POROUS PAVEMENT ALTERNATIVES COST ANALYSIS

Prepared by Century West Engineering for Metro

This cost analysis compares the construction costs of six different types of pavement for three different scenarios. The purpose of the analysis is to give builders a way to compare the relative costs of porous pavements. The cost estimates are based on a number of assumptions and on one engineering firm's designs. Porous and conventional pavement costs vary depending on site conditions, market conditions, engineering designs, local permit requirements and other factors. In addition, this memo presents costs for construction only and does not take into account lifetime cost of each pavement. Metro encourages the use of porous surface options when appropriate and in jurisdictions that permit it, but Metro does not promote any particular pavement material.

1. INTRODUCTION

Due to current requirements for management of stormwater runoff, a number of new technologies have emerged in recent years to manage both the quality and quantity of stormwater runoff associated with urban development. One technology that has received increased attention is porous pavement. Porous pavement allows disposal of runoff via direct infiltration from the developed surface. This ability to use paved surfaces to dispose of storm water offers a number of benefits including; efficient use of developable land by utilizing the paved footprint on a site for stormwater management; improved treatment compared with other stormwater BMP's; and reducing runoff to rivers, lakes, and streams reducing erosion and storm surge and improving overall water quality.

One of the barriers to wider use of porous pavements is the perception that porous pavement is more costly than conventional pavement and related stormwater management systems. In order to provide a better understanding of the true costs of porous pavement compared to other paving systems, the Metro Sustainability Center has undertaken a study to estimate the relative costs for a number of pavement systems both porous and non-porous. The objective is to provide comparisons that will be helpful to land developers and municipalities in the planning and design of site improvements. Century West Engineering has been commissioned to perform the analysis and summarize their findings and results. This memo presents the findings and conclusions of this study.

2. DESIGN SCENARIOS

Three scenarios were considered. Included were:

- **Neighborhood Roadway** – A roadway roughly consistent with a 200' city block. Assuming 50' lots, the street would access eight homes. The width would be sufficient to accommodate two 12' travel lanes with 10' for parking on one side of the street. Based on these requirements the street's paved area would total 6,800 SF. It is assumed that the street will be curbed; however, sidewalks were not considered for this study.

- **Parking Lot** – A parking lot for a small business. The lot would include ten 10’x20’ stalls and a 50’x24’ drive aisle. The total area would be 3,200 SF. Curbs, but no sidewalks, are assumed.
- **Driveway** – A driveway large enough for three cars with room for some maneuvering. 800 SF of pavement is assumed.

3. DESIGN ALTERNATIVES

Six pavement sections were considered for the three scenarios listed above. These included:

- Porous Asphalt Pavement
- Pervious Concrete Pavement
- Permeable Interlocking Concrete Pavers
- Porous Gravel with a Geo-cellular grid
- Conventional Asphalt plus Drainage Structures
- Conventional Concrete plus Drainage Structures

Each section was designed based on uniform assumptions of traffic loading for a 20-year life to produce pavement sections that will perform comparably. The pavement sections presented are based on conservative assumptions resulting in thicker sections than might be typically used. Actual sections for a particular application will depend on site specific soil conditions and traffic loadings.

3.1. PAVEMENT DESIGN

3.1.1. Structural Section – Traffic loading for each scenario was determined based on Equivalent Axle Loadings (EALs) anticipated over a 20 year period and Average Daily Truck Traffic (ADTT). Both construction and operational traffic were considered. Based on these assumptions the following traffic loads were projected.

- Neighborhood Roadway – 25,000 EALs, ADTT=3.5
- Parking Lot – 14,000 EALs, ADTT=1.9
- Driveway – Minimal Traffic

Soils were assumed to have fair suitability for subgrade construction. A California Bearing Ratio (CBR) of 5 was used for pavement section design.

The surface course strength for porous asphalt was considered roughly equal in strength to its non-porous counterpart. However, for concrete the compressive strength of pervious concrete is roughly 2,500 psi, considerably less than the 4,350 psi assumed for non-porous. To offset this difference, thicker slabs are specified for pervious concrete. In this study, concrete slab thicknesses were increased by 50% to offset the lower strength of pervious concrete.

Traditionally, for porous asphalt and pervious concrete surfaces, the aggregate section has consisted of coarse aggregate that serves as the structural section and as a recharge bed for the storage and disposal of storm runoff. This layer was frequently overlaid with a choker course consisting of more finely graded rock. The choker course fills in the larger void space at the surface of the coarse aggregate layer and provides a more stable working surface for construction. In recent years, a use of a finely graded choker course over a coarse aggregate recharge bed, has been replaced with the use of a finer overall section. This is the approach taken for this study.

Uniform-graded aggregate is used. Although a wide range of aggregate grades have been and are used for base courses, 1½”-1/4” was assumed for this study. This aggregate has similar structural properties to the aggregate used for non-porous pavements. The resulting sections are comparable to their non-porous counterparts. The main difference is that porous sections may be thicker due to the need for storage of runoff. This is discussed further in the following section.

For permeable interlocking concrete pavers and geo-cellular reinforced sections, aggregates such as ODOT ¾"-#4 or 1"-#4 are used. These maintain the void ratios necessary for storage while retaining structural properties needed for resistance to rutting from turning, braking, and acceleration movements.

For conventional paved surfaces, standard dense graded aggregates were assumed.

Many of the published design guidelines utilize AASHTO specifications for aggregate base rock. To better relate porous pavement designs to local standards, we have attempted to use commonly available gradations. ODOT specifications for base rock were utilized where possible.

3.1.2. Stormwater Storage – For the porous pavement alternatives, storage of stormwater is considered in the design. A typical porous pavement section must be capable of storing the precipitation total for the design storm event and allowing that total to infiltrate within 24 hours following that event. The design storm event used in the Portland area is a 10-yr/24-hr event. According the City of Portland's Stormwater Management Manual, the precipitation total for this event is equal to 3.4 inches. Given that the aggregate used in most porous pavement sections has a void ratio of approximately 40%, a minimum thickness required for stormwater storage in porous pavement sections is determined from the following calculation.

$$\textbf{Min. Aggregate} = \frac{\textbf{3.4 inches}}{\textbf{0.40}} = \textbf{8.5 inches}$$

This is the minimum thickness used for storage of storm runoff in this study. Depending on structural requirements for a specific pavement section, and the void ratio of aggregate used for a specific application, this thickness may vary.

3.1.3. Based on the above traffic loads and soil characteristics, the following pavement sections were designed. Although each system has its own unique regimen for maintenance, the sections listed are roughly equivalent and, with proper care and maintenance, provide adequate levels of service over a 20-year lifespan.

4. COST ANALYSIS

Paving costs for each of the three scenarios was estimated. Unit costs for construction were estimated based on recent bids for similar work by local contractors. A summary of the costs is given below.

DRIVEWAY				
	Surface	Base		
Material	inches	inches	Size	Cost
Pervious Concrete	6	9	2½"-1½"	$7,570
		2	1"-#4	
Porous Asphalt	3	9	2½"-1½"	$4,330
		2	1"-#4	
Permeable Pavers	Paver	9	1"-#4	$11,760
Plastic Grid Reinforced Gravel	Geocell	9	¾"-#4	$3,930
Conventional Concrete	4	4	1"-0"	$5,330
Conventional Asphalt	3	6	1"-0"	$3,520

PARKING LOT				
	Surface	Base		
Material	inches	inches	Size	Cost
Pervious Concrete	8	9	2½”-1½”	$44,930
		2	1”-#4	
Porous Asphalt	3	9	2½”-1½”	$25,960
		2	1”-#4	
Permeable Pavers	Paver	12	1”-#4	$57,150
Plastic Grid Reinforced Gravel	Geocell	9	¾”-#4	$24,680
Conventional Concrete	5	6	1”-0”	$32,200
Conventional Asphalt	3	8	1”-0”	$23,680

NEIGHBORHOOD ROAD				
	Surface	Base		
Material	inches	inches	Size	Cost
Pervious Concrete	8	9	2½”-1½”	$95,360
		2	1”-#4	
Porous Asphalt	4	9	2½”-1½”	$58,920
		2	1”-#4	
Permeable Pavers	Paver	12	1”-#4	$110,260
Plastic Grid Reinforced Gravel	N/A	N/A	N/A	N/A
Conventional Concrete	5	6	1”-0”	$72,320
Conventional Asphalt	4	8	1”-0”	$57,540

The costs assumed key items related to the construction of each improvement. Maintenance costs were not included. For the non-porous alternatives, costs for drainage facilities were included for the Neighborhood Road and the Parking Lot. For the Neighborhood Road this included four inlets, two manholes, and 300 LF of 12” storm sewer. For the Parking Lot this included a single inlet and 50 LF of 12” storm sewer. No drainage was assumed for the driveway.

Overflow drainage facilities were included for the porous pavement alternatives to capture excess stormwater that may not infiltrate. Overflow drainage facilities may not be necessary for sites with highly permeable soils. This would lower overall costs for these alternatives. Overflow drainage facilities for the Neighborhood Road section included two inlets, one manhole, and 35 LF of 12” storm sewer. For the parking lot, a single inlet and 65 LF of storm sewer were assumed. As with the non-porous driveway, no drainage facilities were assumed.

No water quality facilities such as ponds or swales were considered.

5. MAINTENANCE OF POROUS SURFACES

For some porous pavement surfaces, periodic maintenance is necessary to help ensure the surfaces do not plug with debris and cease to function as designed. Based on monitoring of porous pavement surfaces conducted by the City of Portland, pervious concrete and porous asphalt surfaces are susceptible to plugging. Pressure washing of the surfaces every three years is recommended to help alleviate plugging of the surface and ensure a high infiltration rate is maintained.

Pressure washing is not recommended for permeable interlocking concrete pavers and geo-celluar grid reinforced gravel.

6. CONCLUSIONS

In general, porous asphalt and pervious concrete are cost competitive, particularly where larger areas are involved. This is primarily due to the fact that no drainage is required. For smaller areas, such as the driveway, where drainage was not included in the cost, non-porous alternatives were less.

The most expensive alternative in all scenarios were permeable interlocking concrete pavers. This was due to the fact that placing the pavers is much more labor intensive. However, this could still be a preferred alternative where a highly ornate, ornamental finish is desired.

Gravel reinforced with a geo-cellular grid tended to be the least expensive. However, this low initial cost comes with the drawback that periodic maintenance of the surface will be needed to maintain the gravel surface.

The decision to select porous versus non-porous paving depends on the particular needs of the owner, site specific constraints, and the proposed use of the improved area. Based on this review, porous pavements are cost effective or close to cost neutral alternatives when all development costs are considered.