This item was submitted to [Loughborough's Research Repository](#) by the author.
Items in Figshare are protected by copyright, with all rights reserved, unless otherwise indicated.

Built-in resilience to disasters: a pre-emptive approach

PLEASE CITE THE PUBLISHED VERSION

PUBLISHER

© Emerald Group Publishing Limited

VERSION

AM (Accepted Manuscript)

LICENCE

CC BY-NC-ND 4.0

REPOSITORY RECORD

Bosher, Lee S., Andrew R.J. Dainty, Patricia M. Carrillo, and Jacqueline Glass. 2019. "Built-in Resilience to Disasters: A Pre-emptive Approach". figshare. <https://hdl.handle.net/2134/4242>.

This item was submitted to Loughborough's Institutional Repository (<https://dspace.lboro.ac.uk/>) by the author and is made available under the following Creative Commons Licence conditions.

For the full text of this licence, please go to:
<http://creativecommons.org/licenses/by-nc-nd/2.5/>

Built-in Resilience to Disasters:

A Pre-Emptive approach

Lee Boshier (corresponding author)

Andrew Dainty

Patricia Carrillo

Jacqueline Glass

Address for Correspondence

Dr Lee Boshier,

Department of Civil and Building Engineering,

Loughborough University,

Leicestershire, England, LE11 3TU E-mail: l.boshier@lboro.ac.uk

Biographies:

Lee Boshier is a Research Fellow.

Andrew Dainty is Professor of Construction Sociology.

Patricia Carrillo is Professor of Strategic Management in Construction.

Jacqueline Glass is a Lecturer in Architectural Engineering.

All the authors are based in the Department of Civil and Building Engineering at Loughborough University, England.

Word count: 4,697

Built-in Resilience to Disasters: A Pre-Emptive approach

Lee Bosher, Andrew Dainty, Patricia Carrillo and Jacqueline Glass

Department of Civil and Building Engineering, Loughborough University,

Loughborough, UK

Abstract

Purpose – Professions involved with the construction industry need to become more aware of Disaster Risk Management (DRM) activities if lessons are to be learnt from the past and a resilient built environment attained in the future. This study has focused on identifying which construction associated stakeholders should be involved with DRM initiatives in the UK, and when these stakeholders should be involved. This research is thereby unique and a key step in the longer term aim of identifying how stakeholders should be involved and what issues they need to address regarding the integration of DRM into construction decision making.

Design/methodology/approach – This paper presents the findings of a UK-wide questionnaire survey, semi-structured interviews and a validation exercise involving a range of professionals from construction, planning, insurance, emergency management and local/national government agencies.

Findings – This research identifies the key construction stakeholders that should be responsible for ensuring resilience issues become integrated and the key stages of the Design-Construction-Operation Process where their inputs are required.

Originality/value – The finding presented are an important and logical step in the longer term aim of identifying how stakeholders should be better involved and what issues they need to address regarding the integration of DRM into construction decision making.

Keywords - Disaster risk management; Design; Infrastructure planning; Protocol

Paper type – Research paper

Introduction

Recent natural and human-induced events have highlighted the fragility and vulnerability of the built environment to disasters. At the same time, the ‘Stern Review’ (Cabinet Office/HM 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.

Adaptation to climate change – that is, taking steps to build resilience and minimise costs – is essential. It is no longer possible to prevent the climate change that will take place over the next two to three decades, but it is still possible to protect our societies and economies from its impacts to some extent – for example, by providing better information, improved planning and more climate-resilient crops and infrastructure. (Cabinet Office/HM Treasury 2006: vii)

It is therefore clear that future construction needs to be more sensitive, not only to the human induced drivers of climate change, but also the adaptations that will be required to *mitigate* the impacts of climate change. This needs to be achieved through proactive measures. These proactive measures are likely to have an impact on the professional training and day-to-day activities of designers and engineers.

Designing and constructing a resilient built environment demands 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.* 2007, 2006). The avoidance of threats and hazards (infrequent and daily) falls within the ‘Disaster Risk Management’ (DRM) framework as advocated by the United Nations who are encouraging governments to ‘mainstream’ DRM into national development strategies. Organisations such as the United Nations and the British Government’s Department for International Development (DFID 2006) have highlighted the importance of ‘mainstreaming’ DRM as part of an initiative to build collaboration between stakeholders in order to reduce the impact of disasters by integrating disaster risk reduction into development policies. The Hyogo Framework for Action 2005–2015 (UN/ISDR 2005) urges that disaster risk should be addressed in urban planning, along with other technical matters. Amongst other requirements, it calls on governments to mainstream disaster risk considerations into planning procedures for major

infrastructure projects. However, little research has been done globally on how disaster risk reduction can be effectively mainstreamed into construction projects (Wamsler 2006). Although there is wide ranging agreement that resilience should be systematically built-in to the whole design, construction and operation process, and not simply added on as an after thought, it is apparent that this is not being achieved sufficiently in the United Kingdom (UK) (Bosher *et al.* 2007, 2006). This paper reports on a unique and ongoing research project that aims to ensure a more resilient built environment is attained through the structured integration of DRM strategies into the Design-Construction-Operation Process. The research has revealed the key stakeholders, as well as the most critical phases of the construction decision-making process, where proactive DRM related inputs need to be made.

Disaster Risk Management

The United Nations' International Strategy for Disaster Reduction has adopted a concept of DRM that can be summarised into four phases (Figure 1), being: 1) Hazard identification, 2) Mitigative adaptations, 3) Preparedness planning; and, 4) Recovery (short-term) and reconstruction (longer-term) planning. These phases can be defined as (UN/ISDR 2004):

- **Hazard Identification**

Identification of potentially damaging physical events, phenomenon or human activity that may cause the loss of life or injury, property damage, social and economic disruption or environmental degradation.

- **Mitigative Adaptations** (*Otherwise referred to as 'Hazard Mitigation'*)

Structural and non-structural measures undertaken to limit the adverse impact of hazards.

- **Preparedness planning**

Activities and measures taken in advance to ensure effective response to the impact of hazards, including the issuance of timely and effective early warnings and the temporary evacuation of people and property from threatened locations.

- **Recovery and rehabilitation**

Decisions and actions taken after a disaster with a view to restoring or improving the pre-disaster living conditions of the stricken community, while encouraging and facilitating necessary adjustments to reduce disaster risk. Recovery (rehabilitation and reconstruction) affords an opportunity to develop and apply disaster risk reduction measures.

[Take in Figure 1]

DRM should be concerned with people's capacity to: manage their natural, social and built environments; and take advantage of it in a manner that safeguards their future and that of forthcoming generations. DRM needs to be holistic and new initiatives found in order to ensure that associated strategies are viewed as a shared responsibility that includes issues such as hazard mitigation (Pelling 2003; Trim 2004) and land-use planning (Burby 1998; Burby *et al.* 2000; Wamsler 2004). The concept of hazard mitigation begins with the realisation that many disasters are not unexpected (Mileti 1999), and the impacts of many natural and human-induced hazards can therefore be reduced. It is common to discuss two types of hazard mitigation, as summarised below.

- 1) Structural mitigation – such as the strengthening of buildings and infrastructure exposed to hazards (via building codes, engineering design and construction practices, etc.).
- 2) Non-structural mitigation – includes directing new development away from known hazard locations through land use plans and regulations, relocating existing developments to safer areas and maintaining protective features of the natural environment (such as sand dunes, forests and vegetated areas that can absorb and reduce hazard impacts).

Part of the shared responsibility that is required could be achieved by embedding construction professionals, who possess the knowledge and experience of how to design, build, retrofit and operate what are typically bespoke built assets, into the DRM framework (Bosher *et al.* 2007). The

construction sector should play an important role in the structural elements of mitigation (and adaptation), while developers and planners should be able to positively influence the non-structural elements (Bosher *et al.* 2007; Wamsler 2006).

The Design-Construction-Operation Process

The stages of the Design-Construction-Operation Process (DCOP) that have been used in this study have been drawn from, and defined using, the Royal Institute of British Architects 'Plan of Work' (RIBA 2001) and the 'Construction Process Protocol' (Cooper *et al.* 2005). The DCOP encompasses the earliest stage of 'demonstrating the need' through the design and construction phases to 'change of use' (at which stage the whole Design-Construction-Operation Process would revert back to the first stage); the DCOP is a cyclical process. These stages have been sub-categorised into four broader phases, namely: 'Preliminary', 'Pre-Construction', 'Construction' and the 'Post-Completion' phases. The project stages and phases are detailed below.

A. Preliminary phase

1. Pre-agreement/Demonstrating the need
2. Appraisal/Conception of need
3. Strategic briefing/Outline feasibility
4. Substantive feasibility

B. Pre-Construction phase

5. Outline proposals/Outline conceptual design
6. Scheme design/Full conceptual design
7. Detail design/Coordinated design
8. Production information
9. Tender documentation
10. Tender action

C. Construction phase

- 11. Project planning/mobilisation
- 12. Construction to practical completion
- 13. Monitor cost, procurement and quality
- 14. After practical completion

D. Post-Completion phase

- 15. Evaluation/Implement handover plan
- 16. Operation
- 17. Maintenance
- 18. Change of use

It is important to appreciate that many stakeholders will not be involved in all stages of the DCOP because the scope of their involvement will inevitably be constrained by their professional remits. Accordingly, this research has focused on identifying which construction associated stakeholders should be involved with DRM initiatives in the UK, and at what stages of the project these stakeholders should be involved. The work presented here is thereby an important and logical step in the longer term aim of identifying how these stakeholders should be involved and what issues they need to address regarding the integration of DRM.

The research findings

Between September 2005 and March 2006, 102 questionnaire surveys were elicited and 17 semi-structured interviews ¹ were conducted with a range of professionals from construction, planning, insurance, emergency management and local and national government agencies. This information was then augmented through a ‘Decision Support Framework’ workshop and validation exercise that involved 16 additional practitioners and academics. The respondents (see Table 1) offered a wide range of practical and theoretical perspectives to the research, including: civil and structural

engineering, architecture and design, transport, construction and project management, property development, insurance, risk and emergency management, and urban planning. Approximately one quarter of the respondents were employed by national and local government agencies in the UK.

[Take in Table 1]

A large proportion of the respondents recognised that the Civil Contingencies Act (CCA) 2004 (Cabinet Office 2004) has put in place a framework that enables a wide range of stakeholders, such as transport operators, planners, insurers, and utilities companies to be integrally involved with emergency management (predominately response) planning in the UK. The respondents saw this as an encouraging improvement in DRM, although it was generally acknowledged that the CCA does not thoroughly encompass more proactive processes such as hazard identification and mitigative adaptations that should be intrinsic to the DRM framework. In addition, the extent to which construction associated stakeholders are involved within this framework is unclear (Bosher *et al.* 2007). This lack of involvement is exacerbated by a lack of ‘joined up thinking’ regarding resilience issues, between the institutions responsible for existing information regarding building regulations, planning policy and the Secure and Sustainable Buildings Act. Therefore, the preliminary stages of this study found that there is a lack of guidance (and a significant lack of any complementary guidance) on how to deal with unexpected disaster events and how to use this information to improve the way buildings and infrastructure are designed and built to cope with such risks and dangers (Bosher *et al.* 2007).

Who should be involved?

The data collected during the ‘Decision Support Framework’ workshop and validation exercise is summarised in Table 2. This illustrates which stakeholders should be involved in DRM activities and

also at what stages of the DCOP these stakeholders should be involved. The levels of stakeholder input required to attain ‘built-in resilience’ have been categorised into the following types:

- **Formal specified input** – Essential structured input that may need to be driven by legislation.
- **Formal unspecified input** – Essential input that may be driven by ‘best practise’ guidance rather than legislation
- **Informal input** – Non-essential but nonetheless important information exchange that would be considered as ‘best practice’.
- **No input required** – Stakeholder’s input is not required at this particular stage.

[Take in Table 2]

From this exercise architects/designers were perceived to be the most important stakeholders from the construction sector that should provide a number of essential inputs into disaster risk management activities. With reference to the entire DCOP the participants in the workshop and validation exercise perceived that civil engineers, clients, developers, and emergency/risk managers are also key stakeholders that should provide essential inputs. At the other end of the involvement scale, the participants perceived that trade organisations/representatives, and the general public were not key participants in the DCOP.

The data were also analysed to ascertain whether the perceptions of which stakeholders should be involved, and at what stages they should be involved, was determined by the respondent’s profession. Typically the respondents recognised the importance of their own profession (particularly contractors, architects, engineers, emergency planners and insurers) being involved with the integration of DRM activities into the DCOP. However, this observation should be treated with caution because the respondents who participated in the workshop and validation exercise were not necessarily wholly representative of all stakeholders. It is possible that the ‘non-respondents’ (those

who did not return questionnaires and/or validation worksheets) were not engaged sufficiently with the topic of integrating DRM and therefore would not necessarily recognise the importance of their profession becoming involved in such activities.

At what stages should the stakeholders be involved?

It is important to note that a number of the stakeholders need not be involved in all stages of the DCOP because the scope of their participation will inevitably be constrained by their professional remits. For example, the participants in the workshop indicated that ‘urban planners/designers’ should be involved in half of the entire DCOP, but when the data were disaggregated (Table 3) three quarters of the participants indicated that these important stakeholders should be intrinsically involved in the Preliminary phase, but not particularly involved during construction and post-completion. It is also interesting to note that 95% of the workshop and validation exercise participants indicated that architects/designers should be involved during the pre-construction phase.

[Take in Table 3]

The pre-construction phase emerges as the most critical phase for integrating DRM into the Design-Construction-Operation Process. For example, it is during this phase that participants stated that civil engineers (75%), structural engineers (70%), specialist contractors (75%), engineering consultants (68%), and developers (67%) should be involved. Based on the workshop and validation exercises, the pre-construction phase was identified as *the* critical phase in the Design-Construction-Operation Process when DRM activities can be (and need to be) integrated. Certain stages of the post-completion phase were also deemed to be important, such as the ‘evaluation/handover plan’ and ‘change of use’ stages being important to the integration of DRM while the ‘operation’ and ‘maintenance’ stages require specific forms of input from utilities companies, the end user(s), insurers, the emergency services and emergency/risk managers (refer to Table 2 for specifics). The

summary of the ‘Decision Support Framework’ exercise are provided in Table 4, which shows the phases of the whole DCOP and lists the stakeholders that should make essential inputs and non-essential inputs into the process of integrating DRM activities. This provides a breakdown of who should essentially make inputs to integrate DRM into the specific stages and phases of the whole Design-Construction-Operation Process.

[Take in Table 4]

Some issues that need to be considered

Preliminary Phase

The stakeholders involved in the Preliminary phase should consider what materials they propose to use, where they plan to build a development, what they plan to build, and how the development will be built. All these questions should be explored within the decision-making process before proceeding with planning applications. Proactive risk assessment should be adopted in this phase because it is an answer to two habitual shortcomings; a failure of foresight (Toft and Reynolds 1994) and a failure to learn (Weir 2002). Proactive risk assessment is also a practical response to the ethical imperative for managers and decision makers to create safer industrial and residential environments (Schneider 2002). In addition, technological and societal threats have demonstrated that it is important to recognise that new problems can arise out of the solutions to old problems (Kletz 1996).

Pre-Construction Phase

The design of service networks (roads, railways, pipelines and cables) needs careful locational planning (through hazard identification and mapping) to reduce the risk of widespread failure. It has been proposed that incentives for proactive building design that is resilient to extreme events (including the potential effects of climate change) should be encouraged and could include tax breaks for companies that build to hazard resistant standards (Keane 2005). While the Sustainable Buildings

Taskforce (DTI 2004) has recommended that building regulations require modern standards of flood resistance and resilience for all construction within areas of flood risk, it would also be pertinent for stakeholders to consider whether other climatic extremes (such as strong winds, increased precipitation, and increased solar radiation) should also be considered. During this phase it is important to consider the potential susceptibility of modern construction materials and processes to the climate of the future. Human-induced hazards will also need to be addressed. For instance, the implications of terrorist threats on the security and sustainability of the UK's infrastructure are difficult to quantify, but are obviously worthy of concerted investigation when designing, constructing and retrofitting potential terrorist targets if the structural impacts of terrorist attacks are to be minimised.

Construction phase

This phase is not the most critical in relation to DRM activities as most of the proactive DRM initiatives should already have been considered during the Preliminary and Pre-Construction phases. Nonetheless, the strategic and operational levels of emergency management in the UK would benefit from, for instance, swift access to building plans and schematics of key services in the event of terrorist bomb attacks, fires and floods. Consequently, it is important that information exchanges and liaison be undertaken between key construction and emergency management personnel to ensure that issues such as emergency service access/egress options are considered and that up to date and secure building schematics are made available to the emergency services as projects progress.

Post-Completion phase

This phase not only incorporates new build, but also includes existing developments. Therefore, the retrofitting of buildings and infrastructure at risk from natural and human-induced hazards should be considered. Research needs to be undertaken to appreciate the impact of natural hazards (including the full range of anticipated biological, physical and chemical impacts that may result from climate

change) on historical buildings and infrastructure (UKCIP/EPSRC 2003). For example, to alleviate the potential effects of climate change extra defences may be necessary for seaports and extra protection required for nuclear power stations and transport infrastructure that are located on the coast (Graves and Phillipson 2000). It is also essential that during the 'Change of Use' stage of the DCOP, that key stakeholders use this stage as an opportunity to reconsider the planning, design and engineering issues that are associated with the Preliminary Phase (Stages1-4).

Conclusions

There are important resonances between the United Nation's initiative of 'mainstreaming' 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, and particularly engineers and designers, proactively deal with the hazards that threaten society. It is clear that existing and future threats to civil infrastructure (such as roads, bridges, railways, etc.) in the UK are acutely important issues that all stakeholders 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)

This study has identified the key construction stakeholders who possess knowledge on DRM initiatives, and the key stages of the DCOP when inputs regarding DRM activities should be provided by these stakeholders. It has also revealed a lack of 'joined up thinking' regarding how this expertise is being integrated into the DCOP. What is now required to aid the integration of DRM into the DCOP is a protocol that can enable what are typically disparate entities to synergise this knowledge in a way that is proactive and complementary. For example, the pre-construction phase

was identified as the most critical phase for integrating DRM activities into the Design-Construction-Operation Process. It is during this phase in particular that critical inputs should be made by architects/designers, structural and civil engineers, urban planners, specialist contractors and emergency/risk managers.

It is important to emphasise that it isn't feasible to be too prescriptive about what solutions will be required as these will inevitably be contingent upon the types of built asset and the nature of the hazards that have been identified. Nonetheless, there is an urgent requirement for a protocol or methodology that can enable construction stakeholders, such as civil and structural engineers and architects, to make informed decisions regarding the proactive integration of DRM activities during the design, planning, construction, operation and maintenance of existing and future construction projects.

References

- Bosher L.S., Dainty A.R.J., Carrillo P.M., Glass J., and Price A.D.F., (2007), 'Integrating disaster risk management into construction: A UK perspective', *Building Research & Information*, Vol.35, No.2, pp.163-177
- Bosher L.S., Dainty A.R.J., Carrillo P.M., Glass J., and Price A.D.F., (2006), 'Disasters and the Construction Industry: Towards built-in resilience', *Proceedings of the International Disaster Reduction Conference (IDRC)*, Volume 2, 27th August-1st September, Davos, Switzerland 2006, Swiss Federal Research Institute, pp.81-83
- Burby R., (ed.) (1998), *Policies for sustainable land use, Cooperating with Nature*, Joseph Henry Press, Washington DC
- Burby R., Deyle, R.E., Godschalk, D.R. & Olshansky, R.B. (2000), 'Creating hazards resilient communities through land-use planning', *Natural Hazards Review*, Vol. 1 No. 2, pp. 99-106

- Cabinet Office (2004), *The Civil Contingencies Act 2004 (Contingency Planning) Regulations*, Civil Contingencies Secretariat, Cabinet Office, London
- Cabinet Office/Her Majesty's Treasury (2006), *Stern Review on the Economics of Climate Change*, Cabinet Office/Her Majesty's Treasury, London
- Cooper R., Aouad G., Lee A., Wu S., Kagioglou M., and Fleming A., (2005), *Process Management in Design and Construction*, Blackwell Science, Oxford
- Department of Trade and Industry (2004), *Better buildings - better lives, Sustainable Buildings Taskforce Report*, May 2004, Department of Trade & Industry, London
- DFID (2006), *Reducing the Risk of Disasters*, Department for International Development, East Kilbride
- Graves H.M., & Phillipson M.C., (2000), *Potential Implications of Climate Change in the Built Environment*, Foundation for the Built Environment Report 2, December, BRE, Garston
- Hamelin J-P., and Hauke B., (2005), *Focus areas: Quality of Life – Towards a Sustainable Built Environment*, European Construction Technology Platform, Paris
- Keane B., (2005), 'Major Incident and disaster management', *The Structural Engineer*, Vol.83, No.11, 7th June, pp 22-25
- Kletz T., (1996), 'Disaster Prevention: Current topics', *Disaster Prevention and Management*, Volume 5, Number 2, pp 36-41
- Lorch R., (2005), 'What lessons must be learned from the tsunami?', *Building Research and Information*, Vol. 33; No. 3; pp 209-211

- Mileti D.M. (1999), *Disasters by Design: A Reassessment of Natural Hazards in the United States*, Joseph Henry Press, Washington DC
- Pelling M. (2003) *The vulnerability of cities: natural disaster and social resilience*, Earthscan, London
- RIBA (2001), *The Architect's Plan of Work*, Royal Institute of British Architects, London
- Roaf S. Crichton D., and Nicol F., (2005), *Adapting Buildings and Cities for Climate Change*, Architectural Press and Elsevier Press, London
- Schneider R.O., (2002), 'Hazard Mitigation and Sustainable Community Development', *Disaster Prevention and Management*, Vol.11, No.2, pp 141-7
- Toft B. and Reynolds S., (1994), *Learning from Disasters*, Butterworth-Heinemann, Oxford
- Trim P., (2004), 'An Integrated Approach to Disaster Management and Planning', *Disaster Prevention and Management*, Vol.13, No.3, pp. 218-225
- UKCIP/EPSRC (2003), *Building Knowledge for a Changing Climate: The impacts of climate change on the built environment: A research Agenda*, UK Climate Impacts Programme (UKCIP)/Engineering and Physical Sciences Research Council (EPSRC), Swindon/Oxford
- UN/ISDR (2005), *Hyogo Framework for Action 2005-2015: Building the Resilience of Nations and Communities to Disasters*, United Nations International Strategy for Disaster Reduction, Geneva
- UN/ISDR (2004), *Living with Risk: A global review of disaster reduction initiatives*, United Nations International Strategy for Disaster Reduction, Geneva

- Wamsler C. (2006) 'Mainstreaming risk reduction in urban planning and housing: a challenge for international aid organisations', *Disasters*, Vol.30, No.2, pp. 151-177
- Wamsler C. (2004) 'Managing Urban Risk: Perceptions of Housing and Planning as a Tool for Reducing Disaster Risk', *Global Built Environmental Review (GBER)*, Vol.4, No.2, pp.11–28
- Weir D. (2002), 'When will they ever learn? The conditions for failure in publicly funded high technology projects: the R101 and Challenger disasters compared', *Disaster Prevention and Management*, Vol. 11 No. 4, pp. 299-307

Corresponding author

Lee Boshier, Research Fellow, Department of Civil and Building Engineering, Loughborough University, Leicestershire, England, LE11 3TU. E-mail: l.boshier@lboro.ac.uk

Endnotes

¹ The purpose of the interviews was to elicit perspectives on current guidance and legislation in the UK related to the integration of resilience into the DCOP, and specifically which stakeholders should be involved and when should they be involved.