Innovations in Building Regulation and Control for Advancing Sustainability in Buildings (I)

Brian MEACHAM, Department of Fire Protection Engineering and Department of Architectural Engineering, Worcester Polytechnic Institute, 100 Institute Road, Worcester, MA 01609, USA (bmeacham@wpi.edu) – *The Impact of Climate Change on Building Regulatory Systems* (session moderator)

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Jacques LAUBSCHER, Department of Architecture, Faculty of Engineering and the Built Environment, Tshwane University of Technology, South Africa (laubscherj@tut.ac.za) – *Reviewing challenges between the need for government-subsidised housing in South Africa and the sustainability requirements of the National Building Regulations*

Jeffery NENG KWEI SUNG, Centre for Sustainable Building and Construction, Research Group, Building and Construction Authority, Singapore (Jeffery_NENG@bca.gov.sg) – *Legislating for the Life-Time Environmental Sustainability of Buildings under the Singapore Building Control Act*

Bill DODDS, Scottish Government, Building Standards Division, Local Government and Communities, Denholm House, Almondvale Business Park, Livingston, EH54 6GA, Scotland (Bill.Dodds@scotland.gsi.gov.uk) – *Sustainability Labeling for Building Standards*

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Abstract: *This session brings together policy-makers, government officials, researchers and others to present perspectives on how innovation in building regulation and control, such as performance-based approaches, are currently being used to advance sustainability concepts in buildings, and where and how we might see further innovation in the coming years. In this grouping of session papers, representatives of the Inter-jurisdictional Regulatory Collaboration Committee (IRCC) and the International Council for Research and Innovation in Building and Construction (CIB) Task Group 79 discuss a range of policies implements in their countries or the focus of research and development in their respective countries. Related papers can be found in the corresponding set of session papers (Innovations in Building Regulation and Control for Advancing Sustainability in Buildings (II)).*

Keywords: *building regulatory systems, building control, performance-based, sustainability, climate change, resiliency*

The Impact of Climate Change on Building Regulatory Systems

Abstract: *The contribution of the buildings sector to climate change is significant and widely acknowledged [1]. Carbon emissions associated with energy production and usage for heating, cooling and lighting, as well as for extraction, refinement, production, shipment and use of building materials, is considerable. At the same time, buildings are in turn vulnerable to the effects of climate change, including decreased rain (drought), increased rain (leading to flooding), increased snow loads, more intense storms and more. While some effects of climate change and associated vulnerability may not manifest for several decades, some have already been realized. Long-term drought conditions in Australia have increased bushfires and impacts on urban environments; increased snow loads in Nordic countries and in New Zealand have resulted in increased structural failures dues to snow load; several cities in the USA have experienced building and infrastructure damage during 'super storms'; England has experienced two '100-year' flood seasons within the past five years. While these issues have been studied to various extents, the building regulatory systems, within which buildings are effectively designed and operated, have received almost no attention. To complicate the situation further, the building regulations and codes themselves have not been holistically considering how changes in materials and systems meant to decrease carbon emissions might actually be increasing building vulnerability. These challenges seem to be amplified in building regulatory systems where measures of performance are unclear, responsibility for design, approval and enforcement is diversified and in some cases privatized, and no single entity has an understanding of the holistic building performance. Given the convergence of these factors, strong consideration must be given to restructuring of building regulatory systems to better understand and address holistic building performance in the face of climate change adaptations, physical impacts that are likely given climate change effects, multiple and potentially competing policy directives, government resource limitations, and an increasing reliance on self-control via market mechanisms. If the system as a whole is not adequately considered, there will be opportunities for significant failures, such as experience by New Zealand with its 'leaky building' syndrome [2-5].*

1. The Problem

Building regulatory systems are complex systems of systems. They typically include some type of legislative mandate for building regulation and control, a building code, which includes regulatory requirements for the design and construction of a building, reference standards which address testing, installation and maintenance, and some type of building control. They may include reference to code of practice for designers and others, created by professional organizations. Minimum competency requirements for practitioners, and mechanisms to assess and license those practitioners, may be included as well. In some cases, market-based mechanisms, such as 'private certification,' 'self-regulation,' or third-party market controls, as might be set by the insurance industry, may exist as well. While complex, the system has worked generally well when focused on issues of occupant health and safety.

Increasingly, however, building regulatory systems are becoming complicated by policy mandates originating from outside of the historical realm of building regulation, including environmental and resource legislation (energy, water, material), which are in some cases imposing 'competing objectives' and difficult enforcement challenges. This includes energy performance legislation leading to measures which create fire safety challenges, and planning/zoning legislation which can create fire safety challenges (densely grouped buildings, small roadways) and in some cases the construction of buildings in at-risk locations (prone to flooding, sea-level rise, etc.). Such challenges are also seen with market-based, voluntary approaches aimed at increasing energy performance of buildings, such as BREEAM, LEED, and others. Such approaches are developed completely outside of the building regulatory system, and their implementation is often targeted at existing buildings, for which building regulatory oversight is typically less than with new construction.

As a result, while the number of governmental policies and market approaches aimed at increasing the sustainability of the built environment developed in recent years is considerable, their success in facilitating a sustainable built environment has arguably been limited [6]. The stakeholders in the construction and building regulatory markets are fragmented and not working effectively together [1,6], inconsistent levels of performance is being realized through voluntary measures [7.8], there are incomplete building performance measures, monitoring and enforcement mechanisms [6,9] and increasing liability concerns [10]. The fragmented regulatory approach and introduction of competing objectives has led to unintended consequences being introduced, some of which present considerable risk to building occupants. The push for new technologies for energy efficiency and performance in building is introducing a wide range of hazards, including structural hazards due to moisture-related failures of enclosed structural systems [2-5], health hazards related to mold and indoor air-quality due to weather-tight buildings [11], fire and health hazards due to the flammability of thermal insulating materials [12-14], fire and smoke spread potential through the use of double-skinned façades [15], and fire hazards and impediments to emergency responders associated with interior and exterior use of vegetation (shading, green roofs, etc.), among others [14]. The 'competing objectives' between sustainability and fire safety are particularly complex due to the multidimensional aspects of each. For example, timber is 'sustainable' but also is combustible, so if not addressed appropriately can present a significant fire safety hazard [14]. High strength concrete requires less material and is more sustainable than regular strength concrete, but can be highly susceptible to spalling during a fire if not modified [16]. These 'competing objectives' can result in significant performance challenges for buildings.

2. What Can Be Done?

In part, the fragmented approach to building regulatory development and control, and the resulting competing objectives and creation of potentially hazardous conditions associated with the noble goal of becoming more sustainable, can be related to the lack of a broadly agreed framework for holistically describing and assessing building performance across all societal objectives. Buildings, like building regulatory systems, are a complex system of systems. To function properly, all aspects must be in sync. This is difficult to control if there is no framework within which to test the system. This situation can become exacerbated with deregulation and downsizing of government control if there is not clear guidance to the private sector entities who take on responsibility for the holistic performance of buildings.

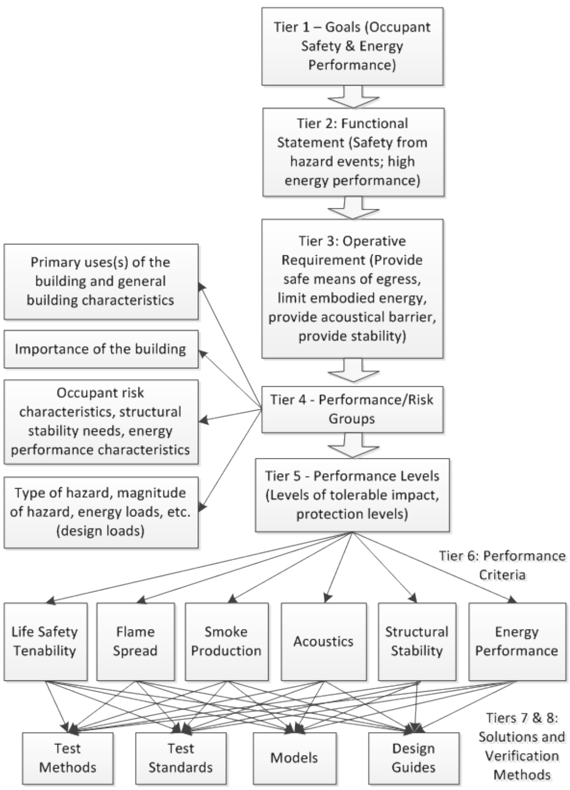
To address these issues, change is needed across the whole of the building regulatory system, including policy formulation, structure of regulations, and means of 'checks and balances' within the system. In some countries, change to the building regulatory development process may be needed. In all cases, a more robust building regulatory framework will be beneficial. In all cases, more explicit identification, acceptance and control of risk needed.

In addition, more data, tools and methods are needed relative to the holistic performance of buildings across all required attributes. That is, instead of focusing primarily on one attribute for a specific policy objective or solution (e.g., thermal performance for an energy efficiency objective), the focus needs to be on adequately characterizing the performance across all essential areas (e.g., thermal performance, fire performance, health effect, etc.) and developing processes, tools and methods to assess influences of one objective on another.

Finally, building regulatory systems need to do a better job of addressing existing buildings. While issues associated with safety performance have been known for decades (e.g., large life-loss events lead to building code changes, in some cases retrospectively), the extent of issues associated with climate change (e.g., energy performance) and resilience to impacts of climate change (e.g., higher strength storms, coastal and other flooding concerns, etc.) have only started to be a focus. The situation is complicated by voluntary measures in some areas, such as energy performance rating schemes resulting in building changes which reduce safety.

3. Starting Point: The IRCC Performance-Based Building Regulatory Framework

Based initially on a structure outlined by the Nordic Building Codes Committee (NKB) in the late 1970s, a model for performance-based building regulations has been suggested by the Inter-jursidictional Regulatory Collaboration Committee (IRCC) [17-19]. Illustrated in Fig. 1, the model assumes that regulatory provisions are based on policy goals (essential interests of the authorities), and through increasing levels of detail, functional and operational requirements are described. Functional requirements provide qualitative statements about the desired function of buildings or specific building elements. Operative requirements provide a level of detail that can be applied to design and construction, ideally presented as quantitative requirements, and expressed in terms of specific performance criteria or expanded factional descriptions. Performance or risk groups aim to provide a mechanism for grouping requirements for different building uses (e.g., residential, business, assembly) based on common risk or performance targets. Performance levels define the common targets under various conditions or events. Instead of prescribing a single set of design specifications for compliance, the approach requires that instructions or guidelines be provided which outline how compliance



with the functional and operative requirements is to be verified. These instructions or guidelines can include engineering analyses, test methods, measurements and simulations. In addition, examples of acceptable solutions, deemed to satisfy the building regulations, are to be provided. Several countries are currently operating with building regulations which fit some, if not all, aspects of the model [17].

The IRCC model is attractive because it places the focus on goals and objectives for the building, and allows for a variety of mechanisms to be used to demonstrate compliance. However, the model does not provide guidelines for how to apply the process / framework to the revision of existing building regulations, or to development of new regulatory requirements and supporting components, such as for sustainability and climate change. In particular, gaps exist in guiding users as to how to best identify and incoporate a suitably broad and informed set of stakeholders for identifying appropriate performance and risk levels, in understanding and applying suitable decision-making processes in the performance and risk criteria setting process, and connection of quantified design criteria to performance expectations. These areas are critical in advancing the applicability of the model for addressing new and emerging issues, such as climate change impacts on building.

4. Where Do We Go From Here?

To move forward, several steps are needed. First, there needs to be a shift in thinking from viewing buildings as a collection of independent systems, to viewing buildings – and building regulatory systems – as complex systems of systems with strong interrelationships between subsystems and overall building performance. Increasing energy performance should not be considered without assessing impacts to structural performance, indoor air quality, fire performance or other attributes. Reducing material should not just be viewed as a cost savings or sustainability measure, but resulting structural performance, fire performance and related factors need to be considered. Viewing the problem as being a complex systems problem is not new [e.g., 5, 20], but thus far a true shift in thinking has not occurred, and the 'silo' based approach to regulatory development and implementation is creating new hazards and risks as it tries to mitigate others.

Second, a broader set of stakeholders is required to feed into the regulatory development and control process to help assure the key societal and policy objectives are met. Experience within the countries participating in the IRCC shows that building regulations are largely formulated by a small group of specialists, be they codes- and standards-making committees, bureaucrats, consultants or some combination [17]. These experts may consult other experts for specific issues, when deemed appropriate, and they may also consult the public. However, given the relatively small numbers of experts involved, it is questionable if the process results in a broad enough discussion of critical issues – technical, political or societal. This has been observed by others in the area of sustainable design and construction as well [e.g., 20-22].

Third, in addition to breaking down the 'silo' based approach and broadening the stakeholder participation in the building regulatory process, governments need to find ways to likewise break down the silos between departments and agencies responsible for the various parts of the problem, and get the right participation from each organization together in the regulatory policy-setting stage. It is impossible to control the changing nature of political agendas. However, the translation of political agendas and policy directives into regulation is largely a function of civil servants, and much more coordination can occur at the upper levels of governmental departments and agencies.

Fourth, while the IRCC model provides a good starting point, advancements are needed in several key areas. Again, these are unfortunately not new, having been identified at least ten years ago [19]. Methods need to be developed to help identify emerging hazards and threats, the likelihood of the hazards or threats occurring, the potential consequences, public expectations with respect to protection, available mitigation technology, cost, and deciding who will pay. Assuming societal expectations can be identified, and performance goals developed, tools, mechanisms and criteria that are necessary to define, measure, calculate, estimate, and predict performance must be developed. To make sure holistic performance is achieved, more research is needed to characterize and define the linkages and interrelationship between goals, objectives, criteria, test methods, and design tools and methods. The right balance of regulatory and market mechanisms are needed for optimization of the system. While some new thinking in risk-informed performance-based regulatory and design structures have been explored [e.g., 23,24], and tools for assessing the interrelationships of performance objectives have been outlined [24], considerably more advances are needed.

Fifth, government needs to recognize that one of the biggest challenges with energy policy, resilience to climate change, and health and safety of occupants in buildings is how to achieve objectives in these areas within existing buildings. In most countries the building regulations do not address existing buildings, except when significant renovation or change of use occurs. To truly make advances in energy, resiliency and safety performance across the built environment, building regulatory systems need to address existing buildings. While this is being done in some areas, like the Energy Performance of Buildings Regulation (EPBR), the silo-based approach (i.e., considering energy but not safety) runs the risk of creating the types of unintended consequences identified above (e.g., fire, health or structural safety hazards).

In conclusion, sustainability in the built environment should be more than just reducing greenhouse gas emissions through better energy performance of buildings and reduced material usage, but should include resiliency against climate change and a continued focus on occupant health and safety. To achieve this, a more balanced approach to building regulation is needed: one which breaks down silos and considers holistic building performance.

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