Concrete Sustainability Conference
City of Glendale - Park and Ride

Glendale Arizona
Sports & Entertainment District
Project site

12 Acres - NE corner of 99th Avenue and Glendale
Arid previous farm land serviced by two arterials
Cost = $11.2 million ($3 million contributed Federal funds)
388 spaces (Phase 1) + 254 (Phase 2) = 642 at build-out
Design concept

ORIGINAL concept

- Hot mix asphalt (HMA) on aggregate base course (ABC) for site
- Standard shade canopies for parking stalls

RE-EVALUATED concept

- Council input – sought multiple alternatives
  - Retained Jacobs Engineering who contacted ASU’s “National Center of Excellence SMART innovations for Urban Climate + Energy”
- Council saw opportunities for a GREEN product and be a leader in the region with emerging technologies AND construct a state of the art facility
Alternative concepts

- Design charrette with council looked for alternative surfacing to hot mix asphalt (HMA)
- Gravel Pave – ruled out for high use area
- Concrete Pavers – ruled out for cost / installation & missed opportunity
- **Pervious concrete** – council intrigued after initial presentation
  - Academia Consultation - **Dr. Kamil E. Kaloush, PhD, P.E. @ ASU’s National Center of Excellence on Smart Innovations for Urban Climate and Energy.**
  - Jacobs presentation to Council workshop / CIP meetings on potential use of Pervious Pavement (parking areas only – PCCP in drive aisles).
  - Positive feedback from City Council - favorable to “GREEN” concept with positive attributes.
- Challenge of no specifications existed in SW United States
Additional benefits of pervious

- Land consumption / pollutant removal / heat island effect

**Table 6-9. Relative Land Consumption of Storm Water BMPs**

<table>
<thead>
<tr>
<th>BMP Type</th>
<th>Land consumption (% of Impervious Area)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retention Basin</td>
<td>2-3%</td>
</tr>
<tr>
<td>Constructed Wetland</td>
<td>3-5%</td>
</tr>
<tr>
<td>Infiltration Trench</td>
<td>2-3%</td>
</tr>
<tr>
<td>Infiltration Basin</td>
<td>2-3%</td>
</tr>
<tr>
<td>Porous Pavement</td>
<td>0%</td>
</tr>
<tr>
<td>Sand Filters</td>
<td>0%-3%</td>
</tr>
<tr>
<td>Bioretention</td>
<td>5%</td>
</tr>
<tr>
<td>Swales</td>
<td>10%-20%</td>
</tr>
<tr>
<td>Filter Strips</td>
<td>100%</td>
</tr>
</tbody>
</table>

Note: Represents the amount of land needed as a percent of the impervious area that drains to the practice to achieve effective treatment.
Source: Claytor and Schueller, 1996
Jacobs Engineering
cost analysis

- Installation costs for Hot Mix Asphalt (HMA) = $693,570
- Installation for pervious concrete = $916,460
- **Difference of $223,070**
- 20 year analysis (present cost) yielded HMA = $844,692
  Pervious concrete = $844,070
Challenges / opportunities of utilizing pervious concrete

- Not structurally sufficient for heavy truck traffic - pervious only in parking areas – Park & Ride uses PCCP in drive aisles
- 6” Pervious on 6” sub-base (¾” aggregate) over filter fabric
- Surface spalling potential – in other pervious projects
- Hydrocarbon and chemical(s) remediation
- Size down / eliminate basins as pervious section has storage capacity (went with “C” value for native soil (.3 vs. .95)
- Design utilized redundant system to compensate for permeability
- Mitigates heat island effect (huge consideration)
Heat island effect
In-house departmental challenges

- Concrete pervious pavement almost exclusively used in non-arid climates – no relevant history in southwest United States extreme hot, dry & dusty desert climate
- Life cycle cost over HMA – accurate?
- Sparse rainfall would predicate pore clogging
- Extreme temperatures impact / affect placement schedule (placement began in August 2007)
- Increased maintenance costs - cleaning surface to retain void structure – extra equipment
- Future product availability for patching / maintenance
Initial technical site specification challenges

- Sub-surface drainage characteristics such as swell
- Voids – drainage / clogging due to arid climate
- No arid data on voids longevity
- No compressive strength requirement – pervious vs. conventional concrete
- SW U.S. - Excess temperature during placement – 0 slump yields no chilled water for temperature reduction
- Visual observation (proposed) was too vague for rejection of mix
- Frequency table / regiment (whom / when / where) location information critical for long term evaluation
Resulting proposed specifications

- For acceptance / placement staff
  - NRMCA – Pervious Certification (8hr. course)
- Voids-15% min. /20% max. or +/-4% of design based on cored results vs. theoretical using as delivered batch weights
- Unit Weight +/- 5pcf of design utilizing jigging method
- Placement monitoring / observation of placement - CRITICAL
- Cores for thickness (6” pervious on 6” - ¾” #57 rock)
- 3/8” riser strips suggested by Progressive concrete during (omitted at construction)
Mix design, placement and production challenges

- 3 – 4 mix designs – strength / workability assessed utilizing test panels
- Riser strips – deleted due to surface consolidation @ contractors request – PROPOSED as required
- Placement monitoring sequence CRITICAL to data integrity - strength – thickness – temperature etc.
- Mix temperature as received / placed >95F criteria for rejection
- Acceptance - 1600psi minimum - insufficient areas re-cored / averaged – removed & replaced
- Voids based on unit wt. of core to theoretical using batch weights (20% minimum)
- Unit weight informational only
- Vehicle rutting due to #57 sub-drainage area
  - Mitigated during construction – potential core thickness issues created
Product acceptance –
“Non-conventional” sampling techniques

- NRMCA (8 hour course) – City and consultants attended
- Temperature <95F, voids by volumetric unit weight - truck batch weights
- 28 day compressive strength measured for thickness, weighed for unit weight and voids L/D correction applied to specimen
- Thickness investigated if >0.25in. MAG Specifications govern for removal-initially cored 14d samples for unit weights & thickness
Pre-construction meeting

- **Include** designers, Inspectors, Contractor / contractors personnel, suppliers, testing personnel. Assure all have a proper understanding and expectation of placement / testing and reporting requirements.

- **Assure** acceptance / rejection criteria is known by all and enforcement / penalty is clear. Notably – ASTM, AASHTO methods for core thickness
Cost control for quality acceptance testing (QA)

- Occurred approximately 4 weeks into placement
- 14 day cores eliminated – taken initially for thickness / compressive strength information
- 28 day cores (design) for acceptance – thickness / voids / compressive strength reduced to average of two cores per daily placement
- Inspector logging meticulous – opportunity to evaluate potential problem areas
- Unit weight of mix in field eliminated due to data accumulated and cost factors
Quality Assurance placement panel layout
Opportunities with data

- Average strengths = 1325 psi to 2900 psi = 2174 psi average
- Unit weight = 103.7pcf to 124.5pcf = 115.1 pcf average
- Temperature – 1 load >95F (rejected by contractor) – no chilled water for temperature control – Night time placement
- Voids = 21.3% to 34.6% Average = 27.3%
- Thickness 6.0” with 5.75” average – need to monitor depth of pavement
- Deficient thickness in multiple cores (thickness <5.5”) – differing opinions on thickness testing measurement – NEED TO MONITOR PLACEMENT @ QC – not utilize core for acceptance
- ANNUAL walk-thru
Challenges with warranty and long term performance

- Challenge No. 1 - Spalling is exhibited but minimal as expected
Challenge No. 2 - Crack propagation

- Longitudinal crack along 3 panels of drive area
- Removed / replaced / cured early April 2009
Challenge No. 3 - differential settlement / expansion of joints

- Grinding was / will be needed to mitigate trip hazard / settlement
- Future monitoring of joints...
Future unknowns

- Life cycle maintenance costs
- Lifetime void structure integrity
- Long term durability of pervious pavement surface
- Long term drainage flow characteristics
- Availability of replacement materials and in-house staff training for maintenance
- 20 year life cycle (as 30 year was suggested)
Project Recognition

- **Valley Forward Association** – 28th Annual Award of Merit – “Site Development and Landscape”
- **SW Contractor** – Best of 08 Awards – “Concrete”
- **2008 PCA** – Sustainable Development
- **2009 ACI** – Sustainable Concrete Construction Award
- **2009 – ASLA** – General Design
- **ACEC** - Engineering Excellence Grand Award for Transportation

**Publications** –
- Roads & Bridges
- Rocky Mountain News
Pervious references

- Dr. Kamil Kaloush, PhD., P.E. – ASU Smart Technology Center
- Stew Waller Arizona Cement Association
- Ken Ricker of RAMM Engineering – Specs. & Testing
- Mark Wavering / Pam Iacovo – Jacobs
- Mike Riggs (Owner) Progressive Concrete Works Inc. – Placement Contractor "Pervious Concrete You tube video"
- ASU National Center of Excellence “Pervious Concrete: Questions Answered” January 17, 2007
- National Redi-Mix Concrete Association (NRMCA) - Pervious Certification Course
Questions