Baker Beach Green Street Project

A Case Study in Failing to Overcome a Myth

Mike Adamow
SFPUC - WWE

San Francisco Water Power Sewer

Dispelling Highway Construction Myths

by Peter Kopac

Examining a few commonly believed half-truths may help materials, structural, and pavements engineers develop sound and effective quality assurance programs.

Sometimes when people hear or read an idea often enough, it becomes accepted as fact and ingrained as a self-evident truth. Invariably, these notions are passed on to others, and soon no one questions them any more. "Man was not meant to fly" was accepted as fact for centuries. But because a few people did not accept that belief, they developed an important means of transportation.

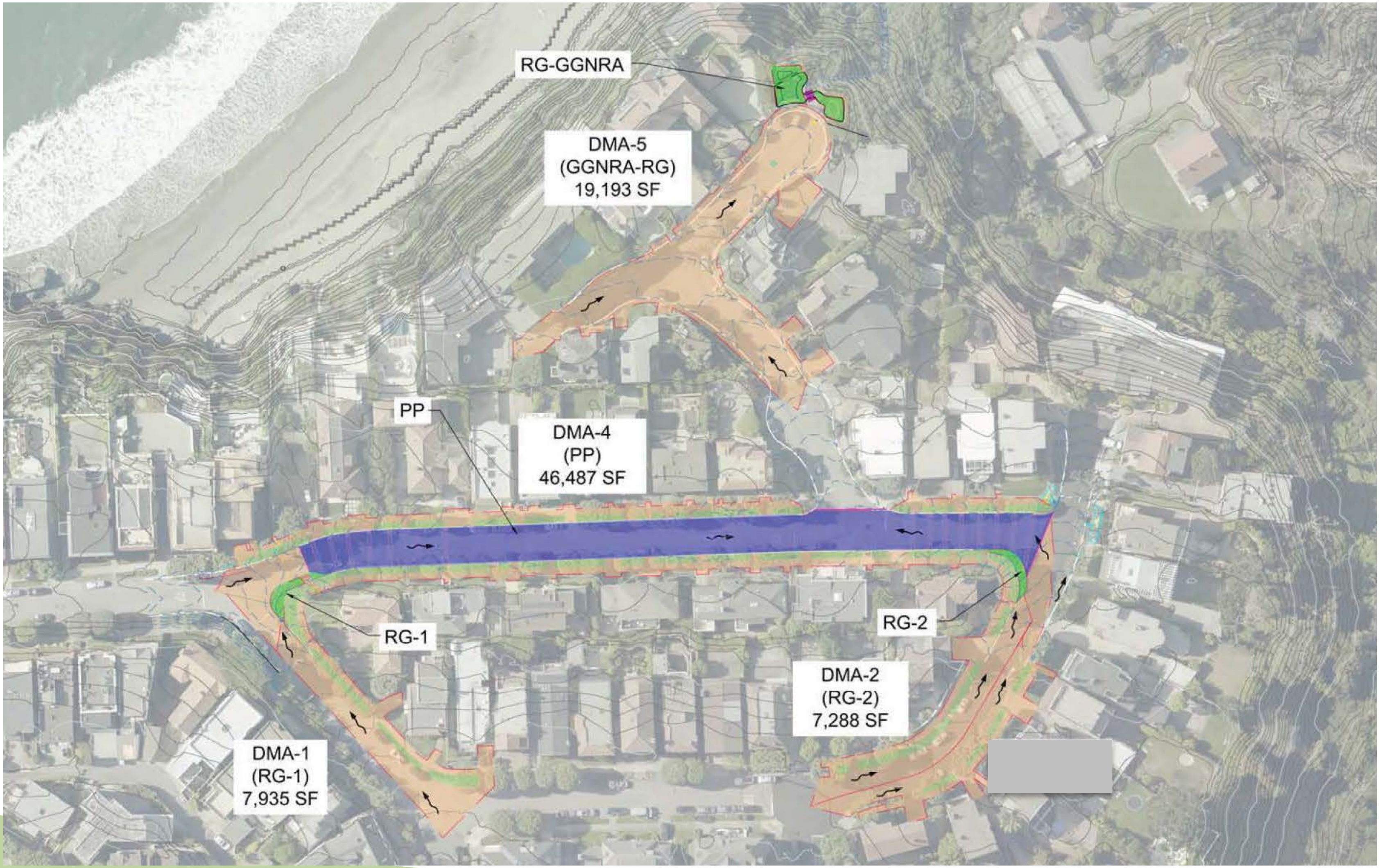
Part art and part science, the discipline of quality assurance for highway construction abounds with half-truths, myths, and misconceptions. These myths typically originate from well-meaning sources. Some myths serve a worthy function by simplifying the difficult to make it more understandable. However, on the negative side, myths:

- May be partly true, but not all of the time, so they can lead to an incomplete understanding of important concepts
- Encourage decision making as a seat-of-the-pants approach rather than one based on facts and data
- Leave a narrow, rigid impression that stifles creativity

https://www.fhwa.dot.gov/construction/pubs/hif07012/03.cfm - Reprinted from Public Roads, May/June 2005.

Baker Beach Green Street
Sea Cliff Avenue Area

San Francisco Water Power Sewer



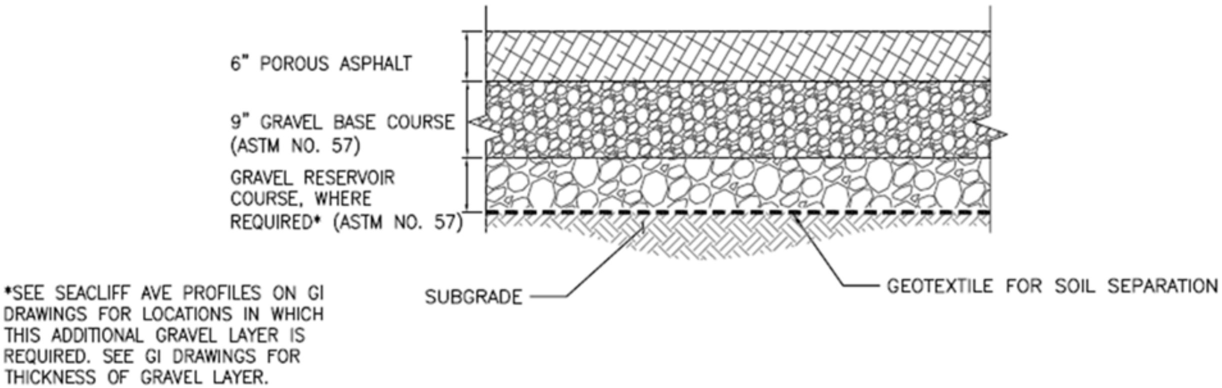
Sea Cliff Avenue Existing Conditions

San Francisco
Water Power Sewer

Material selection considerations:

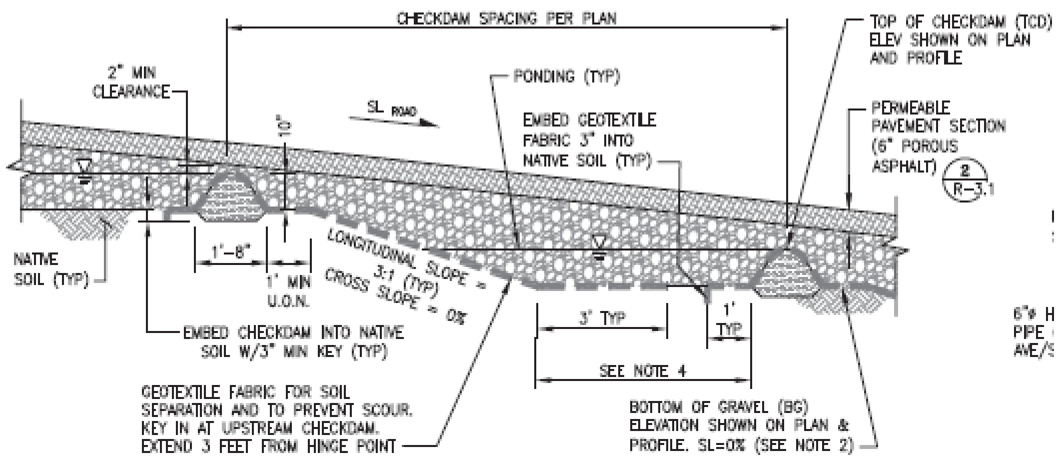
- Testing new materials
- Testing new applications
- Testing new maintenance scenarios
- Constructability
- Minimizing protection requirements
- Minimizing neighborhood disturbance / Opening street to traffic earlier
- Lowering project cost

Sea Cliff Ave Sections



POROUS ASPHALT SECTION 2 / -

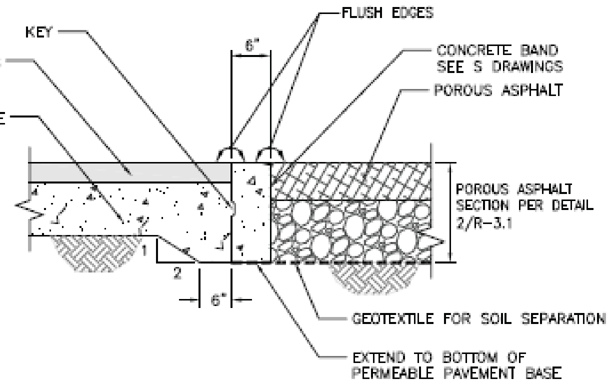
NTS



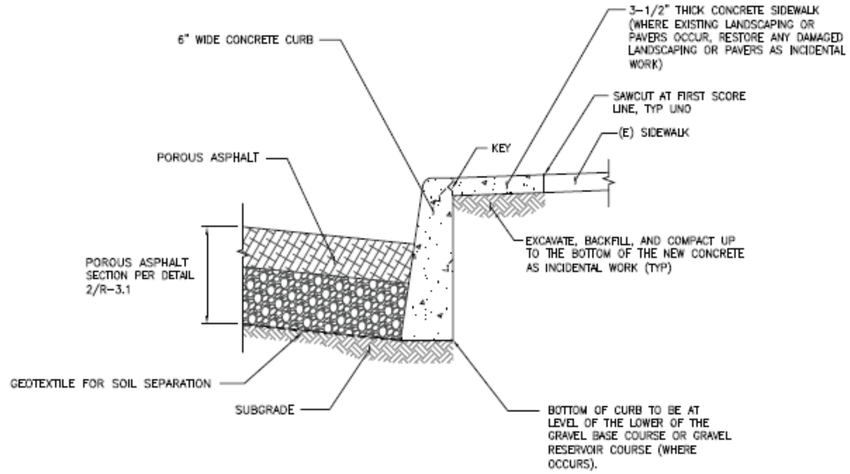
CHECKDAM A / -

SCALE: 1"=2'

Sea Cliff Ave Edge Treatments



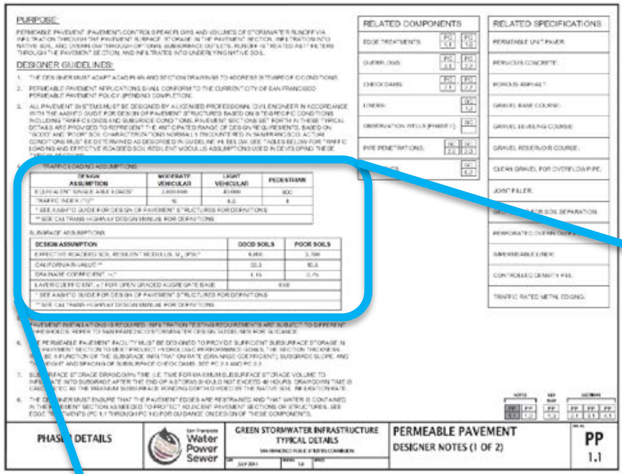
SEACLIFF TYPICAL SECTION
PAVEMENT AT CONCRETE BAND (3/-)
NTS



POROUS ASPHALT AT CONCRETE CURB (4/-)
NTS

San Francisco Water Power Sewer

SFPUC Design Parameters



TRAFFIC LOADING ASSUMPTIONS:

DESIGN ASSUMPTION	MODERATE VEHICULAR	LIGHT VEHICULAR	PEDESTRIAN
EQUIVALENT SINGLE AXLE LOADS*	2,000,000	40,000	800
TRAFFIC INDEX (TI)**	10	6.5	4
* SEE AASHTO GUIDE FOR DESIGN OF PAVEMENT STRUCTURES FOR DEFINITIONS			
** SEE CALTRANS HIGHWAY DESIGN MANUAL FOR DEFINITIONS			

SUBGRADE ASSUMPTIONS:

DESIGN ASSUMPTION	GOOD SOILS	POOR SOILS
EFFECTIVE ROADBED SOIL RESILIENT MODULUS, M_R (PSI)*	6,800	3,700
CALIFORNIA R-VALUE **	33.3	15.6
DRAINAGE COEFFICIENT, m_i*	1.15	0.75
LAYER COEFFICIENT, a_i* FOR OPEN GRADED AGGREGATE BASE	0.08	
* SEE AASHTO GUIDE FOR DESIGN OF PAVEMENT STRUCTURES FOR DEFINITIONS		
** SEE CALTRANS HIGHWAY DESIGN MANUAL FOR DEFINITIONS		

SFPUC Design Parameters

San Francisco Water Power Sewer

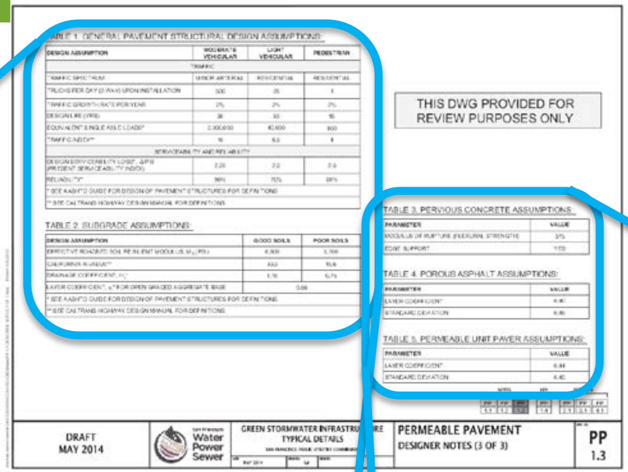


TABLE 1. GENERAL PAVEMENT STRUCTURAL DESIGN ASSUMPTIONS:

DESIGN ASSUMPTION	MODERATE VEHICULAR	LIGHT VEHICULAR	PEDESTRIAN
TRAFFIC			
TRAFFIC SPECTRUM	MINOR ARTERIAL	RESIDENTIAL	RESIDENTIAL
TRUCKS PER DAY (2-WAY) UPON INSTALLATION	500	20	1
TRAFFIC GROWTH RATE PER YEAR	2%	2%	2%
DESIGN LIFE (YRS)	30	30	15
EQUIVALENT SINGLE AXLE LOADS*	2,000,000	40,000	800
TRAFFIC INDEX**	10	6.5	4
SERVICEABILITY AND RELIABILITY			
DESIGN SERVICEABILITY LOSS*, Δ PSI (PRESENT SERVICEABILITY INDEX)	2.25	2.5	2.5
RELIABILITY*	90%	75%	50%
* SEE AASHTO GUIDE FOR DESIGN OF PAVEMENT STRUCTURES FOR DEFINITIONS			
** SEE CALTRANS HIGHWAY DESIGN MANUAL FOR DEFINITIONS			

TABLE 2. SUBGRADE ASSUMPTIONS:

DESIGN ASSUMPTION	GOOD SOILS	POOR SOILS
EFFECTIVE ROADBED SOIL RESILIENT MODULUS, M_R (PSI)	6,800	3,700
CALIFORNIA R-VALUE**	33.3	15.6
DRAINAGE COEFFICIENT, m_i*	1.15	0.75
LAYER COEFFICIENT, a_i* FOR OPEN GRADED AGGREGATE BASE	0.08	
* SEE AASHTO GUIDE FOR DESIGN OF PAVEMENT STRUCTURES FOR DEFINITIONS		
** SEE CALTRANS HIGHWAY DESIGN MANUAL FOR DEFINITIONS		

TABLE 3. PERVIOUS CONCRETE ASSUMPTIONS:

PARAMETER	VALUE
MODULUS OF RUPTURE (FLEXURAL STRENGTH)	375
EDGE SUPPORT	YES

TABLE 4. POROUS ASPHALT ASSUMPTIONS:

PARAMETER	VALUE
LAYER COEFFICIENT	0.40
STANDARD DEVIATION	0.45

TABLE 5. PERMEABLE UNIT PAVER ASSUMPTIONS:

PARAMETER	VALUE
LAYER COEFFICIENT	0.44
STANDARD DEVIATION	0.45

Precedent Research

San Francisco Water Power Sewer

Pervious Pavement Design Guidance

October 2013

California Department of Transportation
Division of Design
Office of Storm Water Management
1120 N Street
Sacramento, California
http://www.dot.ca.gov/hq/oppd/stormwtr/

TechBrief

The Asphalt Pavement Technology Program is an integrated national effort to improve the long-term performance and cost effectiveness of asphalt pavements. Managed by the Federal Highway Administration through partnerships with state highway agencies, industry and academia, the program's primary goals are to reduce congestion, improve safety, and foster technology innovation. The program was established to develop and implement guidelines, methods, procedures and other tools for use in asphalt pavement materials selection, mixture design, testing, construction and quality control.

U.S. Department of Transportation
Federal Highway Administration

Office of Asset Management, Pavements, and Construction

FHWA-HIF-15-009

April 2015

Porous Asphalt Pavements with Stone Reservoirs

This Technical Brief provides an overview of the benefits, limitations and applications of porous asphalt pavements with stone reservoirs. Considerations for design and construction, as well as maintenance, are discussed.

Introduction

Porous asphalt pavements with stone reservoirs are a multifunctional low impact development (LID) technology, which integrates ecological and environmental goals for a site with land development goals, reducing the net environmental impact for a project. Not only do they provide a strong pavement surface for parking, walkways, trails, and roads; they are designed to manage and treat stormwater runoff. With proper design and installation, porous asphalt pavements can provide a cost-effective solution for stormwater management in an environmentally friendly way. As a result, they are recognized as a best practice by the U.S. Environmental Protection Agency (EPA) and many state agencies (EPA n.d.; PDEP 2006; NJDEP 2004).

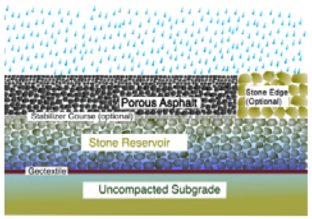


Figure 1: Typical porous asphalt pavement with stone reservoir cross section

Porous Pavement for Control of Highway Runoff in Arizona: Performance to Date

MUSTAQUE HOSSAIN, LARRY A. SCOFIELD, AND W. R. MEIER, JR.

In 1986 the Arizona Department of Transportation constructed a 3,500-ft-long porous pavement experimental test section on State Route 87 in the Phoenix metropolitan area. The objectives of the project were to determine the constructibility and subsequent performance of porous pavement as a drainage system and pavement structure in an urban area and a desert environment. The porous pavement test section has performed satisfactorily for 5 years. Although a slight decrease in the infiltration rate has occurred, both the infiltration rate and the storage capacity are above the design values. The storage capacity of the pavement subbase and trench drain system has been underutilized. If a design intensity storm occurs during the remaining service life, this should be verified. Visual observation during rain storms has shown that the surface of the porous pavement section does not include sheet flow, which provides a marked difference in stripe delineation and pavement glare during nighttime inclement weather driving as compared with conventional pavement. Mu-meter skid test results for the porous pavement section are comparable with those of conventional pavements (control). Material tests conducted on the pavement components indicate that the Marshall stability, resilient modulus, and asphalt cement viscosity of the open-graded asphalt concrete have increased with time. No cracking or significant surface deformation has occurred during the 5 years of service. Annual falling weight deflectometer testing was conducted to establish the changes in layer properties. To date, little change has occurred in the layer moduli except for the open-graded subbase, whose modulus has decreased with time. No unusual presence of moisture was detected in any layer of the pavement system. The subgrade moisture content has achieved equilibrium and less than optimum moisture content determined during the design process.

Paved surfaces increase runoff and overload the existing sewer systems if alternative drainage is not provided. Rainfall is the only source of surface runoff in the Phoenix area. Typical summer storms have high intensity and short duration, whereas typical winter storms have low intensity but longer duration (*1*,*2*). This creates a large volume of runoff requiring costly highway drainage systems. Up to 35 percent of the total cost of highway construction projects in Arizona's urban area is expended on drainage structures (*3*). In an attempt to reduce the need for extensive drainage systems, porous pavements have been suggested as an alternative to conventional pavement (*4*,*5*). The basic concept of porous pavement design is that in addition to carrying traffic, the porous pavement will also serve as a drainage system by absorbing and storing storm waters and dissipating them into the ground. In 1986 the Arizona Department of Transportation (ADOT) constructed a 3500-ft-long porous pavement experimental test section on an urban highway. The objectives of the project were to determine the constructibility and subsequent performance of porous pavement as a drainage system and pavement structure in an urban area and a desert environment.

M. Hossain, Department of Civil Engineering, Seaton Hall, Kansas State University, Manhattan, Kans. 66506-2905. L. A. Scofield, Arizona Transportation Research Center, College of Engineering and Applied Sciences, Arizona State University, Tempe, Ariz. 85287. W. R. Meier, Jr., Western Technologies, Inc., 3737 E. Broadway Road, Phoenix, Ariz. 85007.

PROJECT LOCATION AND LAYOUT

The test section is located in the three northbound lanes of State Route (SR) 87 (Arizona Avenue) between Station 105 + 00 and 140 + 00 in the city of Chandler between Elliot and Warner roads. Chandler is a rapidly growing and developing suburban city approximately 20 mi southeast of Phoenix. SR 87 is heavily traveled by commuter traffic going to and from the Superstition Freeway, which is approximately 2.5 mi north of the project. Currently, the average daily traffic is approximately 30,000. Figure 1 shows the layout of the porous pavement section and the control section.

DESIGN CONSIDERATIONS

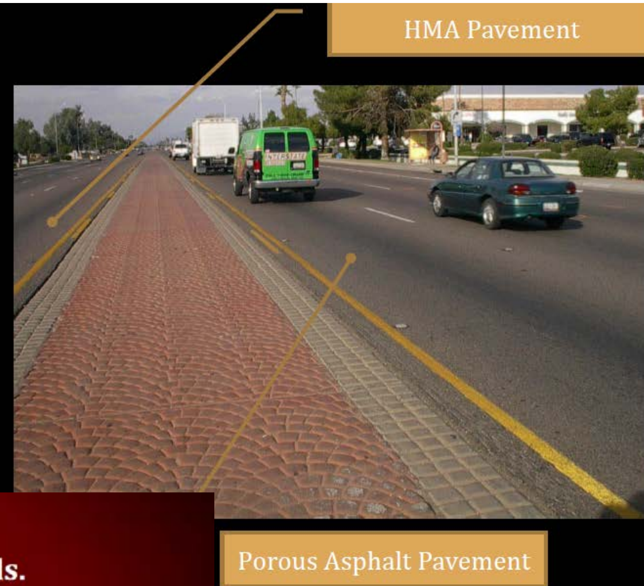
Porous Pavement Section

The porous pavement section consists of 6 in. of open-graded hot-mix asphalt concrete, 6 in. of open-graded asphalt-treated base (ATB), and 8 in. of open-graded subbase. The pavement structure was designed equivalent to the control section of conventional dense-graded pavement. This pavement was designed using the AASHTO (*6*) design equation to carry the design traffic loading of 2,270,653 single-axle, equivalent 18-kip loads for a 20-year design period (*7*).

A woven filter fabric was placed for separation of the subbase and subgrade. The open-graded layers of the pavement drain into a trench at the edge of the pavement, which is filled with open-graded aggregate. The water from the drainage trench was expected to dissipate into the ground. An alternative drainage system was also provided for the experimental section as a backup in the event of failure of the designed experimental drainage system. The pavement structure designed was found to have adequate water-holding capacity to

Precedent Research

San Francisco Water Power Sewer



6. POROUS ASPHALT IS A GOOD PRODUCT FOR LOCAL ROADS, PARKING LOTS AND TRAILS.

Conclusions of Final Report for SR-87 project:

- "The porous pavement test section has performed satisfactorily for five years. Although a slight decrease in the infiltration rate has occurred, both the infiltration rate and the storage capacity are above the design values."
- "Visual observation during rain storm has shown that the surface of the porous pavement section does not include sheet flow. This provides a marked difference in stripe delineation and pavement glare during night time inclement weather driving compared to conventional pavement."

Myth #2 - Porous asphalt will rut under traffic loads.

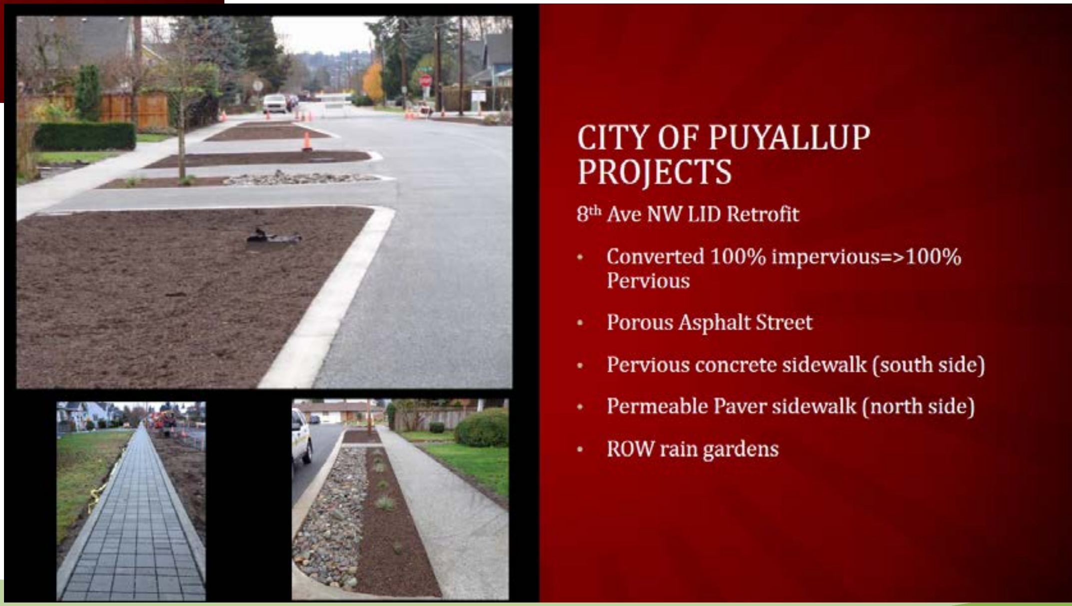
- **Truth –**
- The structural strength of flexible pavements comes primarily from the supporting roadway section, not the asphalt.
- Cahill Associates experience confirms that the deeper pavement sections generally result in a more durable pavement.
- Further, A Caltrans study performed in 1989 on the structural value of open graded asphalt-treated base and open graded asphalt concrete pavement concluded that these materials would be assigned the same structural strength value as their dense graded counter parts.
- ODOT has also concluded in their design guidelines that open graded asphalt will be given the same structural value as dense graded asphalt.
- Previous mix designs did not call for enough compaction, would have resulted in rutting

Washington Stormwater Center June 17, 2015 43

Excerpts from presentation by:
Mark A. Palmer, P.E., LEED AP
City Engineer, City of Puyallup
Jun 17, 2015

Precedent Research

San Francisco Water Power Sewer



Excerpts from presentation by:
Mark A. Palmer, P.E., LEED AP
City Engineer, City of Puyallup
Jun 17, 2015

Outcome

NO - Because porous asphalt isn’t City standard rigid pavement.

Rigid Pavement Standard

SECTION 207

CONCRETE BASE

207.01 GENERAL. - The Contractor shall construct concrete base where and as shown on the plans, 6 inches thick unless otherwise specified

http://sfpublicworks.org/sites/default/files/Part2-StreetsAndHighways.pdf (the "Orange Book")

A minimum pavement section of two (2) inches of asphalt concrete wearing surface over six (6) inches of concrete for residential streets or two (2) inches of asphalt concrete wearing surface over eight (8) inches of concrete for arterials. For streets with grade of over 15%, the pavement section shall be concrete. Any alternative pavement section shall be submitted to the City Engineer for review and approval.

http://sfpublicworks.org/services/street-dedication-and-acceptance

Rigid Pavement Myth

No basis of design, or design parameters exist to support the rigid pavement standard. Therefore, the City's rigid pavement standard is a MYTH.

Myths:

- May be **partly true, but not all of the time**, so they can lead to an **incomplete understanding** of important concepts
- Encourage decision making as a **seat-of-the-pants** approach rather than one based on **facts and data**
- Leave a narrow, rigid impression that **stifles creativity**

https://www.fhwa.dot.gov/construction/pubs/hif07012/03.cfm - Reprinted from Public Roads, May/June 2005.

Examples of the Myth

http://www.sfgate.com/bayarea/article/Bay-Area-SF-sinkhole-historic-photos-10928799.php#photo-12352979

Call to Action

Develop a permeable paving support group similar to the **Green Infrastructure Leadership Exchange** http://giexchange.org/

This group could help municipalities facing barriers to permeable pavement acceptance and implementation by:

1. Providing industry, political, inter-agency and public support
2. Assisting with data collection and sharing
3. Creating access to case studies and precedent research documenting performance and lessons learned
4. Developing effective, collaborative, industry wide communications efforts
5. Normalizing and developing standards, guidance, policies and regulations
6. Helping to cultivate effective partnerships and champions at the local, regional and national level
7. Advancing the economic viability of permeable pavement implementation and maintenance
8. Increase access to high level education and training for public practitioners and the private sector

Thank You

Mike Adamow

madamow@sfwater.org