

**APPENDIX K – PERVIOUS CONCRETE PAVEMENT DESIGN STANDARDS**

ORD. #71-12-07

Section 1	Overview
Section 2.	Design
Section 3.	Subgrade
Section 4.	Mix Design
Section 5.	Pavement Design
Section 6.	Drainage and Detention Design
Section 7.	Site Design
Section 8.	Construction

---

**Section 1. Overview**

Pervious or porous concrete pavements permit the percolation of water through voids in the pavement structure to the subgrade which may reduce storm water runoff and pollutants carried during its transportation and dispersion.

In an attempt to provide a cost effective alternative to conventional storm water detention methods while reducing the impact caused by additional development, the City of Noblesville has developed minimum standard requirements for pervious concrete pavement. The premise of these standards is to:

1. Establish minimum performance criteria for the pavement structure, in a manner consistent with other pavements that are currently permitted by City Standards
2. Establish reasonable compliance with the City’s Stormwater Ordinance, while observing traditional engineering practice, the City of Noblesville’s Ordinances; and,
3. To utilize design and quality control measures recommended by the concrete industry for pervious concrete

The following requirements and standards shall be considered as a supplement to the City of Noblesville Stormwater Technical Standards Manual, which are incorporated by reference herein. These standards shall also reference and incorporate the subject matter in the City of Noblesville’s Unified Development Code that involves projects which propose to utilize this design standard.

These standards shall be observed, applied, and demonstrated to obtain final approval for an Improvement Location Permit and the use of pervious concrete pavement. The purpose of using pervious concrete pavements shall not be to circumvent the requirement of detention or the need to save design costs. The concrete industry recognizes that pervious pavements are sensitive to in-situ conditions and require unique design consideration and expertise in their use. These standards were developed from several resources and incorporate their findings and recommendations. The placement of pervious concrete pavement and its use in a manner similar to conventional paving materials is not acceptable, as it does not perform in a similar manner.

**Section 2. Design**

Design and approval of any pavements utilizing pervious concrete shall follow the requirements of these standards and be subject to the City of Noblesville’s Stormwater Technical Standards Manual, the City of Noblesville’s Construction Standards, and the Unified Development Code, latest editions.

Pervious concrete is NOT a traditional pavement structure and may not be readily and simply substituted for regularly used hot-mixed asphalt (HMA) or customary INDOT (Indiana Department of Transportation) standard concrete mixture without addressing the City of Noblesville’s stormwater detention requirements.

The structure of pervious concrete pavement is designed to function as both an outlet for stormwater runoff and a surface to transport and store vehicular traffic.

The design standards outlined for pervious concrete pavements outlined herein were developed using information, theory, methodology, and guidelines established and published by the Portland Cement Association, the National Concrete Pavement Technology Center, the National Ready-Mixed Concrete Association, the North Carolina State University’s Department of Biological and Agricultural Engineering, and Iowa State University’s Center for Transportation Research and Education.

### Section 3. Subgrade

The subgrade for proposed pervious concrete pavement serves two purposes. It must be pervious to permit the percolation of water into the earth so it may dissipate an acceptable release rate without adversely affecting surrounding off-site areas, while addressing the City's design criteria for the storage of runoff. The subgrade must also be stable enough to adequately support the load from the pavement and applied traffic.

Percolation tests shall be procured by the developer through the designer to determine the suitability of the soil to percolate runoff from the pavement course. The number of tests for the site shall be determined by its overall size, with tests at two evenly-spaced location sites of 10,000-SF or less. Sites exceeding 10,000-SF in size shall submit a percolation plan and report for subsurface soils according to the following table:

SITE AREA (SF)	NUMBER OF PERCOLATION TEST LOCATIONS
≤ 10,000	2
10,000 to 15,000	3
Every 5,000-SF increment exceeding 15,000-SF	1 per 5,000-SF of additional area

A sampling plan shall be provided to the City of Noblesville for approval prior to the completion of the test. In general, test locations shall be evenly spaced and near the middle half or third of the proposed pavement area. The City of Noblesville reserves the opportunity to request any modifications or additions to any proposed sampling plan based on the conditions, shape, size, and use of the lot. This is not to infer that sampling plans will be expanded, it is conceivable that fewer test spots could be needed, depending on the case and situation.

Using the results of the percolation test, the designer shall determine the average **Infiltration Rate** in inches per hour (in/hr) for the site. Calculations and the results of the field investigation for the determination of the average infiltration rate shall be submitted with the proposed site plan for review.

### Section 4. Mix Design<sup>1</sup>

For each project, a mix design shall be submitted for approval with the project plans and specifications. The following section provides material specifications and requirements for the pervious concrete mix. The seven day compressive strength of pervious concrete pavement mixtures shall range from 3,300 to 2,900 psi.

#### 4.1. Cementitious Materials

Portland cements meeting the criteria of ASTM C 150 and C 1157 may be used as well as blended cements meeting the standards of ASTM C 595 and C 1157. Fly ash and pozzolans meeting the requirements of ASTM C 618 may also be used in the proposed mix. Due to problems with odors and discoloration of any runoff which may occur offsite, blast slag may not be used. Mix proportions for cementitious materials in the proposed mix shall be from 550 to 700 lbs/yd<sup>3</sup>.

#### 4.2. Aggregate

##### 4.2.1. Aggregate

Aggregate for the pervious concrete batch mix shall be 2000 to 2500 lbs/yd<sup>3</sup>. The aggregate to cement ratio shall be 4 to 4.5:1. The proportions of coarse and fine aggregates are presented in the following sections.

##### 4.2.2. Coarse Aggregate

The content of coarse aggregate in the batch mixture shall be narrowly graded and consist of aggregate meeting the requirements of coarse aggregate conforming to ASTM C 33 No. 67 or No. 8.

##### 4.2.3. Fine Aggregate

The content of fine aggregate to coarse aggregate ratio in the pervious concrete batch mixture shall be limited to range of 0 to 1:1 by mass.

**4.3. Water Cement Ratio**

The water to cement (w/c) ratio for the project mix shall be 0.27 to 0.30. Water used in the manufacture of the batch shall comply with Section 913.01 of the Indiana Department of Transportation’s Standard Specifications, latest edition.

**4.4. Admixtures**

The use and purpose for admixtures, such as retarding agents, shall be clearly indicated in the mix design submitted for the project. All admixtures shall conform to ASTM C 494.

**Section 5. Pavement Design****5.1. Aggregate Base**

Aggregate base for pavement shall be evaluated by the designer for each individual site to determine whether the minimum required standard depth of aggregate base is suitable for the traffic loads proposed for the site. The standard minimum aggregate base for all pervious concrete pavements shall be 8 inches of INDOT Gradation No. 2 Course Aggregate. The volume of void space for the proposed aggregate base compacted in place should be obtained from the supplier for use in determining the storage capacity of pavement base. The void ratio by volume for the aggregate base layer shall be 35% ± 5%.

**5.2. Pavement**

The minimum thickness of pervious concrete pavement used for commercial or institutional use shall be 8 inches. Locations subject to higher amounts of truck traffic shall be evaluated using traditional rigid pavement design techniques and increasing the depth of the rigid pavement by a factor of 1.25. The void ratio in the mixture shall be determined and range between 15% and 20% by volume.

**Section 6. Drainage and Detention Design**

The completion of runoff and storage computations for analyzing the water storage available in pervious pavements is a “5 part process”<sup>2</sup>. The methodology for the selection of the site’s hydrologic design criteria and storage and runoff computations shall be documented in the design calculations for the project and submitted with the site plan for TAC review. The process to determine storage and runoff is as follows.

**6.1. Section of Design Storm**

The selection of the parameters for the design storm and the pre-developed runoff condition for all sites shall be determined in accordance with the City of Noblesville’s Stormwater Technical Standards Manual.

The runoff coefficient used to determine the runoff from pervious concrete pavement for the required design storm shall be 0.95.

**6.2. Determine the Water Storage Capacity of the Pavement**

The storage capacity of the pervious concrete and aggregate base courses of the pavement shall be determined using the individual void ratios for each section.

The volume of voids in the pavement structure shall be computed as follows:

$$v_T = (A_a \times d_a \times v_a) + (A_p \times d_p \times v_p)$$

Where:

$v_T$  = Total Volume of Voids for Pavement Structure

$A_a$  = Total Area of Aggregate Base

$d_a$  = Depth of Aggregate Base

$v_a$  = Percent of Voids by Volume in Compacted Aggregate Base

$A_p$  = Total Area of Pervious Concrete Pavement

$d_p$  = Depth/Thickness of Pervious Concrete Pavement Course

$v_p$  = Percent of Voids by Volume in Pervious Concrete Pavement

### **6.3. Determination of Storage Volume and Release Rate**

The analysis and design of pervious concrete pavements shall follow the methodology of the Hydraulic Design of Permeable Pavements, July 14, 2000, North Carolina State University's Department of Biological and Agricultural Engineering College of Agriculture and Life Sciences. This publication provides a logical step-by-step method for determining the storage capability for pervious concrete pavements.

An additional acceptable method of analysis and design can be obtained from the Portland Cement Association, the National Concrete Pavement Technology Center, and the National Ready-Mixed Concrete Association. These groups have combined to create an interactive CD that contains an Excel-based design and analysis program.

No site plan utilizing pervious pavement shall be approved through The City of Noblesville's Technical Advisory Committee Review without drainage computations in a format compatible with or similar to the two aforementioned procedures certified by a Registered Professional Engineer in the State of Indiana.

## **Section 7. Site Design**

All other applicable City design standards and ordinances shall be observed during the design of parking lots utilizing pervious concrete.

In areas where the proposed pavement is on grade or is adjacent to a concrete approach that exits onto City right-of-way, the designer and constructor shall use and install an impervious membrane, such as visquine, to separate the aggregate base courses to prevent subsurface drainage from flowing to areas other than the subgrade directly under the area of pervious concrete. This type of separation is discussed in the publications referenced in these standards.

Curbs shall be provided as per the Unified Development Ordinance. The presence of curbs provides lateral support for the pavement structure and to control parking drainage and traffic patterns.

All pervious pavements shall be constructed with a six inch diameter underdrain that has a positive outlet to an existing public drainage facility. The underdrain for the proposed pavement shall be designed in a manner consistent with the City of Noblesville's typical details for street underdrains.

Pervious concrete pavements shall be designed to store a maximum depth of six inches of ponded water on-site in the event of failure or frozen conditions. The depressed area may be designed to permit the discharge of water off-site when six inches of runoff is stored in the parking area. This provision shall be observed to provide the owner to maintain or rehabilitate pervious pavement detention systems that fail or do not operate as intended.

The City of Noblesville may develop standard drawings to supplement or clarify the criteria outlined in these written standards.

## **Section 8. Construction**

Pervious pavements shall be constructed in compliance with the plans and specifications for the project.

These standards have been approved and adopted by the City of Noblesville's Board of Public Works and Safety and shall hereby incorporated into the City of Noblesville's Stormwater Standards Technical Manual. Authority is hereby given to the City of Noblesville's Wastewater Utility to develop and promulgate standards to address and mitigate stormwater quality issues associated with the installation, construction, and maintenance of pervious concrete pavements.

---

<sup>1</sup>Material used in this section developed from "Pervious Concrete Pavements" by Tennis, Leming, and Akers for the Portland Cement Association and the National Ready Mixed Concrete Association.

<sup>2</sup>Hydraulic Design of Permeable Pavements, July 14, 2000, North Carolina State University's Department of Biological and Agricultural Engineering College of Agriculture and Life Sciences.