American Concrete Pavement Association

CONCRETE INFORMATION

# Design of Concrete Pavement for City Streets

Design and construction standards for city streets should provide for pavements with both long service life and low maintenance. As a guide in achieving this goal, this publication provides adequate designs that will result in the lowest annual cost when considering both initial construction cost and pavement maintenance. Three other PCA publications, *Subgrades and Subbases for Concrete Pavements*, *Design and Construction of Joints for Concrete Streets*, and *Suggested Specifications for Construction of Concrete Streets*, discuss the subjects of subgrades and subbases, jointing practices, and specifications in much greater detail.

Following are the factors involved in the design process for concrete streets:

1. Subgrades and subbases
2. Concrete quality
3. Street classification and traffic
4. Geometric design
5. Thickness design
6. Jointing
7. Construction specifications

## Subgrades and Subbases

Unlike other paving materials, the structural strength of a concrete pavement is largely within the concrete itself due to its rigid nature. Because of the remarkable beam strength of concrete, heavy loads are distributed over large areas resulting in very low pressures on the subgrade. This makes it economically impractical to build up subgrade strength with thick layers of crushed stone or gravel. Performance has shown that high-volume roads such as highways generally fail by the pumping and eroding of the subgrade at pavement joints and edges. In these applications when granular subbases are specified, they function not so much as a structural layer, but as a non-pumping layer to reduce the soil erosion under the pavement slab. Since low-volume roads do not fail in this manner, they do not require subbases to prevent subgrade pumping. In most cases these concrete pavements can be placed directly on the compacted subgrade.

It is important that subgrade soils be of uniform material type and density for satisfactory pavement performance. Abrupt changes in subgrade type can result in the differential movement of the subgrades that are susceptible to frost action in northern climates, and excessive shrink and swell of expansive soils. Differential heaving in these special cases can be controlled by ensuring uniform soil type. Changes in volume can be substantially reduced by compacting the soil at 1 to 3 percentage points above optimum moisture. Soft spots that show up during construction should be excavated and recompacted with the same type of materials as the adjacent subgrade.

Additional information on subgrades and subbases can be found in Reference 1.

## Concrete Quality

Concrete paving mixes are designed to produce the desired flexural strength and to give satisfactory durability under the conditions the pavement will be subjected to during its service life.

Since the mode of failure in the design of concrete pavement is flexural fatigue, it is important that the concrete have adequate flexural strength (modulus of rupture) to resist cracking from flexural fatigue. Under average conditions the concrete should achieve a 28-day modulus of rupture (MR) of 550 to 700 psi (3.8 to 4.8 MPa) when measured in accordance with American Society for Testing Materials, ASTM C78, third-point loading.

In frost-affected areas, concrete pavements must be protected from the many cycles of freezing and thawing and from the action of deicing salts. It is essential that the mix have a low water-cement ratio, an adequate cement factor, sufficient entrained air content, and adequate curing. The quantity of air entrainment necessary for weather-resistant concrete varies with the maximum-size aggregate. Table 1 gives the percentages of air content recommended for durable concrete[2]. In addition to making the hardened concrete weather-resistant, entrained air improves the concrete while it is still in the plastic state by preventing segregation, increasing workability, and reducing bleeding.

The quantity of mixing water also has a critical influence on the durability and weather-resistance of hardened concrete. The least amount of mixing water that will produce a plastic, workable mix will result in the greatest durability in hardened concrete. A minimum portland cement content of 564 pounds per cubic yard (335

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kilograms per cubic meter) of concrete, with a maximum water-cement ratio as given in Table 2, will significantly increase freeze-thaw and sulfate resistance of the concrete pavement. References 2 and 3 are excellent resources for further study on this topic.

**Table 1. Recommended Air Contents for Durable Concrete**

| Maximum size aggregate—in. | | Total target air content, percent * | |
|---|---|---|---|
| | | Severe Exposure | Moderate Exposure |
| 3/8 | (9.5 mm) | 7-1/2 | 6 |
| 1/2 | (12.5 mm) | 7 | 5-1/2 |
| 3/4 | (19.0 mm) | 6 | 5 |
| 1 | (25.0 mm) | 6 | 4-1/2 |
| 1-1/2 | (37.5 mm) | 5-1/2 | 4-1/2 |
| 2 | (50.0 mm) | 5 | 4 |

* A reasonable tolerance for air content in field construction is −1 to + 2 percentage points.

**Table 2. Maximum Permissible Water-Cement Ratio for Durable Concrete Pavement**

| Type of exposure | Maximum water-cement ratio by weight |
|---|---|
| Freezing/thawing with deicing chemicals | 0.45 |
| Severe sufate exposure [water-soluble sulfate ($SO_4$) in soil, percent by weight of 0.20 and above] | 0.45 |
| Moderate sulfate exposure [water-soluble sulfate ($SO_4$) in soil, percent by weight of 0.10-0.20] | 0.50 |

# Street Classification and Traffic

Comprehensive traffic studies made within city boundaries have shown that streets of similar character have essentially the same traffic densities and axle load intensities. A practical approach to design is to establish a street classification system that provides an axle load distribution for the various categories of streets. This information sheet has divided city street pavements into six street classifications. Descriptions for each classification include traffic volumes, type of vehicles and maximum axle loadings. These classifications are listed in the Thickness Design section of this document.

# Geometric Design

## Utilities

During the construction of new subdivisions and commercial developments utilities are commonly placed in the right-of-way outside the pavement area to facilitate maintenance and possible additions to the utility systems. Present and future needs must be evaluated and provisions made for them. Forethought can eliminate the tearing up of existing pavements for work on utilities.

## Integral Curbs

A most practical and economical way to build concrete pavements for city streets is with an integral curb section. An integral curb is constructed with the pavement in a single operation—all concrete work being done simultaneously. When using forms, the curb is easily shaped with a templet and straightedge as the pavement is placed. Integral curbs can also be constructed to almost any desired cross section using a slipform paver.

When integral curbs are used, stresses and deflections at the pavement edge are reduced, thus increasing the structural capacity of the pavement, or conversely, allowing a decrease in pavement thickness. The inherent advantages and economy of integral curb construction recommend its consideration for city street pavements.

## Street Widths

Street widths vary according to the traffic the street is designed to carry. The minimum recommended width, except in unusual cases, is 25 ft (7.6 m) with a maximum transverse slope of 1/4 in. per foot (20 mm per meter) of width. Consistent lane widths and cross slope are desirable.

Traffic lanes are customarily 10 to 12 ft (3 to 3.7 m) wide. Widths over 12 ft (3.7 m) are not recommended since experience has shown that drivers will attempt to pass on wider single lanes, promoting accidents.

Parking lanes along the curb are usually 7 to 8 ft (2.1 to 2.4 m) wide. A 7-ft (2.1 m) lane is used where passenger cars predominate, an 8-ft (2.4 m) lane where trucks must be accommodated. Parking lanes of 6 ft (1.8 m) are not recommended. On major streets parking lanes are 10 to 12 ft (3 to 3.7 m) wide and they can also be used as travel or turning lanes.

On streets where parking is prohibited, an extra 2 ft (0.6 m) width is generally provided along the curb as nontraveled space.

# Thickness Design

The design procedure presented in this publication, utilizes the method and theories that are outlined in the Portland Cement Association publication, *Thickness Design for Concrete Highway and Street Pavements*[4], and the personal computer software manual for *PCAPAV*[5].

This design method determines the thickness for both plain and reinforced concrete pavements. By definition, plain pavements are constructed without any reinforcing steel or steel dowels at the control joints. Control joints are usually spaced at 15 ft (4.6 m) intervals or less, with load transfer at these joints obtained through aggregate interlock. Plain-doweled pavements use steel dowels for additional load transfer at control joints. Reinforced concrete pavements have longer control joint spacing—up to a maximum of 30 ft (9.1 m)—with wire mesh reinforcement placed between control joints to hold tightly together the one or more cracks that are expected to develop. Because they have longer joint spacing than plain pavements, reinforced concrete pavements always require steel dowels at control joints in order to provide



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adequate load transfer. Pavements can be designed with or without a concrete shoulder or curb and gutter.

Reference 4 discusses two limiting criteria for pavement design. The first is an erosion criteria where high-volume roads show distress from pumping and erosion of the subgrade or subbase due to the higher number of heavy loads at or near pavement joints or edges. The second criteria is pavement flexural fatigue. This distress occurs on low-volume road facilities where repetitive loadings produce bending stresses in the pavement, eventually resulting in fatigue cracking. It is this latter criteria, flexural fatigue cracking, that controls the design of pavements addressed in this publication.

The most influential factors in the determination of thickness design are described in the following sections.

## Flexural Strength (MR)

Under repeated axle loads concrete pavements bend, producing both compressive and flexural stresses. Since the ratio of compressive stress to compressive strength is relatively small compared to the ratio of flexural stress to flexural strength, the flexural strength of concrete is the controlling factor in pavement design. The flexural strength of concrete is determined by modulus of rupture (MR) tests, usually made on a 6x6x30-in. (150x150x760-mm) beam (ASTM C78 third-point loading). The 28-day strength is most commonly used as a representation of concrete design strength.

For thickness determinations using Table 6, the *average* modulus of rupture at 28 days should be used. The *average* strength is usually 10 to 15 percent greater than the minimum strengths commonly specified for accepting concrete.

## Strength of Subgrade or Subbase (k)

The degree of subgrade or subbase support is defined in terms of the Westergaard modulus of subgrade reaction (k). This is determined by the load in pounds per square inch (newtons per square meter) on a 30-in. (760 mm) diameter plate divided by the deflection in inches (millimeters) for that load. The value of k is expressed as pounds per square inch per inch (psi/in.) or more commonly, as pounds per cubic inch (pci) (megapascals per meter). Since the plate-loading test is both expensive and time consuming, the value of k is usually correlated to other subgrade support values (Fig. 1), or determined from Table 3.

**Table 3. Subgrade Soil Types and Approximate k Values**

| Type of Soil | Support | k values range, pci (MPa/m) |
|---|---|---|
| Fine-grained soils in which silt and clay-size particles predominate | Low | 75-120 (20-34) |
| Sands and sand-gravel mixtures with moderate amounts of silt and clay | Medium | 130-170 (35-49) |
| Sands and sand-gravel mixtures relatively free of plastic fines | High | 180-220 (50-60) |

## Classifications of City Streets

**Light Residential.** These streets are not long and are found in subdivisions and similar residential areas. They may end as dead ends or turn-arounds. They serve traffic to approximately 20 to 30 lots or houses. Traffic volumes are low, less than 200 vehicles per day (vpd) with 2-4 average daily truck traffic (ADTT - average daily truck traffic, two directions, excluding two-axle, four-tire trucks). Maximum loads for these streets are 18 kip (80 kN) single axles and 36 kip (160 kN) tandem axles.

**Residential.** These streets carry similar traffic as light residentials (except more of it) plus an occasional heavy truck. On a grid-type street system, these streets carry traffic serving up to 300 homes as well as collecting all light residential traffic within the area and distributing it into the major street system. Traffic volumes range from 200 to 1000 vpd with approximately 10 to 50 ADTT. Maximum loads for these streets are 22 kip (98 kN) single axles and 36 kip (160 kN) tandem axles.

**Collector.** These streets collect the traffic from several subdivisions and may be several miles long. They may be bus routes and serve truck movements to and from an area, although they are generally not considered through routes. Traffic volumes vary from 1000 to 8000 vpd with approximately 50 to 500 ADTT. Maximum loads for these streets are 26 kip (116 kN) single axles and 44 kip (196 kN) tandem axles.

**Business.** Business streets provide land access to stores and at the same time serve traffic in a central business district. Business streets are frequently congested and speeds are slow due to high traffic volumes, but with a low ADTT percentage. Average traffic volumes vary from 11,000 to 17,000 vpd with approximately 400 to 700 ADTT, with maximum loads similar to collector streets.

**Industrial.** Industrial streets provide access to industrial areas or parks. Total vpd volumes may be low, but the percentage of ADTT is high. Typical vpd are around 2000 to 4000 with an average of 300 to 800 ADTT. Truck volumes are not much different than the business class; however, the maximum axle loads are heavier, 30 kip (133 kN) single axles and 52 kip (231 kN) tandem axles.

**Arterials.** Arterials bring traffic to and from expressways and serve major movements within and through metropolitan areas not served by expressways. Truck and bus routes are usually on arterials. For design purposes, arterials are divided into major and minor arterials depending on traffic capacity and type. Minor arterials carry about 4000 to 15,000 vpd with 300 to 600 ADTT. Major arterials carry approximately 4000 to 30,000 vpd with 700 to 1500 ADTT and are usually subjected to heavier truck loadings. Maximum loads for minor arterials are 26 kip (116 kN) single axles and 44 kip (196 kN) tandem axles. Major arterials have maximum loads of 30 kip (133 kN) single axles and 52 kip (231 kN) tandem axles.

## Truck Traffic Loadings (ADTT) and Axle-Load Distributions

This design method uses the average daily truck traffic in *both* directions (ADTT) to model the loads on the concrete pavement. For design purposes, this traffic is assumed to be equally distributed in each of the two directions (i.e., 50 percent each way). The ADTT value includes only trucks with six tires or more and does not include panel and pickup trucks and other four-tire vehicles.



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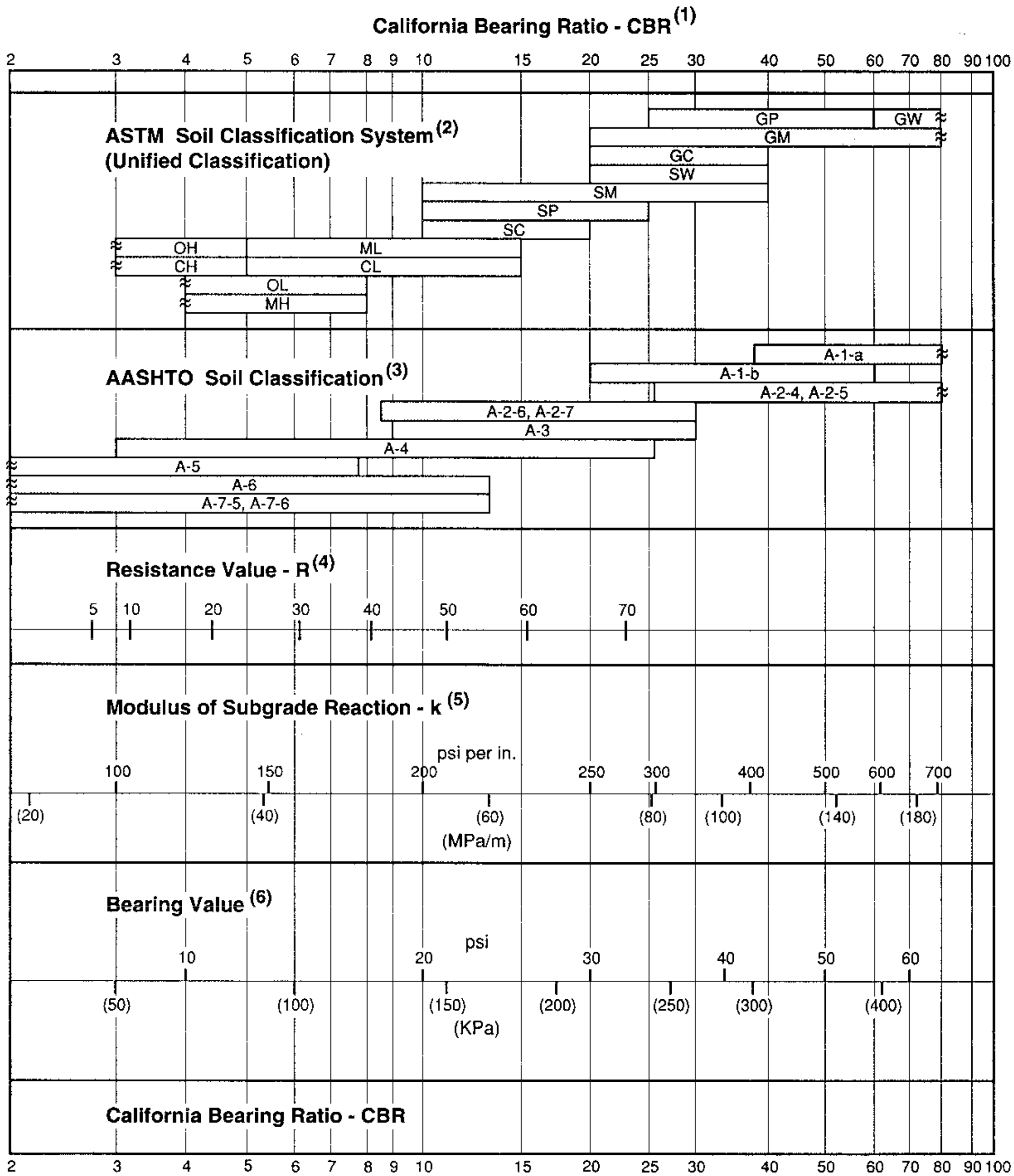


(1) For the basic idea, see O.J. Porter, "Foundations for Flexible Pavements," Highway Research Board *Proceedings of the Twenty-Second Annual Meeting,* 1942, Vol. 22, pages 100-136.
(2) ASTM Designation D2487.
(3) "Classification of Highway Subgrade Materials," Highway Research Board *Proceedings of the Twenty-Fifth Annual Meeting,* 1945, Vol. 25, pages 376-392.
(4) C.E. Warnes, "Correlation Between *R* Value and *k* Value," unpublished report, Portland Cement Association, Rocky Mountain-Northwest Region, October 1971 (best-fit correlation with correction for saturation).
(5) See T.A. Middlebrooks and G.E. Bertram, "Soil Tests for Design of Runway Pavements," Highway Research Board *Proceedings of the Twenty-Second Annual Meeting,* 1942, Vol. 22, page 152.
(6) See item (5), page 184.

**Fig. 1. Approximate interrelationships of soil classifications and bearing values.**



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**Table 4. Axle-Load Distributions Used for Preparing Design Tables**

| Axle load, kips | (kN) | Axles per 1000 trucks* Category LR | Category 1 | Category 2 | Category 3 |
|---|---|---|---|---|---|
| **Single axles** | | | | | |
| 4 | (18) | 846.15 | 1693.31 | | |
| 6 | (27) | 369.97 | 732.28 | | |
| 8 | (36) | 283.13 | 483.10 | 233.60 | |
| 10 | (44) | 257.60 | 204.96 | 142.70 | |
| 12 | (53) | 103.40 | 124.00 | 116.76 | 182.02 |
| 14 | (62) | 39.07 | 56.11 | 47.76 | 47.73 |
| 16 | (71) | 20.87 | 38.02 | 23.88 | 31.82 |
| 18 | (80) | 11.57 | 15.81 | 16.61 | 25.15 |
| 20 | (89) | | 4.23 | 6.63 | 16.33 |
| 22 | (98) | | 0.96 | 2.60 | 7.85 |
| 24 | (107) | | | 1.60 | 5.21 |
| 26 | (116) | | | 0.07 | 1.78 |
| 28 | (125) | | | | 0.85 |
| 30 | (133) | | | | 0.45 |
| **Tandem axles** | | | | | |
| 4 | (18) | 15.12 | 31.90 | | |
| 8 | (36) | 39.21 | 85.59 | 47.01 | |
| 12 | (53) | 48.34 | 139.30 | 91.15 | |
| 16 | (71) | 72.69 | 75.02 | 59.25 | 99.34 |
| 20 | (89) | 64.33 | 57.10 | 45.00 | 85.94 |
| 24 | (107) | 42.24 | 39.18 | 30.74 | 72.54 |
| 28 | (125) | 38.55 | 68.48 | 44.43 | 121.22 |
| 32 | (142) | 27.82 | 69.59 | 54.76 | 103.63 |
| 36 | (160) | 14.22 | 4.19 | 38.79 | 56.25 |
| 40 | (178) | | | 7.76 | 21.31 |
| 44 | (196) | | | 1.16 | 8.01 |
| 48 | (214) | | | | 2.91 |
| 52 | (231) | | | | 1.19 |

* Excluding all two-axle, four-tire trucks.

The truck axle loadings are distributed according to the type of roadway classification in the categories described in Table 4.

Since the ADTT value represents the average daily traffic over the life of the pavement, the designer must adjust the present ADTT to anticipate any future growth of traffic. Table 5 may be used to multiply the present-day ADTT by an appropriate projection factor to arrive at an estimated average daily truck count.

## Design Period

The design period is the theoretical life of the pavement before it requires either major rehabilitation or reconstruction. It does not necessarily represent the actual pavement life, which can be far greater than design, or shortened by unanticipated traffic increases. The design tables in this publication assume a 30-year design life. For design periods other than 30 years, the ADTT may be adjusted. For example, if a 20-year design period is desired instead of 30 years, the estimated ADTT value is multiplied by a factor of 20/30.

The design tables that follow have incorporated the appropriate axle-load categories and load safety factors[4] (SF). The SF are applied to the axle loads to compensate for unpredicted truck overloads and normal construction variations in materials and layer thicknesses for each traffic category.

**Table 5. Yearly Rates of Traffic Growth and Corresponding Projection Factors***

| Yearly rate of traffic growth, % | Projection factor, 30 years | Projection factor, 40 years |
|---|---|---|
| 1 | 1.2 | 1.2 |
| 1-1/2 | 1.3 | 1.3 |
| 2 | 1.3 | 1.5 |
| 2-1/2 | 1.4 | 1.6 |
| 3 | 1.6 | 1.8 |
| 3-1/2 | 1.7 | 2.0 |
| 4 | 1.8 | 2.2 |
| 4-1/2 | 1.9 | 2.4 |
| 5 | 2.1 | 2.7 |
| 5-1/2 | 2.2 | 2.9 |
| 6 | 2.4 | 3.2 |

* Factors represent values at the mid-design period that are widely used in current practice. Another method of computing these factors is based on the average annual value. Differences (both compound interest) between these two methods will rarely affect design.

### Table 6(a)—Concrete Thickness (inches), 30-Year Design

**WITH** concrete curb and gutter or concrete shoulders

| Traffic Classification | ADTT | k=100 pci | | | k=150 pci | | | k=200 pci | | | k=300 pci | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Modulus of Rupture (psi) | | | Modulus of Rupture (psi) | | | Modulus of Rupture (psi) | | | Modulus of Rupture (psi) | | |
| | | 500 | 600 | 650 | 550 | 600 | 650 | 550 | 600 | 650 | 550 | 600 | 650 |
| LIGHT RESIDENTIAL (Cat LR, SF = 1.0) | ADTT = 3 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 |
| RESIDENTIAL (Cat 1, SF= 1.0) | ADTT = 10 | 6.0 | 5.5 | 5.0 | 5.5 | 5.0 | 5.0 | 5.5 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 |
| | ADTT = 20 | 6.0 | 5.5 | 5.5 | 5.5 | 5.5 | 5.0 | 5.5 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 |
| | ADTT = 50 | 6.0 | 6.0 | 5.5 | 6.0 | 5.5 | 5.0 | 5.5 | 5.0 | 5.0 | 5.5 | 5.0 | 5.0 |
| COLLECTOR (Cat 2, SF = 1.1) | ADTT = 50 | 7.0 | 6.5 | 6.0 | 6.5 | 6.0 | 6.0 | 6.5 | 6.0 | 5.5 | 6.0 | 5.5 | 5.5 |
| | ADTT = 100 | 7.0 | 6.5 | 6.5 | 7.0 | 6.5 | 6.0 | 6.5 | 6.0 | 6.0 | 6.0 | 6.0 | 5.5 |
| | ADTT = 500 | 7.5 | 7.0 | 7.0 | 7.0 | 7.0 | 6.5 | 7.0 | 6.5 | 6.5 | 6.5 | 6.0 | 6.0 |
| BUSINESS (Cat 2, SF = 1.1) | ADTT = 400 | 7.5 | 7.0 | 6.5 | 7.0 | 6.5 | 6.5 | 7.0 | 6.5 | 6.0 | 6.5 | 6.0 | 6.0 |
| | ADTT = 700 | 7.5 | 7.5 | 7.0 | 7.5 | 7.0 | 7.0 | 7.0 | 6.5 | 6.5 | 6.5 | 6.5 | 6.5 |
| MINOR ARTERIAL (Cat 2, SF = 1.2) | ADTT = 300 | 8.0 | 7.5 | 7.0 | 7.5 | 7.0 | 6.5 | 7.5 | 7.0 | 6.5 | 7.0 | 6.5 | 6.0 |
| | ADTT = 600 | 8.0 | 7.5 | 7.5 | 7.5 | 7.5 | 7.0 | 7.5 | 7.0 | 7.0 | 7.0 | 6.5 | 6.5 |
| INDUSTRIAL (Cat 3, SF = 1.2) | ADTT = 300 | 9.0 | 8.5 | 8.0 | 8.5 | 8.0 | 7.5 | 8.0 | 7.5 | 7.0 | 7.5 | 7.5 | 7.0 |
| | ADTT = 800 | 9.5 | 9.0□ | 9.0■ | 8.5 | 8.5□ | 8.5□ | 8.5 | 8.0 | 8.0□ | 8.0 | 7.5 | 7.5□ |
| MAJOR ARTERIAL* (Cat 3, SF = 1.2) | ADTT = 700 | 9.0 | 8.5● | 8.0Δ | 8.5 | 8.0 | 7.5● | 8.5 | 8.0 | 7.5● | 8.0 | 7.5 | 7.0● |
| | ADTT =1100 | 9.5 | 9.0● | 8.5Δ | 9.0 | 8.5 | 8.0● | 8.5 | 8.0● | 7.5Δ | 8.0 | 7.5● | 7.0Δ |
| | ADTT =1500 | 9.5 | 9.0● | 8.5Δ | 9.0 | 8.5● | 8.0Δ | 8.5 | 8.0● | 7.5Δ | 8.0 | 7.5● | 7.5● |

□ reduce thickness by (1/2") if dowels used
■ reduce thickness by (1") if dowels used

* For this classification only, the thickness shown is with dowels

● add (1/2") if dowels not used
Δ add (1") if dowels not used

**CONVERSIONS**
1 in. = 25.4 mm
100 psi = 0.689 MPa
100 pci = 27.15 MPa/m

# Jointing

Joints must be carefully designed and constructed to ensure good performance. Except for construction joints, which divide paving work into convenient increments, joints in concrete pavements are used to keep stresses within safe limits and to prevent formation of irregular cracks. Suggested joint details for residential streets are given in *Concrete Streets: Typical Pavement Sections and Jointing Details* [6].

## Longitudinal Joints

Longitudinal joints are installed to control longitudinal cracking. They usually are spaced to coincide with lane markings—at 8- to 12-ft (2.4- to 3.7-m) intervals. Longitudinal joint spacing should not be greater than 13 ft (4.0 m) unless local experience has shown that the pavements will perform satisfactorily. The depth of longitudinal joints should be one-fourth to one-third of the pavement thickness (D/4 - D/3).



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## Table 6(b)—Concrete Thickness (inches), 30-Year Design

**WITHOUT** concrete curb and gutter
or concrete shoulders

| Traffic Classification | | k=100 pci Modulus of Rupture (psi) | | | k=150 pci Modulus of Rupture (psi) | | | k=200 pci Modulus of Rupture (psi) | | | k=300 pci Modulus of Rupture (psi) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 550 | 600 | 650 | 550 | 600 | 650 | 550 | 600 | 650 | 550 | 600 | 650 |
| LIGHT RESIDENTIAL (Cat LR, SF = 1.0) | ADTT = 3 | 6.0 | 5.5 | 5.5 | 6.0 | 5.5 | 5.5 | 5.5 | 5.5 | 5.0 | 5.5 | 5.0 | 5.0 |
| RESIDENTIAL (Cat 1, SF = 1.0) | ADTT = 10 | 7.0 | 6.5 | 6.0 | 6.5 | 6.0 | 5.5 | 6.0 | 6.0 | 5.5 | 6.0 | 5.5 | 5.5 |
| | ADTT = 20 | 7.0 | 6.5 | 6.0 | 6.5 | 6.0 | 6.0 | 6.5 | 6.0 | 5.5 | 6.0 | 5.5 | 5.5 |
| | ADTT = 50 | 7.0 | 6.5 | 6.5 | 7.0 | 6.5 | 6.0 | 6.5 | 6.0 | 6.0 | 6.0 | 6.0 | 5.5 |
| COLLECTOR (Cat 2, SF = 1.1) | ADTT = 50 | 8.0 | 7.5 | 7.0 | 7.5 | 7.5 | 7.0 | 7.5 | 7.0 | 6.5 | 7.0 | 6.5 | 6.5 |
| | ADTT = 100 | 8.5 | 8.0 | 7.5 | 8.0 | 7.5 | 7.0 | 7.5 | 7.0 | 7.0 | 7.0 | 7.0 | 6.5 |
| | ADTT = 500 | 9.0 | 8.5 | 8.0 | 8.5 | 8.0 | 7.5 | 8.0 | 7.5 | 7.0 | 7.5 | 7.0 | 7.0 |
| BUSINESS (Cat 2, SF = 1.1) | ADTT = 400 | 9.0 | 8.5 | 8.0 | 8.5 | 8.0 | 7.5 | 8.0 | 7.5 | 7.0 | 7.5 | 7.0 | 7.0 |
| | ADTT = 700 | 9.0 | 8.5 | 8.0 | 8.5 | 8.0 | 7.5 | 8.0 | 7.5 | 7.5 | 8.0 | 7.5 | 7.0 |
| MINOR ARTERIAL (Cat 2, SF = 1.2) | ADTT = 300 | 9.0 | 8.5 | 8.0 | 8.5 | 8.0 | 8.0 | 8.5 | 8.0 | 7.5 | 8.0 | 7.5 | 7.0 |
| | ADTT = 600 | 9.5 | 9.0 | 8.5 | 9.0 | 8.5 | 8.0 | 8.5 | 8.0 | 8.0 | 8.0 | 7.5 | 7.5 |
| INDUSTRIAL (Cat 3, SF = 1.2) | ADTT = 300 | 10.0 | 9.5 | 9.0 | 9.5 | 9.0 | 8.5 | 9.5 | 9.0 | 8.5 | 9.0 | 8.5 | 8.0 |
| ❑ reduce thickness by (1/2") if dowels used | ADTT = 800 | 10.5 | 10.0 | 10.0❑ | 10.0 | 9.5 | 9.5❑ | 9.5 | 9.0 | 9.0❑ | 9.0 | 8.5 | 8.5❑ |
| MAJOR ARTERIAL* (Cat 3, SF = 1.2) | ADTT = 700 | 10.5 | 10.0 | 9.5● | 10.0 | 9.5 | 9.0● | 9.5 | 9.0 | 8.5● | 9.0 | 8.5 | 8.0● |
| | ADTT = 1100 | 11.0 | 10.0● | 9.5∆ | 10.0 | 9.5● | 9.0∆ | 10.0 | 9.0● | 9.0● | 9.5 | 9.0 | 8.5● |
| | ADTT = 1500 | 11.0 | 10.0∆ | 9.5▲ | 10.5 | 9.5∆ | 9.0▲ | 10.0 | 9.5● | 9.0∆ | 9.5 | 9.0● | 8.5∆ |

* For this classification only, the thickness shown is with dowels

● add (1/2") if dowels not used
∆ add (1") if dowels not used
▲ add (1-1/2") if dowels not used

**CONVERSIONS**
1 in. = 25.4 mm
100 psi = 0.689 MPa
100 pci = 27.15 MPa/m

Street pavements with curb and gutter are restrained by the backfill behind the curbs, which eliminates the need for tying longitudinal joints with deformed tiebars or tiebolts. See reference 7 for a complete discussion of longitudinal joints.

### Transverse Joints

Transverse contraction joints are used to control transverse cracking. Contraction joints relieve (1) tensile stresses that occur when the slab contracts and (2) curling and warping stresses caused by differential temperatures and moisture contents within the slab. Most contraction joints are constructed by hand-forming or by sawing after the concrete has set. Selection of the method to be used is normally based on the economies of the operation. In any case, the depth of the joints in city streets should be equal to one-fourth (D/4) of the pavement thickness. This depth should be increased to D/3 for pavements built on stabilized (cement or asphalt) subbase.



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Distributed steel or wire mesh, as normally used, only serves to hold the edges of cracks tightly together. Steel, in amounts for this use, does not add to the structural strength of the pavement. If transverse contraction joints are properly spaced, no intermediate cracking should occur and distributed steel should be omitted. Thus it is necessary to determine the contraction-joint spacing that will control cracking.

In general, for plain jointed concrete city street pavements, the joint spacing should not exceed 24 to 30 times the pavement thickness with a maximum spacing of 15 ft. (4.6 m). Table 7[7] below lists typical joint spacings for city street pavements. NOTE: Data from a large number of surveys have shown significant variations in joint spacing; therefore, local service records are the best guide for establishing a joint spacing that will effectively control transverse cracking.

The need for dowels in transverse contraction joints depends on the service to be required of the pavement. Dowel bars are not needed in residential pavements or other light traffic streets, but they may be needed on arterial streets carrying heavy volumes and weights of truck traffic. Isolation joints are not required except at fixed objects and unsymmetrical intersections. See PCA publication, *Design and Construction of Joints for Concrete Streets*[7] for additional information on jointing practices for concrete streets.

**Table 7. Recommended Joint Spacing for Plain Concrete Pavements**

| Pavement Thickness | Joint Spacing* |
|---|---|
| 5 in. (125 mm) | 10-12.5 ft (3.0-3.8 m) |
| 6 in. (150 mm) | 12-15 ft (3.7-4.6 m) |
| 7 in. (175 mm) | 14-15 ft (4.3-4.6 m) |
| 8 in. (200 mm) or more | 15 ft (4.6 m) |

* Can vary if local experience indicates; depends on climate and concrete properties.

# Construction Specifications

Although it is not the intent of this information sheet to cover construction specifications, it should be emphasized that a good performing pavement depends not only on its design and materials, but also on quality workmanship and adequate specifications. Suggested specifications[8,9] are available from the Portland Cement Association for city street pavements.

# References


1. *Subgrades and Subbases for Concrete Pavements*, Portland Cement Association, IS029P, 1991.
2. *Scale-Resistant Concrete Pavements*, Portland Cement Association, IS117P, 1992.
3. *Design and Control of Concrete Mixtures*, Portland Cement Association, EB001T, 1991.
4. *Thickness Design for Concrete Highway and Street Pavements*, Portland Cement Association, EB109P, 1984.
5. *PCAPAV*, Portland Cement Association concrete design software, MC003X, 1990.
6. *Concrete Streets: Typical Pavement Sections and Jointing Details*, Portland Cement Association, IS211P, 1980.
7. *Design and Construction of Joints for Concrete Streets*, Portland Cement Association, IS061P, 1992.
8. *Suggested Specifications for Construction of Concrete Streets*, Portland Cement Association, IS119P, 1975.
9. *Guide Specifications for Concrete Curbs and Combined Curbs and Gutters*, Portland Cement Association, IS110P, 1983.





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