Reader's Voice

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A nation's economy and quality of life require transportation infrastructure systems -highways, roadways, bridges, and rail for example - that provide a safe, reliable, efficient, and comfortable experience. The fact that these structures are relied upon en masse is what renders communities vulnerable when these infrastructures fail from climatic or manmade events[1-5].

Today transportation infrastructure is an increasingly interconnected network of high-value assets with long operational lifetimes. Agencies are challenged to plan, build, and operate "sustainable"transportation systems that – in addition to achieving the important goals of mobility and safety – support a variety of asset management, environmental stewardship, climate mitigation/adaptation, and resilient infrastructure objectives. This requires utilizing an integrated, long-term holistic view of all phases of project: planning, designing, constructing, maintaining, operating, repair/rehabilitation, then final decommissioning and disposal at the end of its service life to ensure the highest economic value for the investment[6,7].

EEngineers have practiced many sustainable concepts through the decades including – rapid construction with pre-fabricated components, integration of recycled or beneficial reuse materials, and extended service life through reliable and durable design[8]. Today, additional improvements in sustainable project delivery are achievable through integration of material and design selection based upon life cycle analysis (LCA) measurements; implementation of life cycle costing analysis (LCCA) versus lowest cost economics; use of innovative design, practices and materials technologies; and collaborative platforms during project design and construction. Examples include complementary cementing materials, ultra-high performance concretes[9], high-performance fiber reinforced cementitious composites, recycled concrete aggregates, internal curing, photovoltaic and LED lighting, vertical wind turbines, and accelerated bridge construction which may all impact LCA and LCCA.

LCAs of structures are greatly impacted by service life. Hence, an objective of the design team should be to maximize service life. Proper structural design and detailing, material composition, high quality construction practice, and preplanned operation and maintenance routines, including durability monitoring of the structure will significantly extend service lives and offer much lower predictable operational energy[10,11].

An engineer's responsibility is to consider both the mechanical and environmental loads effects, including future climatic conditions, and potential deterioration mechanisms and durability risks to ensure safety and serviceability over the infrastructure's entire service life[12,13]. Qualitative service life prediction models should be used to link material property improvements and infrastructure life cycle analysis. By coupling materials and structural deterioration models, a quantitative service life maintenance model and full life-cycle impact assessment can be created[14]. Evaluation of environmental factors, loads, materials, service life prediction models during the analysis and design stages coupled with life cycle assessment and life cycle cost optimization should become an integral part of a sustainable infrastructure design.

Development of performance-based approaches and employment of appropriate maintenance strategies is critical to ensure adequate safety, serviceability and extended service life that minimizes the risk of failure for concrete infrastructure. Technologies include high-speed and high-resolution, nondestructive evaluation (NDE) technologies for inspection, evaluation, and performance monitoring feedback to deterioration mechanisms that allow for timely preventive, corrective, and improvement measures to preserve good structural and functional performance with extended service life. Consideration should also include maintenance management programs with inclusion of non-invasive devices and sensors (e.g., smart sensors, embedded sensors and systems) that permit both periodic and continuous performance evaluation and accurate condition assessment[15]. Finally, designing for adaptability and deconstruction provide strategies for climate change adaptation and end of life decommissioning[16].

In closing, infrastructure systems represent an enormous investment of materials, energy, and capital, resulting in significant environmental burdens and societal costs. Development of innovative materials, construction practices, and employment of appropriate inspection and maintenance strategies is critical to ensure adequate safety, serviceability and extended service life that minimizes the risk of failure for structures and infrastructure. Design, construction, maintenance, climate adaptation and resiliency are all considerations to secure long-term sustainability of new transportation assets. Hence, enhancing the resilience of transportation infrastructure through designed robustness, durability, longevity, disaster resistance, and safety should also be a priority for the engineer.

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