13th Australia New Zealand Conference on Geomechanics – Acosta-Martínez & Lehane (Eds.)

Role of the geotechnical engineer in a Delivery Partners' team delivering a major infrastructure project - case example from Woolgoolga to Ballina Pacific Highway upgrade

S. Aryal
WSP Australia

D. Groth
Roads and Maritime Services NSW

ABSTRACT: This paper introduces key specifics of geotechnical services, expected from the role of a geotechnical practitioner, who is part of a DP project delivery team, explains the need for the services requirements within the DP scope and describes the types of geotechnical inputs at various stages of the project. It further demonstrates how geotechnical capability within the DP team can add significant value at each phase of the project development. The paper also presents some perspectives of how the role of a geotechnical team within the DP delivery team can influence the success of the project delivery and what challenges can be faced by the geotechnical engineer in doing so over the course of the project. The paper captures some of the lessons learnt that can be of benefit for those involved in the provision of geotechnical services under similar contracts in the future.

1 DELIVERY PARTNER MODEL

The Woolgoolga to Ballina Pacific Highway upgrade (W2B) is being constructed under a delivery partner model. Pacific Complete, a joint venture between Laing O'Rourke and WSP, was appointed in April 2015 as the Delivery Partner (DP) responsible for the delivery of W2B in partnership with Roads and Maritime Services (RMS).

A delivery partner model is a relatively new project delivery framework for Australia and is based on the model to deliver the London Olympic Games. The DP involves a partnership between the client and engineering design, construction and management industry stakeholders to deliver a large project.

The DP is engaged by the client and responsible for managing all facets of the project delivery including procurement of design and construction services; management of commercial and contractual aspects; and all statutory obligations and commitments, ensuring the project is delivered on time, budget and quality.

2. THE PROJECT

2.1 *Background*

The Woolgoolga to Ballina Pacific Highway upgrade (W2B) is jointly funded by the Australian and NSW governments and comprises the 155km upgrade of the existing two-way Pacific Highway to a dual carriage-way configuration. The DP is responsible for 126km between Glenugie and Ballina. The 24km between Woolgoolga and Glenugie was opened to traffic in 2018. When completed the Pacific Highway will be a continuous dual carriageway from Sydney to Bris-bane.

The 155km long spread of the project site is divided into 11 sections. Excluding section 1 and section 2 between Woolgoolga and Glenugie, the remaining sections are grouped into four portions. These comprise:

- Portion A – Consisting of sections 3 and 4, from Glenugie upgrade to Maclean.
- Portion B – Consisting of sections 5 and 6, from Maclean to Devils Pulpit.
- Portion C – Consisting of sections 7, 8 and 9, from Devils Pulpit to Richmond River.
- Portion D – Consisting of sections 10 and 11, from Richmond River to Ballina Bypass.

The details of the portions and sections are illustrated on a location plan included as Figure 1. The route crosses two major rivers: Clarence River at Harwood and Richmond River at Broadwater. The bridges over these rivers are identified as a separate standalone delivery package each and named Portion E and F respectively. The last remaining section over soft soil treated sites at the southern end of Ballina Bypass is also added to the scope of W2B and identified as Portion G.

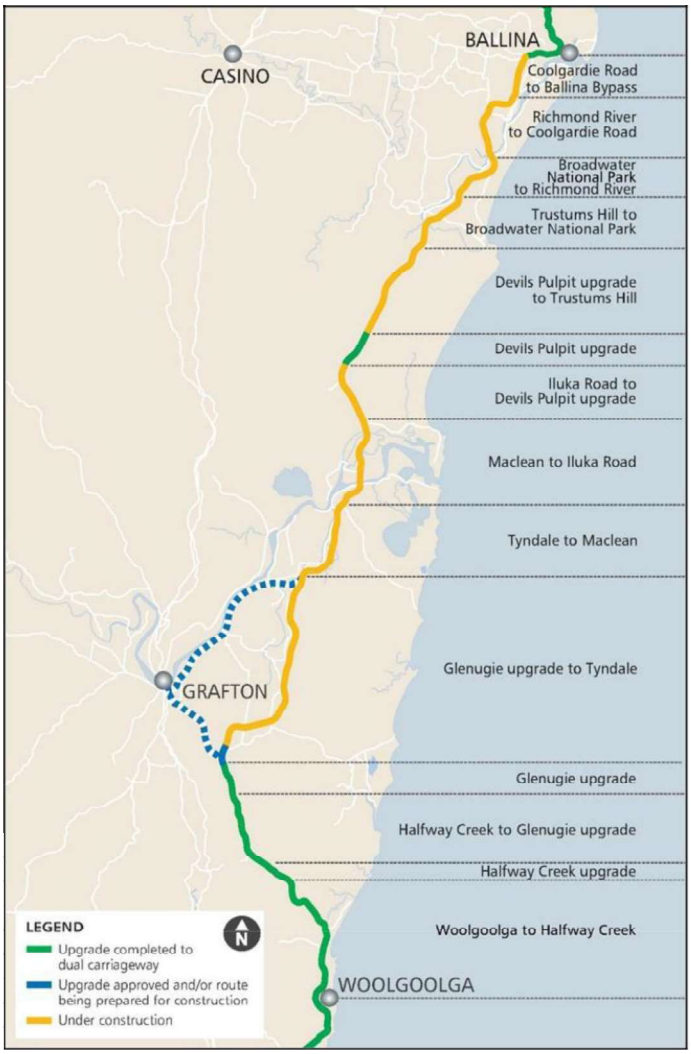


Figure 1. W2B Project location plan

2.2 *Geotechnical services requirements*

Key elements of the project that require geotechnical advice for design and construction include the following:

- 14 million cubic metres of earthworks
- 80 cuttings with a maximum depth of up to 33 metres.
- 174 embankments with a maximum fill height of 15m.
- A combined total of 130 interchange ramps, local roads and service roads.
- In excess of 100 bridge sites
- 110 hectares of soft soil sites over 26 kilometres cumulative route length with 300 individual soft soil embankment sites with compressible ground up to 23 metres thick
- Drainage culverts at approximately 484 locations comprising both pipe and box culverts.

The requirements of project services from the Geotechnical Team to its internal and external stakeholders are schematically expressed in Figure 2 and Figure 3 for the design and construction phases respectively.

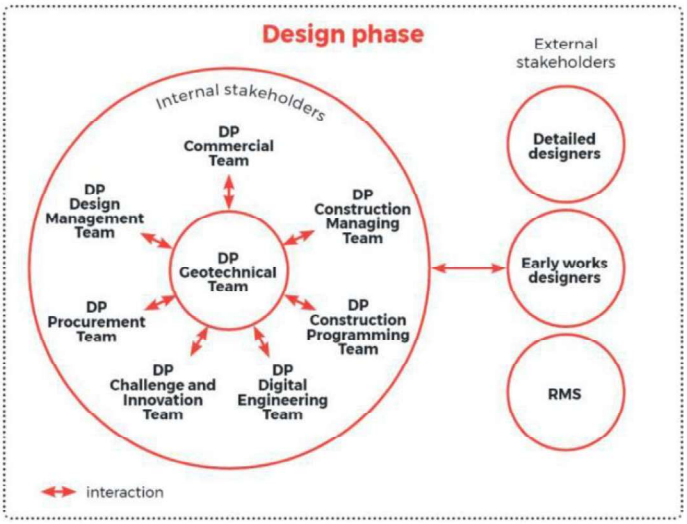


Figure 2. DP Geotechnical Team's services requirements (Design phase)

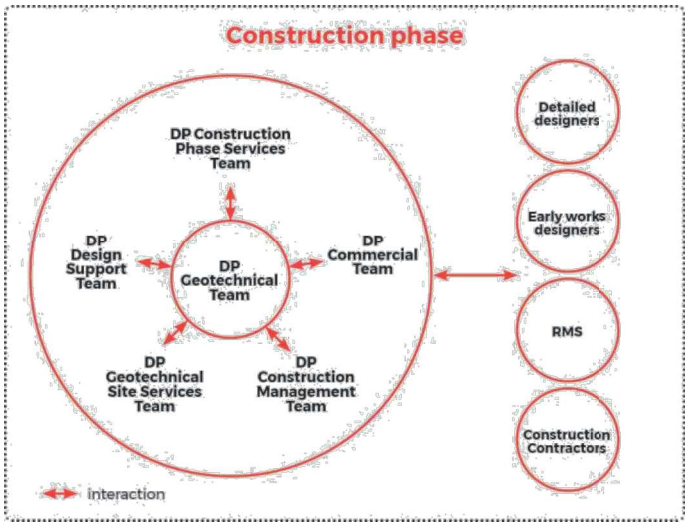


Figure 3. DP Geotechnical Team's services requirements (Construction phase)

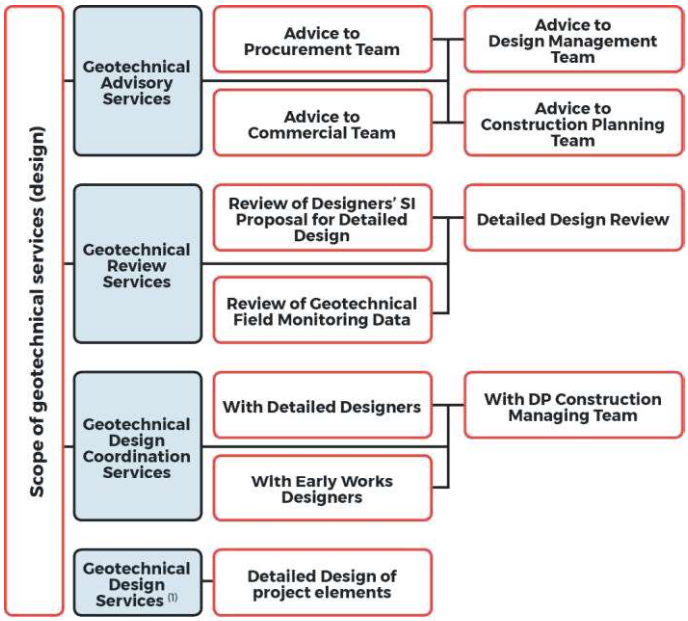
2.3 *Geotechnical Services scope structure*

2.3.1 *Design phase*

Figure 4 illustrates the scope of the geotechnical services from the Geotechnical Team within the overall DP management structure.

2.3.2 *Construction phase*

During construction phase, the setting of the scope of Geotechnical Team within the organizational management structure is represented in Figure 5.



(1) by exception and a variation of DP contract

Figure 4. Scope of DP geotechnical services in design phase

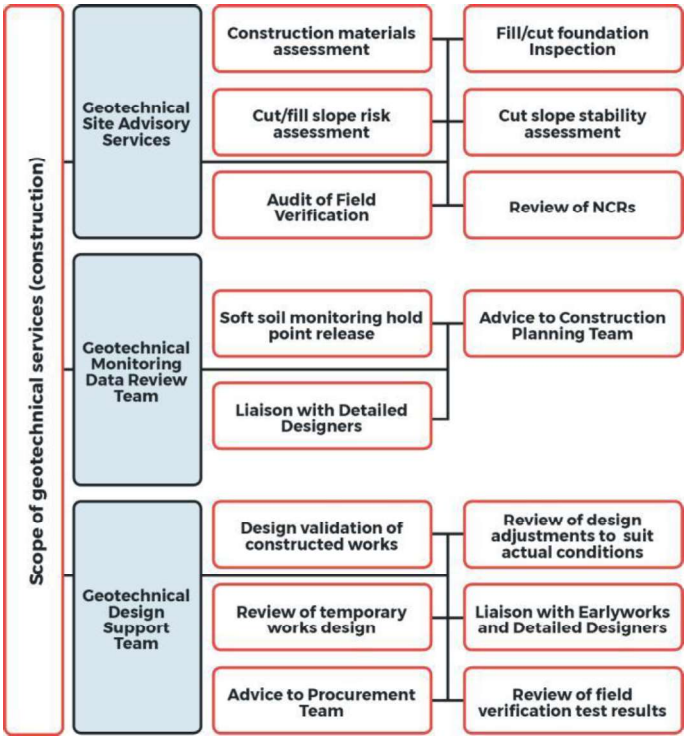


Figure 5. DP Geotechnical services management structure in construction phase

2.4 *Role and responsibilities of geotechnical team*

The following listing captures key roles and responsibilities of the geotechnical team within the W2B DP:

- Providing geotechnical advisory services to the entire project with respect to detailed design and construction phase geotechnical support for all 7 major design and construction portions as summarised Table 1.
- Geotechnical review of detailed design packages at all design development stages from the concept to final designs developed and submitted by the detailed design consultants for all packages and contracts
- Challenging detailed design produced by the detailed designers to achieve the best value for the project
- Ensuring consistency of application of design criteria, technical depths and input on geotechnical design and advice from all relevant services providers
- Advice/assistance to the detailed designer during the design development phases as a representative of the client
- Overseeing implementation of geotechnical design in construction
- Independent review, audit and overseeing construction to ensure construction of the project works complies with the geotechnical design requirements.
- Providing geotechnical advice to design and construction senior management to manage risk, time, costs, quality and performance of the project works

Table 1. Summary of contract types per portion

Detailed Design Package	Alignment. length (approx.) (km)	Design contract type	Construction contract type
Portion A	48.2	Detailed design only	Construct only
Portion B	23.4	Detailed design only	Construct only
Portion C	34.0	Detailed design only	Construct only
Portion D	18.6	Detailed design only	Construct only
Portion E*	1.8	Design and construct construct	Design and construct
Portion F*	1.0	Design and Construct	Design and Construct
Portion G	1.7	Detailed design only	Construct only

* Standalone bridge packages over Clarence and Richmond rivers.

- Geotechnical input in review of tenders for design and construction packages
- Technical review and input of services submission to assist in commercial decision-making process
- Geotechnical input in developing the construction planning and program
- Design support and advice during construction
- Providing geotechnical design/re-design of low risks elements of the project works during construction, if required, subject to Roads and Maritime pre-approval

- Challenging current design criteria, standards and practices
- Implementation of the lessons learnt from past Roads and Maritime projects

2.5 *Project specific geotechnical management challenges*

Amongst potential major project risks identified, a number of risk items for design and construction phases were related to management of geotechnical aspects. The design related risks are listed in Table 2 which also presents a range of mitigation measures implemented under the management of DP Geotechnical Team (DPGT) to de-risk or minimise it so that any follow-on effect on the design can be managed. Similarly, Table 3 provides the geotechnical related risks in construction and mitigation measures addressed at ensuring no major impact on the project progress.

Table 2. Management of geotechnical risks related to design

Risks (Design phase)	Implemented mitigation measures
1. Timely availability of site investigation data to complete detailed design	The SI program was completed in two stages with only the essential minimum number of boreholes which were completed at the first stage to enable un-interruptive progress of detailed design. The rest of the bore holes were completed at the second stage that was carried out towards the end of detailed design phase
2. Inherent variability of geotechnical conditions over the lengthy alignment requiring a greater flexibility in design approaches and construction methodology	DP geotechnical inspection and advisory services were established on site during construction with a team of highly experienced geotechnical engineers to manage any adjustments required into the design in response to the actual geotechnical conditions encountered on site during construction
3. Consistency of quality and standard of design and documentation	A principal level geotechnical engineer from DP visited all 4 design offices on a rotational basis through out the week during the detailed design and documentation period to assist with any technical queries from the designers or additional information that may be needed to develop the design with the least interfacing d design issues with the design of adjacent sections. Interim reviews of in-progress design by the DP representative whilst in the design office helped to minimise in consistencies at very early stage of design and standard of design documentation between the consultants. Formal design package submissions were again reviewed by the DPGT for standard and consistency across different design consultants. Fortnightly meetings with the representatives of all the detailed designers were also undertaken during the design period, where consistency in quality, appreciation of design criteria and seamless transition of design from one portion to the other were in agenda for most meetings.
4. Integration of Early Work design in design of main contracts	All integration issues were resolved by close coordination and liaison between the Early Works and main designers via DPGT.
5. Variance in design approaches between design consultants providing detailed design for adjacent portions of the project	Fortnightly meetings between DPGT and 4 portion detailed designers were a forum where design interfacing issues with adjacent portions were discussed and resolved. In addition, rostered visits by the DPGT representative every week in the peak design period also aimed at facilitating consistency of design details, resolving interfacing issues and streamlining design outcomes and documentation to a common format

Table 3. Management of geotechnical risks related to Construction

Risks	Mitigation measure
1. Construction program dependent on duration of ground consolidation at soft soil treatment sites which occupy about 26% of the total length of the project alignment	Proactive review of soft soil monitoring data was carried out on a daily basis by the soft soil design experts from the DPGT. The sites were grouped into “low risk” and “high risk” on the basis of characteristics and thickness of soft soils together with the targeted performance criteria that must be satisfied before pavement can be constructed. The hold points allowing construction of pavement for the sites categorised as “low risk” were released by the DP-GT based on review of monitoring data progressively which enabled construction to progress as planned For “high risk” sites the DP Geotech - nical Team had intimate involvement in the initial review of the monitoring data to assess the performance of the treatment or any requirement for adjustments or intervention measures. The team proactively engaged the detailed designers, the construction team and DP senior management in decision-making regarding any course of actions or intervention measures required to ensure the site is released on time for construction of pavement as per the project program.
2. Implementation of R44 foundation treatments under	A number of construction strategies were implemented to deal with this risk, including, but not limited to,

embankment areas which are heavily dependent on the seasonal weather regime which is different for different parts of the project	using: - bridging layer treatment, where possible; foundation preparation works completed progressively in small sections at a time to avoid exposure of larger sections of alignment to potential inclement weather; an Early Works package maximised the construction of embankment foundations during the dry season in Portion A; field trials in small sections to confirm what would work, work, what wouldn't; and deployment of a team of experienced geo-technical engineers from DPGT full time on site for advisory services
3. Quality of on-site generated earthworks Materials	The re-use of onsite materials was maximised by customising the earthworks specification and pavement design based on the expected material properties. This included adjusting material, upper zone of formation and bridging rock requirements. Sharing of higher quality earthworks materials between Portions was also undertaken where a portion was deficient in specific materials
4. Availability of detailed designers resources for timely response to geotechnical design support queries arose during construction	In order to assist the project detailed tailed designers to manage their resource commitments to W2B in construction phase, common geotechnical issues on site with low design risks were managed by the DP Geotechnical Team and only those queries that required review of the detailed design were forwarded to the respective detailed designers

3 LESSONS LEARNED

The following list captures a number of lessons learned from involvement as a member of the DPGT for W2B Project:

- Scope of services - Defining a clear scope of geotechnical services required from the DPGT specifically in regards to the design and construction phases.
- Communication protocol - Early development and agreement of a protocol detailing the channel of communication between the construction contractor, DP site management team, DPGT and designers, will assist in avoiding confusion and delays in technical exchange of information between parties.
- Consistency in documentation - Developing a guideline document specifying templates and formatting requirements for submission documents to ensure consistency of design documentation produced by different designers.
- Quality assurance - Ensuring that the project QA system formulates the process and procedure for release of hold points from geotechnical inspections on site and the requirements specified on the design documentation.
- Design brief - Ensuring that the tender brief for procurement of works contracts clearly specifies any geotechnical requirements to be satisfied by the works.
- Management of earthworks - Maximising on-site materials management by a review of portion and section boundaries and tighter contractual controls on early works contractors.
- Design optimization - Reducing construction challenges related to low height embankment construction in floodplains by applying greater scrutiny on design embankment heights during the detailed design stage.

4 CONCLUSION

Geotechnical design and construction management capability is an important asset of the Delivery Part-ner team. Geotechnical services input is required on all facets of the delivery services from concept design for project procurement, detailed design review and challenge, technical input to tendering processes and commercial matters, project geotechnical risk and quality management and construction phase services. Geotechnical engineers as part of the integrated team of DP through proactive participation can deliver cost efficiency and add value to the overall project performance. This was demonstrated on the W2B project as discussed in the preceding sections of this paper.

Some of the key learnings identified in the geotechnical front from the project experience could be a useful consideration to improve the project outcomes for similar future contracts.

ACKNOWLEDGEMENT

The authors would like to express their appreciations to RMS and Pacific Complete Delivery Partner for granting approval to publish this paper.

REFERENCES

Appointment of Delivery Partner for Woolgoolga to Ballina Upgrade – Invitation to Submit an Expression of Interest. 2014. Roads and Maritime Services. (*unpublished*)