Towards a protocol for built-in resilience to disasters

TOWARDS A PROTOCOL FOR BUILT-IN RESILIENCE TO DISASTERS

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Designing and constructing resilient built assets requires an in-depth understanding of the expertise and knowledge on avoiding and mitigating the effects of disasters in order to secure a safe and sustainable future. For that reason, professions involved with the construction industry, and the expertise they can offer, need to become more integrated with Disaster Risk Management (DRM) if lessons are to be learnt from the past and a resilient built environment created for future generations. However, there is a lack of guidance and awareness, and poor involvement in DRM activities by key construction stakeholders in the UK. The ongoing PRE-EMPT Project aims to develop a protocol that can ensure that a more resilient built environment is attained via the structured integration of DRM strategies into the construction sector's decision-making processes. This paper outlines the research programme and explains the role that it could play in developing a more resilient built environment.

Keywords: disasters, project management, protocol, resilience, UK.

INTRODUCTION

There are important resonances between the United Nation's initiative of 'mainstreaming' Disaster Risk Management (DRM) and the recommendations of the 'Stern Review' (Cabinet Office/HM Treasury 2006) regarding the economics of climate change, in that it is not sufficient to merely react to extreme events. It is imperative that all stakeholders proactively address the hazards that threaten society.

Recent natural events (such as the June 2007 floods that affected South Yorkshire and Humberside) and human-induced events (such as the Buncefield oil depot explosion in 2005) have highlighted the fragility and vulnerability of the built environment in the United Kingdom (UK). The built environment has traditionally been designed, built and maintained by a myriad of construction related professions. Therefore, designing and constructing a more resilient built environment requires an in-depth understanding of the expertise and knowledge on avoiding and mitigating the effects of threats and hazards (Lorch 2005; Hamelin and Hauke 2005; Bosher *et al.* 2006, 2007a).

The United Nation's Hyogo Framework for Action 2005–2015 (UN/ISDR 2005) urges that DRM should be addressed in urban planning, along with other construction related activities. Amongst other requirements, it calls on governments to integrate disaster risk considerations into planning procedures for major infrastructure projects. There is wide ranging agreement that resilience should be systematically built into the whole planning, design and construction process, and not simply added on as an after thought, however, this is not yet being sufficiently achieved in the UK (Bosher *et al.*

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2007a, b). This paper briefly discusses the concept of 'resilience' and highlights the key findings from previous research that have informed the development of the ongoing PRE-EMPT (Proactive Resilient Engineering & Emergency Mitigation Protocol Toolkit) project which is attempting to address the need for informed guidance on ensuring built-in resilience.

WHAT DO WE MEAN BY RESILIENCE?

According to The Oxford English Dictionary, 'resilience' means "*an act of rebounding or springing back*" (Simpson and Weiner 1989: 714). Holling (1996) noted that the resilience of a system has typically been defined in two very different ways; the differences in definition reflecting which of two different aspects of resilience are emphasized. For instance, 'engineering resilience' is defined in Gunderson *et al.* (2002:530), as "*the time of return to a global equilibrium following a disturbance*"; this definition therefore implies only one stable state (and global equilibrium). In contrast 'ecological resilience' is based on the demonstrated property of alternative stable states in ecological systems and is defined by Gunderson *et al.* (2002:530), as "*the amount of disturbance that a system can absorb before it changes state*". The consequences of these different aspects for ecological systems were first emphasized by Holling (1973) in drawing attention to the paradoxes between efficiency on the one hand and persistence on the other, or between constancy and change, or between predictability and unpredictability. One definition focuses on efficiency, control, constancy and predictability - all attributes at the core of desires for fail-safe design and optimal performance. The other focuses on persistence, adaptiveness, variability and unpredictability - all attributes embraced and celebrated by those with an evolutionary or developmental perspective. More recently, the term has been applied to human social systems (Agar 2000), economic recovery (Rose 2004), and disaster recovery in cities and urban planning (Vale and Campanella 2005). Post 9/11 metaphors of resilience have been used to describe how cities and nations attempt to 'bounce-back' from disaster, and, amongst a range of topics, to describe the embedding of security and contingency features into planning systems (Coaffee 2005).

There are thus three themes or dimensions around which the concept of resilience can be articulated in the context of disaster management. First, there has been a move towards greater mitigation and preparedness rather than reactive disaster management. Traditional notions of disaster management had been motivated by immediate challenges or a response to single events (Schneider 2002) and towards developing appropriate plans to create 'a business as usual' situation as soon as possible (Coaffee 2006; also refer to UK Resilience 2007). In contrast, more contemporary approaches view resilience as both reactive and proactive. As O'Brien and Read note, "*the term resilience brings together the components of the disaster cycle—response, recovery, mitigation and preparedness*" (O'Brien and Read 2005:359). Others support this idea:

> *"Resilient cities are constructed to be strong and flexible rather than brittle and fragile . . . their lifeline systems of roads, utilities and other support facilities are designed to continue functioning in the face of rising water, high winds, shaking ground and terrorist attacks." (Godschalk 2003: 137)*

Second, there has been a broadening of the disaster management agenda, to cover not just disaster recovery from natural hazards but to increasingly focus on technological and human induced hazards (such as those associated with global terrorism). Third and finally, the concept of resilience within disaster management has been broadened to encompass not only the resilience of public services and governmental mechanisms (as was the focus in the past) but to also include the resilience of private business (through Business Continuity Planning) and 'community resilience'.

The overall shift to a more holistic concept of resilience is particularly pertinent for the PRE-EMPT project because it integrates the physical (both built and natural) and socio-political aspects of resilience and goes some way to illustrating the complex nature of resilience in the modern world. The socio-political aspects are arguably as important to the attainment of resilience as the physical aspects; resilient engineering also demands a more resilient infrastructural context with regards to the professions and the structures and processes which govern construction activity (Bosher 2008 *forthcoming*). Therefore, a resilient built environment should be designed, located, built, operated and maintained in a way that maximizes the ability of built assets, associated support systems (physical and institutional) and the people that reside or work within the built assets, to withstand the impacts of extreme natural and human-induced hazards.

However, it is worth acknowledging that the concept of resilience is also evolving to recognize that in some cases it is not sufficient for a system or built asset to merely to 'bounce back' to its original state. Bosher (2008 *forthcoming*) has acknowledged that there is a need to ensure the system or built asset is an improved (i.e. more robust or resilient) version of what was originally there (this is particularly the case for assets that have been historically at risk from hazards such as flooding, windstorms, earthquakes and landslides). If built assets are repeatedly affected by particular hazards, we need to learn lessons from this and replace the original structure(s) with an improved version that is more resilient (in social, physical and economic terms).

THE RANGE OF THREATS

Threats to the built environment in the UK are diverse and include extreme natural hazards (such as floods and storms) and human-induced hazards (such as terrorist attacks, explosions at industrial facilities and mass transportation accidents). Typically, these hazards cause minor disruption to the economy, infrastructure and residents of the UK, but some commentators (e.g. UKCIP 2002; Keane 2005) believe that the magnitude and frequency of these extreme events are increasing. The impact of global climate change has increased the magnitude of natural hazards in particular (Munich Re 2003).

Natural hazards

The magnitude of natural hazards in the UK can be determined by key factors such as meteorology, topography, hydrology, geology, biodiversity (of flora and fauna) and tidal variations (caused by lunar and meteorological influences, coastal topography and influenced by the type and locality of coastal developments). These processes are typically benign and provide the basis for a population of over 60 million people to exist in harmony with their natural environment. However, infrequently (and some would suggest more frequently) natural hazards impact upon the UK's built environment, causing damage, deaths, disruption and financial losses. Commentators and experts have posited that the impact of global climate change (which is arguably both natural and anthropogenic in nature) has increased the frequency of naturally induced disasters, and will further increase the frequency of such events in the future

(Munich Re, 2003). The impact of these natural events can be psychological, sociological and political but are typically reported in economic terms. Globally, economic losses due to natural catastrophes have increased ten-fold in the last 40 years (Munich Re 2003). The Association of British Insurers (ABI) states that in the UK between 1990 and 2000, weather related insurance claims totalled between £360m and £2.1bn a year (ABI 2003). In economic terms, both at national and global scales, the damages from flooding are greater than those from any other natural hazard (DTLR 2001:4).

Human induced hazards

Human induced hazards, or in other words technological and societal related hazards, include a contrasting range of events such as Bhopal (poisonous gas release in 1984), Chernobyl (nuclear reactor explosion in 1986) the Columbia Space Shuttle (explosion in 2003) and Aberfan (landslip in 1966). Chapman (2005) stated that technological disasters are not random events that defy understanding, in contrast, they can make sense in terms of how technological systems are designed, built and operated.

Human induced hazards infrequently impact upon the UK's built environment, causing damage, deaths, disruption and financial losses. Figures obtained from the EM-DAT disaster database (EM-DAT 2007) show that the most frequently occurring technological hazard related events between 1906 and 2004 were mass transportation incidents, such as the capsize of the Herald of Free enterprise ferry in 1987 and the Ladbroke Grove Rail crash in 1999. The technological hazards that historically affect the greatest amount of people are those associated with industrial incidents, such as the Buncefield oil depot explosion in 2005 and the Flixborough chemical plant explosion in 1974.

There are some societal threats to the built environment that are not significantly affected by natural processes, such as civil unrest, war and global terrorism caused by clashes between local, national and global political ideologies. In the context of attaining a more resilient built environment in the UK, one of the most high profile societal threats is that of global terrorism. Moor (2002) noted that human settlements are designed to protect their inhabitants against attack by intelligent hostile elements. At the same time, the technology of war aims to counteract such defences. Indeed, it would appear that with socio-economic progress, settlements become more vulnerable as they become more reliant on their increasingly extended supply lines, and ever-expanding and vital distribution networks of water, power, gas and telecommunication systems, as well as other resources such as food. Public social and security infrastructure such as health facilities, civil defence and the police also become crucial. Moreover, with globalization, the major settlements are also inter-connected and a disaster in one settlement can precipitate widespread disruption in many others. Acts of terrorism are increasingly threatening communities worldwide (Keane 2005) and in the two few years attacks have occurred on 'soft' (non-military) targets in the UK, Spain, Morocco, Egypt and Turkey.

Other human influences upon the causes of disasters can too often be overlooked as sometimes the influences can be very discrete. In the UK, many people like to live near rivers (and are prepared to pay for the benefit in many cases), for the aesthetic and recreational benefits that rivers can offer, for example, upstream, along the non-tidal stretch of the River Thames, some 12,000 houses are within 500 metres of the riverbank, and their riverside location adds £580m to the value of these properties (McGlade 2002). A flood event that occurs in the non-tidal stretch of the Thames in southern England, inundating people's homes, businesses and lifelines will typically be referred to as a natural disaster, however, the flood event is only a disaster because society has chosen - and planners have allowed developers - to build homes, infrastructure and businesses in an area vulnerable to floods.

Implications for the UK construction industry

The United Nations' International Strategy for Disaster Reduction (UN/ISDR) has adopted a concept of DRM that can be summarized into four overlapping and interconnected phases, being: 1) Hazard identification; 2) Mitigative adaptations; 3) Preparedness planning; and, 4) Recovery (short-term) and reconstruction (longer-term) planning. The '*Safe, Secure and Sustainable Built Environment*' (S3BE) project was developed to align with the DRM framework that calls for the 'mainstreaming' of disaster risk reduction into construction and planning decision-making processes (UN/ISDR 2005). However, the S3BE study identified that there is little or no evidence to suggest that DRM is currently being systematically built-in to the Design-Construction-Operation Process (which includes conceptual design through to planning, procurements, construction, operation and change of use) in the UK.

DRM should be holistic, and initiatives such as structural and non-structural mitigation are required to ensure that DRM strategies are viewed as a shared responsibility, which includes a wide range decision-makers within the construction sector. These initiatives should include hazard mitigation and land-use planning as well as the necessary improvements to professional training that will be required to achieve effective DRM. The specific research findings and advancements forming the outputs of the S3BE project were (for details refer to Bosher *et al.* 2007b):

- there is a lack of information/guidance;
- there is poor awareness of DRM issues amongst construction industry practitioners;
- there is poor involvement by key stakeholders in DRM activities;
- DRM activities with aligned with the Design-Construction-Operation Process (DCOP);
- key construction industry associated stakeholders were identified; and
- the stages when stakeholders should provide inputs into DCOP were identified.

Consequently, the lack of guidance and awareness, and poor involvement in DRM activities by key construction stakeholders in the UK is an issue that needs to be resolved. The 'Stern Review' (Cabinet Office/H.M. Treasury, 2006) warns of a bleak future for the planet if societies and the built environment do not adapt to address the implications of a changing climate and the report goes as far as stating that the benefits of strong and early action far outweigh the economic costs of not acting. The implications of any 'strong and early action' will pose important questions for the planning, design, construction and maintenance of the UK's built environment and the protection of critical infrastructures.

THE NEED FOR A PROACTIVE (PRE-EMPTIVE) APPROACH

It is essential that future construction is more sensitive to hazard mitigation and climate change issues, leading to adaptations to what we design and build (Nethercot 2003). In view of this, the Sustainable Buildings Taskforce (DTI 2004) recommended that Building Regulations in the UK require modern standards of flood resistance and resilience for all construction within areas of flood risk. Lorch (2005) takes this further and asks, *"should we be investigating the capabilities of the built environment under extreme circumstances as well as subtle, protracted circumstances?"* (pg. 210).

There is a paucity of guidance and legislation on how to deal with unexpected disaster events and other threats in the UK and how to use this to improve the way buildings and infrastructure are designed and built to cope with such risks and dangers (Bosher *et al.* 2007a, b). Salford University and the Royal Institution of Chartered Surveyors (RICS) have recently developed a draft '*Process Protocol for Disaster Management*'. However, while the protocol is useful as a structured framework for supply chain integration and as an aid for some construction professionals to formalize preparedness and response activities for large-scale disasters, it does not explicitly incorporate the proactive aspects associated with building-in resilience.

The findings of the S3BE project revealed that resilient design and hazard mitigation features are likely to become significant issues that will be central to construction guidelines and legislation in the near future. These concerns have also been raised by the European Union's European Construction Technology Platform (Hamelin and Hauke 2005). These observations have provided the impetus for the 'PRE-EMPT' project which aims to ensure that a more resilient built environment is attained via the structured integration of hazard mitigation strategies into the construction sector's decision-making process. This will be implemented in the form of a hazard mitigation protocol toolkit for use by a wide range of stakeholders that are (or should be) involved with hazard mitigation strategies. Specific objectives of the project are to:

- Evaluate, identify and prioritize key threats to the UK's built environment. This aspect of the research includes reviewing historical data on the impact of hazards, and a questionnaire survey and interviews with a wide range of construction and non-construction experts.
- Identify building systems (such as architecture, design and structural engineering) to provide robust and economic building solutions that are resistant to disturbances, minimize damage, and are conducive to repair. This will be achieved through a state of the art review of current national and international guidance on hazard mitigation and interviews with a wide range of construction experts.
- Configure and develop PRE-EMPT with various process frameworks via iterative consultation with stakeholders. This will be achieved through the use of charettes with a multi-disciplinary range of experts and consultants from the construction sector. Charrettes are collaborative workshops in which a group of designers, project managers, engineers etc. work together on a real or simulated problem (Glass 2008 *forthcoming*).
- Evaluate PRE-EMPT under a range of scenarios and in partnership with key collaborators. Charettes and interviews will be used to evaluate the utility of PRE-EMPT, because the way the toolkit will be applied might be different from one profession to another (e.g. CD-ROM based, guidance booklet, decision support matrix etc.)

The three-year PRE-EMPT project (to be completed by September 2009) will pro-actively address strategic weaknesses in protecting the built environment and attaining in-built resilience via the development of hazard mitigation guidelines for the construction sector and the PRE-EMPT assessment toolkit. The toolkit will be targeted at construction professionals and other agencies and stakeholders with responsibility for the planning, design, operation and maintenance of the built environment. The initial work packages of the PRE-EMPT project are helping to identify and prioritize the key threats to the built environment whilst also reviewing key legislation, standards and guidance that are currently available to key stakeholders and decision makers (while at the same time identifying any key gaps). Ultimately, it is intended that PRE-EMPT will be developed iteratively to improve the way buildings and infrastructure are planned, designed, built and retrofitted to cope with natural and human-induced threats.

Benefits of a PRE-EMPTIVE approach

PRE-EMPT will be designed to assess the performance of structures in the following areas: management, land use, design, integrated infrastructure, construction methods, materials and security. The toolkit could be applied to a range of critical infrastructures and built assets: offices, residential property, industrial and retail units, schools, hospitals, water supply and sewerage networks, power generation and distribution networks, transport infrastructure, communications infrastructure, and leisure facilities. Clients, planners, local and national government agencies and commercial developers could use PRE-EMPT to specify the resilient performance of not only individual buildings, but also entire developments, in a way that is quick, comprehensive and would be visible in the marketplace. Design teams will be able to use PRE-EMPT as a tool to improve the long-term performance of their structures and developments as well as their own knowledge of natural and human-induced hazards. Property agents could use PRE-EMPT to promote the hazard resilient credentials of a building to potential purchasers and tenants. Managers could use PRE-EMPT to measure the performance of buildings and develop action plans, monitor and report performance at both the local and portfolio level.

PRE-EMPT aims to offer a range of benefits, from societal to financial as follows:

- **Societal**: creating a more protective built environment for people to work and live;
- **Compliance** (potentially a requirement of the future): to assess the resilient design, and hazard mitigation processes undertaken by occupiers, planners, government agencies and developers;
- **Increased resilience**: in support of the protection of critical infrastructure, a wider corporate strategy or as a standalone contribution;
- **Marketing**: as a selling point to potential tenants or customers;
- **Best practice**: provide a thorough tool for comparing buildings and developments;
- **Client request**: responding to the requirements of users;
- **Increased confidence in built assets**: for managers, service users and the general public; and
- **Financial**: to achieve higher rental incomes and the increased protection of built assets and building services (with the possible reduction of insurance premiums).

CONCLUSIONS

Existing and future threats to the built environment in the UK are acutely important issues that decision makers within the construction industry, amongst others, need to urgently act upon. Resilience of the built environment should be high on the agenda and therefore should be systematically built-in to the planning, design, construction and operation processes not simply added on as an after thought. "*For buildings, the*

19th century was the age of the great architect, the 20th century that of the great engineer, and the 21st century will be the age of the resilient building designer, one who combines the skills of the building physicist, architect, engineer, urban designers and community planner" (Roaf *et al.* 2005:349).

The PRE-EMPT project will help to address many of the weaknesses in attaining built-in resilience that have been identified by the S3BE project, because:

- PRE-EMPT will help to signpost appropriate information/guidance for decision-makers while at the same time raising awareness of any identified gaps in knowledge and guidance.
- PRE-EMPT will improve the involvement and awareness of key stakeholders through the possible adoption of PRE-EMPT as best practice for resilient design and construction.
- PRE-EMPT will offer customized information and tools to a range of professions because the protocol will be designed to suit the needs and expectations of the various stakeholders that will be using it.

The PRE-EMPT project will therefore address a significant gap in the construction industry's current approach to delivering a resilient and sustainable built environment. PRE-EMPT will contribute towards the integration of processes that are typically fragmented. This will be achieved through the exchange of ideas and solutions for a more resilient built environment from the perspective of many stakeholders (such as architects, planners, engineers, materials suppliers and emergency managers). In addition, while the government in the UK has the power to legislate for a sustainable and secure built environment via the Stunnell Bill (2004), the industry currently does not have the mechanism to deliver such an environment. PRE-EMPT could therefore help to embed security and resilience (and arguably sustainability) considerations into the construction industry's delivery of the built environment.

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