

GREEN STAR BUILDING CERTIFICATION: A 6-STAR BIM FRAMEWORK ENHANCEMENT

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Designers currently lack an organized framework to facilitate an all-stakeholders' understanding of design processes targeting more sustainable buildings. To address this gap, a case study investigation was undertaken into the conceptual and preliminary design of a high-performance technical building project in Western Australia, that targeted Green Building Council Australia's '6-Star' certification objectives. Interviews with five, BIM and Green Star, experienced building professionals (three structural engineers and two sustainability consultants) informed the development of a 10-step planning and concept design stage framework to help engineers (and other stakeholders) achieve three structural-specific credits required for 6-Star certification: upfront carbon emissions; responsible structures; and life cycle impacts. Framework elements include: assessing a client's expectations and risk appetite to achieve a specific Green Star certification; establishing, and comparing against, a fit-for purpose reference project (the concept of absolute values is promoted as a continuous improvement opportunity); standardized naming protocols between disciplines; and conceptual design iterations with earlier BIM usage to gain benefits of quantity tracking, material opportunity assessments and associated embodied carbon levels. The framework has been implemented in the structural engineer's offices for the past year.

Keywords: Embodied carbon, Integrated design, Life cycle analysis, Reference building.

1 INTRODUCTION

Australia is committed to achieving net zero emissions by 2050, with a 43% reduction in greenhouse gas emissions below 2005 levels by 2030 (Australian National Audit Office 2024). Given buildings contribute 39% of global energy-related carbon emissions (World Green Building Council 2019), improved capital and operational efficiency is essential to meeting these reduction targets. The Green Building Council Australia's (GBCA) Green Star system is the leading green building certification tool used in Australia (Gandhi and Jupp 2014). '6-Star Green Star' under the Green Building Certification System (GBCS) is reserved for the most efficient buildings, representing 'world leadership' in sustainable design.

Sustainability assessments are based upon comparing percentage improvement scoring of the building's design against a 'reference building', which is praised as a strength of Green Star (He *et al.* 2018). GBCA publishes guidelines on the reference building selection process, but transparency of the application of GBCS credit scorecards on case study projects is limited due to confidentiality agreements (Prins 2015). Green Star certification is only granted following application to GBCA after practical completion is achieved (Xia *et al.* 2013).

There remains the lack of an organized framework for stakeholders to understand the design process practicalities to achieve Green Star certification. Structural engineers largely rely on sustainability consultant guidance to meet Green Star credit objectives.

1.1 Opportunities Offered by Building Information Modelling (BIM)-GBCS Integration

BIM enables stakeholder collaboration, lean construction and clash detection benefits during building planning, design, and construction phases (Volk *et al.* 2014). Despite this, there has been limited investigation into the benefits of Green Star and BIM integration (Ghaffarianhoseini *et al.* 2017). Abdelaal and Guo (2022) concluded 87% of stakeholders had no previous experience using an integrated BIM process to meet Green Star requirements. BIM adoption within the industry remains limited due to project and cost constraints (Zhou *et al.* 2019).

Despite it being possible to reduce embodied carbon within a building by 50-60% during the design phase (Häkkinen *et al.* 2015), it is often not achieved due to limited availability of material databases. Although building material environmental product declaration data is increasingly supplied by manufacturers (Dubljevic *et al.* 2023), a lack of confidence in trustworthy data entry remains an existing barrier to BIM usage (Whyte 2015).

Following their systematic literature review into integrating BIM and GBCS processes, Olanrewaju *et al.* (2022) recommended development of a holistic framework for BIM-GBCS integration to meet Green Star credit requirements by using case studies. Dubljevic *et al.* (2023) developed a framework for BIM-GBCS integration, using Excel and BIM software to track credit requirements. Their study was limited to achieving one credit in the Leadership in Energy and Environmental Design system and was not specific to the structural system, which is needed when addressing structure-specific Green Star credits. That framework does not consider practical applications within real construction projects, as proposed by Ghaffarianhoseini *et al.* (2017).

1.2 Closing the BIM-GBCS Gap

Addressing the gap between Green Star strengths and the lack of an organized stakeholder design process framework is this research's focus. Lessons learned from a case study project have informed developed of a 10-step framework (focused on building planning and concept design stages) to achieve three structural-specific Green Star GBCS credits required for 6-Star certification. The resulting framework has since been implemented in one of the structural consultant's design offices.

2 METHODOLOGY

The case study is a high-performance technical (laboratory) building in Western Australia where a deliberate decision had been made to integrate BIM and GBCS objectives. A series of semi-structured interviews were undertaken with a purposive sample of five individuals involved in the conceptual and preliminary design stages of the building. Participants were current employees from two private engineering consultancies - three structural engineers (two with 20+ years' experience and one 11-20 years) and two sustainability consultants (one with 11-20, and the other, 6-10 years' experience). Each participant had been involved with more than five projects that utilized BIM software and two had completed more than five Green Star certified projects.

Interview questions were designed as a data collection method to create discussion about key themes arising from their BIM and GBCS experiences on the project, particularly lessons learned. Questions included:

- BIM usage, particularly in conceptual and preliminary design stages
- Understanding of sustainable building design, and its implications for embodied carbon and Green Star certification
- Which Green Star credits are a particular focus (the ‘scorecard’) - points available and achievable, risks in attaining the credit, and discipline responsibilities to achieve these
- Impacts of BIM in the process, and opportunities for efficiency improvements.

For confidentiality reasons, participants declined to provide the Green Star scorecard for the case study project. However, participants provided commentary on the main headings included within the project’s scorecard documentation.

Interviews transcripts were returned to participants for verification. Transcript content analysis enabled identification of themes associated with design processes and mechanics of BIM-GBCS integration, as well as Green Star credit focuses. From these a framework of recommended steps, and associated responsibilities, during conceptual and preliminary design stages was developed. Participants were contacted to validate the developed framework. One, experienced in structural and sustainability disciplines, provided minor comments and these were incorporated into the final framework. A second case study was subsequently used to validate the framework guidance tool.

3 CASE STUDY INTERVIEW OUTCOMES

Nineteen different themes were raised by the participants. Key themes discussed by all five participants related to: structural design; material quantity modelling (with specific software products); data processing and associated back transfer into models; and resulting sustainability assessments.

3.1 Green Star Processes

All participants confirmed that, despite the increased focus on Green Star building projects, planned 6-Star Green Star building designs remained uncommon in the industry. The key issue being ‘6-Star’ pursuits were client cost/objective driven with any such decision being announced early in a project’s design. Sustainability consultant participants were more positive in their responses towards GBCS than the structural engineers, and (unsurprisingly) took the lead in coordinating the building’s ‘Green Star strategy’.

Participants agreed that the Green Star certification protocol relies on an appropriately selected, following set guidelines, reference building - against which a quantitative assessment is made on the proposed building’s sustainability performance. Reference building selection is a challenge for stakeholders striving for 6-Star accreditation, particularly in identifying and adequately similar, fit-for-purpose project. Target credit priorities on 6-Star Green Star projects differ depending on the client’s appetite for risk and preparedness in funding specific Green Star credits.

Selected credits are part of the overarching ‘Green Star Strategy’ all disciplines must meet to satisfy the 6-Star Green Star requirements. The sustainability consultant determined which Green Star credits were attainable by the structural engineers, while recognizing these are not always acknowledged early in design. Design teams are often more focused on coordination, spatial, and discipline design requirements, which can directly clash with sustainability goals.

Three Green Star credits applicable to structural engineers are: ‘Upfront Carbon Emissions’ (6 points available, with partial contributions from other disciplines); ‘Responsible Structures’ (5 points – the structural engineer’s main focus); and ‘Life Cycle Impacts’ (2 points, again with contributions from other disciplines). Upfront Carbon Emissions credit was most applicable to the structural engineering discipline in the case study with focus on improving material quantities and specification efficiency. Structural system cost, scheduling and construction methodologies have potential to impact all three of these credit targets in the pursuit of a 6-Star Green Star certification. Despite this, participants were concerned there is limited literature on the risks associated with attaining Green Star credits in Australia.

3.2 Integration with BIM

Coordination between disciplines using BIM remains uncommon in the Australian industry. Despite their experiences to date, participants felt they still had limited experience in BIM-GBCS integrated design. BIM was considered more effective for larger-scale projects to find clashes and opportunities for continuous improvement if used and documented correctly. Four participants noted that BIM provided faster access to multi-disciplinary data and design alternatives in the planning and concept design phases.

Material quantities from the BIM model were extracted to facilitate a spreadsheet-based high-level estimate tool for structural engineers early in the early design stages. From these quantities, estimates were also made of the upfront, or embodied carbon, quantities of the proposed materials. This tool was used to assess design alternatives during the conceptual design phase. An identified limitation was data could not be readily exported back into the BIM model after extraction.

3.3 Lessons for a Framework

Participants acknowledged that despite their endeavors, there was a level of confusion associated with the targeted 6-Star credit objectives. They were clear this highlighted the need for an organizing framework, utilizing the benefits offered by BIM, when pursuing 6-Star Green Star projects. One identified example for improvement is ensuring naming conventions are consistent between building disciplines.

One participant raised concerns regarding 6-Star Green Star certification award being based on the newly designed building achieving a (undefined) percentage improvement against the reference building. The participant noted that when the percentage improvement on the reference design was achieved there is no incentive for design teams to push sustainability boundaries. In order to overcome this, ‘absolute value’ is suggested as an improvement to the current ‘reference building’ method.

4 DEVELOPED FRAMEWORK

As each Green Star project is different, depending on the client’s cost, schedule and risk appetite, the framework developed as part of this study (presented in Figure 1.) focuses on processes structural designers should follow to meet 6-Star Green Star building design credit requirements. Headings are purposely fluid to facilitate framework expansion as 6-Star Green Star project minimum requirements change, e.g., moving to an ‘absolute value’ rather than ‘reference building’ approach.

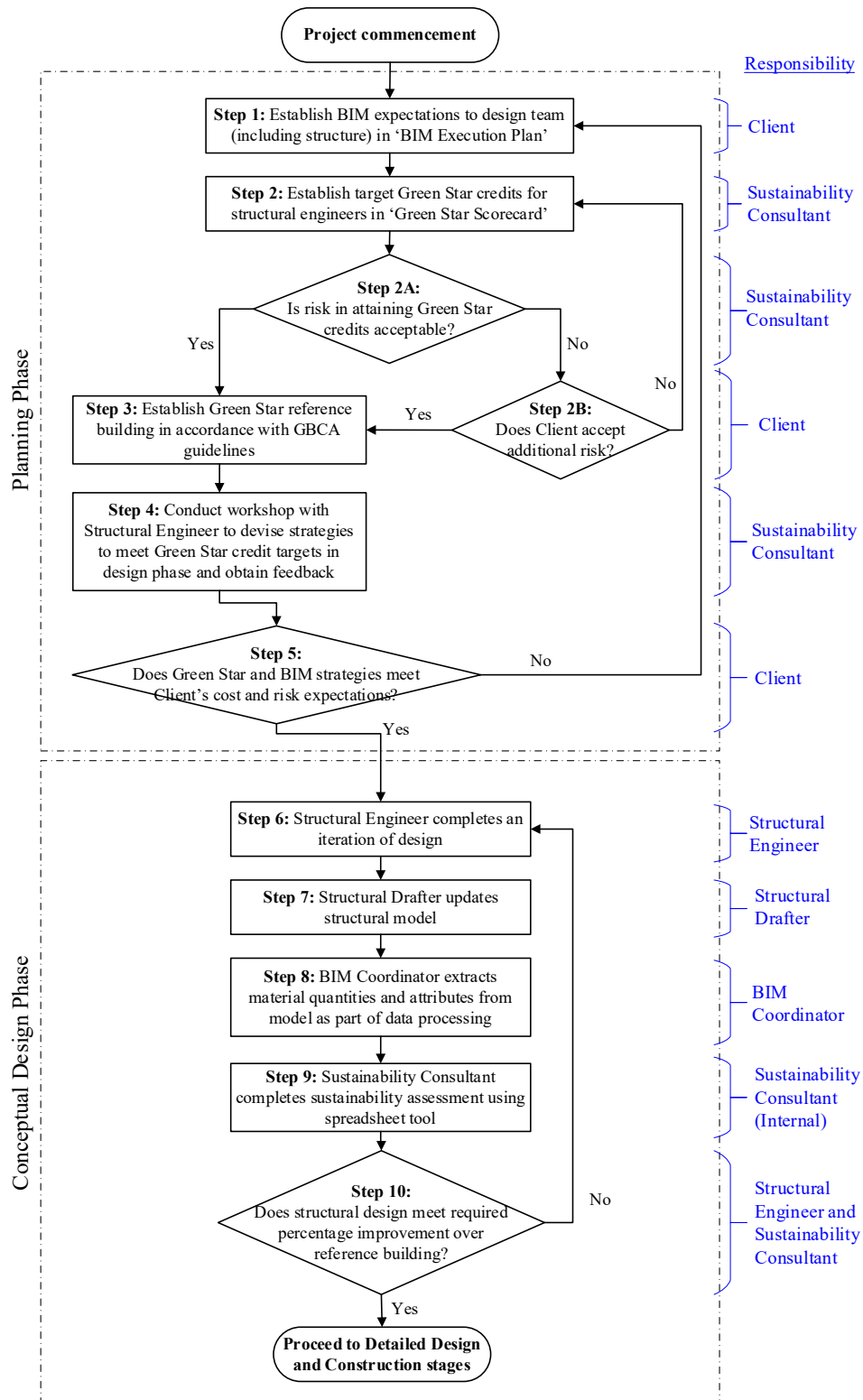


Figure 1. BIM-GBCS integration framework.

A stakeholder management plan should document structural and sustainability disciplines' responsibilities, requirements, and limitations. Standard naming protocols facilitate an accurate model for Green Star certification purposes. Further enhancements may be possible by using validated life cycle assessment software over simple spreadsheet tools.

5 CONCLUSIONS

Opportunities to meet Green Star credit requirements for Structural Engineers are limited. A clear, unambiguous guide to responsibilities and requirements can maximize the savings against reference buildings or absolute values. A validated 10-step framework has been presented here for structural engineers to facilitate 6-Star Green Star certification, which has been implemented in their offices for the past year. Early engagement with the framework is seen as critical.

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