STATEMENT OF
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BEFORE THE
COMMITTEE ON SCIENCE AND TECHNOLOGY
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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 incorporating 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 established acceptance by the US Environmental Protection Agency (EPA) as a recommended Best Management Practice (BMP) means of stormwater management on a local 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 have 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, limits the amount of pollutants being carried away by runoff into our waterways, lakes, and oceans. However, in addition to improving over-all 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 as is that for major pedestrian areas of all types, and there is increasing interest even 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 over-all 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, WA, completed the construction of a 20 home residential subdivision in Sultan, WA, called Stratford Place. 100% 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 over-all 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 and have been rewarded by some 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 stormwater treatment system yet to a facilities owner it is a parking lot.

Moreover, 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 so great on major big box retailers to be responsive to stormwater regulations yet with the perceived increasing lack of "good sites" in most major metropolitan areas they sometimes spend millions of dollars per major big box store to construct 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 over-all 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 resistance and therefore greater fuel efficiency. Pervious concrete can 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 allow air not to become 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 strong 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 has a place to go – directly down. This rapid removal of snowmelt greatly limits the likelihood of ice formation on pavement due to snowmelt refreezing when day time sun and ambient temperatures may convert snow to liquid but then subjects it to becoming ICE when night falls, temperatures drop and it re-freezes.

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 increasing pressure on the water supply. While the strategy focused on green roof technology to harvest stormwater is sound and getting a large amount of attention, we are barely scratching the surface on the potential to broadly harvest stormwater through the technology pervious concrete represents. 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. 12 years ago at Finely Stadium, a sports 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 may not specifically relate only to its superior SRI. 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.

Energy Savings & Urban Heat Island Mitigation

While energy savings and urban heat island mitigation are clearly not technologies, due to their critical roles in the battle to combat global warming, concrete's great potential to benefit in that that battle must be addressed. 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 while not eliminating the additional light poles required of the other type of pavement so as to provide better night driving conditions on roadways and parking lots, and to improve pedestrian safety through increased night visibility. 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.

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 potentials to mitigate with the expanded utilization of concrete pavements presents significant impact potentials not only on the immediate amount of energy consumption but as it relates to the negative health effects of ozone and smog, etc.

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 assessment (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. 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 rests in the inability to define a common methodology to determine the life cycle environmental cost of a material. Another difficulty lies in locating reliable data on the performance of the material and the associated maintenance costs that occur over time. 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 process analysis. Nonetheless, many standards LCA processes 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 LAC pavements to concrete pavements, pervious or otherwise.

However, environmental friendliness can be reasonably well determined through analysis and some level of reliance on existing green building rating systems such as the US Green Building Council's 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 US 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 an open question as to whether LEED, Green Globes, or Energy Star are 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 among the reasons it can be considered environmentally friendly is because it provides an effective means of improving over-all water quality, it offers substantial support to Low Impact Development, it 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

The barriers to the acceptance and utilization of both established and developing environmental technologies by private enterprise are many. While the 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 the EPA are working to educate designers and builders, the lack of understanding by various agencies and especially at the local and state levels does not encourage the process. 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 such.

NRMCA has a National Accounts program which I direct on a national basis and includes a team of technical/promotional professionals who operate primarily from various regional bases and are focused accordingly. Our mission is to provide *technology transfer* relative to the use of concrete to the entities both public and private that have the opportunity to influence the selection of particular building materials. Though primarily focused on private enterprise we attempt to cover the bases with Federal agencies as well. Among the largest facilities owners we have established relationships with are the big box builders and the largest commercial developers otherwise, 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 infiltrated in most applications without additional conveyance and process 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 professionals to overcome many of those perceived obstacles. Professor Ferguson goes on to say, “The 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 overall market transformation. Such tax credits should apply to both the commercial and residential markets.

Funding programs that are focused on increased awareness of existing data, most of which is highly supportive of the technology would not have to be very costly as perhaps the largest challenge is the awareness and acceptance of existing data. Empirical data already exists that is the result of research grants or was developed by a host of universities and other researchers across the country. Much of this data suffers from lack of circulation perhaps because it is generated primarily by private enterprise. The American Concrete Institute’s Technical Committee – 522 – Pervious Concrete perhaps collates such data more than anyone else, but communication of this technology may not exist by any formal means to government agencies at any level. Federal funding to insure such data is transferred on an appropriate basis and broadly distributed would do much to move awareness of existing data forward.

Funds specifically earmarked for agency personnel 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, TN, 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 agency personnel 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. These would be excellent venue for agency officials to pick-up existing technology on pervious concrete.

Increased research grants and tax incentives for building that would deploy 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 where strong leadership and support by 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 EPA and assistance from the RMC Research and Education Foundation.

Positive programs supportive of new technology also exist at the state and local level that would be highly worthy of Federal support. One fine example of such relates to Snohomish County, Washington's goal of implementing Low Impact Development. Snohomish County, WA, is one of a very few, and the first in the State of Washington to do so. Ref: Snohomish County Ordinance 06-044, adopted July, 2006. This ordinance creates staff leeway to approve methods which they determine to meet the County's storm water management goals, and provides incentives to developers who use LID methods and materials. These incentives are in the form of expedited permit processing, which results in real monetary incentive to the developer, who gets to shorten his development period, and get properties to market sooner. A technology like pervious concrete has a much better opportunity to be utilized in this environment and meets the environmental goals of a highly environmentally sensitive area such as the Puget Sound Area of Washington.

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