How do you apply sustainability principles on a daily basis in your job to improve the sustainability of concrete structures, bridges or pavements?

"Global warming", "eco-friendly", "green concrete" and "carbon footprints" were probably not among the buzzwords Romans were using when they built the Pantheon which still exists today. What made it so durable; what kind of methods used; and whether or not "sustainability" was one of their goals to achieve are fun topics we, concrete folks, enjoy discussing. However, one question remains unanswered: If Romans were able to produce "sustainable" concrete structures that can last thousands of years with such limited technology, how come we witness those buildings, bridges, and pavements with span lives of thirty years start deteriorating within the first couple of years despite being constructed with the aid of the sophisticated modern technology of today's world and advanced knowledge in materials science? The answer to this question may not be simple; however, looking at the big picture to determine when concrete construction and technology became inversely correlated may lead us to an answer.

As the world's population rapidly increased, the demand for rapid urbanization has almost mutually grown. The problems we face today started arising when decisions were made based on short-term goals to quickly supply the demand for rapid construction. As the long-term environmental consequences of these short-term solutions have started catching up with us, the concrete industry has begun focusing on potential methods to decrease their environmental impact. Big steps have been taken to lead the concrete industry for being more sustainable, such as paying attention to the energy and carbon emission required for cement manufacturing, looking for alternative "green" materials, replacing higher amounts of cement with by-products, minimizing cement content, and using recycled aggregates. However, we don't seem to put much emphasis on one of the key factors hindering us from being more sustainable: *Assuring the performance and longevity of our concrete structures!* It is of course a legitimate argument if one points out that the Roman ruins managed to stand for thousands of years simply because they were not reinforced, thus corrosion was not an issue. However, it does not explain the dilemma of our structures designed to serve for thirty years that begin cracking only a few years after construction. In this case, wouldn't it be ironic to discuss sustainability, *meeting the needs of the present without compromising the ability of future generations to meet their own needs*, when we struggle to meet our own needs while building concrete structures that can have the desired longevity and performance? Well, this is exactly where my job becomes crucial!

As a concrete scientist, I work closely with field engineers, researchers, ready-mix truck drivers, batchman, contractors, finishers, technicians, and quality control managers on a daily basis. My main responsibility is to help them understanding the materials they are working with, and provide solutions to prevent, minimize, and/or troubleshoot the material related problems that may occur during and after construction. Being able to interact with a wide range of people with different backgrounds makes me feel fortunate because it gives me a better understanding of how and why scientifically proven facts are approached as unrealistic inapplicable information, while some of the myths and misconceptions become known as the truth. Most of the time, these invalid old rules of thumb encourage using most of the mix components at extreme regimes due to the lack of knowledge in the science behind concrete materials, thereby resulting in sacrificed sustainability. Therefore, focusing on these misconceptions helps to oversee the barriers limiting sustainability and guides in overcoming those obstacles.

One of my major efforts in improving the sustainability is correcting a common misconception: "*increasing cement content increases concrete strength*". Considering the direct relation between cement production, and its carbon emission and energy consumption, encouraging the use of excessive cement content further increases the cement production demand, thus increases the environmental pollution. Therefore, as a dedicated supporter of sustainability, I have conducted my Master's research study on "Optimizing Concrete Mixtures with Minimum Cement Content for Performance and Sustainability". I used the findings of this study to deliver numerous presentations and published several papers to inform the industry that increasing cement content increases strength only up to a certain point. Once this point is reached, strength becomes independent of cement content. The results of my study show that high cement content also tends to increase shrinkage and permeability, thus decreasing the durability of concrete. Therefore, high cement content affects the environment due to both its carbon footprints and decreasing its service life. After starting to work, to spread the word among people whom are responsible for concrete mix design, I have been regularly meeting with the technical managers of our concrete producer customers. I advise these decision-makers to optimize their mixes with the minimum cementitious content that is sufficient to achieve the desired performance since this will lead to being both environmentally-friendly and cost-effective. I also encourage them to replace a portion of the portland cement with supplementary cementitious materials such as fly ash and slag cement since these not only improve the ultimate performance but also are more sustainable.

For the sake of protecting the environment, I believe in the importance of informing every person involved with concrete construction, not just simply collaborating with the technical people but also the contractors, finishers and truck drivers. In my opinion, this is very essential because even if you design a "green" concrete mix, it may not necessarily turned out as desired. For example, finishers often ask for the addition of water to concrete for the ease of placeability, consolidation, and finishability. However, they are not aware that any water addition they ask for, if it exceeds the allowable limits, results in decreasing strength, durability, and service life of concrete. Therefore, I interact with finishers and truck drivers to tell them that they have a significant role in producing sustainable good quality concrete. I often ask them to approach concrete as if they are "mixing a cake" that any excessive amount of ingredient will change the taste. I have to admit that giving this example WORKS!

As a person who has done her PhD study on proportioning for performance-based mixtures, I believe that the concrete industry will be more sustainable when prescriptive-based specifications are replaced with performance-based specifications which focus on the fundamental principles of sustainability such as using the materials wisely, and concern with the performance and longevity of the end-product. That's why I am proud of being an active member of various ACI committees that initiates this transition. In addition, I attend the sustainability conferences and workshops organized by NRMCA to inform the industry about the performance-based specifications, and working at a company which provides an innovative technology that aims to produce sustainable good quality of concrete by recording, measuring, and managing the amount of fluids added in ready mix truck both in-transit and at the time of delivery to prevent the addition of undocumented water at the jobsite.

We are all equally responsible for ensuring that the next generations will have the same, or even better, quality of environment as we do. It is easy to destroy the environment, but a lot harder to restore it. As they say, "*Rome was not built in a day, but it burned in one*"…