Exploring Barriers to the Integrated Design and Production of Resilient Buildings in Israel

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SUMMARY:
In this paper we describe the need for an integrated approach to building design which considers the possible synergies between structural durability and energy efficiency. Developing ideas from previous work regarding architectural awareness of earthquake resistance, we introduce three levels of integration needed when designing for resilience: (1) integration in multi-disciplinary design teams; (2) integration in the design process, i.e. integrated design or co-design, and (3) integration of long-term and short-term considerations. The aim of this study is to examine barriers to the integrated design of resilient buildings by looking at incentives and disincentives for non-linear co-design processes along the extended building supply chain. The study will use a novel research approach employing the Delphi technique, a systematic, interactive forecasting method which relies on panels of experts to identify potential and actualized relationships among industry actors.

Keywords: building resilience, co-design, integrated design, Delphi

1. BACKGROUND

Uncertainty and risk generated by the threat of natural hazards are key features involved in shaping the built environment. According to Coaffee (2008), concern for environmental sustainability, linked to climate change and the related threats of natural disasters, is as important as possible terrorist risk as an influence on city and building design. Therefore, the potential complementarities between survivability and environmental agendas may encourage a fruitful discussion between professionals involved in the design of resilient buildings.

Perelman (2008), quoted by Coaffee (2008) argues that the design of resilient buildings has to be driven by two 'independent policy movements' which both focus upon disaster risk management. They are the sustainability movement, which is particularly concerned with green designs for the built environment and the homeland and national security movement, which respond to the threats of attacks or disasters.

Sustainable building can be defined as a set of technologies and practices that meet the multiple requirements of the people and society in an optimized way during the life cycle of the built facility (Sarja, 2000). Resilience is embodied in the concept of sustainability and can be defined as the capacity of a system to absorb disturbance and still retain essentially the same function, structure, identity and feedbacks. In the U.S disaster resilience appears to have emerged as a research and policy priority in the aftermath of the terrorist attacks of September 11, 2001. Interest in the concept expanded further following Hurricane Katrina (Tierney, 2008).

2. THE PURPOSE OF THE PRESENT STUDY AND ITS METHODS

Located in a politically, environmentally and seismically prone area, residential buildings in Israel have to resist a whole range of threats. These special circumstances bring to light the need for an integrated approach to the design and production of buildings, which considers the possible synergies between structural durability and energy efficiency.

The aim of this study is to examine barriers to the integrated design of resilient buildings in Israel by looking at incentives and disincentives for non-linear integrated design processes along the extended building supply chain. Exploring the barriers from the actors' points of view will allow us to better understand different positions, needs and interests of the actors and their locations on the supply chain. The study will use a novel research approach employing the *Delphi* technique, a systematic, interactive forecasting method which relies on panels of experts to identify potential and actualized relationships among industry actors. Preliminary raw material that has been collected by this point will accompany the theoretical background and add the perspective of leading entrepreneurs regarding sustainable building in Israel.

The following literature review relates to various bodies of knowledge. First, the characteristics of the building construction industry are introduced. These characteristics include, for example, the low level of standardization in the industry and the fragmentation of the supply chains. Secondly, different levels of barriers to the adoption of sustainable practices (e.g. improving energy efficiency and reducing CO_2 emissions) are discussed, focusing on the potential conflict between regulation and innovation. Looking at the barriers to the adoption of green practices in the building industry from two angles – the seismic aspect and the energy efficiency aspect – will add another dimension to the study of sustainability. Thirdly, the evolution of research in the field of innovation and environment and technological systems is reviewed with emphasis on the process of "lock-in".

3. BARRIERS TO THE ADOPTION OF SUSTAINABLE PRACTICES IN THE CONSTRUCTION INDUSTRY

Most strategies for managing hazards have followed a traditional planning model: Study the problem, implement one solution and move to the next problem. This approach casts hazards as static and mitigation as an upward, positive, linear trend. However, the reality is, events during the past quarter-century have shown natural disasters and the technological hazards that may accompany them are not linear problems that can be solved in isolation (Mileti, 1999; Tierney, 2008). Many disaster losses are the results of interactions of three major systems: the physical environment, the social and demographic characteristics of the communities that experience them and the built environment. In this study we will focus on the built environment in general and in the design of resilient buildings in particular.

3.1. Unique Characteristics of the Building Sector and Key Influences on Innovation

The construction of buildings, together with related industries, account for some 15% of the gross national product of industrialized nations. However, innovation in this sector are stymied by such problems as poor rates of investment in research and development (R&D), fragmented supply chains, and lack of co-ordination between academia and industry in research activities (Blayse & Manely, 2004).

3.1.1 Fragmented supply chains

Currently, housing supply chains are fragmented and underpinned by poor communication, adversarial relationships and a lack of trust and commitment. Partnering - a long term commitment between organizations - can fill this void. Specific business objectives may be achieved by maximizing the effectiveness of each participant's resources. Furthermore, in order to improve the performance of buildings, each organization should adopt a business process orientation, focused on the client's needs and establish open channels of communication within and outside its own boundaries (Hong- Minh et al, 2001).

One of the leading firm's chief planners reveals in an interview a business-oriented approach to green building: "many times we invest, and it costs us money, we are ready to invest this money in order to get the added value". Regarding the communication within and outside the firm she explains:" “When it comes down to it you work with everybody in one way or another. We do all sorts of tests, reports and documents. The process is long and full of bureaucracy in Israel. Everyone knows the local situation. You need to know how to work with them, what you have to prepare, what is allowed and what is not, how to handle it- in order to get to the final stage, which is the goal, a valid approved plan".

More specific barriers have been identified which tend to impede improvement in the environmental performance of buildings (OECD, 2003). These barriers are related to a number of characteristics that are unique to the building sector in terms of its product, production process, and the way the product is used.

3.1.2. Long lived nature of products

The useful lifespan of a building is typically longer than that of any other manufactured product, usually extending over several decades. The long-lived nature of buildings results in a low turnover rate within the overall building stock, and therefore technical innovation cannot be quickly or easily incorporated through replacement of the “product” (i.e. the building).

3.1.3. Spatially fixed nature of products and production process

The building sector is distinguished by the physical nature of its production process and its products, with a large proportion of the work involved in conventional construction taking place at the site. Although other industrial production processes are site-based, few combine a spatial fixity of production and product such as occurs in construction. This has led to a low level of standardization in the design and production of buildings, and to a relative failure to exploit the economies of scale that exist in industries with more extensive repetition (Finkel, 1997, quoted by OECD, 2003).

Another consequence of poor standardization is that standard quality control methods that are widely used in the manufacturing sector are not easily applied in the construction industry. Therefore the effective enforcement of building standards, such as those regulating environmental performance, requires customized checking of design documents and on-site inspection of buildings by technical experts – which incurs significant administrative costs. In the UK it has even been suggested that private firms enter the building inspection market in order to reduce these costs (OECD, 2003). According to Bennett (2000), growing diversity in the industry is likely to amplify heterogeneity in building designs even further, accelerating the costs of enforcement.

3.1.4 Dominance by a large number of small firms

Furthermore, the construction industry is characterized by the dominance of a large number of small scale builders. The proportion of firms in this sector employing fewer than 10 persons was 81% in the US, 93% in in EU countries, 92% in Israel (CBS, 2010) and 75% in Japan. The dominance of small-scale firms can be explained by the poorly standardized production process in the building sector, which makes it difficult to exploit economies of scale. Small firms generally do not have specialized staff for research and development and are slow to adapt to new technologies (OECD, 2003).

3.2. Different Levels of Barriers

Hoffman and Henn (2008) explored the sociological and psychological dimensions of the green building world analyzing barriers on the individual, organizational and institutional levels.

3.2.1 Barriers on the individual and organizational level

On the individual level they refer, for example, to consumers who are not necessarily amenable to added costs that are not associated with tangible and immediate added value (Hoffman & Henn, 2008). One of the Israeli entrepreneurs who leads the market of green building in Israel referred to this barrier: "without a doubt, the real challenge is to convince the clients, the tenants, of the added value"…He was speaking in the Israel Engineers Association for Construction and Infrastructure's panel discussing: "Do entrepreneurs like green building?"

The organizational level of barriers deals with the unique form of the construction project team - the temporary organization. The members of the team come together, on a temporary basis, to design and build the required project. According to Davidson (2010), the major challenge of any construction project team is to "translate" satisfyingly verbal expression of needs to actual design and construction.

An Israeli entrepreneur referred to this challenge: "Today I build green buildings which cost less than conventional ones. It is not a function of money. It is a function of planning. An efficient design, a good structural engineer, an architect who knows how to plan correctly, symmetrically, less built area, less concrete per square meter, less steel per cubic meter, there are thousand and one ways to save money, believe me. If we reduce the amount of steel in the building from 130 kg to 90 kg per cubic meter - you saved the costs of green building twice over".

In seismic areas when considering measures to reduce the embodied energy of the building envelope, it is recommended to check the configuration of the building. A seismically resistant configuration may encourage structural solutions which rely, for example, on less reinforcing steel.
However, the organizational structure of the temporary organization and the competing interests of its members often limit their ability to identify and internalize the long-term costs and benefits that are implicit in the design decisions made (Hoffman & Henn, 2008).

3.2.2 Barriers on the institutional level

On the institutional level, Hoffman and Henn (2008) refer, for example, to regulative institutions and standards such as the LEED system. Critics charge that LEED has become a point chasing game with participants losing sight of the objectives of green building- to minimize the impact on the environment- and instead focusing on getting more points with the least effort.

Moreover, it has been observed that government regulations and industry standards may hamper innovation (Dubois and Gadde, 2002; Blayse and Manley, 2004). This is particularly the case with prescriptive approaches, which specify the materials, configurations and processes required to achieve a desired regulatory goal, and which are distinguished from performance approaches which leave many of these factors open. In the latter case, only the final regulatory goal is specified, rather than how the goal should be met (Gann et al., 1998; Blayse & Manley, 2004).

3.3. Regulatory development in the building sector in Israel

The Israeli regulatory framework includes a national Planning and Building Law from 1966, and a broad array of planning regulations that have since been promulgated by the Ministry of the Interior to ensure the integrity of new construction and development. Standards related to construction processes and materials are drafted and issued by the Standards Institute of Israel (SII), which is an independent professional agency under the supervision of the Ministry of Industry, Trade and Labor (Bar Ilan et al., 2010).

3.3.1 The long-term safety of buildings in Israel

In 1997 a building regulations coordination unit was established in the Ministry of the Interior, with its main objective being the formulation of a comprehensive building code. This process progressed slowly until 2001, when the Zailer Commission was appointed in the wake of the tragic collapse of the Versailles wedding hall in Jerusalem (Zailer, 2003). As a result of the Zailer report, a governmental decision was issued mandating the preparation of an integrated building code, privatization of oversight and licensing in order to improve the stringency of quality and safety in construction, and the completion of all building standards.

Research in the field of earthquake engineering has provided tools that have been implemented in regulations, with a comprehensive code for seismic resistance in building design approved in 1995. In August 1999 the Israeli Government decided on a preparedness program for potential earthquake events, and the steering committee that was established has assessed the anticipated damage from a strong earthquake centered in Israel. In addition to the preparation and enforcement of codes, preparedness measures that have been taken include assessing the durability of particular facilities and spatially mapping the risks of natural hazards (Sever, 2007).

Most Israeli buildings were built before 1975 and therefore have not been deigned for seismic resistance. The government of Israel has encouraged citizens to strengthen inadequately reinforced buildings under NMP 38 (Inter-Ministerial Steering Committee for Earthquake Preparedness, 2011). The plan encourages the reinforcement of residential building by allowing entrepreneurs to construct extra floors as part of the project. However, this incentive hardly exists in the periphery of Israel, where the seismic risk is high but implementation of the plan would not be cost-effective.

3.3.2 The long-term efficiency of buildings in Israel

A high-profile milestone towards the achievement of energy-efficient buildings in Israel has been the adoption and recent revision of a voluntary standard for labeling buildings with reduced environmental impact, or “green” building (SI 5281). The standard was approved by the SII in 2005 for residential and office buildings (Bar Ilan et al, 2010), and has recently been expanded to cover other building types as well.

An Israeli architect was asked the following question: "how influential he has been, in general, on the adoption of sustainable practices in projects you have been involved in?" His answer was that he has been totally dependant on the entrepreneur in targeting high performance standards. Moreover, according to him, an obligatory standard rather than a voluntary one would have contributed to a better performance of the building.

3.4. Institutional analysis of technical change

The relationship between technological change and the environment has been a critical issue for environmental policy for over two decades. New research has emphasized the importance of looking at the level of technological systems and at the link between technologies and the institutional setting they are imbedded within (Berkhout, 2002).

3.4.1 A technological system

A technological system is defined as networks of agents interacting in a specific technology area under a particular institutional infrastructure to generate, diffuse and utilize technology. Technological systems are defined in terms of the flow of knowledge or competence rather than of ordinary goods and services (Carlsson and Stankiewicz, 1991; Geels, 2004). Due to limitations which exist in the framing of environment-innovation analysis, there has been a shift in more technically informed ‘industrial ecology’ literature towards ‘system studies’ that aim to understand the resource and environmental profiles of technological systems, typically along supply chains (Socolow et al,1994, Graedel and Allenby, 1995; Berkhout, 2002). According to Berkhout (2002), truly revolutionary innovations are likely to start small, and through co-evolutionary processes come to define a new regime for themselves.

3.4.2 A technological regime

A greater emphasis on technological regimes has changed the terms of the analysis of innovation. Regimes are composed of stable assemblages of technical artifacts, organized in co-evolving market and regulatory frameworks. Therefore, for a regime change to be carried through it must be recognized as necessary, feasible and advantageous by a broader range of actors than would normally be the case for a discrete (i.e. micro level) technological change.

Walker (2000), quoted by Berkhout (2002), has stressed the importance of embedded institutional, political and economic commitments to a particular technological regime identified with a long-term need. As described by Berkhout (2002), these commitments constitute a "paradox of entrenchment" – since the innovation and adoption of radical and risky new technological regimes is not possible without overcoming barriers and creating an economic and institutional context for a new process of "locking in". Innovation and novelty are seen as being bounded by working assumptions, institutional networks and capital endowments inherent to a given regime. Technologies and their institutional context, therefore, interact to guide change along preferred channels and form barriers preventing switching to alternative regimes (Berkhout, 2002).

4. DESIGNING FOR RESILIENCE

Many actors are involved in the design and production process. There is a need for integration of processes within construction industry in general and in the construction of resilient buildings in particular. Developing ideas from previous work regarding architectural awareness of earthquake resistance, we introduce three levels of integration needed when designing buildings for resilience: (1) integration in multi-disciplinary design teams; (2) integration in the design process, and (3) integration of long-term and short-term considerations.

4.1. Integration in multi-disciplinary design teams

A high degree of specialization characterizes the contemporary design profession, and contrasts sharply with the image of pre-modern architects like Vitruvius (in the first century BC) or the renaissance scholar Leonardo Da Vinci, who were knowledgeable in a wide spectrum of related fields. Today building design teams usually consist of professionals from different backgrounds who share and create knowledge through design communication – as discussed in the following paragraph.

Construction in general and reconstruction in particular are not easy to manage, nor do they posses a linear decision path leading directly and safely to an optimum solution (Davidson, 2010). Integrated design is a procedure considering and optimizing the building as an entire system for its whole life span. This can be achieved when all actors of the project cooperate across disciplines. The integrated design process emphasizes the iteration of design concepts early in the process by a coordinated team of specialists.

4.2. Integration in the design process (co-design)

The actors involved in the design stage in general, and in the preliminary design process in particular, share and create knowledge through design communication. This collaborative part of the design process, is a process in which experts from different disciplines share their knowledge about both the design process and the design content (Kleinsmann & Valkenburg, 2008). When dealing with resilience in an integrated environmentally-responsive design process, all team members are challenged to discuss and develop solutions for design parameters that in other case would have been addressed separately.

Traditionally, relationships within the design and construction team have followed a linear chronological sequence: the client presents requirements to the architect; the architect prepares a design; the design is handed to the engineers; and the detailed plan is sent out for a bid and built by a contractor (Hoffman and Henn, 2008). According to IEA (2003), linear design processes usually result in poor performance, high operating costs, and the creation of an interior environment that is sub-standard.

Such a linear scheme may fit the design process for a simple structure, when merely basic needs have to be met by the design: for example, every building has to resist gravitational loads, which can be easily predicted according to the building's function. However, when designing for earthquake resistance, there is a great deal of uncertainty. Both the direction and magnitude of the seismic force is unknown; moreover, architectural decisions dealing with the geometry of the building and the location of different elements (walls, piers of staircases, pillars, and so on) have a significant impact on the building's stiffness and on major characteristics of its dynamic response. Therefore, an effective dialogue between the architect and the structural engineer is crucial (Sever, 2007). Moreover, when experts contribute their knowledge very early in the process, they allow the team to develop design concepts collectively, which otherwise would probably not have been developed by each one of the experts separately.

Creating shared understanding between design professionals is difficult because these actors have different backgrounds, interests and perspectives on the new design. For instance, according to Peters (1991), quoted by Charleson and Pirie (2009), the architect uses visual language to examine ideas and the engineer uses mainly mathematical tools – and while the architect explores alternative solutions using imagination and intuition, the engineer's thinking is characterized by rational processes that lead to a single and accurate solution. It has been found that a lack of shared understanding between these diverse types of actors tends not only to hinder the design process but also to reduce the quality of the final product (Kleinsmann & Valkenburg, 2008).

Results from a survey of Wellington structural engineers and architects (Charleson and Pirie, 2009) indicate that an underlying positive attitude exists between the professions. However, there are areas where each profession is critical of the other regarding both the design process and the design content. Structural engineers are critical of architects' lack of structural understanding (design content), and the late stage in which they usually seek for structural advice (design process) – making it almost impossible for the engineer to reach optimal structural solutions.

However, according to that survey, at the early stages of designs, architects require design flexibility and freedom. That is why they are concerned that if a structural engineer is involved too early in the process (design process), he or she can prematurely stifle their design explorations. According to that survey, architects are disappointed by engineers' lack of innovation and poor engagement with architectural design ideas (design content). Therefore, exemplary collaboration requires the meeting of the minds of experienced professionals who possess high levels of technical and design skills and with well-developed personal qualities and communication skills.

4.3. Integration of long-term and short-term consideration

The design of buildings has traditionally been regulated in order to protect occupants from threats such as structural failure and fire. Since the 1970s, regulation has been applied to energy and emissions as well, and according to a report by the OECD (2003), a regulatory approach is one of the most reliable ways to achieve a given goal of energy efficiency.

We stipulate that short-term considerations together with long-term considerations may encourage integrative solutions which could not emerge in a design process, focused only on immediate needs of the client. Moreover, due to the high-risk nature of the building industry, the decisions of developers are most directly driven by initial costs and short-term profitability, rather than by theoretical future returns – especially if such benefits are reaped by customers who have shown unwillingness to pay for them in the form of an up-front premium.

To date, only a handful of buildings in Israel have been accredited with a green building label. The actual success of this incentive for energy-efficiency improvements is limited by a complex set of constraints, which appear to overlap with those inhibiting the uptake of the incentive for earthquake-resistance improvements (NMP 38). In both cases, the inherent conflicts between short-term investment considerations and long-term considerations regarding the resilience and efficiency of the housing stock remain unresolved.

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