Concrete parking lots

Design, Construction Procedures and Specifications

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Design and Construction of Concrete Parking Lots

Foreword

Most people agree that the parking lot for a building is becoming an increasingly important part of the total site development. No longer can responsible businessmen afford to consider the parking lot as an afterthought to be built with leftover funds.

The inherent value of quality concrete parking lots becomes evident when examined in the broad context of a building's construction and financing. Advantages to the building owner include competitive first cost, faster construction, lower maintenance and life-cycle cost, prestigious appearance, increased resale value, resistance to gasoline and oil spills, stability under heat — does not become sticky or fluid — no oil or tar tracked into cars and buildings, benefit to the environment — cooler pavement and improved lighting efficiency. To achieve these benefits for the owner and user, it is important to follow some basic cost-saving guidelines set forth in this publication.

Whitetopping

Whitetopping is a technique for placing concrete overlays directly on existing asphalt pavements. When an asphalt pavement is badly cracked, full of potholes or rutted from heavy loads, it can be whitetopped. When whitetopping a deteriorated asphalt pavement, only minor repair of the existing surface is necessary (i.e. filling in large potholes with flowable fill or compacted sand). For whitetopping design, the last two columns of Table 3 (k=500) are used. Other than that, the same design and construction procedures of normal concrete pavement apply.

Preparation and Layout

The performance of a concrete pavement will reflect that of the material below it. Typically, the native soils in Florida provide an excellent subgrade for concrete parking lots and as a rule, do not require the extensive stabilization or special bases or subbases commonly used with flexible pavements. Nationally recognized design procedures for concrete pavements provide for soil modulus values as low as k=50, which corresponds to a Limerock Bearing Ratio (LBR) of 2.5. This is very low when compared to subgrades and bases for flexible pavements where LBRs of 40 and 100 are required. Even what is considered a very high modulus of subgrade reaction of k=300 (LBR=32) for concrete isn't as high as the lowest values needed for flexible pavements. In fact, the stabilization provided by the commonly used fine-grained materials such as clay, marl and limerock are counterproductive to the performance of concrete pavements, as they tend to trap water underneath the pavement rather than allowing it to drain away. The entrapment of water and the presence of fine materials under the pavement are two of the three ingredients necessary to produce mud-pumping, a potentially damaging effect on pavements. The third ingredient is heavy truck traffic.

Even though high support values are not required with concrete pavements, it is important that the *soil type, moisture content and density* of the subgrade be **uniform**. This includes leveling and recompacting tire ruts that occur during the placing operation so that the concrete placed will be uniform in thickness and subgrade support. Replace and/or crosshaul (blend) non-uniform subgrade areas with materials to assure uniformity of the subgrade soils. Compaction, when necessary, should be performed when the moisture content of the soil is slightly above its optimum (1-3%). Density need only be 95% of the American Association of State Highway and Transportation Officials (AASHTO) T-99 or the American Society for Testing and Materials (ASTM) D 698 (Standard Proctor).

Utility trenches, inlets and manholes should be backfilled with flowable fill to prevent differential settlement and loss of subgrade support. Flowable fill is a unique, very fluid backfill material delivered in a ready-mix truck that flows into place, sets up and can be driven on or paved over the next day. It does not settle after initial set, and yet can easily be excavated with conventional equipment in case of the need for repair or re-excavation. Economically, it is comparable to or below the cost of properly compacted, conventional backfill. If conventional backfill is used, it must be compacted in 6- to 12-inch maximum lifts with appropriate mechanical equipment and verified by density testing.

Materials and Proportioning

Quality concrete is a process. It starts with a correct mix design using proper materials. Make sure that all materials used in the mix are of consistently high quality. When using ready-mixed concrete for reasons of economy, utilize the ready-mix producer's standard mix designs. In most instances these standard mixed have been tested over time and backed by field data and are thus usually acceptable and readily approved.

Compressive strength is the basic indicator of concrete quality, is the universally understood property, and as such, should be the method of concrete specification. For parking lots in Florida's mild climate, a specified compressive strength of at least 3500 psi is recommended. If a higher degree of durability and wear resistance are desired, 4,000 psi can be specified. Economy in using the higher strength may be

achieved in a possible reduction in thickness - see design charts (Table 3).

A nominal amount of air entrainment is recommended for concrete pavements in Florida in the range of 1% to 6% as recommended by ASTM C 94 and the Florida Department of Transportation (FDOT) Standard Specifications for Road and Bridge Construction Section 346 (normally at the lower end; particularly when utilizing fly ash mixes). In addition to providing increased durability, air entrainment enhances workability and reduces the amount of bleed-water. If high concentrations of soil sulfates are encountered, Type II or Type IP cement should be specified or a portion of the cement should be substituted with fly ash or ground iron blast-furnace slag. ACI 201.2R provides further information in this regard.

Early consultation with the ready-mix concrete supplier will help in selecting a mix design that is economical as well as appropriate for the area in which the pavement will be used.

Pavement Thickness

The thickness of the concrete parking lot is determined according to:

1. The support of the subgrade on which it is built.
2. The strength of the concrete used.
3. The amount and kind of traffic loading that it will receive.

Subgrade Thickness

The thickness design table for this publication is based on a Westergaard's Modulus (k) of 200 for compacted subgrades. Florida's predominant A-2 and A-3 provide support in the k=200-250 range with little compactive effort (95% of AASHTO T-99 or ASTM D 698). It is therefore conservative to utilize k=200 for these soils. Clays and silts are usually in the k=50-100 ranges and may need light stabilization. It is important to retain the drainage characteristics of the subgrade i.e. do not bind it up with stabilization materials that will not allow water that gets under the pavement to percolate downward into the soil.

For whitetopping, (overlaying of existing asphalt with concrete) thickness is based on a k=500. The general relationship of the different soil support indicators is given in Table 1.

Table 1. Appropriate Relationship of Various Subgrade Support Values

k[1], pci	50	100	200	300	500
LBR[2]	2.5	3.7	12.5	32	62
CBR[3]	2	3	10	28	50
SSV[4]	2	2.6	4.3	5.7	6.6

Ref. 1,3,4,5,8,10

Notes:
1. Westergaard's Modulus of Subgrade Reaction.
2. Limerock Bearing Ratio.
3. California Bearing Ratio.
4. Soil Support Value-includes a 2.5 safety Factor for FDOT (tested Value minus 2.5). Florida Bearing Values (FBV) have no relationship to k-values and are not recommended for use in pavement design.

Concrete Strength

The concrete property used in pavement design is flexural strength or Modulus of Rupture (M_R). Test data on this is not usually available. However, in the absence of flexural strength data, the following conservative relationship to compressive strength of Table 2 can be utilized.

Table 2. Compressive Strength (f'_c) vs. Flexural Strength (M_R)
Ref. 3,4,5,8,10

f'_c, psi	M_R, psi
3,000	500
3,500	550
4,000	600

Traffic Loading

Pavement thickness design is determined by the amount of vehicles and axle loadings- particularly truck loads. Table 3 was generated utilizing AASHTO Design Guide that is the procedure used by the FDOT for pavement design. A safety factor of 2.0 times the number of axle loads (80% reliability) was used in establishing Table 3.

Truck counts or average daily truck traffic, ADTT and type of trucks are usually obtained from the owner or planner. Guidelines for minimum truck loadings are given in Table 4.

Table 3. 20-Year Design Thickness Recommendations [1]

ADTT[2,3,4]	Compacted Subgrade (k=200)[5]		Whitetopping (k=500)	
	3,500 psi (M_R=550)	4,000 psi (M_R=600)	3,500 psi (M_R=550)	4,000 psi (M_R=600)
0	4.0	4.0	3.0	3.0
50	4.5	4.0	3.5	3.5
130	5.0	4.5	3.5	3.5
200	5.5	5.0	4.0	4.0
300	6.5	6.0	5.0	5.0
450	6.5	6.0	5.5	5.0
650	7.0	6.5	6.0	5.5
900	7.5	7.0	6.5	6.0

1. Thickness recommendations are based on supported edges where load transfer is provided across the joints - i.e. contraction joints, tied joints and keyed construction joints. For butt joints, thickened edges as shown in Fig. 1, Type C-1 or increase pavement thickness by 0.5 inches for pavements equal to or less than 6 inches thick and 1.0 inch for pavements more than 6 inches thick. No thickening necessary when ADTT = 0.
2. ADTT = Average Daily Truck Traffic. Trucks are defined as vehicles with at least six wheels; excludes panel trucks, pick-up trucks and other four-wheel vehicles.
3. Two-way traffic and moderate truck loadings indicated – i.e. collector street loading as defined in Ref. (11).
4. For more than 900 trucks per day use FC&PA's "Design and Construction of Concrete Pavement Manual." (Ref. 11.)
5. For pavement on a compacted subgrade of k=100 add 0.5 inches to thicknesses for k=200. No thickening necessary when ADTT = 0.

Table 4. Suggested Minimum Design ADTT for Parking Lots

(Unless actual truck counts exceed those shown)

Parking Lot Traffic Type	ADTT
Light Commercial:	
Auto parking lots and access lanes	0
Medium traffic lanes	50
Major traffic lanes and entrances	130
Truck entrances and loading areas	200
Buses (City and School):	
Parking lots and access lanes	130
Major traffic lanes and entrances	200
Industrial/Commercial:	
Single Unit Trucks	
Parking lots and access lanes	200
Major traffic lanes and entrances	300
Multiple Unit Trucks	
Parking lots and access lanes	300
Major traffic lanes and entrances	450

Once established, enter Table 3 with the design ADTT and select the thickness under the appropriate column heading on the right-compacted subgrade or whitetopping - 3,500 psi or 4,000 psi concrete. Notice that Table 3 is based on a subgrade support of k=200. However, footnote 5 provides for the use of a compacted subgrade with a k of 100 by increasing the pavement thickness by 1/2 inch.

A thickened edge is recommended on slabs that will be subjected to wheel loads near the edges or unsupported edges that will be crossed by traffic at the interior of the parking lot i.e. butt-jointed construction joints (Fig. 2, Type C-1) or un-doweled isolation joints (Fig. 1, Type D). At the perimeter, edge strengthening is best accomplished by using an integral curb or the edge may be thickened (Fig. 1). Fill material should be compacted behind the curb or thickened edge to minimize lateral movement of the outside slabs. Thickened sidewalk edges also should be utilized for step-up curbs that will serve as a wheel stop for parking. (Fig. 1)

By designating truck lanes on the plans, the use of different thickness for different traffic loadings can be utilized. Depending upon the degree of difference in the loading and size of area involved, the amount of savings could be significant. (Fig. 2)

Jointing

Joints in concrete parking lots aid construction, control the location and spread of cracks, and preclude the need for distributed steel reinforcement. They can also be used to delineate parking areas and traffic lanes. Laying out joints in a slab requires engineering judgment based on a few basic rules. Fig. 2 shows an idealized parking lot that employs the guidelines listed below.

Table 5. Recommended Maximum Joint Spacings

Pavement Thickness (in.)	Joint Spacing (ft)
3.0 (For whitetopping ONLY)	6
4.0	10
4.5	10
5.0	12
5.5	12
6.0	15
Over 6.0	15

Unless local experience indicates otherwise:

- Joint spacing should not exceed the spacings in Table 5 e.g. 10x10 ft for a 4 in. slab thickness. Regardless of slab thickness, joint spacing should not exceed 15 ft in order to maintain aggregate interlock and facilitate load transfer.
- Start the joint layout at obstacles such as manholes, inlets, islands, cutouts, entrance radius returns, channelization tapers etc. and then place joints between at equal increments not to exceed the joint spacing indicated in Table 5.
- The contraction joint pattern should divide the pavement into panels that are approximately square. When this is not practical, rectangular panels can be used if the long dimension is no more than 1.25 times the short e.g. 8x10 ft for a 4 in. slab.
- Joints should run continuously and extend through integral curbs. Joints can be terminated in the interior of a parking lot and offset at isolation joints, although this practice should be avoided wherever possible.
- Adjust jointing layout or location of manholes, catch basins, small foundations, and other built-in structures so that the joints will line up with the corners of the structures.
- Avoid acute angles or small pieces of slab at curves. Offsets should be at least 12-18 inches.
- When sawing contraction joints, use an early-entry dry-cutting saw machine and begin as soon as possible without raveling the new concrete, typically 2 to 8 hours after placement of the concrete depending on set time and weather conditions.
- Construction joint location should be determined by the contractor based on his equipment and procedures. (See Fig. 1, Type C.)
- When ADTT exceeds 24 and in curves with radiuses of 150 ft or less, # 4 - 30 in. tie bars spaced at 30 in. on center should be placed in the first longitudinal joint from the pavement edge to minimize slab separation. Tie bars should not be placed within 15 inches of transverse joints. Tie bars are not necessary in the interior joints as movement of those slabs is restricted by the surrounding slabs.
- Doweled joints are generally not utilized in parking lots in Florida except for isolation joints crossed by heavy truck traffic – pavements 7 inches or thicker. (See Fig. 1, Type D-1)
- Contraction joints are not normally sealed if short joint spacing as recommended herein is utilized. When used, follow joint sealant manufacturer recommendations for the depth and width dimensions. Isolation joints should be sealed.
- Isolation joint materials should extend the full depth of slab and should be used only to isolate fixed objects abutting or within the paved area.

Construction Practices

Many types of equipment are available for paving parking lots, from simple hand or mechanical screeds and floats to sophisticated laser or slipform paving equipment. The choice of construction methods should be made by the contractor based on project size and available equipment. Once the type of equipment has been selected, a paving sequence and jointing plan should be developed to assure smooth operations. On small jobs, the sequence of placing concrete is not critical, but on larger projects it is usually best to place concrete in alternate lanes. Where feasible, a small key should be used in pavements 6 inches thick and over to provide load transfer at these longitudinal joints. (See Fig. 1, Type C.)

Other procedures that will ensure quality paving are:

- Use FC&PA or ACI Certified Finishers. Contact FC&PA for list of preferred finishers.
- Keep subgrade moist, without any free-standing water, at time of concrete placement.
- Slope concrete pavement 1% or 1/8 in. per foot for positive drainage.
- Generally, the most efficient way of placing concrete is to place it in strips. This permits access to the sections being placed and sawed joints are cut transversely to the length. A checkerboard sequence is not recommended as it is not cost effective and because of the slow rate at which shrinkage occurs (about 1 year to achieve 90%), it is ineffective in reducing joint widths.
- Avoid over finishing slabs. Generally a bull-float finish and broomed or burlap texture is adequate.
- The use of jitterbugs and hand or power trowels is not necessary for parking lots and is not recommended as their use may result in scaling.
- The use of a visqueen vapor barrier under the pavement is unnecessary and is not recommended.
- The use of distributed steel reinforcement (wire mesh) is not recommended. According to the American Concrete Institute (ACI) 330, "the sole function of the distributed steel reinforcement is to hold together the fracture faces if cracks should form." Instead use synthetic fibers to minimize plastic shrinkage and bleed water and improve workability.
- Cure fresh concrete immediately. Proper curing of the concrete enhances the strength and durability by as much as 25-30%. A pigmented liquid membrane curing compound applied in a timely manner is usually recommended as the most cost-effective curing agent.
- Keep traffic off the slab until the concrete has gained adequate strength - normally 3 days for automobile traffic and 7 days for other traffic. If shorter opening times are required, fast track (accelerated strength gain) procedures are available that will allow opening to traffic anywhere from 7 days to 6 hours after concrete placement.

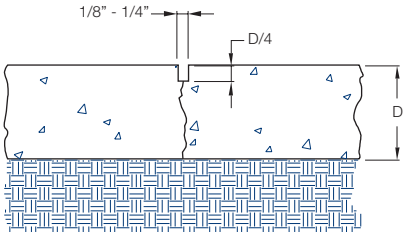
Portland Cement Pervious Pavement

Portland Cement Pervious Pavement is a material that allows water to flow through the pavement providing storage within the pavement structure and recharges the aquifer directly. It is ideally suited for parking lots where storm water retention ponds are not feasible due to site constrictions or economics. For further information on Portland Cement Pervious Pavements, contact the Florida Concrete and Products Association or your local ready-mix supplier.

**Special Note: This information is intended to be used by the design professional competent to evaluate its significance and limitation and who will accept the responsibility for its proper application. The Florida Concrete and Products Association disclaims any and all responsibility for any other use of the information supplied herein.

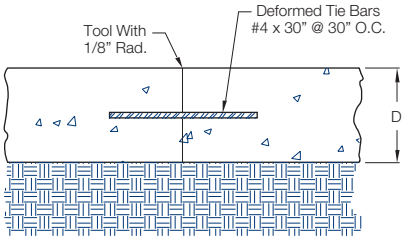
Key References

1. "AASHTO Guide for Design of Pavement Structures," American Association of State Highway and Transportation Officials, Washington, DC.
2. "Design of Concrete Overlays of Asphalt Parking Lots (Whitetopping)," PA 153, Portland Cement Association, Skokie, IL.
3. "Guide for Design and Construction of Concrete Parking Lots," ACI 330, American Concrete Institute, Detroit, MI, 1997.
4. "Hot Weather Concrete in Florida," Concrete Materials Engineering Council, Orlando, FL.
5. "Portland Cement Pervious Pavement Manual," Florida Concrete and Products Association, Orlando, FL.
6. "Ready-Mixed Flowable Fill," National Ready Mixed Concrete Association, Silver Springs, MD.
7. "Think Concrete - When You Think About Parking," Florida Concrete and Products Association, Orlando, FL.
8. "Utility Cuts & Full Depth Repairs in Concrete Streets," IS235, Portland Cement Association, Skokie, IL.
9. "What, Why & How? Flowable Fill," National Ready Mixed Concrete Association, Silver Springs, MD.
10. "Whitetopping an Asphalt Parking Lot," PA 152, Portland Cement Association, Skokie, IL.
11. "Design and Construction of Concrete Pavement Manual," Florida Concrete and Products Association, Orlando, FL.



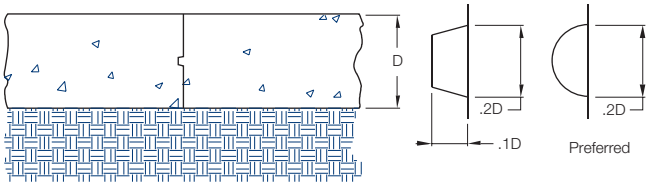
Type "A" Undoweled Contraction (Control) Joint

Undoweled Transverse Contraction or Longitudinal Joint, Sawed or Pre-molded. Do Not Dowel Pavements Less Than 7" Thick.



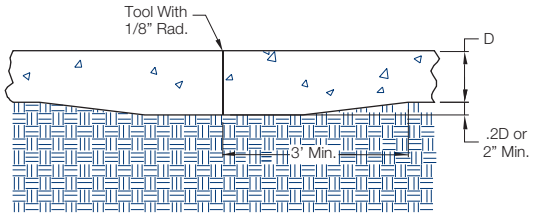
Type "B" Tied Joint

Tied Longitudinal Construction or Contraction Joint Where Required. Do Not Tie More Than Three Lanes Together.



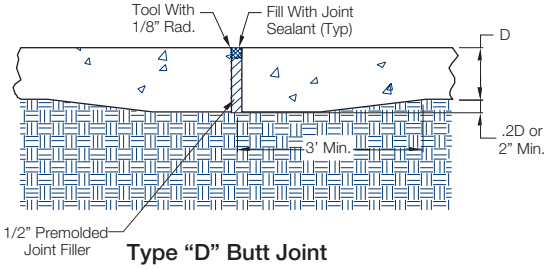
Type "C" Construction Joint

Longitudinal Keyway Construction Joint For Pavement 6 Inches or Greater. Type C-1 Straight Butt Type Joint Used For Pavements Less Than 6 Inches.



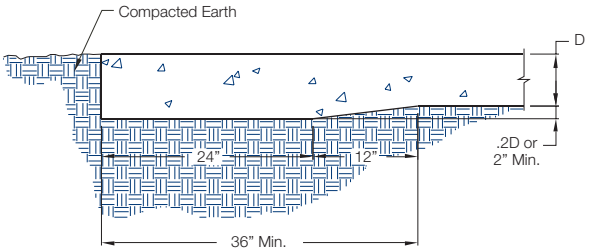
Type "C-1" Butt Joint

In Lieu of Thickening Edges, Overall Pavement Thickness May Be Increased as Follows: 6 Inches or Less, Add 0.5 Inch. More Than 6 Inches, Add 1 Inch.

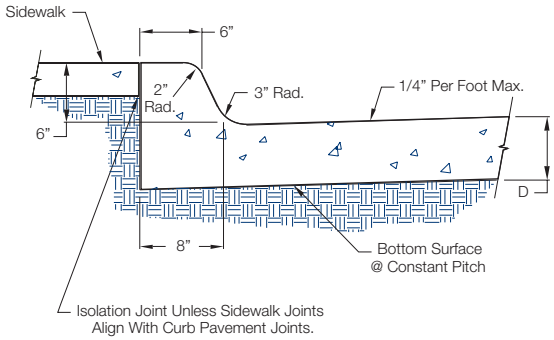


Type "D" Butt Joint

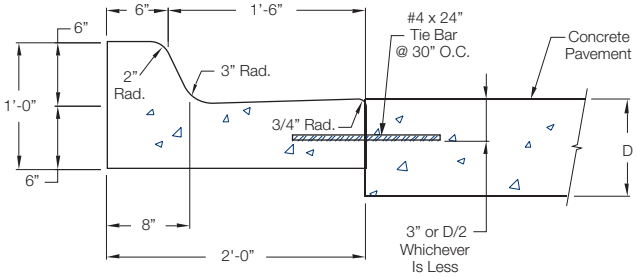
Isolation Joint For Pavements Less Than 8 Inches Thick.



Thickened Edge

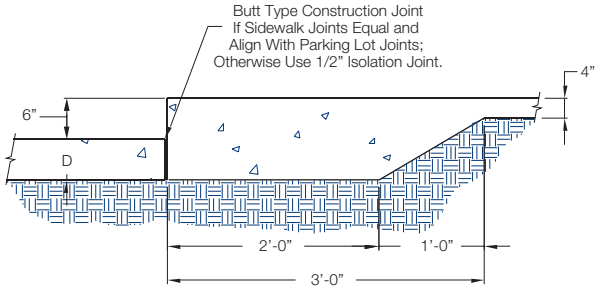


Integral Curb



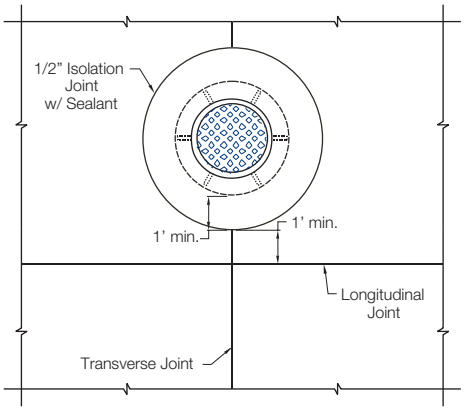
Tied Curb

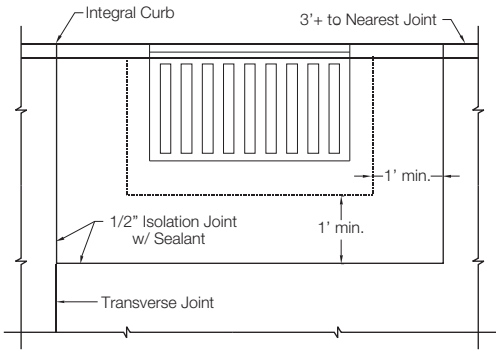
Type F, FDOT Curb Shown, Other Type May Be Used With The Same Tie Bar Configuration.

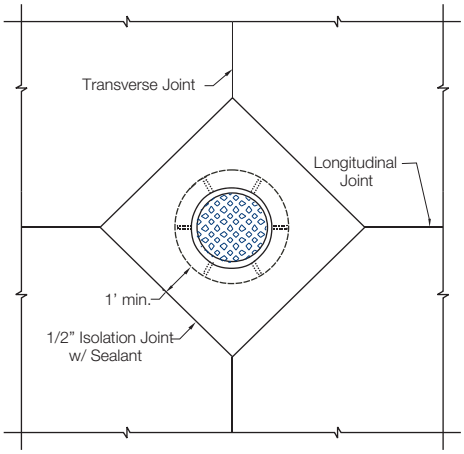


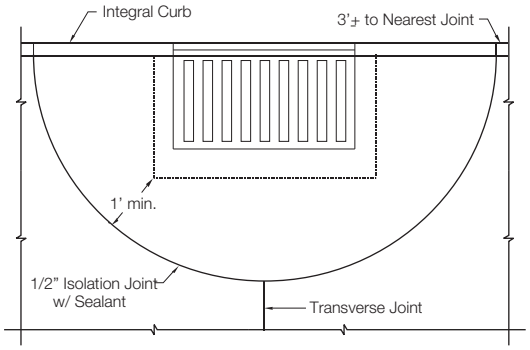
Sidewalk/Curb

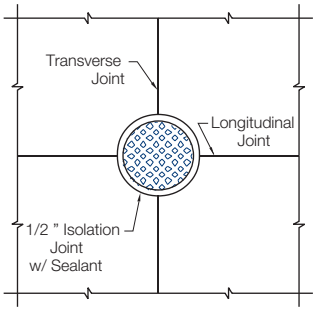
Note: For a digital AutoCAD,® contact FC&PA.

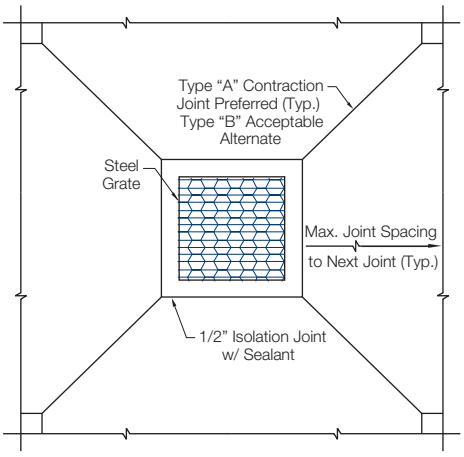




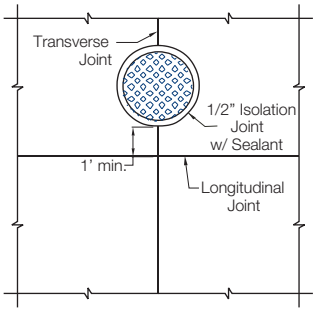








Joints at Inlet

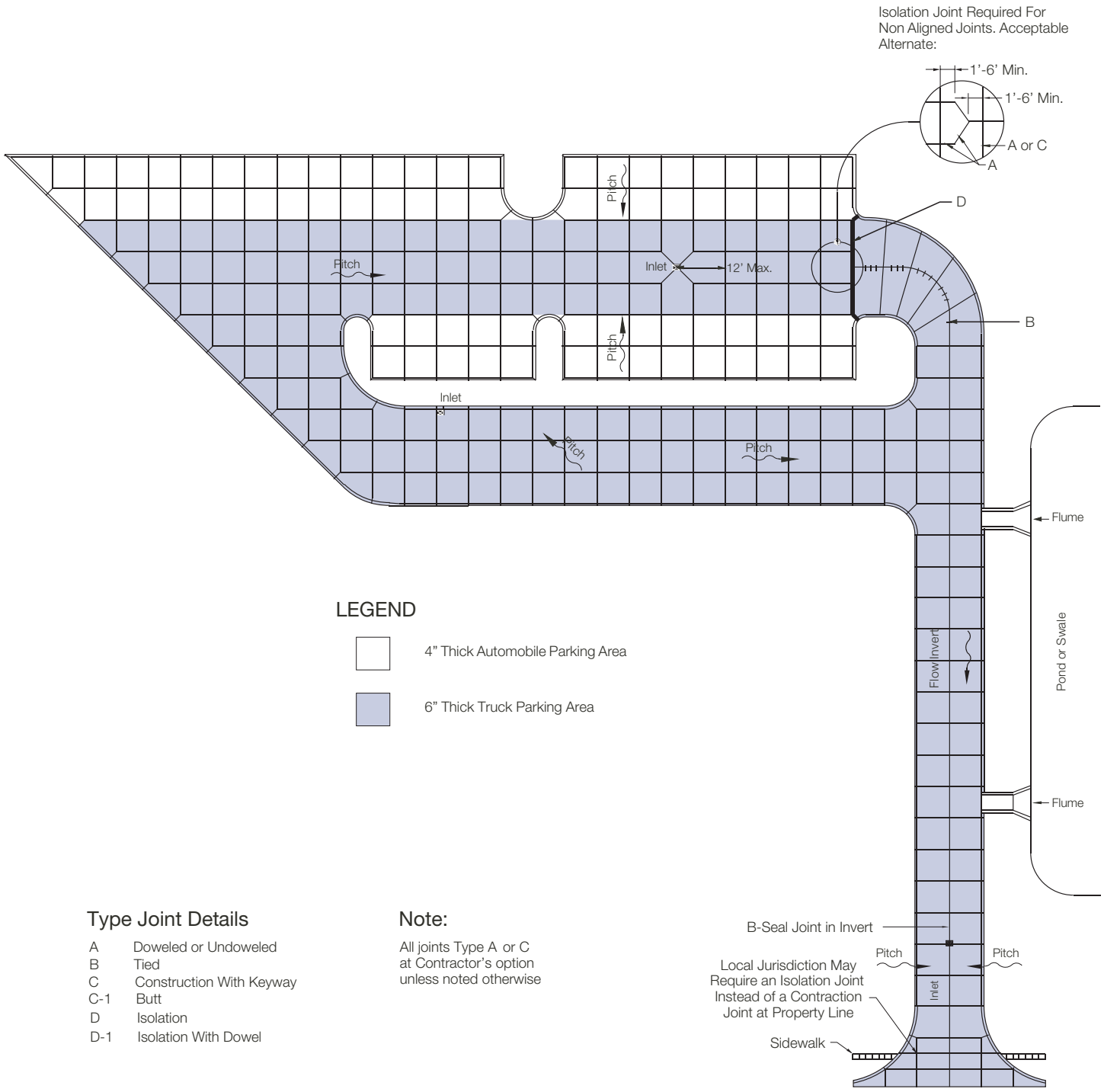


Joints at Manhole

Type Joint Details

A Doweled or Undoweled
B Tied
C Construction With Keyway
C-1 Butt
D Isolation
D-1 Isolation With Dowel

Typical Parking Area (Joint Layout) Figure 2



LEGEND

4" Thick Automobile Parking Area

6" Thick Truck Parking Area

Type Joint Details

A	Doweled or Undoweled
B	Tied
C	Construction With Keyway
C-1	Butt
D	Isolation
D-1	Isolation With Dowel

Note:

All joints Type A or C at Contractor's option unless noted otherwise

Note: For a digital AutoCAD,® contact FC&PA.

Recommended Specifications For Unreinforced Portland Cement Concrete Parking Lots

1.0 General Provisions

1.1 Scope of Work: The work to be completed under this contract includes the furnishing of all labor, materials and equipment necessary for construction of the proposed improvements in conformance with plans and specifications.

1.2 Contractor's Qualifications: ACI Certified Concrete Flatwork Finishers or equivalent shall be required. Contact the FC&PA for a list of certified finishers.

1.3 Submittals and Approvals: Contractor to submit: "Proposed Paving Construction Plan," which shall show the concrete paving joint types and locations and shall include a statement of proposed sequence and schedule of paving operations with a brief description of motorized paving equipment, if applicable. Proposed joint layout plan shall be submitted to owner or agent 7 days prior to the commencement of paving operations unless other arrangements have been accepted. Unless the contractor is notified of required changes prior to the scheduled paving commencement date, the "Proposed Paving Construction Plan" will be considered accepted and approved.

2.0 Subgrade Preparation and Formwork

2.1 General: The subgrade shall be brought to proper grade and cross section by means of proper machinery.

2.2 Subgrade Material: The top 6 inches shall be composed of granular or gravely soil that is predominantly sandy with no more than a moderate amount of silt or clay. Subgrade shall be moist without freestanding water when placing concrete.

2.3 Subgrade Support: Material shall be placed and compacted in layers of a thickness that can be compacted to a density of 95% (+/- 2%) of maximum density as determined by AASHTO T-99 or ASTM D 698. A Limerock Bearing Ratio (LBR) of 12 (+/- 2) shall be obtained in the top 6 inches of the subgrade.

2.4 Utility Trench Backfilling: All utility trenches, inlets and manholes shall be backfilled and finished with ready-mixed flowable fill or with compacted soil similar to that adjacent to the trench. Soil backfill under the pavement and out to a line extending on a 45 degree angle to horizontal from the back of curb shall be compacted in 12 in. maximum lifts to a density of at least 95% (+/- 2%) of the maximum density determined by AASHTO T-99 or ASTM D 698.

2.5 Forms: Forms may be of wood or steel and shall be the full depth of the pavement. Forms shall be of sufficient strength and stability to support mechanical equipment without deformation of plan profiles following spreading, strike-off consolidation and finishing. Instead of using fixed forms, the contractor may place concrete in one complete pass of the machine.

3.0 Materials

3.1 General: Locally available materials having a record of satisfactory performance shall be used.

3.2 Cement: Portland Cement Type I or II - ASTM C 150.

3.3 Blended Cement: ASTM C 595, Type IP or IS.

3.4 Cementitious Materials:

3.4.1 Fly ash: ASTM C 618

3.4.2 Ground Iron Blast-Furnace Slag: ASTM C 989.

3.5 Aggregate:

3.5.1 Fine Aggregate: ASTM C 33, or FDOT Standard Specifications, Section 902.

3.5.2 Coarse Aggregate: ASTM C 33 aggregates not meeting the size gradings of C 33 may be used if they comply with the grading requirements of ASTM D 448.

3.6 Air Entraining Agent: Shall comply with ASTM C 260.

3.7 Admixtures: ASTM C 494: Type A water reducing, Type D water reducing and retarding, Type E water reducing and accelerating, and Type G high range water-reducing and retarding.

3.8 Water: Potable or shall comply with FDOT Standard Specifications, Section 923 or ASTM C 94, Section 4.

3.9 Flowable Fill: Shall comply with FDOT Standard Specifications, Section 121.

3.10 Joint Material: Provide full depth pre-molded joint material for isolation joints.

3.11 Curing Compound: Use a pigmented liquid membrane curing compound, which shall meet requirements of ASTM C 309 (AASHTO M-148).

3.12 Joint Sealant: Where required, shall be hot poured rubber asphalt or joint sealing compound conforming to AASHTO M-173 or Federal Specifications TT-S-0011543a or TT-S-00230 or equivalent.

4.0 Concrete Quality

4.1 Mix Designs: Submit for approval recommended proportions, which will provide the specified compressive strengths at 28 days, in accordance with ACI 318, Chapter 5.

4.2 Classes of Concrete: Concrete shall have a minimum compressive strength of 3,500 psi at 28 days, (4,000 psi if so specified in the contract documents). Coarse aggregate size shall be No. 67 (3/4

in. to No. 4) or No. 57 (1 in. to No. 4) or larger. Slump shall be 3.5 + 1.5 inches unless chemical admixtures are used to increase the slump. Water may be added on site in accordance with ASTM C 94 at the option of the contractor provided that the slump does not exceed 5 inches.

4.3 Air-Entrainment: Shall be between 1% and 6 %.

4.4 Chemical Admixtures: Use in conformance with manufacturer's recommendations.

5.0 Mixing, Hauling and Placing

5.1 Ready-Mixed Concrete: Batch, mix and transport concrete in accordance with ASTM C 94.

5.2 Placing and Finishing Equipment: Unless otherwise approved by the owner/agent in writing, the contractor shall provide mechanical equipment of either slipform or form riding type that will strike-off, consolidate and finish the pavement to the required cross section. When required, approved vibrators for consolidating concrete along the faces of forms and adjacent to joints shall be provided by the contractor.

5.3 Concrete Placement: Disturbed grade shall be properly reshaped and re-compacted prior to placing concrete. If any traffic is allowed to use the prepared grade, the grade shall be checked and corrected immediately ahead of placing the concrete. Do not place concrete around manholes or other structures until they have been brought to the required grade and alignment. Concrete shall be deposited and consolidated in such a manner as to prevent dislocation of joint devices. Deposit and spread concrete in a continuous operation.

5.3.1 Unless approved by the architect/engineer, do not place concrete when ambient temperature is below 35 degrees F or when the concrete is likely to be subjected to freezing temperatures before it has reached 500 psi strength.

5.3.2 During hot weather, keep the concrete temperature as low as possible and use an approved set-retarding admixture. Do not re-temper concrete which has attained initial set.

5.3.3 In the event of rain, terminate placing of the concrete as soon as practical. Protect freshly placed concrete by covering with waterproof material.

5.4 Joint Construction: Construct contraction (control), construction and isolation joints true to line with face perpendicular to surface of the pavement as shown on Approved Paving Construction Plan. Joints shall be provided in both the longitudinal and transverse directions. Maximum spacing of longitudinal and transverse contraction joints shall be 10 ft for 4" pavements, 12 ft for 5 in. pavements and 15 ft for pavements 6 inches and over.

5.4.1 Contraction (Control) Joints: Provide contraction joints for a depth no greater than 1/3 or less than 1/4 of the pavement thickness. Contraction joints must be continuous across the slab unless interrupted by a full depth isolation joint material and must extend completely through any integral curbs. Contraction joint alignment may be skewed or warped where necessary to reach points of stress concentration. Sharp or acute angles of less than 45 degrees should be avoided in joints at intersections and radiuses to prevent cracked and broken corners and slivers under traffic.

5.4.1.1 Sawed Joints: Form contraction joints using an early-entry dry-saw equipped or equivalent with shatterproof abrasive or diamond rimmed blades. Cut joints into concrete pavements as soon as the surface will not ravel or otherwise damage by the cutting action. Joints must be completed between 2 and 8 hours after pavement has been placed.

5.4.1.2 Hand-Formed: Contraction joints may be installed in the concrete pavement with the use of a mason's hand groover or other approved grooving device while the concrete is in the plastic state. The blade of the hand-groover must be of sufficient depth to leave a finished joint greater than "D"/5 and less than "D"/4. Hand-formed joints must have a finished radius along the joint edge equal to 1/8 in.

5.4.2 Construction Joints: Place full depth construction joints at the ends of concrete placement and at locations where placement operations are stopped for a period of thirty minutes or more.

5.4.3 Isolation Joints: Provide isolation joint materials to isolate fixed objects abutting or within the paved area. They must contain pre-molded joint filler for the full depth of the pavement slab. All isolation joints shall be sealed.

5.5 Finishing: FC&PA or ACI Certified Finishers are recommended. Perform concrete finishing using machine and/or hand tools as required. Adding water to the surface of the concrete to assist in finishing operations shall not be permitted. A uniform, non-slip finish shall be provided by brushing the surface with a stiff-bristled broom or by dragging a "burlap drag" over the surface. Do not perform any finishing operations while bleedwater is on the surface.

5.6 Curing: Concrete shall be cured to protect it against loss of moisture and mechanical injury for at least 3 days after placement. A pigmented liquid curing membrane shall be applied immediately after the finishing operation.

5.7 Opening to Traffic: Unless authorized by the architect/engineer in writing, automobile traffic shall not be allowed on the pavement until the concrete is 3 days old and 7 days for other traffic. This does not include sawing and sealing equipment or other light miscellaneous equipment.

6.0 Evaluation and Acceptance of Pavement

6.1 Testing and Inspections: Shall be performed by a testing agency currently accredited by the Concrete Materials Engineering Council (CMEC), NVLAP or other accreditation authority of equal standing, on the basis of its compliance with the requirements of ASTM C 1077.

6.2 Sampling and Testing Concrete: Shall be performed by ACI Certified Concrete Field Technicians Grade I or personnel with equivalent qualifications.

6.3 Sampling Procedure: Obtain random sample in accordance with ASTM C 72, "Method of Sampling Fresh Concrete." Record time batched and time sampled, water additions at the site, strength class, the delivery ticket number, the concrete supplier's mix designation and the location of the concrete in the work.

6.4 Strength Tests: Obtain one strength test for each 150 cubic yards of concrete placed. Cylinders/beams shall be casted, cured and transported in accordance with ASTM C 31 "Laboratory Cured Specimens."

6.4.1 Perform slump and air tests with each set of strength test cylinders. Conform to methods listed in ASTM C 94 "Methods of Sampling and Testing."

6.5 Acceptance of Concrete Strength: The strength level of the concrete shall be considered satisfactory if the averages of all sets of three consecutive strength tests of an individual class of concrete equal or exceed the specified strength and no individual strength test result falls below the specified strength by more than 500 psi.

6.5.1 Strength Test Failure: If an individual strength test result falls below the specified strength by more than 500 psi, determine the approximate location and strength concrete represented by the test by a method listed in ASTM C 823, such as Penetration Resistance, ASTM C 803, or Rebound Number, ASTM C 805. If presence of under-strength concrete is confirmed, obtain three cores from the concrete in question in accordance with ASTM C 42.

6.5.2 Core Tests and Their Evaluation: Strength shall be considered adequate, if the average strength of three cores representing the concrete in question equals at least 85% of the required strength and if no individual core strength is less than 78% of the required strength.

6.6 Test Reports: Promptly report all concrete test results to the owner/agent, the contractor and the concrete supplier. Report shall include method of initial curing and date specimens are received at the laboratory.

6.7 Tolerance in Pavement Thickness: Before final acceptance of the pavement, at the option of the owner, its thickness may be determined by coring at random locations in each placed strip so that a core represents an area not exceeding 2,500 square yards. The depth of each core shall be determined by average measurements of the core in accordance with AASHTO T-148.

6.7.1 Deficient Core Thickness: When the measurement of the core is deficient in thickness by more than 5% from the plan thickness, two additional cores will be taken at 25 ft. intervals from the original core. If the average thickness of the three cores is not deficient more than 5% from the plan thickness, full payment for the unit will be made. If the average thickness of the three cores is deficient more than 5% but not more than 10% from the plan thickness, an adjusted unit price will be applied for the area represented by these cores as shown in the following table for thicknesses:

Table 1. Deficiency in Thickness Percentage of Contract Price Allowed

Where the thickness of the pavement is deficient by more than 10% and the judgment of the engineer is that the area of such deficiency should not be removed and replaced, payment will be 50% of the contract price. No additional compensation will be allowed for pavement placed in excess of the specified thickness.

Deficiency in Thickness	% of Contract Price Allowed
0-5%	100%
5.1-6%	95%
6.1-7%	90%
7.1%-8%	85%
8.1%-9%	80%
9.1%-10%	75%

****Special Note:** This information is intended to be used by the design professional competent to evaluate its significance and limitation and who will accept the responsibility for its proper application. The Florida Concrete and Products Association disclaims any and all responsibility for any other use of the information supplied herein.