NRMCA®

STATEMENT OF
DANIEL J. HUFFMAN
MANAGING DIRECTOR, NATIONAL RESOURCES
NATIONAL READY MIXED CONCRETE ASSOCIATION

BEFORE THE

COMMITTEE ON SCIENCE AND TECHNOLOGY
SUBCOMMITTEE ON TECHNOLOGY AND INNOVATION
UNITED STATES HOUSE OF REPRESENTATIVES

ON

GREEN TRANSPORTATION INFRASTRUCTURE

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The National Ready Mixed Concrete Association (NRMCA) appreciates this opportunity to share its views on green transportation infrastructure technologies and the challenges that exist to incorporate these technologies into current infrastructure projects.

NRMCA is a national trade association representing producers of ready mixed concrete and those companies that provide materials, equipment and support to the ready mixed concrete industry. Our association has been working vigorously over the past several years to promote the broader use of concrete materials as an environmentally friendly technology. These technologies exist within the realm of concrete materials being broadly produced today, especially as it relates to concrete pavements. Pervious concrete pavement is just one of many forms of concrete that are especially beneficial for environmental transportation related applications. In addition, there is a vast range of highly significant environmental qualities that conventional concrete contributes to transportation and all other environmental applications depending upon the targeted goal (i.e. urban heat island mitigation, energy savings, use of re-cycled materials, etc.)

GREEN PAVEMENT TECHNOLOGIES

Pervious Concrete

Material known as pervious concrete is especially compelling as a leading edge green building technology. It was reportedly first used in Europe more than 100 years ago for non-pavement applications, its limited use in the United States in pavement began only 20-25 years ago, and primarily in Florida. In addition to offering the opportunity to deploy a major element of Low Impact Development (LID) and even initiate substantial water harvesting, pervious concrete already has been accepted by the U.S. Environmental Protection Agency (EPA) as a recommended Best Management Practice (BMP) for stormwater management on a local and regional basis. However, it has recently garnered much attention due to increasingly stringent Clean Water Act stormwater management guidelines and particularly in response to the National Pollution Discharge Elimination System (NPDES) Phase II Stormwater Program. Among other modifications, Phase II applied guidelines to commercial projects sites of one acre or more and combined with the increasing focus on LID has greatly stimulated interest in *infiltration technology*, which is essentially what pervious concrete provides.

Pervious concrete is a performance-engineered structural material using the usual constituents of conventional portland cement concrete, only with little or no sand in the mixture, allowing for a 15-30 percent air void factor. Taking advantage of the corresponding decreased density, pervious concrete is incredibly permeable while still able to provide a quality structural pavement. Instead of moisture (i.e., rain/snow melt) running off the surface horizontally, virtually all stormwater falling onto the pavement is immediately infiltrated directly through the pavement and eventually into the subgrade. In most places in the United States, placed immediately below the pavement is an even more porous aggregate base layer that functions as a stormwater reservoir accommodating all the precipitation necessary for a design storm event. The depth and volume of the aggregate base layer is calculated relative to the percolation rate of the native soils along with the expected rates of moisture that need to be infiltrated over time. Where there are poor percolating soils or other hydrology challenges, outfall designs and supplementary drainage may be required for which perforated piping systems and other devices exist. Pavement design thicknesses are adjusted to meet the necessary load bearing capability for a broad range of applications. Properly designed and placed pervious concrete usually results in a pavement that can pass water at a rate in excess of 200 inches of rain per hour, thus exceeding the requirements of almost any design storm event. The use of pervious concrete supports the many positives of infiltration technology, including both groundwater recharge and attempts to control increasing aquifer depletion.

Pervious Concrete – Benefits and Costs

Pervious concrete provides many environmental and some cost benefits by reducing stormwater volume, and limits the amount of pollutants being carried away by runoff into our waterways, lakes and oceans. However, in addition to improving overall water quality by reducing the volume of runoff, pervious concrete performs effectively as a filter of the moisture it infiltrates. The complex matrix of aggregate, hardened cementitious paste and air voids retains at least 80% of the pollutant solids. With the aid of naturally occurring microorganisms, also within the matrix of the pavement, a substantial level of treatment of the retained solids takes place which are only further enhanced by exposure to the elements over time (varying temperature and sun, etc.) It is generally accepted that what pollutants do pass through the pervious concrete system (including the granular base layer) are further converted by native soils and the total affect on groundwater is positive in terms of water quality and level of replenishment.

Far and away the most common application of pervious concrete is for commercial parking lots. Also, its use in residential street applications is slowly growing along with its use for major pedestrian areas of all types. There is also increasing interest for the largest of retail shopping centers. Unlike so many other green building technologies that may come with increased cost, most major utilizations of pervious concrete technology, such as for commercial parking lots, benefit from a lowered first-cost of construction when considered on an overall project site basis.

While hard cost data is often difficult to obtain, that relating to the experience of one residential housing developer is perhaps representative of how the optimization of pervious concrete can lower the first-cost of construction and also provide additional revenue through increased site optimization. In 2006, owner/developer Craig Morrison of CMI Homes in Bellevue, Washington, completed the construction of Stratford Place, a 20 home residential subdivision in Sultan, Washington. One hundred percent of the subdivision's original general hardscape was built with pervious concrete – roadway, driveways and sidewalks. CMI has provided cost data supporting the cost savings resulting from the conversion from a site estimate using conventional asphalt pavement and traditional on-site stormwater detention to one where pervious concrete was actually used. While the developer is rather detailed in his calculations showing a net savings overall of approximately $264,000, he could also have projected increased net revenue relating to the development of two additional home sites he was able to add resulting from the elimination of the traditional stormwater treatment system.

The CMI case demonstrates that progressive owners and developers see the use of a green technology like pervious concrete as a public relations opportunity. In some cases they have been rewarded by agencies in the permitting process for proposing and building with green technologies. NPDES Phase II regulations requiring the treatment of runoff prior to it leaving a site presents very attractive cost and site optimization dynamics to an owner who deploys pervious concrete. The site optimization dynamic is not always easy to quantify in financial terms but it is frequently perceived by some owners as highly valuable. The positive for pervious concrete in this respect is that it has the ability to provide a multi-functional facility that to a stormwater professional will function as a stormwater treatment system yet to a facilities owner as a parking lot.

Traditional stormwater management devices such as retention/detention ponds, swales and similar devices are greatly lessened and in most cases totally eliminated where pervious concrete is deployed on a major scale. In some cases, pressures are great on major big box retailers to be responsive to stormwater regulations. With the perceived increasing lack of "good sites" in most major metropolitan areas they may spend millions of dollars per store to construct complex underground stormwater treatment systems to accommodate an acceptable minimum amount of on-site parking. With the optimization of pervious concrete, an owner could instead eliminate the conventional devices (which may consume 10-20% of a site) and maintain or expand the area of his parking lot, possibly increase the footprint of his building or use the increased optimization for some other revenue generating or aesthetic purpose. The bottom line economics strongly suggest that it is usually less costly to build with pervious concrete on an overall site basis compared to all that relates to traditional stormwater device utilization. Indeed, the financial benefits of increased site optimization are potentially highly significant and for a high volume big box retailer could be paramount depending on other site location dynamics.

Pervious concrete also has a number of other important benefits. Like conventional concrete it is a "hard-riding" surface that provides less rolling resistance and therefore greater fuel efficiency. In fact, heavily loaded trucks use less fuel when traveling on concrete pavements, with savings reaching as much as 6.9%. Pervious concrete can also have a substantial effect on sound mitigation. Much of the sound of tires rolling on pavement relates to the way air is compressed and released "as the rubber hits the road." The open graded surface of pervious concrete diminishes this sound effect as it does much to keep air from becoming trapped beneath moving vehicle tires. Instead, air can move relatively easily within the upper layers of the pervious concrete void matrix, thereby muffling any road noise. There is also evidence that in many places in the country subjected to snowfall, snowmelt actually leaves the surface of pervious concrete much faster than that of conventional pavement because the moisture percolates through the concrete. This rapid removal of snowmelt greatly limits the likelihood of ice formation on pavement due to snowmelt refreezing after the day time sun and ambient temperatures convert snow to liquid but then subject it to icing when night falls and temperatures drop.

Pervious Concrete Contributes to Environmental Protection

A largely untapped and potentially huge opportunity exists for society to HARVEST STORMWATER. This could especially be of interest in the very dry climates of the far west and other areas of the country with water supply pressures. While the strategy focused on green roof technology to harvest stormwater is sound and getting a large amount of attention, the surface is barely being scratched on the potential to broadly harvest stormwater through pervious concrete technology. The amount of hardscape that is non-roof material offers vast potential. Taking the example of many retail shopping centers, the surface area of on-grade parking is generally considered to be 3-4 times that of the buildings it is serving. Why not use pervious concrete to harvest water for gray water re-use? The technology to do that already exists and is relatively simple. Twelve years ago at Finely Stadium, a sport venue at the University of Tennessee (Chattanooga), a parking lot was constructed using pervious concrete in all the parking spaces. The water passing through the pervious concrete into the granular base reservoir is piped to an existing site adjacent building that was modified to become a cistern. The water that otherwise would have been pollutant carrying runoff 12 years ago has been used instead as gray water for watering not only the vegetation directly on the site but also a nearby baseball field.

Other important environmental benefits supporting the use of pervious concrete include its potential to save energy. Like conventional concrete, portland cement and other supplementary cementitious materials are used in pervious concrete pavement and are much lighter in color than the binder used by their respective petroleum based counterparts. Concrete is vastly superior in light reflectivity, increasingly evaluated by Solar Reflectance Index (SRI), so the amount of night illumination and its corresponding energy could be greatly reduced where some concrete pavements are deployed. Additionally, concrete's superior position as a pavement to enhance urban heat island mitigation is well documented by the EPA and other study groups. The decreased density of pervious concrete also has a positive effect on heat island dynamics because of the way it simply absorbs less heat in the first place, a quality that does not specifically relate only to its superior SRI. Indeed, as it relates to temperature dynamics, and beyond that directed primarily at the cost of energy, the concern for stormwater runoff's thermal pollution is also benefited through the use of pervious concrete. Unlike other man-made pavements, pervious concrete does not share the heat retaining properties that contribute to thermal pollution. Less than optimally controlled levels of stormwater runoff are known to increase the temperature of streams, rivers, lakes, and perhaps may have some effect on ocean temperatures. This thermal pollution of waterways negatively effects the survival of fish and various riparian life forms.

Energy Savings

Energy savings, urban heat island mitigation and vegetative dynamics play critical roles in the battle to combat global warming. While in the context of pervious concrete, energy savings was briefly discussed; conventional concrete may be even more underutilized as a means of providing impressive energy savings. The Solar Reflectance Index (SRI) data supporting the benefit conventional concrete provides due to its potential to lessen the need for night illumination is only one aspect of energy savings.

Table 1. Solar reflectance (albedo), Emittance and Solar Reflective Index (SRI) of select material surfaces[1],[2],[3],[4]

Material surface	Solar Reflectance*	Emittance	SRI*
Black acrylic paint	0.05	0.9	0
New asphalt	0.05	0.9	0
Aged asphalt	0.1	0.9	6
"White" asphalt shingle	0.21	0.91	21
Aged concrete	0.2 to 0.3	0.9	19 to 32
New concrete (ordinary)	0.35 to 0.45	0.9	38 to 52
New white portland cement concrete	0.7 to 0.8	0.9	86 to 100
White acrylic paint	0.8	0.9	100

(1) Levinson, Ronnen and Akbari, Hashem, "Effects of Composition and Exposure on the Solar Reflectance of Portland Cement Concrete," Lawrence Berkeley National Laboratory, Publication No. LBNL-48334, 2001, 39 pages.

(2) Pomerantz, M., Pon, B., and Akbari, H., "The Effect of Pavements' Temperatures on Air Temperatures in Large Cities," Lawrence Berkeley National Laboratory, Publication No. LBNL-43442, 2000, 20 pages.

(3) Berdahl, P. and Bretz, S, "Spectral Solar Reflectance of Various Roof Materials", *Cool Building and Paving Materials Workshop,* Gaithersburg, Maryland, July 1994 14 pages.

(4) Pomerantz, M., Akbari, H., Chang, S.C., Levinson, R., and Pon, B., “Examples of Cooler Reflective Streets for Urban Heat-Island Mitigation: Portland Cement Concrete and Chip Seals,” Lawrence Berkeley National Laboratory, Publication No. LBNL-49283, 2002, 24 pages.

The US Green Building Council’s LEED green building rating system recognizes the value of the albedo or reflectivity dynamic and allows credit toward LEED certification relative to SRI capability. The differences in pavement materials in night lighting situations is even more pronounced in wet weather conditions when “dark wet roads” seem to absorb the light given off by vehicle headlights which are only compounded when “puddles” and pot holes also exist. At least one extensive study documents that a 35% reduction in the amount of lighting required is warranted where conventional concrete is used instead of the most commonly used pavement material. Another means of taking advantage of concrete’s superior SRI would not save energy but would improve public safety. That is, allow for the use of concrete pavement’s increased brightness to improve pedestrian safety through increased night visibility so as to provide better night driving conditions on roadways and parking lots. The option also exists for improved security in high crime areas due to increased brightness. Possibly, the best option is to take advantage of concrete’s reflectivity to seek the middle ground in *energy reduction* and *safety* consideration relative to the specific environment – the best of both worlds.

Urban Heat Island Mitigation

The energy savings issue and conventional concrete’s superior SRI are also closely linked to urban heat island mitigation dynamics. Where higher SRI materials are used, they are holding and generating less heat which in warmer climates would result in a corresponding energy savings especially as it relates to air conditioning utilization. Where some major urban areas are thought to have ambient temperature increases of up to 8 degrees F. due to heat island effects, the opportunity to mitigate with expanded utilization of concrete pavements presents significant potential not only with respect the immediate amount of energy consumption but also as relates to the negative health effects of ozone and smog.

Environmental Vegetative Dynamics

Landscape architects are usually highly supportive of pervious concrete technology because of its benefits as an infiltration mechanism. Moisture and oxygen that is otherwise denied to adjacent trees and other vegetation due to the impermeability of conventional hardscape pavement is facilitated by pervious concrete’s substantial air void structure and rapid infiltration to the root systems of close by vegetation. As a part of LID, trees can flourish in the presence of pervious concrete, which also supports heat island mitigation. The shade and corresponding “coolness” trees provide, plus the impact trees have on our overall health in providing oxygen, limiting CO2 and smog, is vital to those parts of the country with large urban populations and/or hot-dry climates. In Florida and other places in the country, the concerns are such that conventional pavements are frequently denied by regulations to be within the “drip line” of a tree placed within a commercial parking lot. Pervious concrete may be used in such instances and in a number of places pervious concrete is frequently seen within tree wells that are placed integrally into sidewalks and other pedestrian or even vehicular related hardscapes.

Wetlands protection is yet another environmental benefit of pervious concrete. Many cities and towns adjacent to wetlands have established setbacks from the border of the designated wetland within which land development may be totally restricted. The use of pervious concrete is sometimes used in these situations but it could be applied far more broadly due to its infiltration attributes. For this reason, pervious concrete is increasingly used for nature trails and other environmentally sensitive areas where a hardscape is desired and where awareness of pervious concrete technology exists.

MEASURING ENVIRONMENTAL IMPACT

Answering the question of what makes a product environmentally friendly is difficult and complex. It is important that there is a predictable and reliable process for answering this question because both citizens and their elected representatives are concerned about the environmental consequences of producing and using various materials and products and they are demanding “green” products. This is the result of a societal awareness that consumption of manufactured products have an effect on resources and the environment. These effects, which can be direct or indirect, occur at every stage in a product’s life cycle-from the extraction of the raw materials from the ground through the processing, manufacturing and transportation phases, ending with use and disposal or recycling. One methodology increasingly in use today is life cycle-analysis (LCA), which attempts to quantify these direct and indirect effects of products and processes.

LCA has the potential to have a significant impact on determining the true “greenness” of a material. Standards organizations such as the American Society of Testing and Materials (ASTM) and the International Standards Organization (ISO) have worked to develop consistent LCA methods and procedures in order to quantify environmental impacts and aggregate them to get a single measure of the product's environmental impact. Notwithstanding these efforts, LCA continues to receive both positive and negative comment on its utility as a process to evaluate environmental impact. Part of the difficulty lies in locating reliable data on the performance of the material and the associated maintenance requirements that occur over time. Another difficulty rests in the disagreement around the weighting of different environmental impacts in the process of combining the results of a life cycle inventory into a single measure of environmental performance, known as impact assessment. Indeed, despite all the activity in standards organizations and elsewhere, there is still debate within the LCA practitioner community as to whether a scientific basis exists for applying impact assessment techniques to the data derived from an LCA inventory analysis. Nonetheless, many standard LCA studies demonstrate that concrete's thermal mass, combined with an optimal amount of insulation, saves energy over the life of a building, thus reducing energy consumption in the building sector which accounts over 40% of greenhouse gas emissions from fossil fuels. However, NRMCA is not aware of any rigorous applications of LCA to concrete pavements, pervious or otherwise.

With respect to buildings, environmental friendliness can be reasonably well determined through analysis and some level of reliance on existing green building rating systems such as the U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED) rating system, the Green Building Initiative's Green Globes program or by EPA's Energy Star system. As it relates to general building, it could be noted that the U.S. General Services Administration and the Department of Defense (among other federal entities) have produced statements perceived as favorable toward LEED in particular. The basic focus areas of the LEED, Green Globes and similar programs seem to be much the same. There is consistent emphasis on "Sustainable Sites," "Water Efficiency," "Energy and Atmosphere" and "Indoor Environmental Quality."

It is an open question as to whether LEED, Green Globes or Energy Star is really suited to meet the needs of green pavement technologies. In this respect, leading members of the green community have concluded that the answer to the question of what is environmentally friendly is most apparent when actual use is considered. In the case of pervious concrete, it can be considered environmentally friendly because it provides an effective means of improving overall water quality, offers substantial support to Low Impact Development, is included among the EPA's Recommended Best Management Practices as an element of stormwater management on a local/regional basis, and green building rating systems such as LEED and Green Globes clearly allow it to contribute to the credits registered projects can accumulate for certification.

BARRIERS TO BUILDING GREEN

While improved public relations opportunities and other values associated with green building are increasingly of interest, off-setting the perceived increases in first costs are still greatly at issue. Owners and their consultants are frequently challenged in their awareness of green building technologies. While organizations like EPA are working to educate designers and builders, the lack of understanding by various agencies, especially at the local and state levels can sometimes be challenging. It is not that agencies and regulators are so often taking a position that overtly denies the utilization of a technology like pervious concrete, or LID for that matter, it is more likely that their Best Management Practices (BMPs) just don't address them.

NRMCA has a National Accounts program that includes a team of technical/promotional professionals who operate primarily from various regional bases. One of the National Accounts' most critical missions is to provide green technology transfer relative to the use of concrete in both public and private sector applications. Though primarily focused on private enterprise we attempt to cover the bases with federal agencies as well. We have established relationships with big box builders and the largest commercial developers and a large number of consultant organizations to those builders and developers. A challenge for us comes in the ability to gain acceptance of a technology like pervious concrete and other technologies such as insulating concrete wall systems that have the potential to save as much as 35% in the cost of heating/cooling a home.

While regulations and codes that simply do not address pervious concrete technology are certainly barriers to acceptance, some of the challenge is simply "human". When presented with an unfamiliar LID technology, the difficulty that some people have with pervious concrete is not that it is LID, but that it is not an existing, established convention. The relatively simple concept of allowing moisture to fall to earth, pass immediately through the filtration process pervious concrete provides and then be infiltrated without additional conveyance is difficult for some to accept. That is not to say that there cannot be legitimate concerns about various soils related dynamics and other aspects of hydrology. However, numerous designers and acknowledged experts in the field such as Bruce Ferguson, Franklin Professor and former Director of the School of Environmental Design at the University of Georgia, and author of the book, *Porous Pavements*, suggests that it is usually within the capability of sound engineering and hydrological design to overcome many of those perceived obstacles. Professor Ferguson goes on to say, "[t]he observed, measured, documented, scientific fact is that properly designed, installed and maintained pervious concrete is structurally durable and environmentally beneficial. Proven facts allow us to discard blindly uniform convention, and to select the most appropriate technology for each separate site-specific situation."

FEDERAL INCENTIVES TO BUILD GREEN

Federal support to innovative building technologies can come through a variety of means. States and local governments are proving that modest tax credits can stimulate market interest in green building practices by offsetting any additional upfront costs such as energy modeling and commissioning. Tax credits should be tied to green building technologies that deliver promised results and speed market transformation. Such tax credits should apply to both the commercial and residential markets.

Increased research grants and tax incentives for construction that deploys targeted new technologies would be of huge benefit. A positive model currently funded and under final development relates to the cooperative effort and partnership between EPA's Region III and NRMCA. Strong leadership and support by Region III's Dominique Lueckenhoff, Associate Director for Water Quality, has led to a research grant for Villanova University to evaluate the water quality and other capabilities of competing porous pavement systems, in this case pervious concrete and porous asphalt pavements. The grant funding has come from the EPA with assistance from the RMC Research & Education Foundation and from Villanova University.

Models for regulatory programs supportive of new technology and LID currently exist at the local level. One example of a fine program relates to Snohomish County, Washington's goal of implementing Low Impact Development (see: Snohomish County

Ordinance 06-044, adopted July 2006). The ordinance creates agency staff leeway to approve methods which are determined to meet the county's increasingly aggressive stormwater management goals and provides incentives to developers who use LID methods and materials. One encouragement expedites the permitting process and produces real monetary incentive to the developer by shortening his development period and getting properties to market sooner. A technology like pervious concrete has a much better opportunity to be utilized in this situation and meets the environmental goals of an increasingly high-sensitive area such as the Puget Sound Area of Washington.

Relating not only to general funding but to innovation as well, funding could be established to study and respond to the advantages of moving toward more performance based solutions and newer technologies. This could occur through funding of demonstration projects. A program such as the "P2P Initiative," (Prescription to Performance) advocated by NRMCA as a progressive alternative to the way specifications are written for the design and use of concrete, is just one example. The basis of P2P is change the paradigm where a product is specified prescriptively for an end result. The "prescription" is too often designated by someone without the necessary experience on a given green technology. Increased government research grants could better establish performance characteristics of a material like concrete that would also satisfy the end result needs of designers now relying primarily on prescription. Performance based solutions very strongly support sustainability initiatives by optimizing use of resources and prolonging the service life of structures.

Funding that stimulates innovation to better understand the way particular pavements systems can affect the constituents of stormwater runoff is also an area of need. Environmental evaluations of all types of pavements should include those materials and processes used in projected maintenance schedules. Funding for programs should incorporate performance goals supportive of environmental goals. The benefit of programs focused on increased awareness of existing data supportive of innovative technologies could come at a moderate cost.

Funding should be available for government officials to attend national, regional and local programs that are increasingly available on specific innovative technologies like pervious concrete would also be highly beneficial. In the spring of 2006, a major national symposium on pervious concrete took place in Nashville, Tennessee that was sponsored by NRMCA with a call for technical papers widely advertised. While the private sector sent people from all parts of the country, attendance by government officials was limited. On an on-going basis, NRMCA sponsors regional seminars (10 or more in 2007) charging moderate prices and are presented by some of the top technologists in the industry. Local and regional groups within the concrete industry also sponsor programs of their own. These would be excellent venue for government officials to pick up existing technology on pervious concrete.

NRMCA recognizes that sustainable development and environmentally friendly transportation technologies are about balancing human needs with the earth's capacity to meet them. Concrete, and in particular pervious concrete, offers a wide range of capabilities to help achieve this balance.

NRMCA appreciates the opportunity to present this statement for the record.