

THE BRIDGE BETWEEN CONTRACTORS AND CONSULTANTS

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ABSTRACT

For the past five years, I have been working as an employee of EIC Activities (a member of the CIMIC Group) as an in-house geotechnical engineering advisor providing technical support to CIMIC Group companies. This is a non-traditional role for a design engineer in the Australian civil infrastructure industry, as most design engineers work for consulting firms operating independently from construction companies and are engaged in project-specific contracts. Being in this unique role has allowed me to understand the operations of contractors, while building upon my technical skills acquired in the previous stage of my career as a geotechnical engineer in a more traditional role within a consulting firm. The perspectives I have gained from both forms of engagement have allowed me to effectively form a bridge between contractors and consultants.

One of the primary objectives of my current role is to contribute to creating value and minimising risk on projects and tenders. This objective influences the behaviours and approaches I take in my role. Using a number of case studies, this paper will discuss some of the actions and mindset my colleagues and I have adopted to fulfil this objective whilst bridging the contractor-consultant gap.

Innovation projects take place in addition to our existing project commitments to advance our knowledge in the pursuit of value creation and risk minimisation in the long term. Some innovation projects involve funded partnerships with universities to undertake research into challenges on construction projects. Such collaborations facilitate much needed dialogue between universities and the industry, and further cements our role as a bridge, in this case, between construction and academia.

1 INTRODUCTION

Conventional design and construct (D&C) contracts for large civil infrastructure works involve a head contractor signing an agreement with the Principal “project client” as the party bearing full responsibility for implementation of the project contract. The engineering skillsets required to implement such large-scale contracts are vast. Construction engineers or contractors will manage all aspects of delivery including, logistics, program management, and the physical construction of a project. Contractors frequently engage technical consultants to support delivery and address technical needs.

Conventional contractor-consultant engagements for D&C contracts in the civil infrastructure industry are formed on a project-by-project basis, whereby the consultant provides expert technical services to the contractor in a pre-negotiated, fee-for-service model. In return for the fee, the consultants’ deliverables will be in the form of design recommendations and advice documented within reports and construction drawings. This engagement structure is drawn up diagrammatically in Figure 1 for D&C contracts. Note this paper focuses on D&C contracts only. Construct only and alliance type contracts will not be discussed.

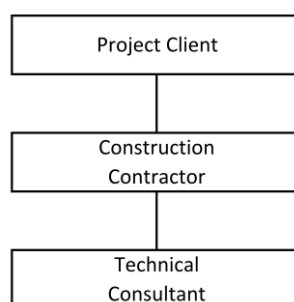


Figure 1: Conventional engagement model between contractors and consultants in “design and construct” contracts in Australian civil infrastructure industry

For the first ten years of my career, I was employed as a geotechnical engineer in consulting firms based in New Zealand and Australia. For large-scale projects, all consultant engagements with contractors were established in a similar format to that shown in Figure 1. This model is largely adopted on major civil infrastructure projects in Australia. From these projects and engagements I established the building blocks of my technical expertise.

I have since transferred away from conventional consulting firms, and for the last five years, I have been working with my current employer, EIC Activities (a member of the CIMIC Group), tasked with a geotechnical specialist advisory role. As in-house technical advisors, EIC Activities partner with CIMIC Group companies comprised of CPB Contractors, Leighton Asia, UGL, Thiess, Sedgman, Broad and Pacific Partnerships to provide engineering and technical advice and services. This engagement format is illustrated in Figure 2.

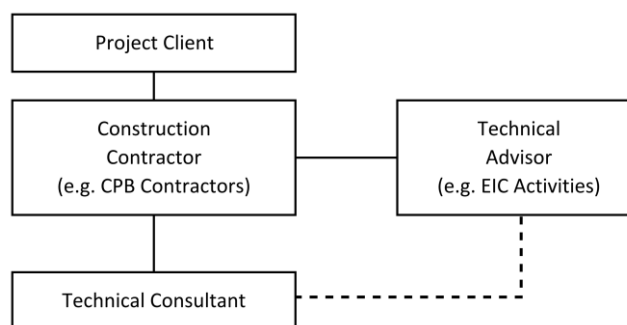


Figure 2: Engagement model with in-house technical advisor role supporting contractors

This paper will describe how I approach my unique role as an in-house technical advisor, allowing me to effectively form a bridge between contractors and conventional technical consultants to establish successful outcomes. I will be using a number of case studies to illustrate my perspectives.

2 PURPOSE OF TECHNICAL ADVISOR

As the party responsible for the implementation of a project, contractors have an obligation to ensure technical design solutions align with their motivators, such as constructability, cost, program and safety.

My role as a technical advisor is to facilitate design reviews with the contractor's core values and motivators in mind. I provide geotechnical expertise to support the contractor in ensuring the technical aspect of design and constructability are covered, allowing for a more holistic assessment of the solution from the contractor's perspective

Ultimately, the engineering and risk mitigation expertise provided by technical advisors, such as EIC Activities' is intended to provide contractors, such as CIMIC Group, with a competitive advantage for winning and delivering profitable projects that also generates value for clients.

3 GOALS OF TECHNICAL ADVISOR

3.1 VALUE CREATION AND RISK MITIGATION

One of the primary functions of technical advisors is to work alongside our contractor partners to create value and mitigate risk to establish a competitive advantage for winning and delivering profitable projects. Value creation can be defined as improving cost efficiency and can be realised through many avenues such as challenging assumptions, optimising whole-of-life solutions, using innovation to drive efficiency and productivity, and improving outcomes across the project and asset lifecycle in partnership with our contractors .

However, our motivations are not limited to reducing quantities and sizes to minimise expense. As geotechnical professionals we operate in a high-risk industry with many variables and unknowns. Being able to appreciate geotechnical uncertainties and construction constraints allows me to identify and quantify risks, thereby achieving the goal of "risk minimisation". Further, to attain the goal of project profitability one cannot focus solely on short term gains during the construction timeframe, but also potential risks in the long-term project life beyond the immediate construction and delivery.

3.2 COLLABORATION

The pursuit of value creation and risk mitigation is not a unilateral exercise which can be attained by the technical dimension alone. The true value of technical advisors is the ability to collaborate and integrate technical perspectives with the motivators held by the contractor to establish an optimal solution.

For example, I am often requested by contractors to provide a second opinion or alternate solution to existing designs. Upon receipt of the request, I will often seek clarification about the construction constraints, be it constructability, program, or budget and apply my technical design skills and experience to conduct an independent assessment. I will then engage in collaborative sessions with the consultant where we share our insights and opinions on the technical solution and construction constraints. This process ensures the solution generates the greatest value based on the motivators driven by the contractor.

Teamwork mentality is important to adopt with all the individual parties, including contractors and consultants. The purpose is not to find fault with others, but to provide the contractor with all the necessary tools to assess the solution from a technical perspective and foster dialogue between the technical design consultants and contractors.

Engineering design and construction of large-scale infrastructure is a significant and complex undertaking and it is important that all perspectives are considered. Often, as individuals we may not know all the limitations and earlier discussions which influenced the design to land where it has. It is our role as technical advisors to gather all the pertinent points and perspectives and bridge the technical expertise with the construction and design know-how to get to a best-for-project solution.

4 CAPABILITIES OF TECHNICAL ADVISORS

4.1 KNOWLEDGE AND EXPERIENCE

The fundamental requirement of a technical advisor is to have expert skills and knowledge in the appointed subject to complement the existing technical capabilities of a contractor.

However, technical skill alone will not suffice. Experience plays a large part in a technical advisor's role. It is the *integration* of technical solutions with the contractor's core engineering motivations to balance budget, program, risks and safety, which is paramount to the delivery of an optimal solution. For example, often, the most economical solution may not be feasible due to access constraints or program limitations. Experienced engineers have greater appreciation for the implications and integrations with stakeholders due to experience. Asking the right questions to uncover constraints is often key to finding the optimal solution, and that comes with experience.

It is for this reason, that the majority of the sector leaders performing advisory roles tend to have more than 25 years of experience, and are supported by a "top-heavy" structure, i.e. a large number of principal or senior engineers with 15 to 20 years of technical experience, each with their individual specialist areas of expertise, such as finite element modelling, seismic design, dam engineering, soft soils etc. An example of this is observed at EIC Activities.

4.2 CONSULTING BACKGROUND

In a similar fashion to my own career path, many of the technical advisors at EIC Activities have a background in consulting. Thus, we are familiar with the design processes, challenges, drivers and motivators held by most consultants. With this knowledge and our unique positions as technical advisors, we are well equipped to facilitate discussions around technical solutions between consultants and contractors.

5 MODES OF ENGAGEMENT

5.1 GENERAL

From my experience as a technical advisor, engagements on projects are varied and I am required to respond to the evolving needs of the business. For example, EIC Activities' technical advisory engagements and outputs vary substantially between each task.

I am often advising on numerous projects at one time, and the duration of my involvement may vary from a few days to a few months, sometimes more. The nature of my engagement is dynamic – I can be called upon to rectify issues quickly, or I may have a long-standing involvement on a project to undertake reviews on each design package. Technical advisors

can be engaged at all stages of a project, from the pre-tender stage through to construction and delivery. The duration and style of engagement will be guided by the needs of the contractor thus our response must be flexible to meet varying demands. The list below outlines the various modes and nature of engagement as a technical advisor.

- **Value engineering workshops.** In the early inception of a project, such as expression of interest (EOI), tender or commencement of detailed design, I have been requested to participate in value engineering workshops with a contractor where high-level discussions around alignment, and large-scale opportunities and risks are identified. These sessions allow the team to establish a holistic understanding of the most critical constraints and challenges on the project.
- **Design review.** At any stage during tender I may be requested to undertake high-level or detailed reviews of geotechnical related drawings or reports prepared by the design consultant. In this capacity, the contractor is typically expecting a check to ensure designs have been carried out in accordance with the specifications, and to identify potential opportunities or risks.
- **Ad hoc requests.** Ad hoc requests from contractors occur frequently. These will usually be initiated by the contractor who may be seeking additional technical insights and exploring whether the design is optimal or whether the solution carries excessive risk
- **Design management.** While I have not experienced this role myself, some technical advisors at EIC Activities are appointed by the contractor to perform design management duties on individual projects. This role allows us to have greater involvement throughout the design process.

6 APPROACH TO TECHNICAL ADVISOR ROLE

Some of the approaches technical advisors adopt are summarised below.

6.1 CONCEPTUAL FOCUS

As technical advisors, the success of our input can usually be achieved by interrogating conceptual design methodologies from a high level rather than undertaking an in-depth review. For example, if asked to challenge the design of a 500-metre-long retaining wall, a technical advisor may only undertake one or two independent assessments involving the critical wall heights and / or worst-case ground conditions. If the difference between the independent assessment and the original solution are significantly different, one would engage in discussions with the contractor and design consultant to understand the source of the differences and suggest whether a compromise or change to the solution would be required or accepted. In this example it is not necessary for the technical advisor to interrogate every drawing and design section along the 500m wall in detail; if the desired outcome is achieved by reviewing one or two critical sections, there is no need to review any more.

6.2 CONCURRENT DESIGN

One of the key imperatives of the consultants and contractors during the delivery phase is to settle on a workable design solution and progress it to completion as quickly as possible. A technical advisor's role is to explore potential alternative designs that can then be compared to the initial solution without disrupting the development of that initial solution. If the alternative proves to be better, then a change can be made. If not, then the design program is not affected.

So as not to hinder the delivery program, I will develop my alternatives concurrently, as the consultants develop and document their solutions. An example of concurrent design is shared in Section 7.1 below.

6.3 ALTERNATIVE PERSPECTIVE

In my role, I establish alternative perspectives for both the contractor and consultant and initiate dialogue towards solutions which would not have otherwise occurred. The contractor and consultant often have their own differing perspectives and by developing an understanding of both viewpoints, I am able to act as a bridge between both parties, as shown in the example documented in Section 7.2 below.

6.4 RISK BASED DESIGN

Very often, engineers are compelled to develop innovative solutions and / or multiple options for the purpose of assessing the cost variance between the differing options. However, there are instances where the pursuit of reducing costs will result in increased risk. There is an art to striking a fine balance between these two seemingly opposing set of motivators. As a technical advisor, I have developed alternative solutions and options for contractors which vary depending on the contractor's risk appetite. The risk assessment process involves the contractor being presented with a full set of the associated facts, opportunities and risks for each option which allows them to choose the most suitable

solution. This has allowed me to present more aggressive (cost effective, but higher risk) solutions when it comes to less critical works, such as smaller temporary works, but all solutions I present must ensure that the contractor is not exposed to undue risk and all safety requirements are met. To minimise the potential for unwanted consequences, the author develops contingency solutions in the event the risks are realised.

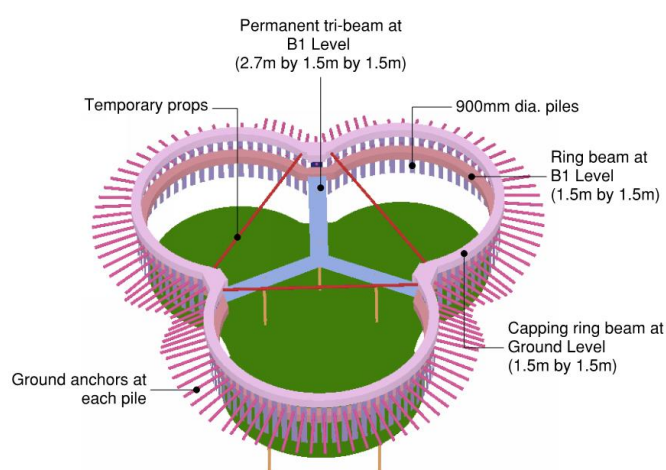
6.5 CONTRACTOR CONFIDENCE

The contractor's ultimate aim is to construct the most cost-effective and safe design which meets requirements. If upon review, technical advisors find no changes are necessary to the existing design solution, the contractor may be satisfied with this outcome, considering their advisors have provided them with confidence around the existing solution.

7 CASE STUDIES / OUTCOMES OF TECHNICAL ADVISOR APPROACH

7.1 CASE STUDY 1 – TRIFOLIATE SHAPED SHAFT OPTIMISATION

On the WestConnex M4 East project in New South Wales, EIC Activities were approached by the construction joint venture (CSJJV, CPB Contractors, Samsung and John Holland) to investigate the feasibility of optimising a ventilation shaft design in order to optimise program. The 60-metre wide by 47-metre deep shaft comprised an amalgamated form of three circular shafts, forming a trifoliolate shape as shown in Figure 3.



(a) EIC Activities' PLAXIS 3D model



(b) Aerial image of shaft construction

Figure 3: Trifoliolate-shaped ventilation shaft for WestConnex M4 East

The original retention solution proposed by the technical consultant included 900mm diameter reinforced concrete piles supporting the upper 10 metres of residual and medium strength rock, supported by two layers of temporary props and ground anchors in the short term. For the long term, permanent concrete tri-beams measuring 2.7 metres wide by 1.5 metres deep were proposed in place of the temporary props, at the ground level and at B1 level.

Given the shape of the shaft, it was clear that opportunities to optimise the strutting solution could be realised if three-dimensional soil-structure interaction modelling was adopted. However, the time and resources needed to undertake such modelling would be time consuming – and the benefits could not be quantified prior to the analysis.

Consequently, EIC Activities began pursuing alternatives using three-dimensional model simulations as construction continued to progress based on the original design. EIC Activities simulated the trifoliolate structure in three-dimensional finite element software PLAXIS 3D, which allowed soil-structure interactions to be captured within this distinctly three-dimensional structure. Refer to Figure 3 for an illustration of the PLAXIS 3D model. Back analysis methods were used to calibrate the results of the three-dimensional model with those observed on site. The results from the three-dimensional

modelling concluded that the permanent tri-beam at ground level could be eliminated without any negative impact on the already-constructed elements and future structure.

This solution was not adopted due to program limitations, as the design change necessitated another round of lengthy design reviews. Nevertheless, this example demonstrates the benefits and potential opportunities which a technical advisor can provide without derailing an existing design schedule

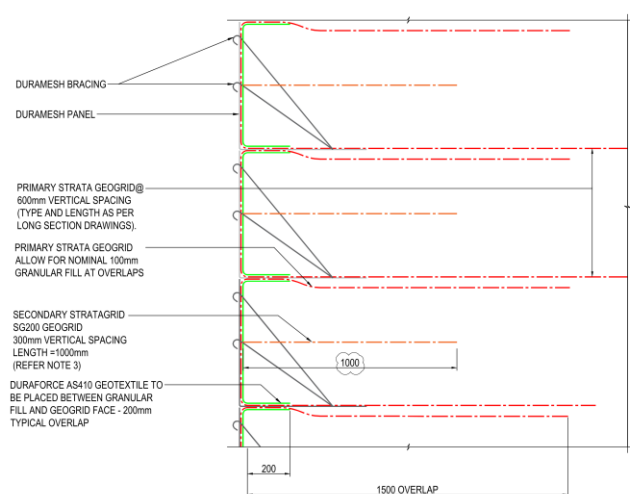
7.2 CASE STUDY 2 – MECHANICALLY STABILISED EARTH WALL CONSTRUCTION

On the Baypark to Bayfair Link Upgrade project in Tauranga, New Zealand, the consultant requested the contractor to remove a partially constructed MSE (Mechanically Stabilised Earth) wall, as the vertical spacing between the installed geogrid layers had exceeded the maximum vertical offset stipulated in the drawings by 100mm. The contractor raised an RFI (Request for Information) requesting the wall be accepted “as-is” as the deviation was considered to be within allowable construction tolerance. The consultant maintained the wall be taken down and re-built as the design solution was sensitive to the vertical offset. An example of an MSE wall on the project is shown in Figure 4.

I was contacted by the contractor for my opinion, whereupon I reviewed the design calculations in detail to assess the governing factors and elements of the design. I found that the “sliding” failure mechanism was governing the solution, and the consultant’s comments were justified – the calculations showed little to no room for exceedance of the vertical geogrid spacing. However, I also recognised the resistance to “sliding” failure was also contributed to by the *length* of the geogrid upon which the sliding mechanism would occur. In my experience, installed geogrid lengths on site were likely to exceed the prescribed minimum design lengths as contractors tend to install beyond the minimal lengths to minimise handling and cater for rounding errors.

I confirmed my assumptions with the contractor and reviewed the as-built geogrid lengths which were found to exceed the minimum design lengths by up to one metre. Armed with this information, the contractor presented my findings and records of the as-built geogrid lengths to the consultant, who retracted the request to rebuild the MSE wall.

This example demonstrated the benefit I was able to provide through bridging the design considerations of the consultant and constructed conditions by the contractor.



(a) MSE geogrid drawing detail



(b) Partially constructed MSE wall

Figure 4: MSE walls on the Baypark to Bayfair Link Upgrade project

7.3 CASE STUDY 3 – DRIVEN PILE SPECIFICATIONS

Construction of the Waikeria prison facility in New Zealand involved the installation of over 3000 units of 20-metre-long closed-end circular driven piles. A trial procedure including 22 piles spread across the site was undertaken with dynamic testing prior to production. The purpose of these trials was to establish the pile acceptance specification during production, such as a minimum target end-of-drive (EOD) set of 9mm. During production, the achieved end-of-drive sets for most of the piles were significantly higher than those recorded during the trial procedure, thereby failing the pile acceptance criteria. The consultant requested additional restrikes and pile tests, such as dynamic testing and pile wave analysis to verify the supporting capacity of the installed piles. All the additional testing proved the piles had the required capacity.

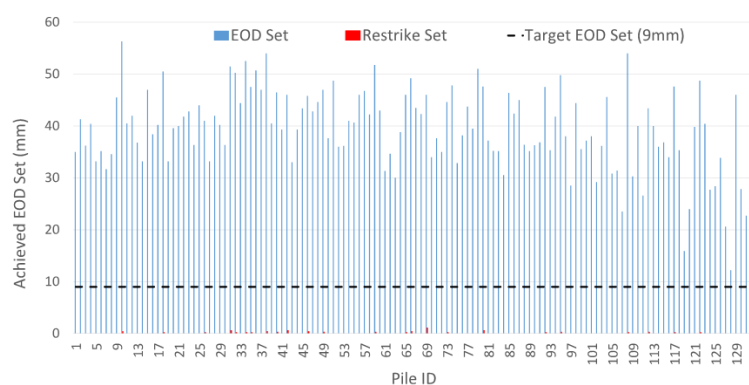
However, the time taken to undertake the additional restrikes and tests caused significant delay to the contractor's tight construction program.

I was requested by the contractor to review the situation and expedite the process. Initially, it was difficult to comprehend why all the piles were failing the acceptance criterion established during the trial procedure – the trial piles had been strategically located to cover most of the site, in an effort to capture varying ground conditions. The same piling crew had been engaged to undertake the trial piles and production piles; we interrogated the production piling records which were installed immediately adjacent to trial piles and there were no obvious differences between the piles, yet their achieved end-of-drive set differed substantially. At one location, the achieved end-of-drive set was 1.7mm for the trial pile and between 16mm to 40mm for the surrounding production piles.

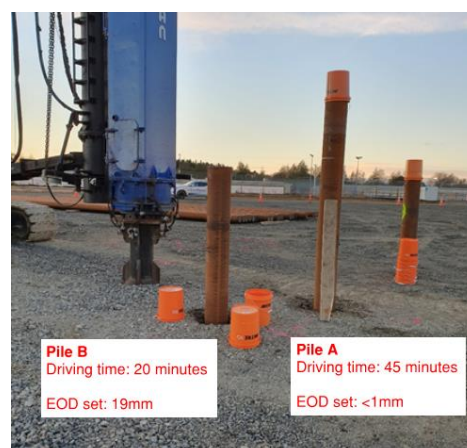
Upon interrogation of the piling records, I noticed one observable difference between the production piles and trial piles – the driving times for the trial piles were substantially longer. On average, the production piles were installed in 13 minutes, versus 39 minutes for the trial piles. A slower rate of advancement was implemented during the trial procedures, as the piles were tested at multiple stages during the course of installation. By contrast, the no tests were undertaken on the production piles, until the desired termination level had been reached.

Despite the difference being only a matter of minutes, I postulated the difference in driving time had allowed the ground to achieve greater set-up i.e. increased pile capacity due to pore pressure dissipation, during the trial procedure. To verify this postulation, I requested the construction team drive two separate piles immediately adjacent to each other on site at a number of locations, each of identical length and size, but at varying installation rates. At each of the test locations, the piles driven at a slower rate achieved significantly smaller sets. For example, at one location, shown in Figure 5, Pile A was installed over 45 minutes, and Pile B installed in 20 minutes. The achieved EOD at the target pile length was <1mm and 19mm respectively. Thus, I concluded the reduction in driving time during production had not allowed the same degree of setting-up to occur as that during the trial procedure, causing the production piles to “fail” the acceptance criteria.

Once the discrepancy had been identified, I collaborated with the consultant to establish a revised set of pile acceptance criteria, including increasing the end-of-drive set to 16mm, which was tailored to the actual rates of installing the production piles. The revised criteria allowed a greater proportion of the piles to be approved without necessitating additional testing to verify the supporting capacity of the pile. Construction was able to progress at a quicker rate, much to the contractor's satisfaction.



(a) Summary of achieved EOD set for a building illustrating achieved EOD sets >>9mm



(b) Comparison of achieved EOD sets between piles installed at different rates

Figure 5: Waikeria Prison driven pile records

8 INNOVATION PROJECTS

Innovation projects take place in addition to our existing project obligations at EIC Activities to advance our knowledge in the pursuit of value creation and risk minimisation in the long term. Some innovation projects involve funded partnerships with universities to undertake research into existing challenges on construction projects. Such collaborations

facilitate much needed dialogue between universities and the industry, and further cements our role as a bridge, now between academia and construction.

For example, I am currently working on a research project in collaboration with University of Technology Sydney (UTS). The project was set up to investigate landfill behaviour due to the increasing number of projects involving construction around and upon existing landfill sites.

The innovation project aims to establish a more reliable set of testing procedures and variables for landfill engineering design and predictors of landfill behaviour. One aspect of the research involves the collection of landfill samples from a project site in NSW for testing in the university laboratory. Whilst on site, a large embankment has been constructed on the landfill and its performance is monitored closely with an intensive instrumentation schedule. The results of the laboratory testing will be compared against the site records to verify the reliability of the developed parameters established in the laboratory.

9 CONCLUSIONS

As an in-house technical advisor for a group of construction contractors, I use my technical experience and background to complement the contractor's existing capabilities such that holistic assessments can be made and optimal solutions can be developed. The main driving force in my role is creating value and minimising risk to the client and contractor so they are better able to achieve their outcomes. The mindset I adopt in my role is one of collaboration and teamwork with all the individual parties, including contractors, consultants and universities. My purpose is to foster dialogue between the technical design engineers and construction teams. I see myself as part of a team working towards a common goal of creating a successfully engineered structure. My role is to bridge technical expertise with the construction and design know-how to get there.

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