ENGINEERS
AUSTRALIA

Building Confidence: How to use engineers to improve building and construction

SUPPLEMENT

Summary

Engineers Australia convened a building industry working group to develop a paradigm for good practice of engineers across the building sector.

The paradigm proposed is to introduce two key professional engineering roles into the delivery and approval of a building project:

- Engineer of Record
- Proof Engineer

Introduction

The building and construction industry has been plagued by poor building practice leading to a loss of confidence in the building sector as evidenced by high profile cases such as Opal Tower, Mascot Towers, Neo 200 and Lacrosse. The rise of design-and-construct as a delivery method has also seen the industry lapse into poor building practices with a driver to maximise profits by shortening the design-construction period and sidelining input from professional engineers.

The Building Confidence report by Shergold and Weir which was commissioned by the Building Ministers Forum in 2017, makes 24 recommendations towards improving the effectiveness of compliance and enforcement systems for the building and construction industry across Australia. Building controls can only go so far to improve practices, a significant paradigm shift is called for.

The implication of evidence considered by and conclusions reached by the Report is that the contribution of professional engineers to the design and construction of buildings has become compromised.

Purpose

"The building and construction industry needs to actively participate in lifting standards, competency and integrity if it is to produce safe and reliable buildings...."[1]

As a response to this call, Engineers Australia convened a building industry working group to develop a paradigm for good practice of engineers across the building sector. Members of the working group came from various sectors and jurisdictions within the building industry.

This paradigm supports many of the Building Confidence report recommendations and is intended to:

- Improve the likelihood that the building production system (design, fabrication, construction) gets it right every time. Sign off by an Engineer of Record; and
- Improve the likelihood that the building approval process (verification) gets it right every time. Verification by a Proof Engineer.

The particular recommendations that this paradigm contributes to are 2, 13, 14, 15, 16, 17, 18, 19, and 20. This document supplements Engineers Australia's ***Building Confidence: How to use engineers to improve building and construction*** publication by providing further background to the development of the paradigm.

1 P. Shergold and B. Weir, *Building Confidence*, 2018, p. 4

Making the case

Poor design documentation and ineffective enforcement of compliance was identified as a contributing factor to the diminishing public confidence in the building industry by the Building Confidence report. While the Report aims to support delivery of compliant and safe buildings, a key concern is the confused roles, responsibilities and accountabilities of different parties in the industry.

Parties involved in the building industry are:

The **building owner or developer** who finances the building project and aims to make a profit from its use or sale. Workplace Health and Safety legislation makes the building owner responsible for safety during building construction and for the delivery of a building that can be safely maintained and demolished. This responsibility may be shared but cannot be transferred to other parties.

In many jurisdictions, the building owner is also required to compile a building manual, containing documentation relevant to the development approval, design and construction, including design reports, fire safety solutions, building components and systems (operations manuals), as-constructed details and ongoing building and building systems maintenance requirements.

The **building approval authority** who approves the construction (commencement) of a building project and approves its occupation. Approval is based on compliance with the National Construction Code (NCC), referenced documents and various state and territory variations, additions or deletions from the NCC. The building approval authority may seek advice from a competent person in deciding to approve work.

In several states and territories, a private building surveyor may be engaged to provide the services of the building approval authority.

The **building surveyor/certifier** who assesses and certifies the compliance of a building with the National Construction Code (NCC). The building surveyor may seek advice from a competent person in deciding to certify work. In some jurisdictions building surveyors may also act as the building approval authority and issue building and occupancy permits. Building surveyors are regulated by various legislation in most jurisdictions. However, processes for training and accrediting building surveyors entering the industry are not so well developed. The building surveyor has a pivotal role in certifying the compliance of building design and construction with NCC requirements, but the authority or power the building surveyor can exercise to ensure compliance with NCC is not so clear.[2]

Building inspectors may be engaged by building approval authorities or other parties to observe, check or measure construction work as it progresses.

Engineers involved in building projects come from various areas of practice. Professional engineers interpret the building owner's requirements and expectations into engineering systems. They design, check and certify that their engineering systems comply with the NCC and meet other compliance as required. There are many engineering systems involved and often include foundations, structure, cladding, fenestration, fire safety, building services (such as HVAC and vertical transportation), hydraulics (water and wastewater), power reticulation, communications and security.

The **builder/head contractor** enters into a contract with the building owner to construct the building project and like the building owner, aims to maximise profit and actively looks for cheaper ways to deliver the building

2 ibid., p. 19

project. The builder resources materials, components and expertise to construct, assemble and deliver the building components and systems as required by the building project, including the engineering systems that are integral to the building project. They may also be required to share responsibility for Workplace Health and Safety during construction.

Subcontractors provide the expertise, specialized components and materials that the builder/head contractor requires to deliver the building project.

Project managers manage delivery of the project and may include developing schedules to coordinate the work of designers, builders and builder's subcontractors to manage interactions and interferences that could delay project delivery. They may be engaged to marshal resources and personnel to design, construct and deliver building projects or systems.

The **architect/building designer** has traditionally held the responsibility for the overall project coordination, including discussions with the building owner, negotiating contracts with other design consultants and paying for their services, writing specifications for all elements of the construction, and dividing roles and responsibilities among members of the design team.[3]

With these financial and procedural arrangements, the architect had the ability to control the quality of the finished product. However, with a more progressive approach to compressing the design-construction period, the traditional architect role is diminishing along with a reduction in technical supervision during construction.

Traditionally the architect, building owner, design professionals and builders all knew the structure of their relationships and could settle information on building requirements.

With an apparent lessening role of the project architect, disconnect from original design concept, and the greater use of design-and-construct contracts directly with the builder, the work of design professionals has become more focused on minimising costs and meeting deadlines. Poor design documentation has gone unchecked and forced builders to "improvise, making decisions on matters which affect safety, ... exacerbate disputes about quality and compliance and ... result in inadequate information to guide the future maintenance of safety systems in buildings."[4] At the extreme, underfunded and ineffective enforcement of standards on complex commercial building projects has left those involved in high-rise construction largely to their own devices.[5]

There is an ever increasing complicated building environment to be navigated. With this comes risks of error or omission associated with the design of related engineering systems.

The concept design for a building project is usually based on a design brief provided by the building owner and is influenced by many of the parties involved in the building industry. Often the design brief will evolve as opportunities and challenges emerge during the design and construction phases, so the concept design needs to be flexible enough to accommodate change. Under a design-and-construct contract, design changes are often implemented to reduce cost yet there is no mandatory requirement that these changes are confirmed appropriate with the design intent. In this context, change management is crucial and risk management processes need to be robust to appropriately manage the complexity of the building project's engineering systems.

3 ATC/SEA Joint Venture Training Curriculum, *Roles and Responsibilities of Engineers, Architects, and Code Enforcement Officials Part A: The Need for Improved Coordination*, pp. 2-3

4 Shergold and Weir, op. cit., p. 4

5 ibid., p. 11, p. 29, p. 30, p. 33

In a design-and-construct building project, design work and construction often run concurrently, designs being delivered just in time for construction. Compressed project delivery times increase the risk of poor-quality documentation due to errors or omissions on the part of the design engineer or engineers involved in construction. This is often attributed to lack of change control associated with design and construction changes. Process improvement is necessary to manage and mitigate these risks. Engineers Australia's paradigm for good practice in the building industry introduces enhanced coordination of engineering systems and design verification to support a better project outcome.

Building complexity

The Australian Building Codes Board (ABCB) provides a definition of a building's complexity in their Definition: Building Complexity Exposure Draft 2020 as "Building complexity means those attributes that are complicated or organisational, which increase the likelihood of non-compliance in a situation where the safety and/or health consequences of that non-compliance would be significant."[6]

There are a number of considerations that go into determining the complexity level of a building such as:

- number of occupants
- vulnerability of occupants
- complication of the building design, construction and material used
- organisational factors, including ownership structure, method of procurement, future maintenance requirement

There are six complexity levels ranging from Level 0 through to Level 5. Typical building examples against complexity level are:

- Level 0 – single storey residential
- Level 1 – small hospice, data centre, four storey office building
- Level 2 – shopping centre, concert hall
- Level 3 – thirty storey residential building procured by design-and-construct contract
- Level 4 – thirty storey residential building, containing an early childhood centre, procured by design-and-construct contract
- Level 5 – post-disaster recovery buildings or hazardous facilities

The exposure draft provides a decision tree to assist in determining the level of building complexity which in turn is tightly tied to building classifications[7]. Within this building complexity framework lies the various engineering systems which can add a further intricate element. Such engineering systems include structural, fire safety, electrical, lifts, HVAC (heating ventilation air conditioning), hydraulics (water and wastewater), and so forth.

With increasing complexity, the role of the engineer in guiding decision making becomes valuable.

6 Australian Building Codes Board, *Definition: Building Complexity Exposure Draft*, 2020

7 Ibid.

The Paradigm

Significant improvement to engineering processes are necessary to lift standards and lead a paradigm shift in the building construction industry.

The engineer supports the architect or building designer with specialist advice and develops the concept for and details of engineering systems. The engineer supports the builder with specialist advice on how to construct engineering systems efficiently and effectively. The engineer supports the building surveyor with specialist advice on the compliance of engineering systems with the National Construction Code (NCC).

Determination of building complexity is another key area where the engineer can make a beneficial contribution, recommending an appropriate level of engineering review. In a complex building project, the engineer will also ensure that the concept of the engineering system fits well with the overall design brief and concept design.

No matter who commissions professional engineering services, the engineer must exercise their ethical responsibility, serving the community above all. In doing so, the engineer is to demonstrate integrity, practice competently, exercise leadership, and promote sustainability, all of which requires the engineer to communicate honestly and effectively with all stakeholders who rely on their engineering expertise.

The paradigm proposed is to introduce two key professional engineering roles into the delivery and approval of a building project:

- Engineer of Record
- Proof Engineer

These professional engineers should have at least fifteen years' experience and be registered in a relevant area of engineering as required by jurisdictional law. If there is no statutory requirement to be registered then the engineer should, at a minimum, be registered on Engineers Australia's National Engineering Register (NER).

Engineer of Record

The Engineer of Record for an engineering system is a senior professional engineer who is engaged by the owner to endorse drawings, reports, or documents for a project. Endorsement means review and assessment for compliance with the performance objectives and compatibility with the concept design. The Engineer of Record may not necessarily have directed or guided the preparation of all drawings, reports or documents by other engineers for the relevant engineering system. However, the Engineer of Record must have been given the opportunity to assess and certify the engineering system as a whole, even though detailed design and fabrication may have been undertaken by other engineers working for specialist consultants or subcontractors.

There are many engineering systems in a building project. For each engineering system the Engineer of Record should:

- plan, monitor and coordinate professional engineering service delivery to ensure that the documentation of their engineering systems meet the contractual and regulatory requirements
- be satisfied that the professional engineers engaged on the engineering system are aware of the National Construction Code (NCC) and have the required competency and capacity to deliver the required services

- help determine when independent checking or enhanced verification is justified such as building complexity levels 2, 3 and 4
- liaise with the builder concerning planning, management and monitoring of the construction phase especially concerning design changes initiated during construction
- coordinate regulatory certification of the engineering system and advise on the inspection of engineering systems and implementation of building safety during the construction phase
- interact with the responsible building surveyor over concerns about non-compliant construction work
- advise the building owner on meeting statutory approval requirements

Whilst the concept of an Engineer of Record is relatively new to Australia, the use of Engineers of Record has been well established in many jurisdictions of the USA.

Establishing the role of an Engineer of Record will support the Building Confidence report recommendations.

Proof Engineer

Buildings with a high complexity level need more robust independent design checking and verification[8].

Proof Engineers are specifically engaged by the building approval authority to verify the integrity of complex engineering systems for compliance with the NCC. In the context of the building environment, verification means review of calculations and design documentation prepared by others and may also involve checking by independent calculation. A Proof Engineer is to be truly independent and act on behalf of the community and in the public interest. Appointed Proof Engineers must also respect commercial-in-confidence material that comes under review.

The ABCB provides a definition of a building's complexity. The level of a building's complexity should drive the basis for engagement of a Proof Engineer.

The Proof Engineer is a senior professional engineer who verifies that each engineering system is coherent and meets the applicable standards. The Proof Engineer must not be part of the engineering design team, is entirely commercially independent and carries out third party certification for a project.

Where the level of building complexity requires a Proof Engineer, the Proof Engineer should:

- have in-depth knowledge and understanding of the NCC and the supporting Australian Standards
- identify the Performance Requirements from all sections and parts of the NCC that may be relevant to any aspect of Performance Solutions proposed for critical systems
- verify that the engineering system, if constructed as intended, will comply with all relevant Performance Requirements of the NCC
- verify that the engineering system as constructed complies with all relevant Performance Requirements of the NCC
- certify that verification has been made and provide supporting documentation that identifies applicable sections and parts of the NCC to the building approval authority or the relevant Engineer of Record

8 Shergold and Weir, op. cit., p. 33

- report to the building approval authority on non-compliance of design or construction of critical systems
- raise issues with building approval authority where Performance Solutions have been used inappropriately to approve non-compliant construction work

A Proof Engineer should be engaged for all buildings with a complexity level of 3, 4 and 5 and in some instances 2.

Whilst the concept of a Proof Engineer in the building industry is new to Australia, the use of Proof Engineers has been well established in Germany particularly for structural systems and fire protection systems.

Establishing the role of a Proof Engineer will support the Building Confidence report recommendations.

Conclusion

Professional engineers have an important role in the successful delivery of engineering systems. The paradigm for engineers engaged in the building industry, as presented here, will support a number of the recommendations from the Building Confidence Report.

The **Engineer of Record** will provide assurance on the integrity of the engineering system.

The **Proof Engineer** will provide assurance of compliance with the NCC.

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