Integrating Hazard Resistant Design with Green Building Design for Life-Cycle Improvements in Building Sustainability

Quick Description

This NSF-funded project proposes a new building life-cycle assessment method, based on the tradeoffs and interdependence of structural, economic, and environmental features. The framework quantifies environmental impacts of hazard-resistance and green design, promoting a more holistic approach to decisions about building design and hazard mitigation. Measurement of future socio-economic and environmental losses after hazard events will provide developing communities with a more comprehensive analysis tool for structural performance. Post-disaster reconstruction costs and ecological degradation increase the vulnerability of already-struggling communities; a local building stock with fewer negative environmental effects and better hazard-performance will reduce post-disaster losses and increase community stability.

Purpose and Hypothesis

Although green building rating systems such as LEED provide metrics for the "sustainability" of new and existing construction, few rating systems measure the hazard-resistance performance of a building. The goal of this project is to outline a procedure for the life-cycle assessment of building design that lowers environmental impact and improves hazard performance. The framework will be illustrated through a series of case studies in which a commercial office building is designed with common "green" building features and analyzed under various natural hazard events (earthquake, wind, and snow loads). Validation of this life-cycle assessment tool will encourage a more interdisciplinary design process and inform decision-makers about improvements to current building codes and rating systems. Additionally, it will educate engineers and infrastructure managers in developing communities how to better invest in projects that will perform well within the categories of Energy, Ecology, Damage, and Dollars. The research hypothesis for the project is four-fold:

1. Green buildings perform poorly in hazard events
2. Poor hazard performance increases life-cycle environmental impact
3. Hazard-resistant design reduces post-disaster socio-economic losses
4. Life-cycle activities of hazard-resistant buildings are not always ecologically-positive

These ideas lead to the guiding research question: can building design that compromises on green, hazard-resistant design yield better hazard performance and less environmental impact?

Review of Literature

The design of a building based on sustainability and building life-cycle assessment typically falls into two categories: "green building design" and "sustainable building design." These terms are often used interchangeably, but in reality possess significantly different meanings. The Environmental Protection Agency considers a green building as a design that is environmentally-responsible and resource-efficient throughout a building's life-cycle (Environmental Protection Agency, 2012).

The natural hazards for which a building is designed may depend on the region, but typically included earthquakes, hurricanes, landslides or strong winds. The conventional, codified approach to hazard-resistant design provides structures with the strength, stiffness and inelastic

deformation capacity to withstand a given level of natural hazard-generated forces without endangering life safety (Multi-Disciplinary Center for Earthquake Engineering Research, 2010).

Both hazard-resistant design and green building design are performance-based in the sense that they aim to optimize building performance for certain criterion. Within performance-based structural engineering, however, these two concepts exist as distinctly separate fields. Moreover, as noted by the Federal Emergency Management Agency, "green building practices […] have the potential to compromise a building's resistance to natural hazard events" (Gromala, 2010). Some studies, such as the ATC-86 initiative, have begun in recent years to consider how the environmental impacts of seismic hazard damage may be applied to expand traditional building life-cycle assessments, but not made formal recommendations for how this might occur (Federal Emergency Management Agency, 2012).

Results

This research is still in the analysis stage, with preliminary results forthcoming. The quantification of hazard performance and environmental impact is multi-stage assessment, combining structural and environmental analysis techniques. Results from these analyses will convert separate measurements of environmental and hazard losses into a matrix of life-cycle building performance. A rating for each life-cycle stage will be given based on the building life-cycle environmental impact (measured in CO_2 equivalents), and the potential material needs (expressed in present-value U.S. dollars). This rating will compare the relative influence of four categories: Energy, Ecology, Damage, and Dollars.

Conclusions

The current step of this project investigates both the environmental impact of seismic hazard damage, and the structural vulnerability from green building features in hazard events. The first component of this project offers further insight into the effects of seismic hazard performance on building environmental impact. Later applications of the framework will develop a comprehensive analysis of the environmental and hazard performance impacts of designs that are both green and hazard-resistant. The metrics used and the format of the proposed ratings will be modified based on responses from public and private stakeholders. It is hoped that the results of this project will promote policies for better communication between architects and engineers, as well as providing communities and governments with a better understanding of potential economic and environmental losses.

Reference List

Environmental Protection Agency (2012), *Basic Information: Definition of Green Building*. Retrieved June 13, 2013, from Environmental Protection Agency website: http://www.epa.gov/greenbuilding/pubs/about.htm

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