Villanova Urban Stormwater Partnership
Lessons Learned II - Porous Concrete Demonstration Site Fall 2004 Update

By Robert Traver, Andrea Welker, Michael Horst, Megan Vanacore, Andrea Braga, and Leo Kob

Executive Summary:

This article provides an update on the current status of the porous concrete surface for the Villanova University Porous Concrete Best Management Practice. Originally constructed in 2002, the original surface failed and was replaced in 2003 providing valuable lessons learned as featured in *Stormwater Magazine (*Traver et al. August 2004). After a second winter, limited portions of the site failed a second time and were replaced in October 2004, again providing valuable lessons as to the use of this material. Street sweeping was performed on site and found to be a viable means of maintaining the porosity of the concrete by removing fines and debris from the surface.

Project Overview:

A porous concrete infiltration "Best Management Practice" (BMP) was constructed during the retrofit of an existing paved area in the center of the campus of Villanova University in August 2002 (Figure 1). The contributing watershed area is approximately 50,000 ft^2 and is highly impervious, consisting of pedestrian walkways, rooftops and some grass areas. The rooftops and some adjacent paved areas are directly connected to three separate rock storage beds (four feet deep) that are outlined by the porous concrete surface. The rock beds are linked through piping systems to distribute the runoff between beds and allow for overflow for major storm events. The porous concrete surface is edged using decorative pavers with the porous concrete outlining the site and standard concrete in the center of the site. Installation involved demolishing the original site, extensive regrading, and construction of the infiltration BMP (Traver et al., 2004). A strength additive was used. The site was designed to capture and infiltrate the first two inches of runoff, thereby reducing downstream stormwater volumes, stream bank erosion, and non-point source pollution. The project joins the Villanova University "Best Management Practice Demonstration Park" as both a research and demonstration site (Traver 2002). Funding for the project was through the Pennsylvania Non-Point Source Pollution Section 319 Program, and the site has been designated as an EPA National Monitoring site. Further information on this and other projects can be found through the Villanova Urban Stormwater Partnership website (www.villanova.edu/VUSP).

Figure 1 – VU Porous Concrete Site

In October of 2004, during Villanova University's Fall Break, construction was performed at the site to replace sections of the porous concrete that had failed or were not functioning properly, approximately 40% of the reconstructed surface (Figure 2). It was observed that the areas of porous concrete that had failed were from the later parts of each individual pour, and that the first portion of each pour was in acceptable to good condition. It was also observed during the original reconstruction that the end of each pour was less malleable, and extremely hard to work. As only the top layer of the porous concrete had failed, it is speculated that impermeable layers were formed at the end of the pours allowing freeze thaw to occur.

Figure 2 –Demolished Concrete on Upper Bed

Figure 3 –Sections of removed PC

Demolition began on site on October 12, 2004 with the uppermost bed. A total of twelve sections of porous concrete were removed from the site (Figure 3). The sections to be replaced had been marked prior to demolition by Villanova's Facilities Management Office. Each section was saw cut and subsequently jack hammered to break up the porous concrete. The large chunks that were removed appeared to be in good condition other than at the surface. The large pieces were removed by hand and some of the gravel was shoveled out. This process did produce some fines and gravel, but the magnitude of which was not substantial enough to clog the pores and prevent water from infiltrating into the bed. The demolition also ripped up the joints between the porous concrete and the standard concrete, which were to be replaced during pouring. Demolition was completed at the end of the first day.

Four test pads had been poured on Villanova's campus prior to the reconstruction in '03 and were reevaluated prior to this renovation. Two of these pads were formed with the same proprietary additive used in the original and the 2003 pour, while the remaining pads used the "Florida Mix", a standard porous concrete mixture, with no proprietary strength additive. As all four pads had remained in good condition and had maintained

their porosity, it was decided that the strength additive (used in the previous pours) was not necessary.

Figure 4 – Hand Trowling PC

Pouring began at 6AM on October 13th in the upper bed. The expansion joints had been replaced, marking each separate porous concrete pad. Initially, the pour from the first mixer appeared to be too gravelly and dry. The placement was halted, and workers spread out what had already been poured. The remaining concrete was mixed in the drum for an additional period of time and the pour was resumed. This pour was a much better consistency, and they began again and worked along in small sections. The mixture was poured 1½" above the surrounding surface, as opposed to ½" higher as in the reconstruction in '03, so that a roller with higher compaction could be used. The higher compaction also allowed the workers to get the porous concrete flush to the standard concrete already in place, without the elevation difference that was noted during the previous construction (Figure 4). A hand trowel was used after the porous concrete was raked into place to ensure the pour was even and filled all gaps. The concrete sections were then quickly compacted with the roller which was hosed down each time before passing over the concrete to prevent the concrete from sticking to the roller.

On the first section poured, a hand tamper was used preceding the roller, presumably to compact portions of the porous concrete at the edge in order to ensure that it was flush with the standard concrete. However, the roller itself seemed to be accomplishing this, so this was not continued. Also, on another section the contractor attempted to have water continuously flowing from the roller, rather than having it sprayed on the roller by hand, but this produced a smooth (non-porous) surface, due to the porous concrete becoming too hydrated and created an impervious section (Figure 5).

Figure 5 – Rolling Porous Concrete

After compaction, each section poured was covered with wet burlap strips (Figure 6). This material is heavier than the plastic that had been used in the previous construction so it remained in place over the concrete throughout the recommended 48 hour period and provided for better hydration.

Figure 6 – Wet Burlap Covering

The second mixer on site had a similar consistency to the first mixer, but at the end of the second mixer the remaining material that flowed down the chute was extremely wet and gravely, leaving water ponding on the surface of the pad (Figure 7). This section was removed and repaved when construction resumed on October 16th at 6AM following a two day delay due to adverse weather conditions. Paving was completed on the second day of pouring. It was observed that the "florida" mix was much easier to pour then the previous mixture, and no problems with stiffening occurred during the pours.

Figure 7 – Non Porous Area at End of Truck

Once the porous concrete had cured, approximately 48 hours, the burlap strips were removed. The color of the new sections was fairly consistent and close to the existing color. Over time it is believed that the color will even out further. A few small sections do look less pervious where the different compaction techniques were attempted, but overall the new sections look to be in good shape and their effectiveness looks promising.

Figure 8 – VU Vacuum Street Cleaner

It is generally recommended that porous concrete surfaces be vacuum swept at least twice a year to keep the concrete free of pore clogging debris. Street sweeping was performed on the Villanova site in August and December 2004 (Figure 8). This cleaning was very successful in removing the particles that could potentially clog the porous concrete. The porous concrete was visibly cleaner after the street cleaner passed over it and the removed debris could be seen in the truck.

Villanova Urban Stormwater Partnership

The mission of the Villanova Urban Stormwater Partnership is to advance the evolving comprehensive stormwater management field and to foster the development of public and private partnerships through research on innovative SWM Best Management Practices, directed studies, technology transfer and education. We invite firms interested in joining the partnership to contact us through the VUSP website. (www.villanova.edu/VUSP)

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The design firm for the infiltration portions of the project was Cahill Associates from West Chester, PA. The site contractor was N. Abbonizio Contractors.

References

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