JOINTS
WELDED WIRE FABRIC
CURB DOWEL
SECTION B-B
BAR REINFORCEMENT
SECTION B-B
WELDED WIRE FABRIC
LONGITUDINAL CONSTRUCTION JOINTS
SECTION C-C
BAR REINFORCEMENT
SECTION C-C
WELDED WIRE FABRIC
LONGITUDINAL SAWED JOINTS
SECTION D-D
BAR REINFORCEMENT
SECTION D-D
WELDED WIRE FABRIC
TRANSVERSE SAWED JOINTS
TWO LANE PAVEMENT PLAN
BAR REINFORCEMENT
WELDED WIRE FABRIC
THREE LANE PAVEMENT PLAN
BAR REINFORCEMENT
WELDED WIRE FABRIC
STATE DEPARTMENT OF HIGHWAYS AND PUBLIC TRANSPORTATION DISTRICT 12
JOINTED REINFORCED CONCRETE PAVEMENT DETAILS
JRCP - 69 DIST. 12 (1)
SHEET 1 OF 2 SHEETS
STD B - 3

Figure 12

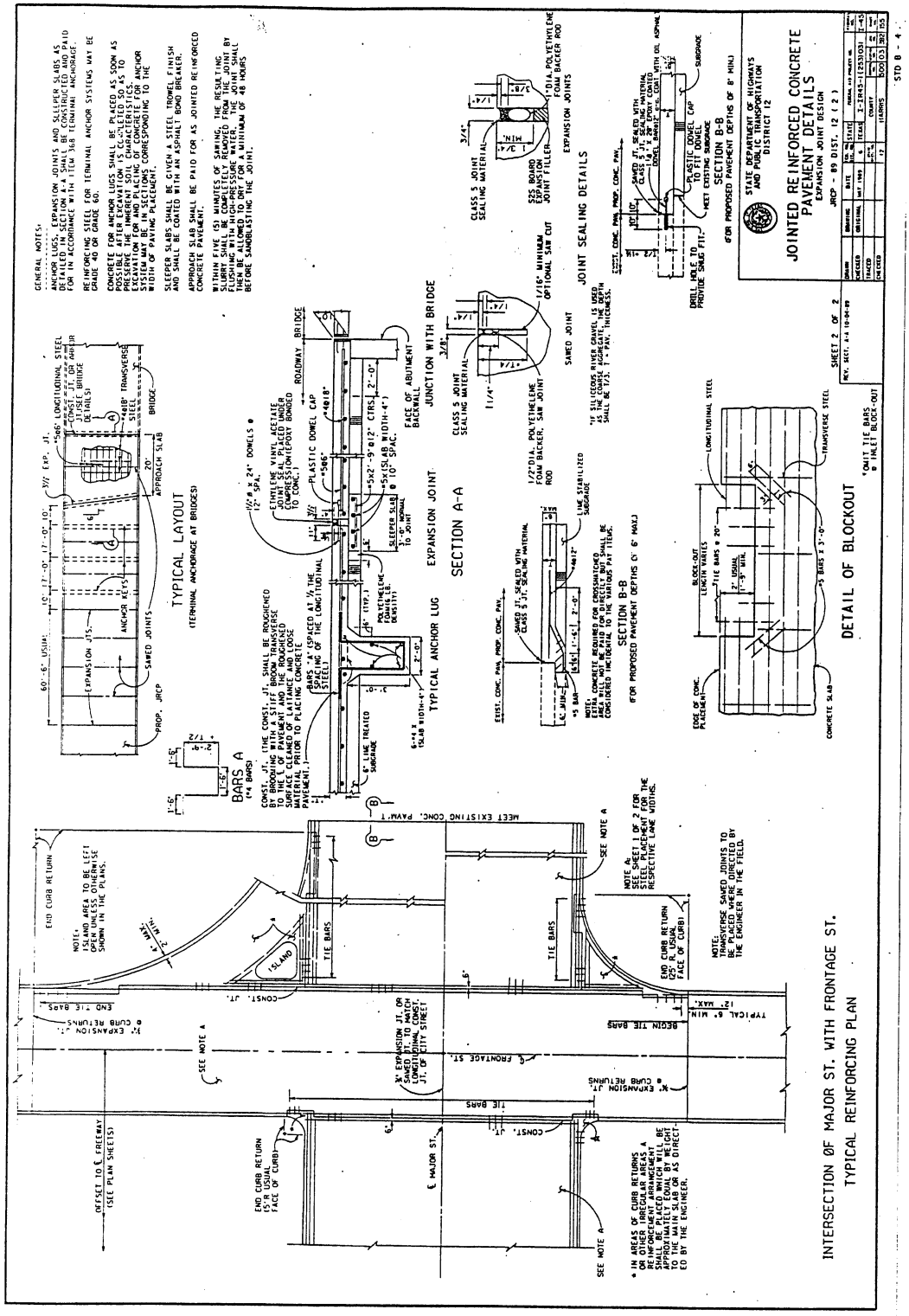


Figure 12 (continued)

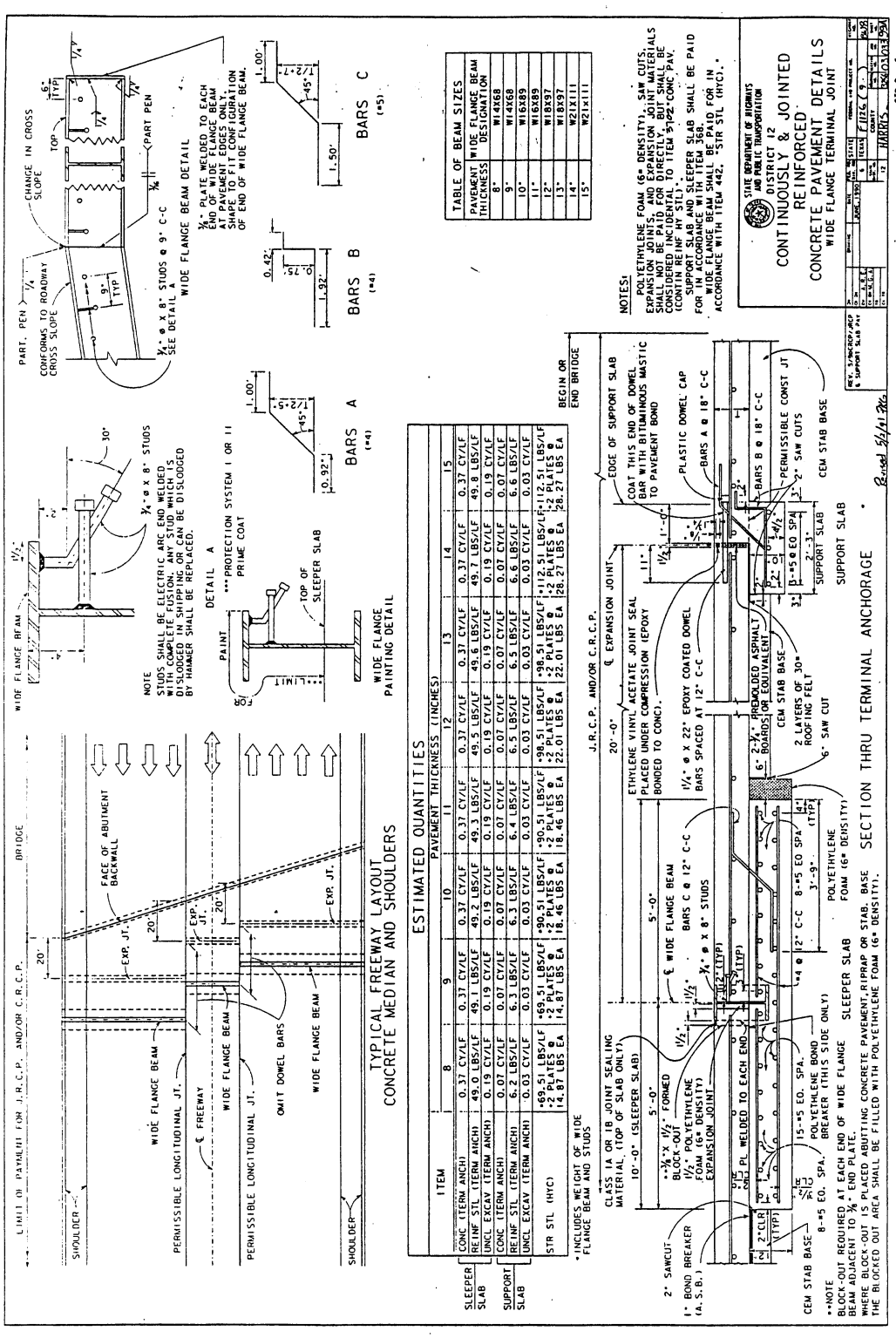
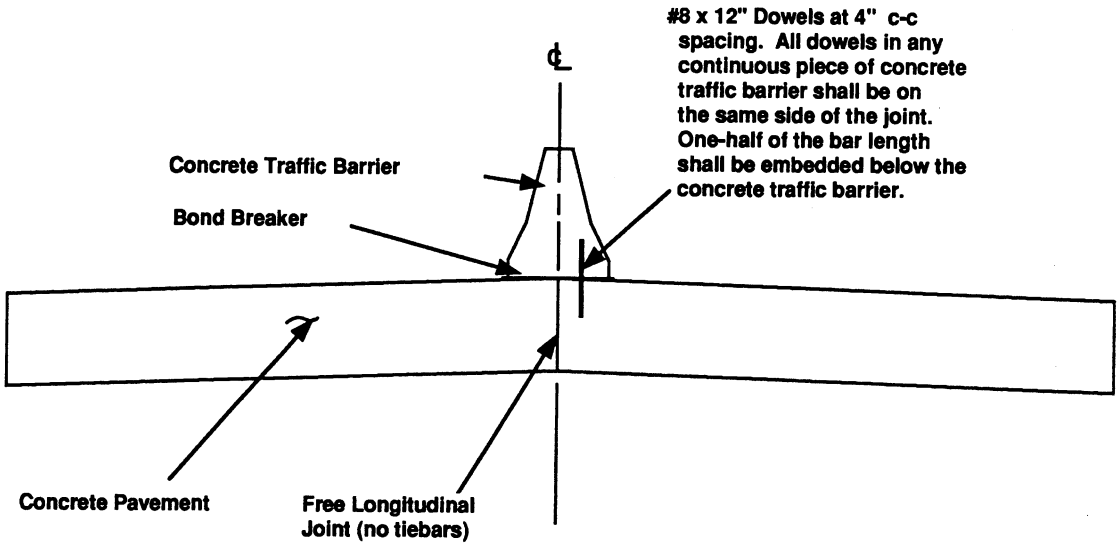

TYPICAL FREEWAY LAYOUT
CONCRETE MEDIAN AND SHOULDERS
ESTIMATED QUANTITIES
PAVEMENT THICKNESS (INCHES)
WIDE FLANGE BEAM DETAIL
WIDE FLANGE PAINTING DETAIL
SECTION THRU TERMINAL ANCHORAGE
TABLE OF BEAM SIZES
NOTES:
CONTINUOUSLY & JOINTED REINFORCED CONCRETE PAVEMENT DETAILS
WIDE FLANGE TERMINAL JOINT

Figure 13



SUGGESTED FREE LONGITUDINAL JOINT DETAIL UNDER A CAST-IN-PLACE CONCRETE TRAFFIC BARRIER

Figure 14

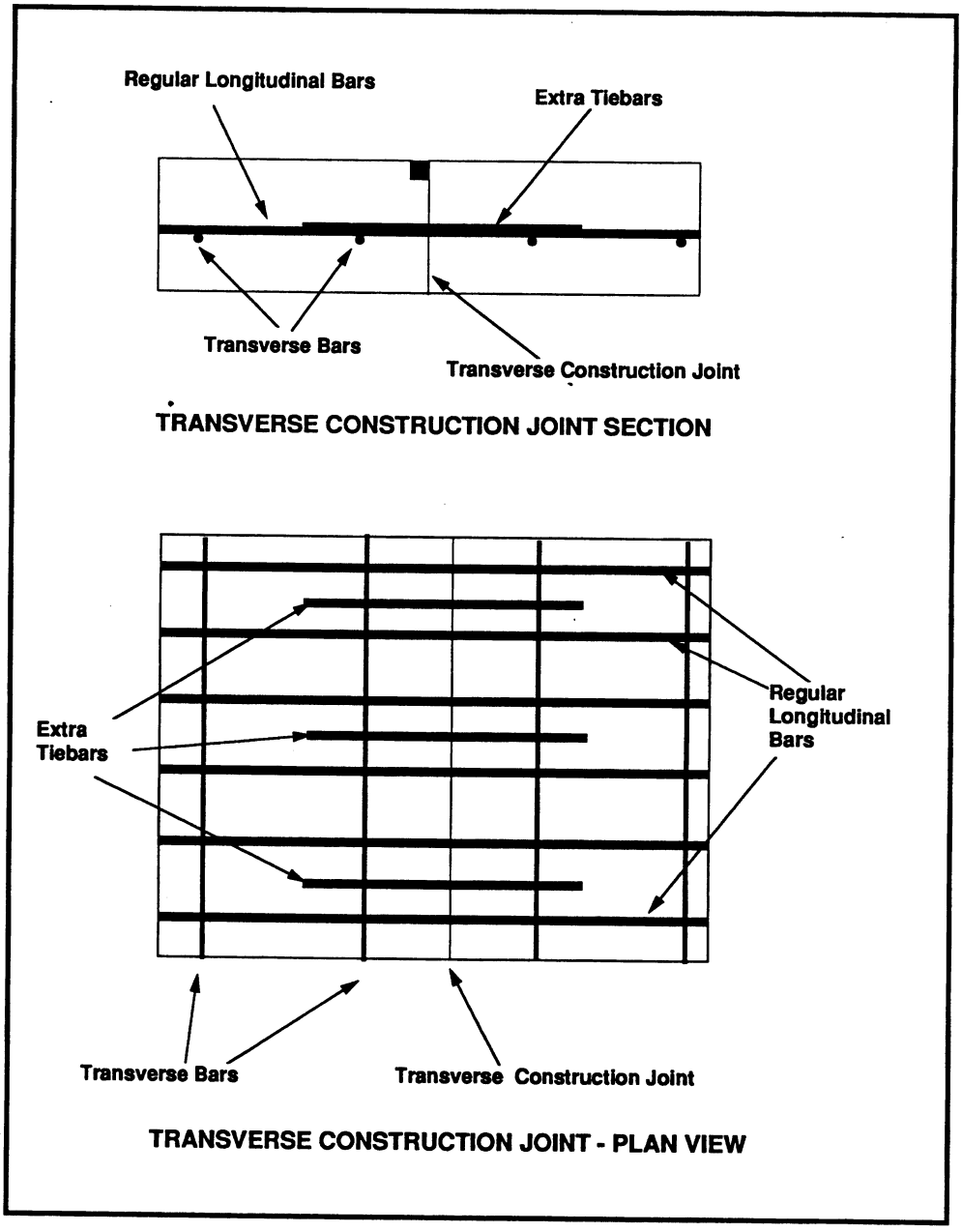

Regular Longitudinal Bars
Extra Tiebars
Transverse Bars
Transverse Construction Joint
TRANSVERSE CONSTRUCTION JOINT SECTION
Extra
Tiebars
Regular
Longitudinal
Bars
Transverse Bars
Transverse Construction Joint
TRANSVERSE CONSTRUCTION JOINT - PLAN VIEW

Figure 15