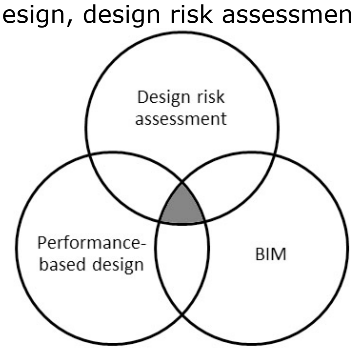
International Council
for Research and Innovation
in Building and Construction

Innovation Reports on Buildings and the Built Environment
for Planning, Design, Engineering, Construction, Manufacturing, Management, Maintenance, Use and Deconstruction

BIM and Design for Lifecycle Safety

Challenge

The need for designing for safety is being recognized by a growing number of governmental agencies, owners, constructors, engineers, and architects. Design for Safety or Construction Hazard Prevention through Design (CHPtD) demands workers safety in construction, operation and maintenance, and decommissioning being considered and addressed through design. Furthermore the broadening adoption of Building Information Modelling (BIM) is supporting integrated design pursuing high performance standards in user comfort, energy usage, lifecycle impact, design risk assessment, etc. However, there is lack of knowledge on what Prevention through Design (PtD) tools designers utilize for safety design and subsequently how BIM can facilitate this process. The challenge is that the lifecycle phases involve various parameters of which some are difficult to codify for formalized design processes involving performance-based design, design risk assessment and BIM.

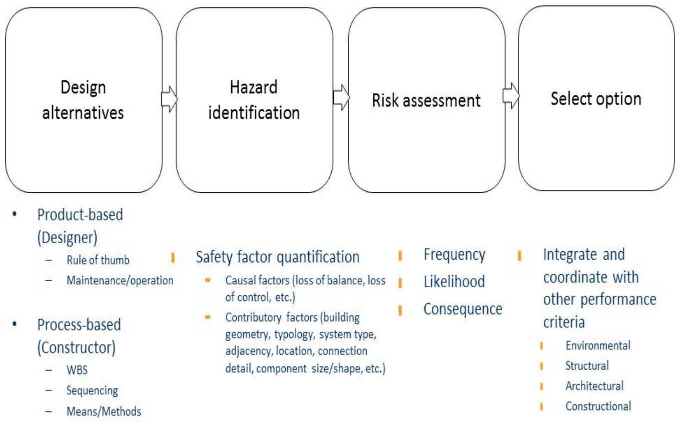


[Research area of BIM for Lifecycle Safety Design]

Innovation

Few case studies describe the use of PtD tools. The evidence is anecdotal and the impact of these tools on PtD processes needs to be better understood. The lack of integration between design information and safety knowledge can be resolved by accommodating construction planning and visualization techniques with BIM and other computational developments.
Addressing the lack of PtD tools, this study contributes to a baseline understanding of PtD tools and processes and identifies potential improvements through BIM.

Computational tools, supplementary to traditional ones, encourage earlier collaboration of the designer and constructor to enhance hazard identification, analysis, and design optimization.



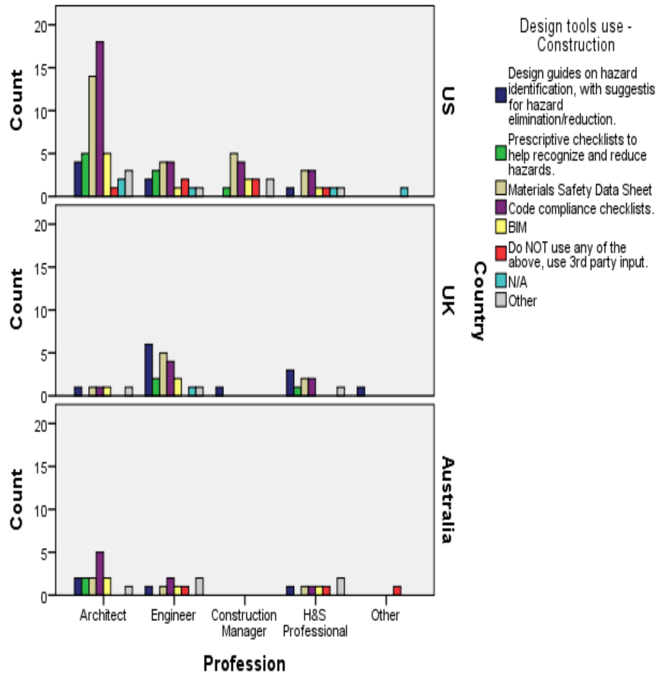
[Diagram of PtD and design risk assessment process]

A critical point of view of this research is that technology can enhance the collaboration between the designer and constructor by assisting the designer and constructor in hazard identification, analysis, and supporting decision making. The study examined related technologies; how technology is addressing the CHPtD needs during the various design stages; and what tools and media design teams are using and what their challenges are. Improvements and adjustments to existing tools suggest potential areas for BIM based tools.

Application

This research offers benchmarks and guides for practitioners and software developers through (1) Characterization of the current use of Prevention through Design (PtD) tools in the industry; (2) Design process maps of lifecycle safety design; and (3) Needs assessment of BIM tools for PtD.
The findings are based on expert interviews, a broad industry survey involving professionals from the US, UK, Australia and other countries, and structured case studies.

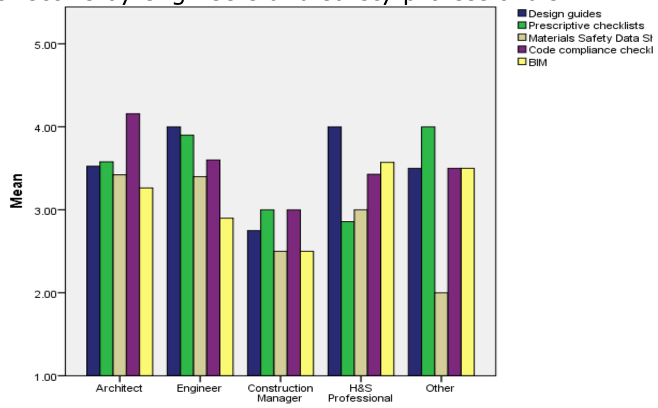
Expert interviews revealed that designers consider occupational safety and health as part of the broader notion of constructability, maintainability, and usability. Architects take a lead role in design risk assessment of maintainability and usability employing quality control methods such as design reviews (30%, 60%, 90% completion of design documents). However, hazard identification and risk assessment of construction safety demands close collaboration between the designer and contractor, where the designer's role usually takes on a support role. US expert views differ from UK and Australian experts. The US design professionals were not as familiar with PtD concepts, considering code compliance as the primary role of PtD whereas UK and Australian experts acknowledged the importance of their role in promoting occupational safety and health and advocated use of more flexible tools such as design guides.
BIM was commonly considered a beneficial tool for communication and visualization of physical interference between building systems, but the experts expressed shortcomings of BIM as a decision support tool for safety design and mentioned that current BIM technology hinders effective management and navigation of larger projects in BIM for safety.
The industry survey illustrates most commonly used tools and effective strategies, type of design tools used for construction, maintenance/operations, and comparisons by disciplinary perspectives and by countries.



[Usage of design tools for construction and maintenance/repair safety by profession and country]

Overall US professionals show a larger reliance on code compliance checklists and material safety data sheets whereas more UK professionals use design guides. Hazard checklists and BIM tools are less adopted for considering safety in design.

Accordingly, code compliance checklists are considered the most effective tools by architects whereas design guides and hazard checklists are considered more effective by engineers and safety professionals.



[Effectiveness of tools by profession]

Examination of practices in the US, UK, Australia, and Germany, highlight the use of various visualization tools. One category of tools involves visualization techniques such as a master plan for safety and health, or annotated drawings with colour coded highlights and symbols.

[Example of visualization of hazards of roof and equipment access by Scott Brownrigg Architects[1]]

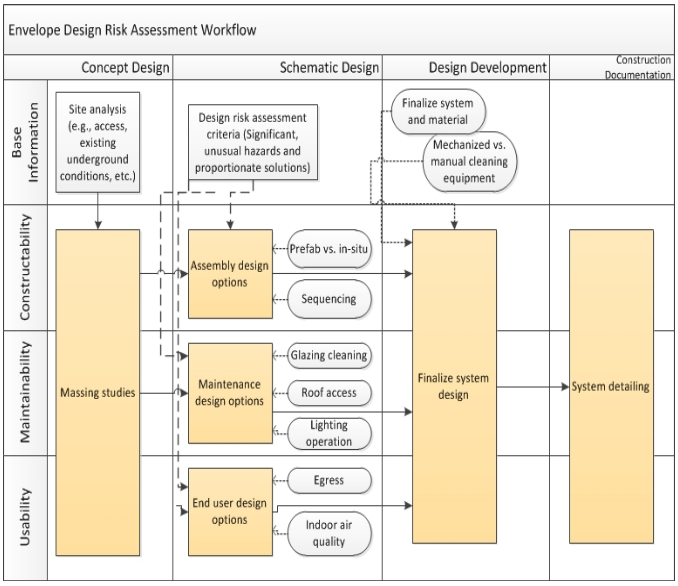
Another category observed in practice is visual design guides related to building systems. These guides include information on specific hazards related to geometric configuration, access, and support surfaces. Through structured case studies, design process mapping focusing on the use of code compliance checklists, design guides, and visualization tools during design reviews were conducted to analyse gaps in current processes.

[Example of German Glass and Façade Cleaning Guide[2]]

[1] Source: http://www.diohas.org.uk/web_documents/RIBA-SB%20Presentation%2010%20Top%20Tips%20for%20Architects%20(Revised%202012-10-11).pdf

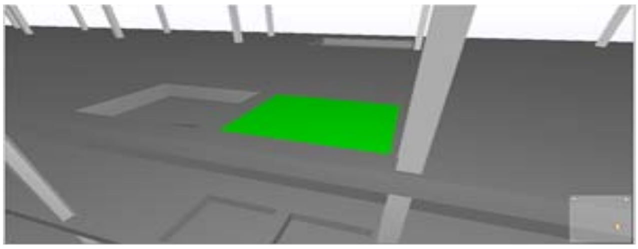
[2] Source: http://www.google.com/url?sa=t&rct=j&q=&esrc=s&frm=1&source=web&cd=2&cad=rja&uact=8&ved=0CDkQFjAB&url=http%3A%2F%2Fwww.bgbau-medien.de%2Fhtml%2Fpdf%2Fi_glas_neu.pdf&ei=lTYrU5ukAYSk0gHB24CgDA&usg=AFQjCNEBQEFcvEJcUoZwUV9ciMT6Ryfc3Q&sig2=Cnm5lE1UsQG4q1HbA4k3cw&bvm=bv.62922401,d.dmQ

The use of design process mapping contributes to identifying potential areas for BIM and automated decision support tools.



[Example of process map of design risk assessment of building envelope design]

Based on the benchmarking studies, a number of research areas for BIM technologies for designing for safety were identified: (1) the tools should be based on best practice design workflows. Concepts and terminology should reflect design thinking and processes such as risk assessment of the building envelope, site, roof, rather than focusing on checklist type tools; (2) Tools for hazard identification – existing tools such as Solibri Model Checker offer potential to incorporate rule-based algorithms for code checking such as OSHA Parts 1910 and 1926 or performance-based criteria that concern access, clearance, adjacencies of spaces, and support surfaces. In addition to assigning geometric attributes of the building, equipment and workspace attributes need to be incorporated.



[Example of automated detection of hole/opening larger than 2 inches (5.1cm) in slab using Solibri Model Checker]

(3) Visualization tools – simplified representations of hazards such as colour coding and various data formatting should allow (semi-)automated reporting to communicate residual risks; (4) manual entry interfaces or automated databases for probabilistic risk assessment should be developed and incorporated.

Impact

This research offers a baseline study of PtD tools in designing for lifecycle safety. Review of current and best practices in the US, UK, Australia, and Germany, offer multidisciplinary and global perspectives that contribute to the understanding of proven tools in the industry. Addressing the gap in automation and visualization tools for design teams, the most often used tools have been classified. The study suggests potential areas for BIM-based tools and processes that can assist design teams addressing occupational safety and health. Design teams including architects, engineers, and multidisciplinary teams including contractors can use the findings to consider their own design strategies and processes. BIM software developers will benefit from better understanding of the designer needs for lifecycle safety.

Validation

Utilizing BIM to impact safety and health across the life cycle of the built environment is a novel application and will have appeal to clients who are concerned about not only construction but also for maintenance activities, which can also be performed by construction workers. The document presents various BIM-based tools and processes for consideration which could have great utility in predicting hazards throughout the lifecycle of the built environment.

Michael Behm, PhD CSP
Joint Coordinator CIB Commission W099 – Safety and Health in Construction
Associate Professor, Occupational Safety, East Carolina University, USA

More information

CIB World Building Congress paper 2013
http://www.conference.net.au/cibwbc13/papers/cibwbc2013_submission_376.pdf (p. 190-200)
NIOSH Program Portfolio NORA Construction Sector
http://www.cdc.gov/niosh/programs/const/noragoals/projects/00000025.html

Expert / Information contact:

Philadelphia University, USA
Dr. Kihong Ku
Assistant Professor
mailto:kuk@philau.edu

Acknowledgement

This work was supported by Grant Number 7R03OH009982-02 from the Centers for Disease Control and Prevention (CDC). Its contents are solely the responsibility of the author and do not necessarily represent the official views of CDC.