Opportunities for Cyber-Enabled Discovery and Innovation in Civil Infrastructure Development and Health Monitoring

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The most recent large-scale bridge disaster, the structural failure of the I-35 bridge over the Mississippi River, serves as a painful reminder that our civil infrastructure is not infallible. In the wake of this disaster, experts are renewing calls for new building material technologies, improved structural health monitoring, and access to and analysis of structure data to help prevent future disasters like the Minneapolis bridge collapse.

The CI-TEAM Implementation Project: Using Cyberinfrastructure to Develop Next Generation Civil Infrastructure is an existing NSF-funded project[1] to explore the successful deployment and adoption of cyberinfrastructure (CI) tools and practices to enhance research, technology transfer, structural design code development, and human capital development within the Community for International Studies of Engineered Materials (CISEM). In this project, CISEM is deploying CI tools to facilitate research on next-generation building materials such as engineered cementitious composites (ECC)[2] that would extend the life of structures such as bridges.

In addition to new building materials like ECC, the CI-Team Project will also be looking at wireless sensors as an emerging data acquisition technology that can help (i) characterize structural vibration characteristics, (ii) validate design models, and (iii) better understand a structure's responses to its environment[3]. Wireless sensor data can also be continuously streamed via a cellular modem to networked data acquisition systems for real-time viewing and for archival storage. The datasets created on the CI-Team Project will be accessible to the CISEM and subsequently to the broader research and industrial communities outside of CISEM.

The CDI initiative provides opportunities to support research that capitalizes on the potential of next-generation civil infrastructure and sensing technologies to produce more effective structural health monitoring for civil infrastructures. Wireless sensing technologies and self-sensing materials such as ECC provide unprecedented access to real-time data about a structure's performance. Distributed computing environments, computational resources to store and maintain petascale datasets, and networks to support massive dataflows make it possible to gather, store, and eventually to analyze the data provided by new sensing technologies.

The availability of such large datasets poses a number of interesting socio-technical problems of analysis, collaboration, and storage. For example, improved real-time structural health data may be able to help anticipate incipient failures and would also be invaluable for disaster response teams; future research could explore how designers, builders, engineers, and first responders can collaborate in responding swiftly and safely when civil infrastructure weakens or fails. Within academia, the data collected could facilitate the development of novel models of structure decay and response that enable new kinds of materials research. Capitalizing on the benefits of such sensor data requires insight into the use, storage, and sharing of such data. Better understandings of what information can be extracted from the data, how that information can be used, and what new models can be built upon it will require additional research efforts.

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[1] http://www.nsf.gov/awardsearch/showAward.do?AwardNumber=0636300

[2] For more information on ECC, see the ECC Technology Network at http://www.engineeredcomposites.com/

[3] Jerome P. Lynch (2007), "An Overview of Wireless Structural Health Monitoring for Civil Structures," Philosophical Transactions of the Royal Society of London. Series A, Mathematical and Physical Sciences, The Royal Society, London, 365(1851):345-372. http://www-personal.umich.edu/~jerlynch/papers/PTRSPaperLynch.pdf