Green Streets and Porous Pavement: Lessons for Sustainability, Savings, and Success

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LEARNING OBJECTIVES:

• **SUSTAINABILITY**: (AT LEAST) FIVE TECHNIQUES FOR **STREET RUNOFF INFILTRATION**

• **SAVINGS**: WHAT TO COMPARE & COSTS

• **SUCCESS**: POST-CONSTRUCTION PERFORMANCE
EVOLUTION OF WATER QUALITY

• 1972 – CLEAN WATER ACT
• 1970s-80s -- INDUSTRIAL POLLUTION TARGETED
• Late 1980’s – present – SEWER OVERFLOWS
• Late 1990’s – PHASE I TARGETS MS4 POINT/NON
• 2000’s – present PHASE II – KEY QUESTIONS:
  – What is Non-Point Source (NPS) Pollution?
  – Will Public Education Take care of NPS?
  – Who can have the biggest impact on NPS?
WALT KELLY
DEBUNKS “NON-POINT SOURCE”

• ANN ARBOR, MI: POP. ~115,000: 27.5+ SQ. MI.
• ROW = **2.9 SQUARE MILES** IMPERVIOUS AREA
• =**10.5%** of total City area
• =**25.9%** of the total impervious area within the City of Ann Arbor
• LARGELY UNTREATED!!
• =**54%** OF NPS POLLUTION – **IT IS US!!**
CITY = 54% OF NPS POLLUTION

• HOW TO HANDLE THIS??
• DON’T BUY SWIRL CHAMBERS!!
• OPPORTUNISTIC INFILTRATION
  – CURB NOTCHES/RAINGARDENS, BUMP-OUTS, ETC
  – FIND SAND -- PERFORATED PIPE, CISTERN SHAFTS
  – POROUS BASE UNDER POROUS/PERVIOUS PVMT
TSS Removal Efficiencies

SOURCE: 2005 DATA REPORT, UNH STORMWATER CENTER
Top 5 TSS Removal Efficiencies

- POROUS PAVEMENT – 100%
- GRAVEL WETLAND – 100%
- STORAGE BASIN INFILTRATION – 100%
- TREE FILTER – 93%
- BIORETENTION – 92%
Performance of Porous Asphalt

Willard Beach Park: Porous vs. Regular Asphalt
Battle Creek, MI

Entrance to Pringle Creek Community: Porous vs. Regular Asphalt
Salem, OR
POROUS vs. REGULAR ASPHALT

PAVER & TRANSVERSE JOINTS

POROUS vs. REGULAR
Case Study: Boulder Hills
Pelham, NH

- 2009 -- 900’ OF PRIVATE RESIDENTIAL PAVING IN NE
- SITE GOAL OF ZERO DISCHARGE
- 55+ ACTIVE ADULT COMMUNITY
- SANDY SOILS (NOT A MUST)
The Design

1. BASE COURSE - COBBLES LARGER THAN 6" SHALL BE REMOVED.
2. PRIOR TO PLACEMENT OF SUBBASE TOPSOIL SHALL BE REMOVED AND STOCKPILED.
2009 SMALL PROJECT PAVING COSTS

900 FEET OF RESIDENTIAL PAVEMENT

• HMA $100/ton (PLACED BY MACHINE)
• PA $125/ton PLACED BY MACHINE
• COMPLEX/HANDWORK = $170/ton

SOURCE: Boulder Hills Case Study
COST AVOIDANCE

• 1616’ CONCRETE CURB
• 785’ PIPE
• 8 CATCHBASINS
• 2 DETENTION BASINS & 2 OUTLET STRUCTURES
• SAVED 1.3 ACRES IN LAND CLEARING/CONSUMPTION
• CONVENTIONAL = $789,500 vs. LID SWM = $740,300
• INFILTRATION COST SAVINGS = $49,000 = (6.2%) 
• O/M DISCUSSION LATER – ALSO LESS
# Comparison of Unit Costs

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<th>Item</th>
<th>Conventional</th>
<th>LID</th>
<th>Difference</th>
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<tr>
<td>SITE PREPARATION</td>
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Other Project Benefits

- LESS SALTING NEEDED - $$ AND ENVIRONMENTAL
- BETTER TRACTION THAN HMA
- SOUND REDUCTION USE BY CALTRANS, OTHERS
- ELIMINATED ICING & CRASHES IN ANDERSON CO, OH
- LESS MOSQUITO BREEDING AREA
- REDUCES THERMAL IMPACT TO STREAMS
- LESS IMPACT OVERALL TO RECEIVING STREAM
PREVENTING PITFALLS OF POROUS

✓ KNOW YOUR MIX DESIGN -- MULTIPLE OPTIONS IF LOADING OR RAVELING ARE CONCERNS

✓ SUB-BASE COMPACTION IS IMPORTANT TOO

✓ CHOKER LAYER IS KEY TO A WORKING PLATFORM

✓ NO SANDING FOR WINTER MAINTENANCE!!

✓ THE MYTH OF “MORE EXPENSIVE MAINTENANCE”
HOW POROUS O/M IS MUCH LESS

• WHAT IF YOU HAD PAVEMENT THAT NEVER CRACKED?
HOW POROUS O/M IS MUCH LESS

...AND IS SUPPOSED TO HAVE WATER IN THE BASE
HOW POROUS O/M IS MUCH LESS

• WHAT IF YOU HAD PAVEMENT THAT NEVER CRACKED?
• AND PAVEMENT THAT DIDN’T FAIL DUE TO WET BASE?
• WHO IS UNDER AN NPDES PERMIT?
• SWEEPING COSTS ARE ACTUALLY SIMILAR
• A MILE OF POROUS CAN COST $57,750 LESS IN O/M
HOW POROUS O/M IS MUCH LESS

HMA Maintenance With Sweeping
Cumulative Porous Sweeping Costs
HOW POROUS O/M IS MUCH LESS

• *$57,750/MILE HMA PAVEMENT MAINTENANCE COSTS
  – YEAR 0-4 – NO COSTS
  – YEAR 5: FIRST CRACK SEALING; $750
  – YEAR 6-10: LIMITED PATCHING; $6,000 ($2,000/LANE MILE)
  – YEAR 6-10: 2ND CRACK SEAL; $3,000, CHIPSEAL; $15,000
  – YEAR 10-15: 3\textsuperscript{RD}/4\textsuperscript{TH} CRACK SEAL; $12,000
  – YEAR 16-20: MAJOR PATCHING, POSSIBLE SEALCOAT; $21,000
  – 4x ANNUAL STREET SWEEPING, $1,000/YR--IF PERMIT REQ’S.

*YOU MAY WISH TO REVISE COSTS BASED ON YOUR AGENCY PRACTICES
BASED ON 20 YEAR CYCLE FOR 1 MILE RESIDENTIAL STREET WITH 36’ PAVEMENT WIDTH
HOW POROUS O/M IS MUCH LESS

• POROUS PAVEMENT MAINTENANCE COSTS:
  – 2x ANNUAL STREET SWEEPING, $1,000/yr REGEN VACUUM
  – NO CRACK SEALING
  – NO PATCHING DUE TO FROST HEAVE OR BASE FAILURE
  – NO RESURFACING DUE TO CRACKING, ETC

• TOTAL LIFE CYCLE COST SAVINGS:
  – $57,750 IF STREET SWEEPING IS DONE ON HMA ANYWAY
  – $37,750 IF NO HMA STREET SWEEPING

BASED ON 1 MILE RESIDENTIAL STREET WITH 36’ PAVEMENT WIDTH
REPAIRS AND REPLACEMENT

• UTILITY CUTS, OTHER PATCHING NEEDS

• BASE FAILURES TYPICALLY RARE – BETTER BASE

• CAN REPAIR WITH REGULAR HMA

• CAN REPAIR BY HEATING AND RE-ROLLING

• TO REPLACE – MILL TO CHOKER COURSE
INfiltration Toolkit:

1. Porous Mix Designs Are Not All The Same
2. HMA With Pavers Or Porous Is An Option
3. Infiltration Under Traditional HMA

Easy Street, Ann Arbor, MI
INfiltration Toolkit #1:

- Mix design is important (strength & durability goals) – AZ-87 30,000 vpd

- Key variables:
  - Agg size
  - Fiber/additive
  - Asphalt content

- See resources 1 & 2 for mix design info – Washington DOT, UNH
Reconstructed in 2010
Approx. 825’ long; and 20’ wide.
Scope: Full reconstruction; full replacement of sidewalks, curb & gutter; construction of permeable HMA section; some infiltration at east 200’ of project, but remainder had an impervious line to prevent flooding of adjacent basements; installation of underdrains below sidewalks with tees to allow connection of sump pumps from individual properties.
Construction Cost: $385,000
TOOLKIT #1: SYLVAN AVE, ANN ARBOR, MI
INfiltration Toolkit #1:
INFILTRATION TOOLKIT #2:

Permeable HMA 4” or as designed

Permeable Asphalt Typical Cross Section
INFILTRATION TOOLKIT #3: NO POROUS PAVEMENT

• CITY OF ANN ARBOR, MI 2013 INFILTRATION PAVING
• TRADITIONAL HMA WITH SITE-SPECIFIC BASE INFILTRATION

— FOREST STREET
— FOURTH AVENUE
— MADISON STREET
West Madison Street Cross Section
NOTE: DENSITY TESTING PER CITY ANN ARBOR STANDARD SPECIFICATIONS

NOTE: TRENCH DETAILS SHOW TYPE OF BACKFILL ONLY

NOTE: ALL TRENCHING TO CONFORM TO ALL APPLICABLE M.I.O.S.H.A. STANDARDS

NOTE: SUBBASE, AGGREGATE BASE AND HMA PAID SEPARATELY

STONE RESERVOIR TRENCH DETAIL
FOREST STREET X-SECTION 2

PAVEMENT CROSS SECTION
APPLIES AT STA 1+07.00 TO P.O.E.
NO SCALE
FOREST STREET LEACHING BASIN

LEACHING BASIN - 48" DIA
NO SCALE
ALL ITEMS PERTAIN TO "LEACHING BASIN - 48" DIA" UNLESS SPECIFIED.
FOURTH AVE. PLAN AND PROFILE
FOURTH AVE. LEACHING BASIN

LEACHING SINGLE INLET STRUCTURE

1. USED WITH ONLY SINGLE OUTLET PIPE, AND NO INLET PIPE.
2. FRONT EDGE OF INLET CASTING SHALL BE FLUSH WITH FRONT EDGE OF CUTTER (EDGE OF VALLEY)
INfiltration ToolKit #3: No Porous Pavement

- HMA Pavement with Porous Base
- Strategic Infiltration Areas in Row
Curb & Gutter vs. Swales
Street Trees and Planter Design

• Tree planting areas often too small
• Tree planting areas typically raised
• Can be lowered to accommodate stormwater
• Many design alternatives
IN CONCLUSION...

• UP TO 54% OF POLLUTANTS FROM STREETS
• INFILTRATION IS BEST, MOST SUSTAINABLE
• MANY OPTIONS FOR INFILTRATION
Acknowledgements

Thank you to the City of Ann Arbor and the University of New Hampshire Stormwater Center for their support.
• *Porous Pavement Presentation*, City of Puyallup, WA– Resource 1 under this session number on the conference website. Extra focus on mix design and aggregate selection for asphalt, choker, and base courses.


• Resource 3 under this session number on the conference website includes a detailed listing of contacts at agencies that have porous pavement installations, and other helpful resources accessed for this presentation.