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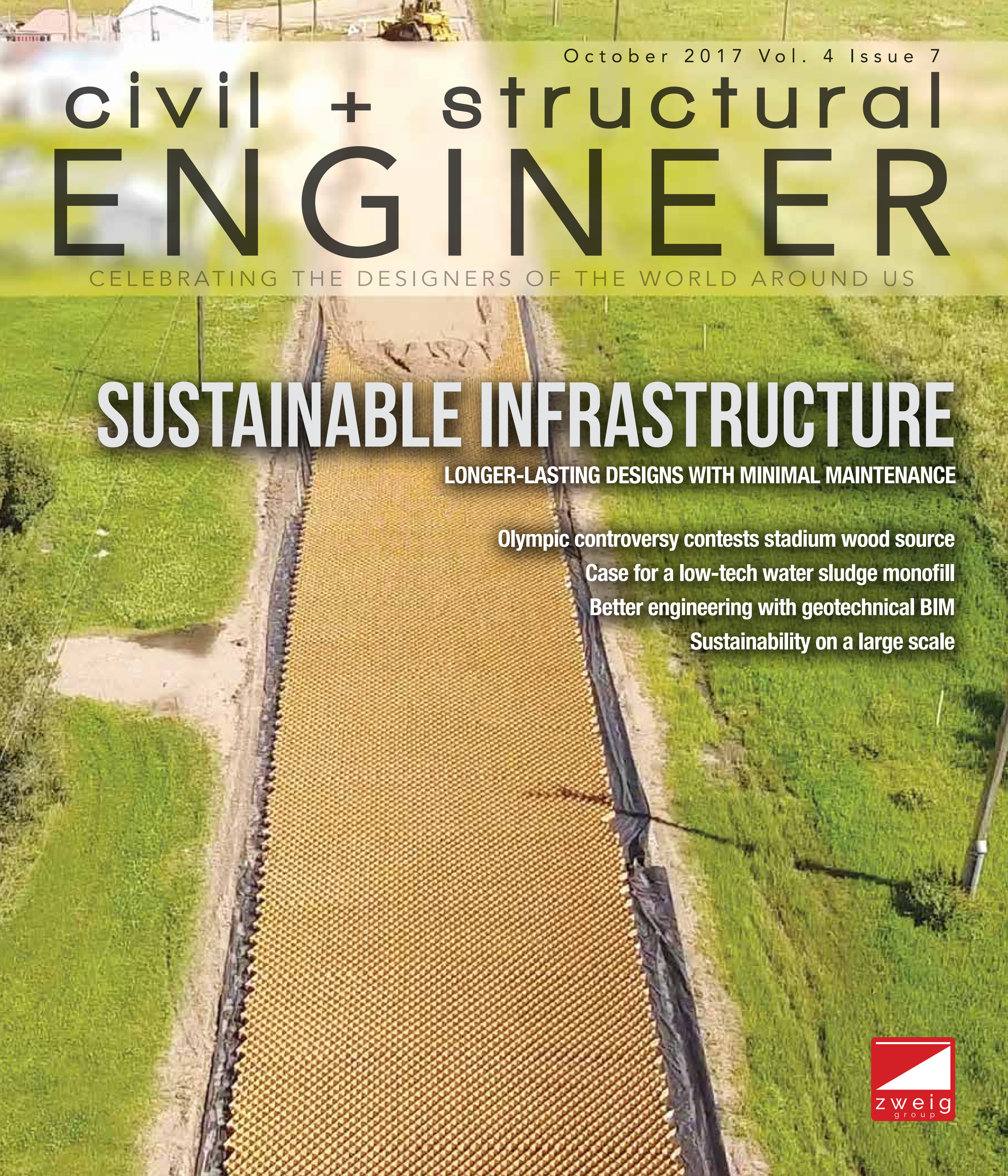
civil + structural ENGINEER

CELEBRATING THE DESIGNERS OF THE WORLD AROUND US



SUSTAINABLE INFRASTRUCTURE

LONGER-LASTING DESIGNS WITH MINIMAL MAINTENANCE

Olympic controversy contests stadium wood source

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zweig group

NPA Geocells were used in the Village of Ryley in Central Alberta, Canada, for a municipal paved road project.

PERPETUAL INFRASTRUCTURE

HIGH-PERFORMANCE GEOCELLS CAN PROVIDE COST-EFFECTIVE, SUSTAINABLE SOLUTIONS.

By Sanat Pokharel, Ph.D., P.Eng. M.ASCE

THE NEEDS of our rapidly growing population exert ever-increasing demands that global infrastructure must continuously strive to meet. According to a recent report from McKinsey Global Management Consulting, to keep pace with projected growth, the world must invest a total of $3.3 trillion annually through 2030. Much of this sum will be "repeat" investments to rehabilitate existing infrastructure that has deteriorated and approaches the end of it's serviceability.

But growth and investment alone won't get us where we need to be. Today, sustainability is a major factor when it comes to construction and one that we cannot ignore as we move forward. Sustainability rests on a "three-pillar base of environment, economy, and society." Reducing CO_2 emissions and offsetting carbon is crucial, but sustainable infrastructure must also focus on building to last in a cost-effective manner.

Accelerating sustainable growth in the North American construction industry is essential to our economy and prosperity. In 2000, the Asphalt Pavement Alliance introduced the concept of Perpetual Pavements — pavements built to last longer with minimal upkeep. In 2017, it is not just the Perpetual Pavements that are needed but Perpetual Infrastructure. The way to push Perpetual Infrastructure forward is through increased utilization of cutting-edge technologies such as geosynthetics. Geosynthetics are a relatively recent innovation made of polymeric materials that can provide more durable and longer-lasting construction solutions.

Access road design for MEG Energy using NPA Geocells eliminated the need for muskeg (peat) removal, dewatering, disposal, and soil replacement, and reduced the need for imported aggregates.

In the past, sustainability was often costly, and because of this, McKinsey refers to sustainability as a "premium" that could add an additional $14 trillion to the global infrastructure bill through 2030. While geosynthetics provide compelling solutions for infrastructure, building in a truly cost-effective way can only be achieved through the continuous innovation and development of new and better-performing products.

According to an infrastructure investment report published earlier this year by PricewaterhouseCoopers, to bridge the global infrastructure gap, it will be incumbent on both the industry and governments to devise, sponsor, and champion innovative structures to enable low-cost capital to be better used in meeting the world's infrastructure needs. This is where next-generation geosynthetics come in.

Geosynthetic innovations

Geosynthetics were first used in 1926 in road construction field tests by the South Carolina Highways Department. During the last few decades there have been leaps and bounds in innovation, giving way to high-performance geotextiles, geogrids, and other geosynthetic products. Within this market, geocells show great promise and are, according to a report from Future Market Insights, increasingly gaining preference among infrastructure developers for sustainable infrastructure development. With a compound annual growth rate of 8.8 percent in revenue, the global geocells market is expected to reach a total of $2.9 billion by 2025.

Geocells are honeycomb-like structures filled with granular material, which work particularly well on soft subgrades such as beaches due to their ability to confine and increase the modulus of infilled material (soil reinforcement), thereby increasing the bearing capacity of soft soils. Geocells were invented in the 1970s and patented by the U.S. Army Corps of Engineers (USACE) to provide an engineering solution for beachhead landings in military campaigns.

After the Gulf War in Kuwait (1990-1991), the USACE began to license the geocell-cellular confinement technology for civilian use. The Corps required a quickly deployable solution that was relatively light and flexible during installation. Long-term design strength was of less concern since the structures were built for relatively short-term use and the geocells were fabricated from high-density polyethylene (HDPE).

Public-sector civil engineers began to adopt HDPE geocells and apply them to temporary access roads, grade-change applications, and for erosion control. However, the public-sector civil engineering community was hesitant to embrace the geocell technology for paved road construction, as HDPE is susceptible to deformation (polymeric creep) and there was no design methodology to apply the technology within accepted road construction requirements (such as ASHTO 1993 or the MEPDG).

In comparison, it is interesting to note the effect of the Giroud-Han Design Methodology (first published in 2004) on the incorporation of geogrids in road building and on the adoption of geogrids in pavement structures, bringing the geogrid industry to a total of $761 million in 2015, with an expected global market of $1.5 billion in 2021.

As witnessed in the development of other geosynthetics such as geomembranes, geotextiles, and geogrids, industry innovators began to look for alternative materials for geocell fabrication. Limitations in terms of stiffness, thermal, and elastic properties and long-term creep resistance prevented HDPE geocells from contributing their inherent structural and mechanistic benefits in high cyclical impact loadings (as witnessed in paved highways) and deemed them susceptible to creep or brittleness in extreme heat or cold conditions.

Invention of nano polymeric alloy (NPA) Geocells incorporating Neoloy (a polymeric nano-composite alloy of polyester/polyamide nano-fibers dispersed in a polyethylene matrix) followed years of geocell research initiated by PRS Mediterranean Ltd. and five U.S. state departments of transportation and at the University of Kansas, Kansas State University, University of Delaware, Columbia University, Clausthal University of Technology, Indian Institute of Technology (Madras), and many additional meticulous evaluations. This research transformed geocells from a short-term military solution to a wide-scale public-sector civil engineering, geosynthetic innovation.

NPA Geocells have unprecedented creep resistance, stiffness, tensile strength, flexural storage modulus, resistance to stress-cracking, low coefficient of thermal expansion, oxidation and UV resistance, and provide reliable performance in cold and large-swing, fluctuating climatic regions. In 2010, as part of my Ph.D. thesis working with Dr. Jie Han, I modified the Giroud-Han design methodology (2004) for NPA Geocell reinforcement for unpaved roads, creating an industry-accepted design methodology for NPA Geocell reinforcement in pavements.

With these innovations, NPA Geocells are well positioned to deliver compelling cost and time advantages when compared with unreinforced and conventionally reinforced bases by reducing the amount of aggregate and the construction time of projects and minimizing maintenance and rehabilitation requirements. NPA Geocell-reinforced construction also reduces the amount of virgin aggregate and reduces the need to transport materials to a construction site by utilizing local materials, thereby reducing CO_2 emissions and carbon footprints.

Stratum Logics

Stratum was founded in 2012 following years of infrastructure construction experience and a deep understanding of the need for improved technological solutions for civil engineering infrastructure development. As Stratum's principal engineer, I have successfully applied NPA Geocells to a wide range of infrastructure projects.

One example of Stratum's application of NPA Geocells was in 2012 with MEG Energy, a Canadian oil sands company focused on sustainable, in situ development and production in the southern Athabasca oil sands region of Northern, Alberta. MEG needed a temporary access road to traverse very poor soil conditions. Our design for MEG eliminated the need for muskeg (peat) removal, dewatering, disposal, and soil replacement, and reduced the need for imported aggregates. The design met all technical requirements, provided substantial carbon savings, and was deemed the most cost-competitive offer, demonstrating that sustainability does not need to come at the expense of cost savings.

The project had a tight timeline of six weeks, and more than 3.4 kilometers of road needed to be built on challenging ground. Using NPA Geocells, we were able to meet this deadline, transforming what was a muskeg winter road into an all-weather heavy traffic road. Today, after five years of operations, MEG continues to use this road, which has surpassed its design-life expectations many times over and alleviated the need to build an alternative "permanent" road, saving time and millions of dollars.

Another application example of NPA Geocells was in the Village of Ryley in Central Alberta, Canada. This municipal paved road project had a limited budget and had already suffered from continuous, recurring, and costly road repairs. The village sought a solution to reduce the amount of capital required for repairs, increase the durability of their roads, reduce the amount of future road maintenance, and provide an environmentally responsible solution by lowering the CO_2 footprint of the project.

Our solution incorporated NPA Geocells to provide a mechanically stabilized and reinforced structural pavement with equal or better structural pavement strength accommodating greater traffic loadings. We achieved a 20 percent savings in CO_2 emission reduction and a pavement structure with a greater design life. The design will require 50 percent less maintenance than conventional designs and reduced initial capital cost savings by nearly 10 percent of the total project construction cost.

Sustainable geosynthetic future

Throughout my work I have seen that the innovative application of high-performance geosynthetics can deliver significant cost-benefits to large-scale infrastructure projects. Using NPA Geocells will allow us to build a future of Sustainable Infrastructure — structures and designs that last longer with minimal upkeep. A key part of correctly utilizing geosynthetics is establishing a partnership that can deliver research and innovation expertise together with a proven track record of on-the-ground implementation.

Sustainability and success rest on a three-pillar base of environment, economy, and society. By utilizing innovative technologies we can reach the same structural capacity while saving time, money, and reducing environmental impact.

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