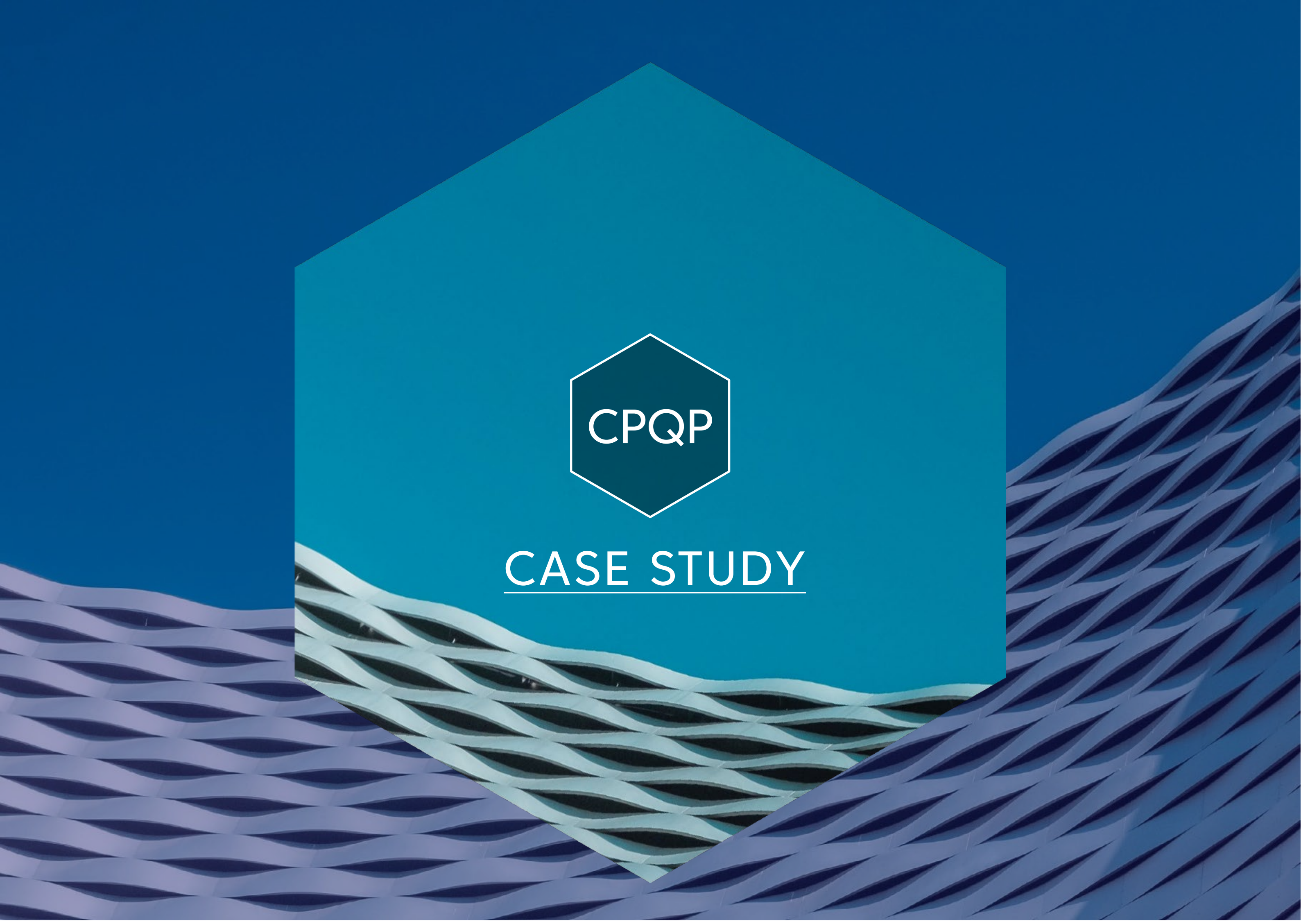

CPQP Case Study Report

March 2023

CONSTRUCTION INNOVATION HUB

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1. Introduction

The adoption of modern methods of construction (MMC) is underway and has been achieved by a select few pioneers in the construction industry. This is a shift away from traditional methods of construction. The need to meet the higher demand rate of new products with lower variability in quality and improved profit margin are just two of the many reasons the platform-based approach is of keen interest to developers, integrators and government. To further support this transition, guidance issued via the Transforming Infrastructure Performance (TIP) Roadmap is aimed to mandate platform approaches for social infrastructure and the Construction Playbook mentions the benefits of platform-based approach construction which could facilitate early supply chain engagement, enhancing market stability and competitive enhancements [1].

Taking into consideration this shift in industry, the Construction Innovation Hub adapted the Advanced Product Quality Planning (APQP) tool to suit the needs of the construction industry. The Construction Product Quality Planning (CPQP) Guidelines are a set of easy to interpret quality planning toolset that encourage the Design for Manufacturing and Assembly (DfMA) approach. The maturity of the guides allows the commencement of a crucial phase of validating these guides with platform partners and industry leaders in platform-based construction.

To this end, the necessity of a product quality management framework embedded into the constructors New Product Introduction (NPI) programme becomes increasingly beneficial with product complexity and volume increase. CPQP aims to support introduction of the quality framework for new construction products that will be designed and delivered through manufacturing-led approach for the purpose of off-site construction projects. To validate CPQP methodology the team is collaboratively working with industry partners to encourage the use of CPQP within the construction product development stages and record their feedback. The experience gained from implementing CPQP in various case studies contributed to validate strengths and address weaknesses of the framework.

The work of the Hub is supporting implementation of CPQP framework via applying quality tools for three industry pioneers at the same time in different phases of their product development.

1.1. CPQP Implementation

The team at the Hub, led by BRE, delivered a CPQP validation campaign by developing case study applications with industry leaders in off-site construction. The aim of the case studies is to capture customer feedback, measure impact generated within their processes and collect lessons learnt as part of a continuous improvement culture. The team is supporting the industry in the adoption of advanced manufacturing toolset to showcase the way to upskill engineers on the quality processes.

1.2. Purpose

A period of consultation followed the launch of CPQP in August 2022. Government and stakeholders recognised the potential impact of CPQP and industry leaders began to express their interest in implementation. The industry agreed on the need of a cultural shift from defect detection to defect prevention. This agreement confirmed that the proposal for a standardised and structured process for introduction of new products into the market was well received.

The current industry is ready to embed MMC that contribute to overcoming some common concerns in the construction sector.

Some of these concerns are:

- The current industry performance does not always meet the customer expectation
- The sector does not meet the Government's annual requirement for new housing
- Reworks on site impact profits, add delays and further disruption to clients
- Local and future targets on environmental impact are currently not being met, and
- Inability to utilise repeatability of components leading consequently to fluctuations on quality from build to build.

For a smooth and optimal movement towards this target, we believe the sector should adopt quality assurance tools to develop a structured way of planning and produce first time right component. This should ensure the construction industry can reduce variance and control tolerance for the final products that are manufactured off-site. It would also enable the reduction/elimination of non-value-added reworks on-site.

The aim of the work delivered by the Construction Innovation Hub was to achieve these targets via implementation of the CPQP framework for the off-site manufacturing pioneers that are looking to improve and maintain the quality within their manufacturing process, which should also lower the risk level for the final delivery of the projects. Following the implementation strategy, the team can assess the efficiency of this framework by capturing the industry feedback and the success level.

1.3. CPQP Case Study Partners

BMI Group, MetLase Unipart Construction Technologies and Ecosystems Technologies are the three leading organisations assessing the use of CPQP elements as part of their own NPI process. They are implementing the Failure Mode and Effect Analysis (FMEA) approach within their product design and assembly process to deliver defect free product at the customer expectation level.

BMI Group and MTC

BMI Group and MTC collaborated to create a modular roofing system for use in commercial and industrial. The development of Active Roof as a key sub-assembly of the Hub Platform Construction system has been achieved using an iterative rapid design, prototype, test and validate approach.

Active Roof is built using predominantly off the shelf materials that have been tried and tested with in the construction industry, which insures familiarity by the existing workforce. The key innovation behind the design is the proprietary lifting block system that maximises safety during lifting/handling, allows for accurate positioning and maximises load density per lorry load.

MetLase Unipart Construction Technologies

MetLase specialise in rapidly solving engineering problems by combining laser-cutting, CNC press-brake, and ingenuity, into a system that could rapidly solve a huge class of engineering problems. It is a growing company, whose speed and responsiveness are supported by the engineering pedigree, manufacturing and logistical expertise of their parent companies.

The team have the ability to apply patented techniques, honed in the demanding aerospace industry, to a vast range of problems across all manufacturing sectors and all parts of the value chain, and to do so with speed and precision.

Ecosystems Technologies

Ecosystems Technologies design, manufacture and install high-quality, versatile, modular buildings for residential, education, healthcare, leisure, office and industrial sectors. Ecosystems Technologies is at the forefront of a new approach to delivering a sustainable built environment in response to the climate crisis.

Ecosystems Technologies are creating the conditions where timber innovation can be applied. The key thematic areas within the build environment are Accessibility and Inclusivity, Digital Innovation and Sustainable Design and Manufacturing.

They use design and manufacturing processes that are underpinned by a digital approach that allows them to work efficiently without compromising on quality. Central to this approach is a hierarchical digital twin which enables streamlined workflows and facilitates data-driven decision-making at every stage.

2. Background

2.1. CPQP Introduction

Construction Product Quality Planning (CPQP) is a quality planning process aimed at enterprises that design and manufacture construction products through manufacturing-led approaches. CPQP sits within a wider family of quality management tools and processes that have been developed as part of the Construction Innovation Hub's transformative programme. Together, these tools will help to deliver both quality and safe buildings by strengthening the oversight throughout the entire life cycle.

CPQP supports the New Product Introduction (NPI) process for the development and introduction of new products on the market through a structured process. The NPI process encompasses all new product development activities within an organisation ranging from product definition, through development to production launch.

CPQP is an adaptation of Advanced Product Quality Planning (APQP), which is employed throughout the manufacturing sector on a global scale to effectively 'build in' quality when developing new products. APQP ensures that quality is factored into the entire product development cycle, from concept design through to the full-scale implementation of a manufacturing strategy [2]. The APQP process is then validated through a Production Part Approval Process (PPAP). For the purpose of providing a standardised approach to APQP and PPAP for the construction sector, the Construction Innovation Hub has developed this guide and uses analogous terminology: Construction Product Quality Planning (CPQP) and Construction Production Approval Process (CPAP).

An important development seen in the growth of quality assurance has been the emergence and adoption of risk management. CPQP is a very good example of up-front planning and risk management tools used within product development and manufacturing processes. By using CPQP, products are de-risked which in turn will lead to de-risking the entire construction project.

In the construction industry, there is a new emphasis on the golden thread of information following the recommendations of the Hackitt Review. CPQP will ensure that clear and accurate records about product development, manufacturing and production monitoring are kept and made accessible, ensuring that information persists throughout the whole building lifecycle. Product information and design records will enable higher levels of control that go beyond simple traceability.

Moreover, that information will also support the transformational change that digital technologies are bringing into the construction sector.

3. Methodology

The team at the Hub has delivered a high-level of understanding of the CPQP functionalities as well as its benefits via an early engagement with the pilot partners. This has been achieved by providing access to the CPQP toolset document, relevant templates and presentations developed by the team.

The CPQP implementation process has been refined with the objective of maximising the impact by focusing on the partner's priorities. The refined process ensures that the objective to deliver a high-level of understanding on the implementation of CPQP and, in particular, Failure Modes and Effects Analysis (FMEA) for both design and process are delivered with minimum resource. To this end, a preliminary scope of work and collection of pre-requisites are conducted before a workshop is held to conduct a design or process FMEA.

The steps followed are highlighted below:

1. Scope of work

- Provide Introductory session on CPQP (1 hour presentation). Support client to gain understanding on elements/tools within CPQP that may be useful to pilot.
- Allocate time to receive an introductory session on clients NPI program and promote further discussions on their specific needs.
- Visit to their manufacturing plant to observe

their manufacturing process.
- Conduct gap analysis of client NPI against CPQP.
- Propose a single CPQP element and tool to pilot considering client NPI program and time constraints.
- Ensure key pre-requisites to pilot a specific tool are considered and evaluated with client.

2. CPQP Implementation

- Provide client with In-depth training via a workshop on the specific element and tool selected.
- Support client with strategies to engage workforce in the new process.
- Support client with strategies to implement specified tool.
- Support client to engage and prepare entire participant group.
- Support client in dedicated workshop to train on first use of the tool.
- One 4-hour workshop on applying the specified tool.

Due to time constraints, some of the above activities were merged and conducted over a single full day workshop. The time constraints for this project further showcase how efficiently the training and workshop could be conducted.

4. Case Study

This section aims to summarise and present the most relevant highlights of the CPQP implementation by reporting what worked well and supported the partner in the process of developing and introducing a new product. The highlights showcased below are the results of the implementation methodology presented in the Methodology Section.

4.1. Active Roof Cassette

PFMEA was conducted on the Active roof cassette system developed as part of the Construction Innovation Hub Sandpit project with BMI and MTC.

Pre-requisites necessity:

The process was outlined as a pre-requisite to populating the PFMEA. This provided the learning to ensure you can populate the critical items and key characteristics of the process that need to be controlled.

The Hub team actively engaged with the partner's team prior to workshop to ensure the pre-requisites are captured from the design risk elements. The Active Roof team were diligent and had prepared beforehand.

Process flow requirements for PFMEA:

To support this process, the Active Roof team already had a process flow diagram (CPQP guidelines available). The process flow available was robust and streamlined our ability to progress through the workshop. The steps highlighted in the scope of work were key to the efficient approach to populating the PFMEA.

Collaborative nature of FMEAs:

Population of the PFMEA around the holding blocks and structural load points induced longer conversations on best practises. These moments during a PFMEA really highlighted how the collaborative nature of performing any FMEA drives the reduction in risk but also introducing best practises for future products.

FMEA population training:

When populating any FMEA, it's imperative that the steps to populate the columns are followed. We have seen numerous attempts where populating across the columns and moving on before populating the "Recommendations" section yields poor commitment from the group. The Hub Team ensured correct population of the FMEAs were followed which provided motivation for those involved.

It's essential that the team realise the importance of providing practical options for corrective actions and nominate an action owners and target completion date. This section of the FMEA ensures the efforts to understand the risk associated with a process or component are followed and therefore reduce the

risk. The "Action results" section then provide an opportunity to numerically assess the lowering of a given risk and provide the ideal opportunity to showcase the benefits of conducting FMEAs.

FMEA scoring system:

Utilisation of the scoring system for Severity, Occurrence and Detection tend to be a point of discussion and can sometimes become a distraction. Using the presentation on FMEAs, created by the Hub team, alleviates this issue by providing a process map of how to classify correctly. More information is available on the Construction Innovation Hub website, here.

4.2. MetLase Unipart Construction Technologies

A DFMEA was conducted on their bespoke structural beam product to support the industry in driving efficiency and development in modern manufacturing led approach to building components.

Product Checklists:

Specific product checklist recommendation were born out of DFMEA risk assessment. The team quickly realised the importance of creating checklist items for the product under consideration.

Book of Knowledge:

The FMEA recommendation actions saw numerous occasions where the need for a "Book of Knowledge" to capture the extensive knowledge held with the experienced design engineers. The was a common theme across the three case studies.

Interface FMEA:

The team highlighted the duplication issues related to specific items and the Hub team suggested the need to consider interfaces in either a separate section of the FMEA template or consider and specific interface template.

Peer reviewing recommendation:

The robust processes already in place highlighted the low risk associated with their beam product. As a result, some of the recommended actions was simply to ensure SMEs peer reviewed the structural loading quality checks. This added another layer of protection, ensuring the quality of the product was delivered.

Clash Detection Systems:

The MetLase team ensured the independent checks and secondary human check points provided a low Risk Priority Number (RPN) score (below 30). With a possible max RPN score of 1000, this number is very low. Even though the team realise the risk is very low, an additional clash detection automated system was considered for recommended actions. This provides insight on how quality centric the MetLase team is.

Drawing Requirements:

The DFMEA revealed risk associated with point loading failures that were currently controlled by verbally working with customers. To reduce this risk further, additional requirements were going to be embedded in the fabrication drawings to ensure there was a clear understanding of the correct usage of the product.

4.3. Ecosystems Technologies:

A PFMEA was conducted with the Ecosystems Technologies team.

Key roles identification:

Key roles needed for FMEA were identified quickly. This was an important step as a small business needs to ensure the experienced individuals within the business were quickly highlighted for the FMEA workshop.

Process Mapping (pre-requisites):

Ecosystems Technologies went through a thorough process improvement exercise prior to the PFMEA study. This yielded many benefits when performing a PFMEA:

1. Were able to produce process maps for all manufacturing processes. This was a huge benefit when conducting a PFMEA as the critical process steps can be extracted from the process map quickly.
2. Verified the new processes put in place have lowered the process risk associated with their manufacturing platform.
3. Following through with the PFMEA identified that their new processes were working well and validated the efforts taken by Ecosystem thus far.

Collaboration across the business:

Ecosystems Technologies have recently gone through a recruitment phase.

Finding the time to bring the new members together with the wider team does not always occur immediately. The nature of CPQP and the FMEA workshop facilitated this opportunity to bring the relevant team members across the organisation together. A further benefit was the clear identification of the core responsibilities for each team member associated with the risks in their processes.

CPQP Templates:

The Ecosystem Technologies team quickly realised the processes set out in CPQP are followed by the individuals in their respective teams. The templates associated with the workshops (particularly for FMEAs) provide a structured format behind these processes and support the need to digitise their risk assessment in line with the golden thread initiatives. This showcased the practical benefits of implementing a quality planning processes such as CPQP.

Efficient delivery of workshops:

Due to time constraints, it was not possible to ensure the pre-requisites needed for workshop were collected prior to the PFMEA workshop. However, this did not delay the commencement of the workshop, as providing the necessary training in the morning allowed quick extraction of the population of the process steps.

5. Conclusions

The collaboration with all three case study partners focused extensively on the implementation of Failure Modes and Effect Analysis procedures. The team worked on efficiently implementing both Design and Process FMEA procedures that would avoid in-group biases, have the right level of information granularity and objectively score/rate failure modes.

Some of the key highlights across all three collaborators were how the hub team supported the teams in following through with a structured approach on the population of the FMEAs.

When conducting the DMFEA, the team quickly concluded that a Book of Knowledge was needed. This not only provides a safer product, but safer future products. Equally important is capturing this knowledge reduced the business risk associated with loss of staff.

A key theme seen across the case study partners was the improved internal communication of risks between technical and non-technical staff. A consequence if this was setting the seed for cultural change on risk prevention and challenging the status quo.

As with the previous case study implementation, emphasis was placed on understanding and processing customer’s need to ensure that the workshop provided the best possible chance of future workshops without the assistance of the Hub team. This was done by ensuring that the right FMEA population strategy was in place prior to commencing.

By performing dedicated training session and the workshop on the same day, ensured the collaboration team members were ready to participate in the workshop. This exercise highlighted how the Hub team themselves have taken on board the lesson learnt from previous deployments and embedding efficiency in implementing these crucial elements of CPQP.

The outcome of the implementation of the CPQP tools was successful and the target objectives were achieved. It provided the partners with the required knowledge and experience to continue applying the CPQP tools in their processes and design, reducing risks and further enhancing the quality and safety of their products. It shall lead to improved customer satisfaction and raised awareness of the benefits of off-site construction and CPQP for future applications.

6. Bibliography

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Disclaimer

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The Construction Innovation Hub is a consortium between:

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