

EL Program: Disaster Resilient Systems

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Strategic Goal: Disaster Resilient Buildings, Infrastructure, and Communities

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Summary: This program addresses the gap between basic research and building codes, standards, and practice through measurement science research to: (1) predict structural performance up to failure under extreme loading conditions; (2) define and measure disaster resilience and associated tools for evaluation of resilience at the community, state, and regional scales; (3) assess and evaluate the ability of existing structures to withstand extreme loads; (4) design new buildings and retrofit existing buildings using cost-effective, performance-based methods; and (5) derive lessons learned from disasters and failures involving structures. The program enhances the resilience and robustness of structures by focusing primarily on cross-cutting research topics including resilience strategies for the built environment, prevention of disproportionate collapse, measures of disaster resilience, disaster and failure studies, and multi-hazard failure analysis, along with the specific hazards of extreme winds and coastal inundation.

DESCRIPTION

Program and Strategic Goal: Disaster Resilient Systems/ Disaster Resilient Buildings, Infrastructure, and Communities

Objective: To develop and deploy advances in measurement science to enhance the resilience of buildings and infrastructure to natural and manmade hazards by 2016.

What is the problem? Natural and manmade disasters cause an estimated \$57 billion in average annual costs (and growing), with catastrophes like Hurricane Katrina and future “Kobe” earthquakes causing mega-losses exceeding \$100B. Existing extreme load-related prescriptive requirements of building codes, standards, and practices stifle design and construction innovation and increase construction costs. The risk in large disaster-prone regions of the Nation is substantially greater now than ever before due to the combined effects of development and population growth. As noted by the National Science and Technology Council, “...a primary focus on response and recovery is an impractical and inefficient strategy for dealing with [natural disasters]. Instead, communities must break the cycle of destruction and recovery by enhancing disaster resilience.”¹ Preventing hazards (e.g., earthquakes, hurricanes, and community-scale fires) from becoming disasters depends upon the disaster resilience of our buildings and infrastructure. Disaster resilience is the ability to withstand the

¹National Science and Technology Council, *Grand Challenges for Disaster Reduction – A Report of the Subcommittee on Disaster Reduction*, June 2005.

impacts of natural or man-made hazards and recover quickly to pre-disaster societal functions, and is at once a local and a national issue. Regional and national disaster resilience is impacted by pre-event mitigation, immediate response, and long-term recovery.

Currently, the link between basic research and building codes, standards, and practices is weak. Further, the measurement science is lacking to: (1) predict structural performance up to failure under extreme loading conditions; (2) define and measure disaster resilience and develop associated tools for evaluation of resilience at the community, state, and regional scales; (3) assess and evaluate the ability of existing structures to withstand extreme loads; (4) design new buildings and retrofit existing buildings using cost-effective, performance-based methods; and (5) derive lessons learned from disasters and failures involving structures.

Why is it hard to solve? The natural processes that produce risks in the built environment and the information relative to those risks for use by design professionals, standards developers, and emergency planners are not well understood. Cost-effective mitigation strategies that improve the performance of building and infrastructure systems are complex, often lying outside the breadth of the prescriptive procedures that dominate building codes, standards, and practices. Methods for transferring basic research results into practice are limited. The engineering community lacks standard methods of predicting, evaluating, and assessing the disaster resilience of structures as they respond to extreme loads. Communities, states, and regions lack standard methods of assessing disaster resilience at their respective scales for use in making disaster preparedness and mitigation decisions. The lack of metrics to assess performance and complex interdependencies among building systems and infrastructure lifeline systems make predicting, evaluating, and assessing disaster resilience technically challenging. What makes it more difficult is the “stove-piped” approach to research, design, codes, and standards for building and infrastructure systems, along with a fragmented U.S. construction industry.

How is it solved today, and by whom? The problem is not solved today although progress is being made. The disaster resistance of buildings, infrastructures, and communities is determined by codes, standards, and practices used at the time of construction. Most codes, standards, and practices are highly prescriptive, simplified, and inconsistent with respect to risk – resulting in inconsistent performance, stifling innovation, and increasing cost. There is a lack of validated tools and metrics to evaluate structural and community performance, as well as the risks to which they are exposed – the lack of accurate models increases conservatism and decreases cost-effectiveness. In the U.S., codes and standards are developed by private sector organizations that often lack the resources needed to develop the technical bases to improve them – practices, codes, standards used in design, construction, and retrofit are based largely on research performed or supported by the government. The situation is different in Europe and Japan where building code requirements are promulgated by their governments. In Europe and Japan, the development of technical bases for building codes and standards are carried out by universities, private sector research organizations, and quasi-government laboratories with research funding provided by government. Research topics being addressed by European organizations on disproportionate collapse mitigation and wind resistance of structures are relevant to the scope of the NIST research, as well as the development of the standards in these areas. Cooperative research being carried out by U.S. and Japanese universities and research institutions on the characterization of seismic and tsunami performance of building systems

will provide experimental data to fill gaps in defining and quantifying structural system robustness to measure the disaster resilience of capital assets including buildings and civil engineering structures.

Why NIST? This program supports the EL mission of promoting U.S. innovation and industrial competitiveness in areas of critical national priority by anticipating and meeting the measurement science and standards needs for technology-intensive manufacturing, construction, and cyber-physical systems in ways that enhance economic prosperity and improve the quality of life. The program supports the EL core competencies in resilience and fire protection. A broad national consensus is emerging on the value of focusing on community resilience among a diverse critical mass of thought leaders from the public and private sectors. Federal agencies (notably DHS) and the private sector are coming to NIST for leadership in defining the resilience concept, including the multiple independent components, complex interactions, and interdependent factors that must be considered to achieve resilience. NIST is the right organization to lead such a major multi-pronged national effort. It has the credibility, the knowledge base, the required experience, and broad stakeholder relationships essential to achieving success. The program further fulfills a national knowledge transfer role that is not well-supported by a fragmented U.S. construction industry (ACI 318, AISC, ASCE 7). Finally, NIST has statutory responsibilities including: (1) the National Windstorm Impact Reduction Act (2004); (2) the Fire Prevention and Control Act (1974); and (3) the National Construction Safety Team Act (2002).

What is the new technical idea? The fundamental new idea is that disaster resilience can be enhanced significantly by developing a robust capability to *predict* the effects of hazards on the *performance* of complex building and infrastructure systems and on community-wide response. This will be achieved by developing: (1) validated *data* to characterize the hazard environment; (2) validated physics-based *models* to predict performance of structures to failure; (3) *metrics* for measuring performance; (4) acceptance *criteria* for differing levels of performance objectives; (5) *mitigation* strategies based on evaluated performance; (6) science-based *tools* to estimate losses and predict resilience at the community scale; and (7) a *disaster resilience framework* providing, at three different levels (community, state, and regional) a consistent definition of resilience, consistent performance goals and metrics, and tools for evaluating disaster resilience and progress made toward achieving resilience.

The cross-cutting work in this program will address the following dimensions of resilience: (1) performance targets progressing from a baseline of life safety to higher levels of performance—such as immediate occupancy or a fully operational system—for buildings and lifelines essential to community resilience; (2) low probability, high-consequence hazard levels (i.e., “black swan” events) that exceed the hazard levels used in design; (3) the increased risks from events with multiple hazards that many communities face; (4) the preparedness of a community’s emergency response and evacuation systems; (5) emergency preparedness of residents and workers; and (6) the interaction of technical, social, and economic factors that determine pre-disaster mitigation and post-disaster response.

While other programs within the Disaster Resilient Buildings, Infrastructure, and Communities strategic goal deal with specific hazards such as fires in communities, fires in buildings, and

earthquakes, the scope of this program is primarily cross-cutting research topics including resilience strategies for the built environment, disproportionate collapse, disaster and failure studies, and multi-hazard failure analysis, along with the specific hazards of extreme winds and coastal inundation. This program, thus, provides an overarching framework for measuring and achieving disaster resilience for communities, states, and regions by providing critical science-based metrics, tools, standards, and other innovations essential to achieve national infrastructure resilience.

Why can we succeed now? It is possible to succeed now because there is strong demand from the general public and policy makers for enhancing disaster resilience of communities and reducing losses from future disasters as well as demand from the private sector to fill science and technology gaps. Recent advances in the relevant technical disciplines and in computational capabilities make possible significant advances in the component research topics. Finally, there is an increasing body of fundamental structural behavior knowledge available from NSF-supported basic research.

What is the research plan? The program consists of six research thrusts:

(1) Develop validated tools that predict structural performance to failure under extreme loading conditions. This research thrust consists of three elements:

- Develop an improved understanding of the hazards to the built environment. The outcomes of this element will include: innovative methods for defining design wind speeds and loads; risk-based storm surge maps; and improved understanding of disproportionate collapse of structures.
- Develop validated structural response models that characterize structural response from initial loading to failure for individual hazards (e.g., wind) and within a multi-hazard context. The outcome of this element will be rational assessment of safety and reliability of structures at specified performance levels for individual hazards and within a multi-hazard context.
- Develop validated, simplified tools to characterize structural response from initial loading to failure for individual hazards and within a multi-hazard context. The outcome of this element will be validated, simplified tools that can be used by practicing structural engineers in routine structural design.

(2) Develop community-scale resilience assessment tools to predict consequences of disasters, leading in turn to increased resilience. This research thrust consists of two elements:

- Develop science-based tools to assess disaster resilience and estimate losses at the community scale due to individual hazards and within a multi-hazard context. The outcome of this element will be rational assessment of potential community-scale losses due to individual hazards and within a multi-hazard context.
- Integrate science-based tools for loss estimation at the community scale with cost-effectiveness tools for risk management technologies. The outcome of this element will be decision support tools for risk mitigation at the community scale.

(3) Develop validated tools to assess and evaluate the capabilities of existing structures to withstand extreme loads. This research thrust consists of three elements:

- Develop validated tools for use in initial visual evaluation and in simplified analyses. The outcome of this element will be rapid visual screening methodologies and simplified analytical tools to evaluate the ability of existing structures to withstand extreme loads.
- Develop validated models for detailed analysis from initial loading to projected failure. The outcome of this element will be experimentally validated, high-fidelity models of the behavior of existing structures in response to extreme loads, from initial loading through collapse.
- Develop validated, simplified models for routine analysis from initial loading to failure. The outcome of this element will be validated, simplified tools that can be used by structural engineers in routine practice for analysis of the response of existing structures to extreme loads from initial loading through collapse.

(4) Develop performance-based guidelines for cost-effective design of new buildings and, where warranted, rehabilitation of existing buildings. This research thrust consists of four elements:

- Develop acceptance criteria for different performance levels. The outcome of this element will be published performance criteria for structures subjected to extreme loads and under disproportionate collapse.
- Develop performance-based design guidelines for new structures. The outcome of this element will be published design guidelines for new structures to address individual hazards, multi-hazards, and disproportionate collapse.
- Develop cost-effective mitigation strategies for existing structures. The outcome of this element will be published guidelines for mitigation strategies for existing structures to individual and multi-hazards and disproportionate collapse.
- Develop performance-based pre-standards for new and existing structures. The outcome of this element will be to provide to standards bodies performance-based pre-standards to address individual and multi-hazards and disproportionate collapse.

(5) Derive lessons learned from disasters and failures involving structures. This research thrust consists of three elements:

- Develop and implement procedures for preliminary site reconnaissance and perform preliminary site reconnaissance as required. The outcome of this element will be to conduct site reconnaissance efforts using uniform procedures for site access, data collection and archiving, reporting on findings, and criteria for recommending more detailed investigations.
- Perform and report on comprehensive technical studies, when warranted, involving specific structures or classes of structures. The outcome of this element will be documented findings and conclusions from the studies, and recommendations for changes to practices, standards, and codes to reduce the potential for similar failures in the future.
- Develop national data archiving capabilities and implement information dissemination technologies. The outcome of this element will be a national resource data repository to store and broadly disseminate findings from studies of disaster and failure events.

(6) Provide the measurement science and federal leadership to convene a Disaster Resilience Standards Panel (DRSP) to bring together the highly diverse stakeholder interests across all hazards to enable the development of:

- A comprehensive Disaster Resilience Framework for achieving community resilience that considers the technical interdependence of the community's physical and human assets, operations, and policies/regulations
- Model Resilience Guidelines for critical buildings and infrastructure lifelines essential to community resilience based on *existing* model standards, codes, and best practices.

How will teamwork be ensured? Within each of the component projects, the individual team members have been assigned based upon their specific expertise and have well-defined, complementary roles within their projects. This program is highly synergistic with EL's National Earthquake Hazard Reduction Program (NEHRP), Fire Risk Reduction in Buildings Program, and Fire Risk Reduction in Communities Program; and there will be close coordination between the four programs, especially through the work of the Disaster Resilience Standards Panel. Established collaborations with the Fire Research Division, the Applied Economics Office, the Statistical Engineering Division (ITL), and the Applied and Computational Mathematics Division (ITL) will bring important capabilities to bear on the component research projects. Partnerships with other Federal agencies complement the capabilities of the NIST team (e.g., large-scale experiments). In addition NIST will convene the DRSP, modeled after the Smart Grid Interoperability Panel. The DRSP will bring together the highly diverse stakeholder interests (planners, designers, contractors, state and local officials, insurers and re-insurers, SDOs, code organizations, industry organizations, professional organizations, and other agencies) to engage the larger community and accelerate the development of standards.

ACCOMPLISHMENTS and IMPACT

R&D Impact:

- **Top Journals:**

- *Journal of Structural Engineering*, ASCE (IF: 0.955)
- *Structural Safety* (IF:1.867)
- *Engineering Structures* (IF: 1.351)
- *Journal of Wind Engineering and Industrial Aerodynamics* (IF: 1.119)
- *ACI Structural Journal* (IF: 0.67)
- *Journal of Constructional Steel Research* (IF: 1.251)
- *Journal of Engineering Mechanics*, ASCE (IF: 0.990)

- **Research Outcomes:**

Measurement of Building Resilience and Structural Robustness:

Main, J.A. (2013). "Composite floor systems under column loss: Collapse resistance and tie force requirements." *Journal of Structural Engineering*, ASCE, in review.

Bao, Y., Lew, H.S., Sadek, F., and Main, J.A., (2013). "A Simple Method to Enhance Catenary Action Development in Beams of R/C Frame Structures." *ACI Concrete International*, in review.

Wind Engineering and Multi-Hazard Failure Analysis:

Yeo, D. (2013). "Generation of Large Directional Wind Speed Datasets for Estimation of Wind Effects with Long Return Periods", *Journal of Structural Engineering*, ASCE, in review.

Dunn, C.L., Friedland, C.J., and Levitan, M.L., (2013). "Statistical representation of design parameters for hurricane risk reduction of structures", *Structural Safety*, in review.

- **Potential Research Impacts:**

Measurement of Building Resilience and Structural Robustness:

Lew, H.S., Bao, Y., Pujol, S., and Sozen, M.A. (2013). "Experimental study of RC assemblies under a column removal scenario." *ACI Structural Journal*, in press. (accepted in FY13)

Main, J.A. and Sadek, F. (2013). "Modeling and analysis of single-plate shear connections under column loss." *Journal of Structural Engineering*, ASCE, in press. (accepted in FY13)

Bao, Y., Lew, H.S., and Kunnath, S.K. (2013). "Modeling of reinforced concrete assemblies under a column removal scenario." *Journal of Structural Engineering*, ASCE, in press. (accepted in FY13)

Wind Engineering and Multi-Hazard Failure Analysis:

Gabbai, R. and Simiu, F., (2013). "Evaluation of Mean Recurrence Intervals of Wind Effects for Tall Building Design", *Journal of Structural Engineering*, ASCE, in press. (accepted in FY13).

Simiu, E., Letchford, C., Isyumov, N., Chowdhury, A.G., and Yeo, D. (2013). "An Assessment of ASCE 7-10 Standard Methods for Determining Wind Loads", *Journal of Structural Engineering*, ASCE, in press. (accepted in FY13)

Yeo, D. and Potra, F., (2013). "Sustainable Design of Reinforced Concrete Structures through CO2 Emission Optimization", *Journal of Structural Engineering*, ASCE, (accepted in FY13)

Yeo, D., Lin, N., and Simiu, E. (2013). "Estimation of Hurricane Wind Speed Probabilities: Application to New York City and Other Coastal Locations," *Journal of Structural Engineering*, ASCE (accepted in FY13)

- **Realized Research Impacts:**

Measurement of Building Resilience and Structural Robustness:

Lew, H.S., Main, J.A., Robert, S.D., Sadek, F., and Chiarito, V.P., (2013). "Performance of steel moment connections under a column removal scenario. I: Experiments." *Journal of Structural Engineering*, ASCE, 139(1), 98-107. (published in FY13; citations: 3)

Sadek, F., Main, J. A., Lew, H.S., and El-Tawil, S. (2013). "Performance of steel moment connections under a column removal scenario. II: Analysis." *Journal of Structural Engineering*, ASCE, 139(1), 108-119. (published in FY13; citations: 3)

Sadek, F., Main, J. A., Bao, Y., and Lew, H. S., (2011), "Testing and Analysis of Steel and Concrete Beam-Column Assemblies under a Column Removal Scenario," *Journal of Structural Engineering*, ASCE, 137(9), pp. 881-892. (published in FY11; citations: 7)

Alashker, Y., El-Tawil, S., and Sadek, F., (2010), "Progressive Collapse Resistance of Steel-Concrete Composite Floors," *Journal of Structural Engineering*, ASCE, 136(10), pp. 1187-1196. (published in FY10; citations: 15)

Khandelwal, K., El-Tawil, S., and Sadek, F. (2009). "Progressive collapse analysis of seismically designed steel braced frames." *Journal of Constructional Steel Research*, 65(3), 699-708. (published in FY09; citations: 45)

Sadek, F., El-Tawil, S., and Lew, H.S. (2008). "Robustness of composite floor systems with shear connections: Modeling and evaluation." *Journal of Structural Engineering*, ASCE, 134(11), 1717-1725. (published in FY09; citations: 27)

Khandelwal K., El-Tawil, S., Kunnath, S., and Lew, H.S. (2008). "Macromodel-based simulation of progressive collapse: Steel frame structures." *Journal of Structural Engineering*, ASCE, 134(7), 1070-1078. (published in FY08; citations: 50)

Bao, Y., Kunnath, S., El-Tawil, S., and Lew, H.S. (2008). "Macromodel-based simulation of progressive collapse: RC frame structures." *Journal of Structural Engineering*, ASCE, 134(7), 1079-1091. (published in FY08; citations: 55)

Wind Engineering and Multi-Hazard Failure Analysis:

Yeo, D., (2013). "Multiple Points in Time Estimation of Peak Wind Effects on Structures", *Journal of Structural Engineering*, ASCE, 139, 462-471. (published in FY13, citations: 0).

Fu, T.C., Aly, A.M., Chowdhury, A.G., Bitsuamlak, G., Yeo, D. and Simiu, E. (2012). "A Proposed Technique for Determining Aerodynamic Pressures on Residential Structures," *Wind and Structures*, 15 (1). (published in FY13, citations: 8).

Lombardo, F.T., (2012). "Improved extreme wind speed estimation for wind engineering applications," *Journal of Wind Engineering and Industrial Aerodynamics*, Volumes 104–106, Pages 278–284. (published in FY12, citations: 3)

Yeo, D. and Simiu, E., "High-Rise Reinforced Concrete Structures: Database-Assisted Design for Wind," *Journal of Structural Engineering*, ASCE. (published in FY12, citations: 6)

Crosti, C., Duthinh, D., and Simiu, E., "Risk-consistency and synergy in multi-hazard design," *Journal of Structural Engineering*, ASCE. (published in FY11, citations: 5)

Coffman, B., Main, J., Duthinh, D., and Simiu, E., (2010). “Wind Effects on Low-Rise Metal Buildings: Database-Assisted Design vs. ASCE 7-05 Standard Estimates,” *Journal of Structural Engineering*, ASCE. (published in FY10, citations: 14)

Duthinh, D., and Simiu, E., (2010). “Safety of Structures in Strong Winds and Earthquakes: Multihazard Considerations,” *Journal of Structural Engineering*, ASCE. (published in FY10, citations: 9)

Simiu, E., Gabbai, R.D., Fritz, W.P., “Wind-induced tall building response: a time domain approach,” *Wind and Structures*, 11, 427-440. (published in FY09, citations: 16)

Lombardo, F.T., Main, J.A., and Simiu, E. (2009) “Automated Extraction and Classification of Thunderstorm and Non-Thunderstorm Wind Data for Extreme-Value Analysis,” *Journal of Wind Engineering and Industrial Aerodynamics* 97(3-4), 120-131. (published in FY09, citations: 16)

Fritz, W.P., B. Bienkiewicz, B. Cui, O. Flamand, T. C. E. Ho, H. Kikitsu, C. W. Letchford, and E. Simiu, “International Comparison of Wind Tunnel Estimates of Wind Effects on Low-Rise Buildings: Test-Related Uncertainties,” *Journal of Structural Engineering*, ASCE, 134 87-90. (published in FY09, citations: 14)

Impact of Standards and Tools:

Technology Transfer Outcomes:

Measurement of Building Resilience and Structural Robustness:

A new ASCE/SEI Standards Committee on disproportionate collapse mitigation of building structures has been established, based on a proposal by NIST. NIST is leading the development of a chapter on acceptance criteria for structural performance and making substantial contributions to a chapter on design and analysis approaches. Project team prepared white papers outlining the scope and content for both chapters. (FY13)

A new PCI Task Committee has been established to develop guidelines for design of precast concrete frame structures to resist disproportionate collapse based on the outcome of NIST research that revealed a vulnerability of precast concrete connections. NIST is participating in the committee and is tasked with examining the effectiveness of proposed connection configurations in reducing vulnerabilities to disproportionate collapse. (Committee established in FY12)

Developed evaluation tools, acceptance criteria, and performance metrics to be used in a performance-based design approach to mitigate disproportionate collapse. (FY12)

Developed “A Guide to Assessing Vulnerability of Buildings to Disproportionate Collapse” in collaboration with industry. (Draft completed in FY12, to be published in FY13)

McAllister, T.P. (2013) “Developing Guidelines and Standards for Disaster Resilience of the Built Environment: A Research Needs Assessment”, TN 1795.

Wind Engineering and Multi-Hazard Failure Analysis:

Proposals submitted to the ASCE 7 Standard on combined wind and storm surge, combined wind and seismic loads, database assisted design, and the wind tunnel method. (FY13)

New hurricane shelter design wind speed map submitted to and accepted by the ICC 500 Storm Shelter Standard committee. Updated draft standard will be released for public comment soon. (FY13)

- **Potential Technology Transfer Impacts:**

Disaster and Failure Studies:

Forty model building and fire code changes consistent with NIST's World Trade Center investigation recommendations are now required by the International Code Council's (ICC) I-Codes. Similarly, the National Fire Protection Association (NFPA) has adopted 15 changes responsive to the WTC Recommendations for inclusion in the 2009 Editions of the NFPA 5000 Building Code, NFPA 1 Fire Code, and NFPA 101 Life Safety Code.

NIST submitted three code change proposals (and collaborated with ASCE/SEI on an additional proposal) to the International Building Code (IBC) based on the recommendations from the study of the collapse of the Dallas Cowboys Indoor Practice Facility. The ASCE/SEI and one of the NIST proposals were accepted by the IBC structural committee during the code hearings in May 2012. Implementation of these code changes will result in safer membrane-covered frame structures during windstorms.

Measurement of Building Resilience and Structural Robustness:

ASTM E2506 Guide for Developing a Cost-Effective Risk Mitigation Plan for New and Existing Constructed Facilities (Revisions adopted 2012)

Wind Engineering and Multi-Hazard Failure Analysis:

Database Assisted Design for Tall Reinforced Concrete Buildings software tools. (Posted online in FY11)

- **Realized Technology Transfer Impacts:**

Measurement of Building Resilience and Structural Robustness:

Project team wrote a section on structural systems for the ASCE/SEI Standard 59-11 on Blast Protection of Buildings. (published in FY11)

Structural integrity requirements for tie reinforcement submitted by NIST based on experimental and analytical research have been incorporated in the ACI 318-09 Building Code. (published in FY09)

Structural integrity requirements proposed by the Ad Hoc Joint Industry Committee on Structural Integrity have been adopted for the 2009 IBC (published in FY09)

Best practices guide for preventing progressive collapse in buildings (NISTIR 7396) published and widely cited, including adoption in the ASCE 7-10 Standard as part of the commentary section on general structural integrity. (published in FY07; citations: 52)

Wind Engineering and Multi-Hazard Failure Analysis:

Technical Basis for Regulatory Guidance on Design-Basis Hurricane-Borne Missile Speeds for Nuclear Power Plants, issued as NUREG/CR-7004, U.S. Nuclear Regulatory Commission. (Published in FY12)

Other:

Recognition of EL:

Emil Simiu was included in the 2012 Structural Engineer's Power List based on his work in the wind engineering field

Therese McAllister was selected to be a Fellow of the Structural Engineering Institute of the American Society of Civil Engineering in 2013 for her work on structural response to fire conditions and the resilience of building and infrastructure systems to disaster events.

Fahim Sadek received the 2012 Moisseiff Award from the American Society of Civil Engineers for a paper entitled "Progressive collapse resistance of steel-concrete composite floors," published in the Journal of Structural Engineering.

