F. Madeo and M. A. Schnabel (eds.), *Across: Architectural Research through to Practice: 48th International Conference of the Architectural Science Association 2014*, pp. 279–290. © 2014, The Architectural Science Association & Genova University Press.

RISK IN TRANSLATING RESEARCH OUTCOMES INTO PRACTICE

A case study in managing risk when introducing new construction techniques into design and construction practice

GREGORY NOLAN, JON SHANKS, and GEOFF CLARK
University of Tasmania, Launceston, Australia
{Gregory.Nolan, Jon.Shanks, Geoff.Clark}@utas.edu.au

Abstract. Risk management influences the effective adoption of research outcomes into architectural practice. Worthwhile architectural research invariably involves risk through uncertainty in outcomes as the researcher seeks to understand or improve building performance through systematic investigation. If investigations are successful, the researcher's conclusions usually require translation and a subsequent change in the practitioner's behaviour, through the adoption of new design approaches or different construction methods. In contrast, architectural practice generally involves managing the risk in the building procurement process. This often encourages the practitioner not to change approaches and methods so that the results can be reliably predicted, even if they may be viewed as providing less than optimal performance. This paper discusses the opportunities and constraints in introducing the product of architectural research into active building design practice through the prism of caution, compromise and decision. It presents a case study of a current building project that incorporates applied research into practice: the design, prototyping, and documentation and construction of a 120-unit development in northern Tasmania.

Keywords. Prefabrication, innovation, technical risk, risk management

1. Introduction

Risk management influences the effective adoption of research outcomes into architectural practice. Worthwhile architectural and allied research invariably involves risk as the researcher seeks to understand or improve building performance through systematic but creative investigation. The researcher accepts the risk that even in a well-managed process, the quality of research outcomes is uncertain. However, for these research outcomes to generate beneficial impacts in the built environment, they have to be translated into practical solutions in design practice where attitudes to risk are significantly different. While creativity is in the architect's province, the practicing professional has to balance the potential for securing a benefit through innovation, as promoted by the researcher, against the realities of the project budget, supply chain capability, and the preferences of partner professionals in the design team. Practitioners can be innovative but only inside the bounds of acceptable risk and within the reasonable constraints of experience across the whole design and construction team. To optimise the benefits of their work, the researcher can be a catalyst for its adoption. Innovation in the built environment through the effective adoption of research outcomes often needs to be a collaborative and educative process between researchers and practitioners where risk is to be expected and managed so potential benefits can be realised.

2. Risk and the building procurement process

Risk is an uncertain event or condition, that if it occurs, has a positive or negative effect on a project's objective (Weaver 2008). It can be both an opportunity and a threat. The potential level of risk in a situation is assessed by comparing the likelihood of an event occurring against the consequences of its occurrence. Risk occurs at several scales. In the building procurement process, risks at the project scale generally apply to the design for a single site, building or building complex. The risk of subsidence due to adverse foundation conditions is an example. Strategic risks are more varied and often apply to a building sector or all buildings of a similar construction type. These risks can range from reliance on a single construction system to poor licensing procedures for builders. Strategic risks can lead to adverse events happening across a range of projects.

Buildings are procured through a complex sequence of stages involving various participants. These includes:

- A client who needs a new or altered building.
- A building design team who design the building or its alterations.
- Design approval by the client for functional requirements and cost, and an approving authority for regulatory requirements.
- The design team's tendering of the building work to capable builders, often through a competitive process.
- The construction team's coordination and assembly of the building.

- The finished building's final approval, acceptance and occupation.

As shown diagrammatically in Figure 1, cost considerations moderate the whole process while contracts seek to define and ensure the parties' performance. Major decision and risk assessment points occur at the client, design and tendering stage, while a restricted decision point occurs during construction.

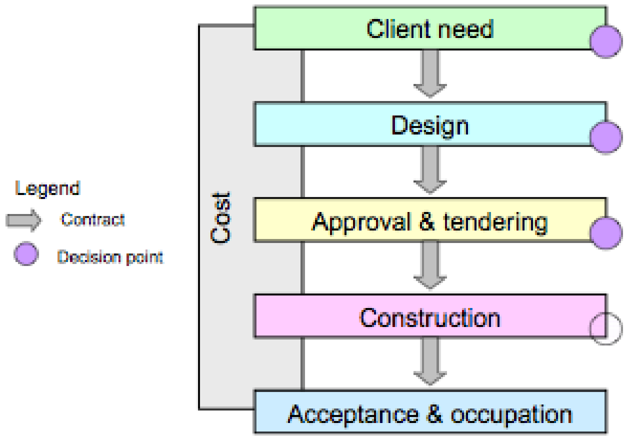

Figure 1. The building procurement process (from Nolan, 2011)

The building procurement process can generate significant risk by:

- The need for the completed building to satisfy its performance requirements. These include regulatory, functional, technical, architectural, and budget factors.
- The quality of action of those involved in the design and construction process.
- The structure and performance of the building material, equipment and system supply chain.

The likelihood of adverse events in building procurement such as unanticipated costs, unexpected construction delays, functional unsuitability and systems breakdowns is high and can occur regularly. The consequence of failure can also be high. In the worst cases, they can lead to death and significant injury. Invariably, building remediation is expensive and time-consuming.

Given the likelihood and consequence of adverse events, architectural practice generally involves deliberate and structured risk management processes. These inevitably encourage the practitioner not to change approaches or methods whose performance can be reliably predicted, even if they may be viewed as providing less than optimal performance.

3. Innovation in the built environment

Research is the creation of new knowledge or the use of existing knowledge in a new and creative way so as to generate new concepts, methodologies and understandings (Australian Department of Education 2014). This creative process invariably involves risk. In architectural and allied technical research, the process necessarily involves an uncertainty in outcomes as the researcher seeks to understand or improve building or material performance through systematic investigation. If investigations are successful, the researcher's conclusions require interpretation to satisfy the demands of the project and a subsequent change in the practitioner's behaviour, through the adoption of new design approaches or different construction methods.

New methods inevitably face resistance to adoption as the potential impact of adverse events that they may cause is often given more weight than the potential benefit of favourable events. This is based on an explicit sensitivity to risk as 'something bad happening' (Cambridge Dictionaries Online 2014) by clients, architectural practitioners and partner professionals and an implicit lack of understanding and confidence in the delivery of innovation. This resistance is the norm and results from the real and imagined risks perceived at each stage of the procurement process. The level of this resistance at the key decision points in the procurement process is critical. If the perceived risk of innovation is felt to be higher than its identifiable benefit at any point in the process, innovation will generally be abandoned. As novelty undermines confidence in the delivery of innovation, participant caution is generated. The standard consultant response to caution is over-specification while the standard builder response is to load the tender price.

The researcher must expect and, if possible, manage these perceptions and reactions if the benefits of their results are to be realised. The preferred means of introducing substantially new approaches to a building is by collaborative engagement between the researcher and the design and construction team. This is an educative phase where the researcher introduces, trains and builds confidence in the design team, cost consultants and the risk managers in the delivery of innovation and its benefits. This allows them to adjust their perceived risk / reward ratio, or identify means of risks mitigation. In this role, the researcher can become an intelligent broker of innovation between the parties.

Disentangling this educative phase from the rest of the procurement process can also reduce perceived risks. With better knowledge gained during this separate stage, practitioners can take informed decisions and confidence increases (European Commission 2010 p.97). Prototyping the solution enhances this educative phase.

Acceptance of innovation and confidence in its use is often incremental. The first application of innovation regularly involves excess discretionary tolerances until experience with the system generated confidence and increases efficiency (Edgerton 2006). As most architect-designed buildings are unique, each presents additional challenges or the opportunity to refine innovative approaches.

Open, competitive tendering processes can also limit the benefits of this educative phase as it can preclude collaborative approaches. Open tendering requires all enforceable requirements to be fixed, documented and available to all tenderers equally. While early integration with building contractors may be possible, a preferred contractor's eventual appointment cannot be guaranteed. The alternative to this is for a nominated subcontract to supply the innovative component. This may reduce the innovation risk but increase the risk of excessive costs. This is another constraint on the researcher's innovative potential: to be most widely accepted, a range of potential contractors has to be able to use or supply the solution.

4. The NRAS Inveresk project

In November 2013, a consortium of Tasmanian architects invited the authors to join a tender to the University of Tasmania for the role of principal design consultants in a National Rental Affordability Scheme (NRAS) project at the University's Inveresk campus in northern Tasmania. The project brief called for proposals for a student accommodation building of 120 discrete apartments and associated common and services spaces on a flat site adjacent to the North Esk River. While strict cost and time constraints applied, the call for proposals specifically encouraged innovation. The successful tenderers were to be appointed in early 2014, construction was to start in early 2015, and building hand-over occur before February 2016.

The NRAS Inveresk project was the last of the University of Tasmania's four NRAS-funded project to be tendered. The first, well into construction in November 2013, set the basis as the acceptable 'default' solution for this type of projects. It used a basic pre-cast and tilt concrete slab structure with internal joinery, fit-out and services installed on site.

The NRAS Inveresk site posed particular challenges to this 'default' solution's adoption. Located on a river flood plain, ground conditions were known to be very poor with a solid foundation about 18m below existing ground level. A workable solution had to either accept the cost of piling or be light and resilient enough to make a raft slab a viable option.

The authors had first hand experience in successful prefabricated module construction, advanced timber fabrication, engineering design with wood, and exposure to European practice. The authors and design team proposed that the preferred innovative approach for the project was a design based on the construction of complete, factory built apartment modules, assembled from readily available timber systems by experienced local subcontractors.

4.1. PROPOSED NRAS INVERESK DESIGN SCHEME

In shaping their proposal, the project team embraced the client's call for innovation and the need to avoid costly foundation works if possible. They developed a three-storey solution based on prefabricated, load-bearing timber apartment modules. See Figure 2 and Figure 3.

Figure 2. NRAS Inveresk preliminary proposal: Level 2 plan

Figure 3. NRAS Inveresk preliminary proposal: Section

They proposed that the modules would be finished in a factory, complete with internal finishes and joinery and external façade elements, arrive at site in protective wrapping and be lifted into their final position by crane. See Figure 4. To highlight the potential of this construction system, the team conditionally offered to deliver the completed building one year earlier than the required completion date.

Figure 4. NRAS Inveresk preliminary proposal: Model of a module

4.2. INTERNATIONAL TIMBER PREFABRICATION PRACTICE

The prefabrication of timber-framed, load-bearing apartment modules is accepted construction practice in some parts of the world. Internationally, the best practice in this form of construction is found in Austria, Switzerland, Germany and the Nordic countries.

In these solutions, cross-laminated timber (CLT) panels are often deployed in the module's floor, wall and ceiling/roof systems. The wall to the external façade is often stud framed to readily accommodate openings, cladding systems and high levels of insulation. When complete, the modules are wrapped, transported to site often over long distances, and lifted into position in the building. See Figure 5. This approach offers clear benefits in design and construction: shorter construction times, higher build quality, and minimised site impacts.

Unfortunately, the use of CLT and largely complete, timber prefabricated modules is novel in Australia. There is no indigenous CLT production and CLT construction is limited. The first predominantly CLT structures completed are the Lend Lease constructed Forte apartments and Docklands Library building, both in Melbourne's Docklands precinct. This location has considerable market potential but very poor foundation conditions. Lend Lease's use of CLT in the Docklands projects can be viewed as the company's acceptance of greater project-based risk in an attempt to moderate potentially more significant strategic risks.

Figure 5. International best practice in prefabricated timber modules

The use of a novel, imported construction system, CLT panels from Austria, in a 10-storey inner-city apartment building in Australia generated significant project-based risk. However, the strategic risks potentially avoided were the exposure to additional costs and on-going building stability issues due to the poor foundations and what was felt to be as an unhealthy reliance on reinforced concrete construction options. In 2008, many builders suffered significant losses due to unexpected rises in the cost of steel reinforcing. Having suffered these costs once, Lend Lease wanted to moderate its exposure to this system by having another viable construction option available for buildings of this type. CLT is the chosen option. This was possible as Lend Lease is a vertically integrated company. As client, project manager and builder combined, Lend Lease management could recognise, quantify and accept the risks involve and make a single strategic decision to accept them.

The use of largely complete, timber-prefabricated modules is novel in Australia. Multi-level timber framed residential buildings are built, but these are invariably stick-built solutions, usually combining prefabricated timber frames for the walls and commodity joist products or floor trusses for the intermediate floor plates. Plasterboard systems provide fire resistance between floors and apartments. Advanced timber prefabrication for multi-residential building is very rare. Wall frame and truss (F&T) manufacturers provide the principle timber prefabrication capacity in Australia but their production is usually optimised to produce small to medium house and project lots efficiently (Nolan 2011). Given this, they are wary of involvement in large projects or more complex prefabrication techniques.

4.3. MANAGING RISK IN THE NRAS SOLUTION

Securing the project with an innovative and locally untried solution and satisfactorily delivering that solution required separate risk-reduction strategies. These in turn elicited particular responses from the participants.

To secure the project, the project team had to convince the client that the Tasmanian building supply chain could successfully deliver a timely and cost-effective timber solution to the project based on prefabricated modules. To simplify this task, they sought to reduce in the client's mind the perceived risk of the innovative leap by:

- Proposing the modules be constructed from readily available timber sections and engineered wood products. This was to remove any perceived material performance or availability risk.
- Ensuring that several F&T fabricators would assemble the modules' floor, wall and ceiling panels. Three fabricators were consulted to confirm supply chain capacity.
- Inviting a major builder (and likely project tenderer) to view, cost and provide an opinion on the viability of the sketch design.
- Recommending that a prototype module be built during design development to resolve construction and façade details.

Each of these approaches reinforced the argument put to the client that the proposed innovation presented a manageable risk in a project of this size, and was a refinement of accepted local building solutions.

The builders and F&T fabricators consulted welcomed the project and the process of engagement. Having read about practice internationally, they were glad that these techniques may finally be introduced to local construction practice. They confirmed capacity and provided the independent opinions requested.

For their part, the University of Tasmania's selection committee listed the team's proposal as the preferred option citing its evident innovation, but retained the 'default' concrete solution as a fall-back option. To confirm their risk exposure, they conducted an review of the preferred option: requesting supplementary tender information, and commissioning independent cost and engineering analyses. This was a time-consuming process but when positive assessments were returned, the client finally accepted the design team's proposal in mid-June 2014, and appointed them as principal consultants.

With the project secured, the design team had to ensure that the solution could be delivered through the supply chain in a timely and cost-effective manner. To minimise the chances of adverse risk, the design team proposed and the client accepted the construction of effectively a 1:1 model (prototype) of a standard accommodation module. The strategic aim of commissioning the prototype was to generate designer and builder knowledge and confidence in the module components. The more practical aims were to:

- Test the module's performance and resilience.
- Clarify fabric and services detailing and construction tolerances.
- Allow the module fabricator to confirm supply chain capacity.
- Provide tenderers with sufficient three-dimensional information to allow them to price the project competitively.

In effect, the design team split project development into three distinct phases. The first two, scheme design development, and detailed development of the modules through prototyping ran in parallel. The last phase, design documentation, is where the outcomes of the first two phases are integrated into an information set for tendering. In doing this, the module development phase, where innovation is translated into usable building solutions, was effectively separated from the more low-risk design development activities.

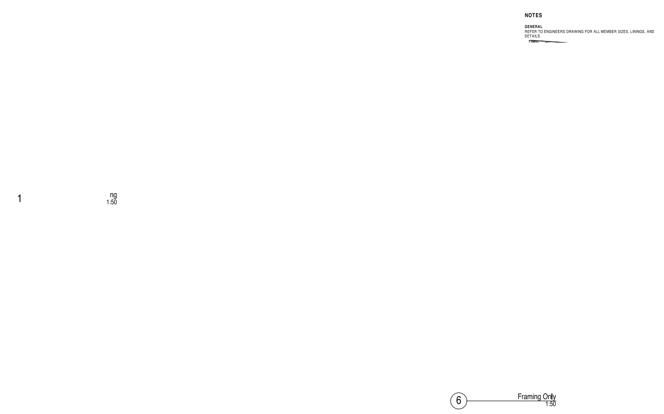

Figure 6. Computer model of the prototype structure.

Module prototype development is also scheduled in stages to:

1. Develop and design the module through a series of pre-construction workshop sessions.
2. Construct the prototype structure with subcontractor-provided components, partially line it with fire resistant plasterboard, partially finish it internally and complete services rough-in.

3. Demonstrate the module's robustness in transport through a trial lifting, transport and return journey of more than 20km.
4. Use of the module to develop wall cladding system including glazing details, fixing systems, and flashings.
5. Construct additional floor and wall panels to refine details of inter-module connections of adjacent wall and floor junctions. Test acoustic separation, junction details and tolerance.
6. External storage of the completed module to demonstrate water-tightness and facilitate tenderer inspection.

The prototype was documented and modelled graphically, see Figure 6, and was under construction in August 2014.

5. Conclusions

Risk and approaches to its management influence the effective adoption of research outcomes in architectural practice. Worthwhile architectural research invariably involves risk through uncertainty in its outcomes. If investigations are successful, the researcher's conclusions usually require a change in practitioner behaviour. In contrast, architectural practice generally involves managing the risk in the building procurement process. This often encourages the practitioner not to change approaches and methods so that the results can be reliably predicted.

For the NRAS Inveresk project, the authors and other members of the design team sought to introduce technical innovation to the local industry by transferring a solutions developed and successful elsewhere to the construction of a 120-unit development in northern Tasmania.

Securing the project and satisfactorily delivering the solution required separate risk-reduction strategies. These in turned elicited particular responses from the project's participants. To secure the project, the project team had to convince the client that the Tasmanian building supply chain could successfully deliver an innovative but timely and cost-effective solution.

To deliver the solution, they have commissioned a prototype to build designer and builder confidence in the module's reliance and reliability. So far, these approaches have been successful and the prototype is under construction. Construction on site is expected to start in early 2016.

References

Australian Department of Education: *2014: Higher Education Research Data Collection: Specifications for the collection of 2013 data*. Available from: http://docs.education.gov.au/documents/2014-herdc-specifications> (accessed 24 July 2014).

Cambridge Dictionaries Online. Available from: <http://dictionary.cambridge.org> (accessed 18 July 2014).

Edgerton, D.: 2006 *The shock of the old: Technology and global history since 1900*, Profile Books, London

European Commission: 2010, *Risk management in the procurement of innovation and empirical evidence in the European Union EUR 24229 EN*, European Commission Available from: <http://ec.europa.eu/research/era/docs/en/investing-in-research-expert-group-risk-management--eur242209-2010-.pdf>(accessed 25 July 2014)

Nolan, GB.: 2011, *Timber in multi-residential, commercial and g-industrial building: Reco nising opportunities and constraints, Project report PNA140-0809*, Forest Wood Products Australia, Available from: <http://www.fwpa.com.au/rd-and-e/market-access/226-timber-in-multi-residential-commercial-and-industrial-building-recognising-opportunities-and-constraints.html> (accessed 18 July 2014)

Weaver, P.: 2008, *The meaning of risk in an uncertain world, PMI Global Congress 2008 - EMEA*. Available from: < http://www.mosaicprojects.com.au/Resources.html> (accessed 20 July 2014)

Translating Research to Practice in Bullying Prevention. Catherine P. Bradshaw University of Virginia. Bullying continues to be a concern in schools and commu-nities across the United States and worldwide, yet there is uncertainty regarding the most effective approaches for preventing it and addressing its impacts on children and youth.Â One of the challenges in evaluating bullying prevention programs is assessing the outcome of bullying. Only re-cently has there been consensus regarding the denition of bullying to include intentional aggressive behaviors, which are typically repeated and usually occur in the context of a power imbalance (Gladden, Vivolo-Kantor, Hamburger, & Lumpkin, 2013; Olweus, 1993). The process of translating that evidence into practice in ways that are tailored to each patientâ€™s clinical profile, eating habits and lifestyle, and learning style needs team collaboration including referral to lifestyle programs or registered dietitians for medical nutrition therapy.Â To reduce risk for diabetes complications, patients and providers discuss achieving an A1c level of about 7%; a blood pressure of <140/90 mmHg; and a cholesterol profile of low-density lipoprotein (LDL) <100 mg/dl if there is no overt cardiovascular disease (CVD) and an LDL of <70 mg/dl if there is overt CVD, with high-density.Â 5. The diabetes prevention program research group, reduction in the incidence of type 2 Request PDF on ResearchGate | Managing risk while translating research outcomes into design and construction innovation | Significant tension can exist between the goals of architectural research and of architectural and building practice. Worthwhile research involves generating risks its benefits are uncertain and require interpretation in practice as new design approaches or construction...Â In contrast, professional practice generally involves managing building procurement risk. This can encourage participants to resist change and enhance solution reliability, even if this delivers less than optimal performance. Practitioners can be innovative but often only through incremental development, nudging participants along the path to increasingly innovative action.