

Constructing a Railway Viaduct Crossing KL – Kuala Selangor Expressway (LATAR) for ECRL Project: Technical Feasibility and Challenges

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Abstract

This study investigates the technical feasibility and engineering challenges in constructing a railway viaduct crossing the KL-Kuala Selangor Expressway (LATAR) at Bridge 18, as part of the East Coast Rail Link (ECRL) alignment. A mixed-methods approach was applied, combining qualitative interviews and focus group discussions with field measurements and technical data analysis. Key challenges include limited construction space, soil instability, and minimum clearance requirements above the expressway. Findings indicate that a special span using a Segmental Box Girder (SBG) with full-span launching and bored pile foundations is the most viable solution. The study offers practical references for future viaduct construction projects in similarly constrained locations in Malaysia.

1. Introduction

Railway viaducts are essential in enabling uninterrupted railway alignments through urban areas, highways, and complex terrains. In the ECRL project, Bridge 18 presents significant construction challenges due to its location across LATAR, a major expressway. This study explores technical solutions to span the expressway while adhering to regulatory, environmental, and safety standards. The aim is to identify a structural approach that fits the site's physical constraints while maintaining constructability and operational efficiency. The construction of a railway viaduct at Bridge 18, which crosses the KL-Kuala Selangor Expressway (LATAR) as part of the ECRL alignment, presents a unique set of engineering challenges.

The site is constrained by limited working space, moderately dense soil conditions, and the necessity to maintain a minimum vertical clearance above an active expressway. Using conventional span designs would require multiple piers, potentially disrupting traffic and complicating construction logistics. Conversely, the use of special spans such as Segmental Box Girders (SBG) could resolve these issues but involves more complex design processes, higher costs, and a need for precise construction techniques. Despite the growing use of SBGs in Malaysian infrastructure, there remains a lack of detailed technical guidance for their application in constrained viaduct sites like Bridge 18. This study was thus initiated to address that gap by exploring viable structural strategies suited to the physical and regulatory context of the project.

To guide the investigation, the study sought to answer the following questions: What factors influence the selection of special spans in spatially constrained viaduct construction? How can structural design be adapted to the geotechnical and clearance limitations at the site? What span solution offers the most technically feasible and practical approach? In line with these questions, the study was conducted with three main objectives: (1) to identify the key design considerations for both normal and special span types, (2) to analyse the site-specific

constraints that influence the choice of span, and (3) to propose an optimal structural solution that balances design efficiency, construction practicality, and regulatory compliance.

2. Methodology

This study employs a mixed-methods research approach to evaluate the technical feasibility of constructing a railway viaduct across the KL-Kuala Selangor Expressway (LATAR) at Bridge 18. The methodology section includes a description of the research design, data sources, site characteristics, and the techniques used for analysis. Both primary and secondary data were collected to ensure a comprehensive understanding of the site conditions, structural requirements, and construction limitations.

The study integrates both qualitative and quantitative analysis techniques. The qualitative component involves interviews with six professionals and a focus group discussion (FGD) with four engineering practitioners, aimed at capturing expert insights on span design decisions, site challenges, and construction methods. Meanwhile, the quantitative analysis includes on-site measurements such as span width, expressway clearance, slope gradient, and soil conditions. These were assessed using tools such as Google Earth, AutoCAD, and technical documentation from Aconex and MRL's SharePoint. Data triangulation was employed to validate findings across different sources, ensuring the accuracy and relevance of the proposed viaduct design.



Fig. 1: The site condition for Bridge 18 crossing LATAR Expressway

The quantitative aspect of this study was grounded in detailed field observations conducted at the actual site of Bridge 18. Measurements were taken to assess key physical parameters such as the total width of the LATAR Expressway, vertical clearance requirements, ground slope angles, and surrounding land use conditions. These observations were essential to evaluate spatial constraints that could affect pier placement, span length, and launching zones. Tools such as Google Earth and manual measurement verification were used to map out the potential alignment and support locations. These measurements provided the foundation for structural feasibility assessments and span comparison analysis, particularly in identifying the suitability of long-span solutions like the Segmental Box Girder.

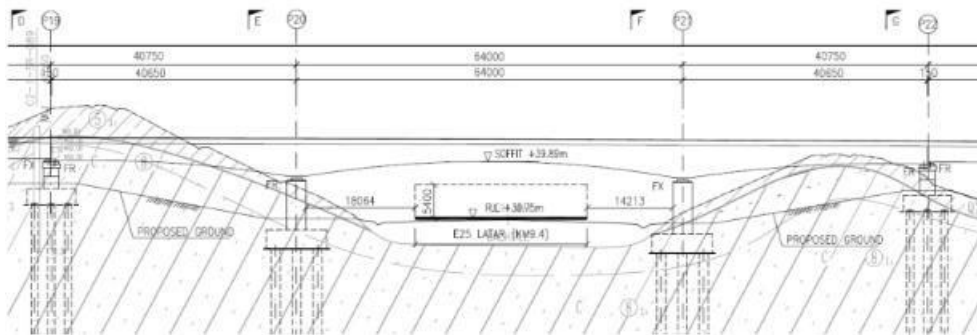


Fig. 2: The drawing shows the Bridge 18 design crossing LATAR

As part of the qualitative component, a Focus Group Discussion (FGD) was conducted involving four experienced engineers directly involved in viaduct and infrastructure design. The discussion aimed to explore practical perspectives on span selection, site constraints, and construction challenges at LATAR. Participants shared insights on the trade-offs between normal and special span configurations, especially in terms of traffic impact, safety, and constructability. The FGD also helped validate findings from individual interviews by encouraging open dialogue and consensus among professionals, making it a valuable tool for refining the study's technical assumptions and proposed design strategies.

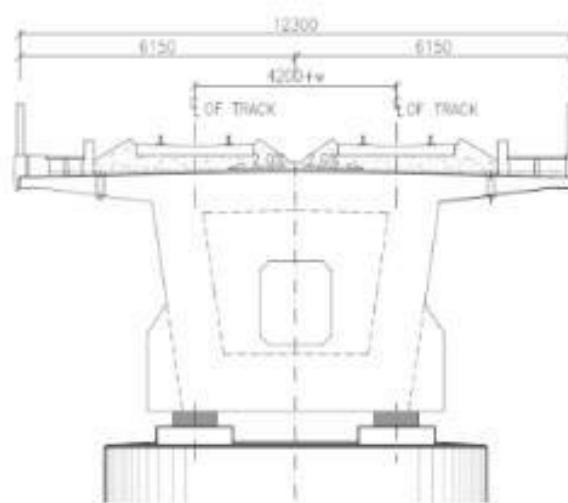


Fig. 3: The Cross section drawing for the Special Span used for Bridge 18

In addition to primary data, this study referred to various secondary sources to guide the evaluation of structural options. Notably, since the ECRL project adopts **China Railway Design standards**, key technical specifications and span requirements were referenced from Chinese design manuals and standard drawings provided through the MRL-Aconex and SharePoint systems.

Supplementary references included general Malaysian guidelines such as the JKR ATJ 11/87 for contextual understanding, and Eurocode 2 for cross-validation of concrete design principles. Construction drawings, soil investigation reports, and alignment plans were also reviewed to assess site limitations and regulatory expectations. These documents provided a critical foundation for analysing the feasibility of using Segmental Box Girders under the specific engineering and compliance framework of the ECRL project.

3. Result & Discussions

This chapter presents findings from both qualitative and quantitative analyses to assess the technical feasibility of construction Bridge 18. It integrates data from semi-structured interviews, focus group discussion (FGD),

and technical comparison of span types. The structure of this chapter aligns with the key research objectives, focusing on span selection, influencing factors, and structural design assessment.

3.1 Thematic Analysis of Conducted Research

3.1.1 Semi - structured Interviews

Thematic analysis of expert a total of six engineers involved in the ECRL project were interviewed using a semi-structured approach. The responses revealed several key themes related to span selection. One of the main findings was the necessity of using a span system that could minimize traffic disruption during construction at an active highway site. All interviewees agreed that the use of a Segmental Box Girder (SBG) provided a major advantage in terms of traffic safety, particularly for construction over existing infrastructure such as the LATAR Expressway. Furthermore, most engineers pointed out that SBG is well suited for long-span applications and does not require extensive falsework, thus minimizing the impact on the surrounding environment and traffic flow.



Figure 1: Interview Insights on SBG Feasibility (Number of Engineers Supporting Each Factor)

Participants The semi-structured interviews conducted with six engineers yielded several consistent themes related to the feasibility and technical justification of using Segmental Box Girder (SBG) for Bridge 18. As visualized in Figure 4.1, the most unanimously agreed-upon factors were Traffic Safety and Span Length Compatibility, each receiving support from all six interviewees (6/6). This 100% agreement indicates an exceptionally strong consensus within the expert group that SBG is uniquely suited to span the LATAR expressway without compromising safety or performance.

Other prominent themes include Clearance over LATAR and Structural Load Distribution, each mentioned by five engineers. These reflect critical engineering requirements at the site: maintaining vertical clearance above an operational highway and ensuring optimal load distribution across long spans. Meanwhile, Construction Space Limitation was cited by four engineers. Though slightly less emphasized, it remains a significant factor — especially considering the site's constrained conditions due to existing slopes and limited access for large-scale staging.

These results suggest that expert support for SBG is not only widespread but strongly aligned with structural and site-specific constraints. The statistical consistency across key themes strengthens the reliability of the interview data and supports the conclusion that SBG meets both performance and constructability needs for Bridge 18.

3.1.2 Focus Group Discussion (FGD)

A focus group discussion (FGD) was conducted with four engineers from various project stakeholders, including contractors, consultants, and the client. The discussion identified four consistent themes: traffic management, ground conditions, pier accessibility, and compliance with regulatory authorities such as LLM and APAD. The participants collectively emphasized that SBG constructed in-situ using traveler formwork was the most practical solution, as it avoids the need for large staging areas and minimizes interference with existing traffic. Additionally, the presence of groundwater and sloped terrain makes conventional systems like RC beams more challenging. As such, SBG was seen as not only safer, but also more practical for complex sites like Bridge 18.

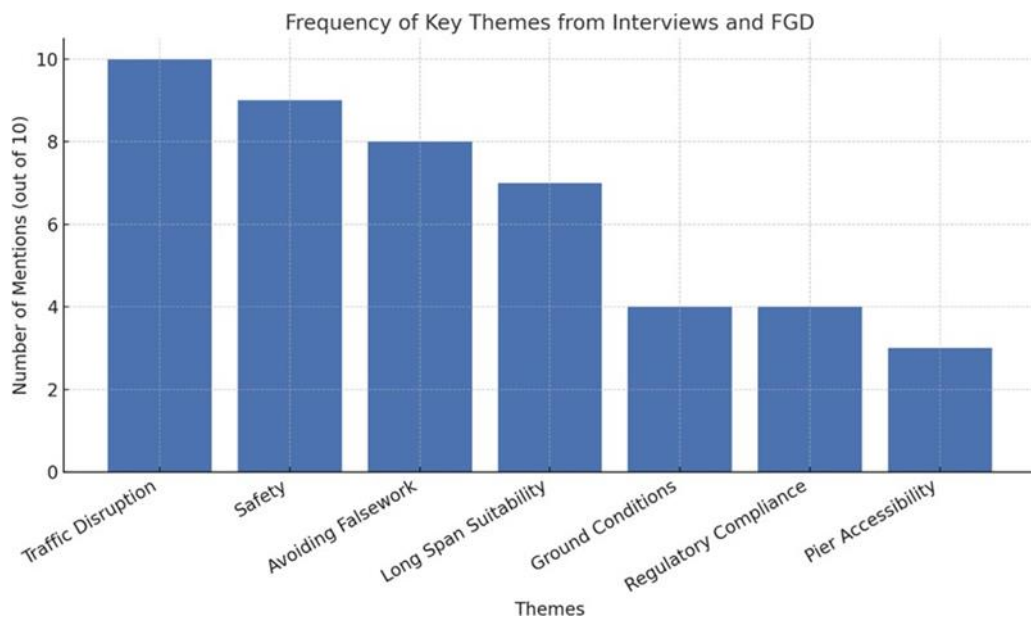


Figure 2: Frequency of Key Themes from Interviews and Focus Group Discussion (FGD)

Focus Group Discussion (FGD) was held with four engineers representing key stakeholders in the project, including contractors, consultants, and project owners. The FGD aimed to identify the challenges and considerations specific to constructing Bridge 18 and to validate themes that emerged during the semi-structured interviews. To deepen the thematic analysis, the findings from both the interviews (6 participants) and FGD (4 participants) were consolidated, resulting in a combined total of 10 expert inputs. The resulting frequency distribution of recurring themes is shown in Figure 4.1. This integrated dataset allowed for a broader validation of issues such as construction risks, site constraints, and regulatory alignment.

The most frequently cited issue across the combined dataset was traffic disruption, raised by all 10 experts, indicating a universal concern regarding live expressway conditions during construction. Safety concerns followed closely with 9 mentions, while avoiding falsework was cited 8 times — reflecting the group's strong preference for construction methods, such as traveler form, that reduce ground-level intervention. Long-span suitability was also a recurring technical priority, mentioned by 7 experts, reinforcing the need for spans longer than what conventional RC beams could offer. Secondary themes, including ground conditions and regulatory compliance, received four mentions each, while pier accessibility was mentioned three times.

This consolidated analysis demonstrates a high level of convergence between individual and group perspectives. The strong thematic alignment across all data sources supports the technical rationale for selecting the Segmental Box Girder (SBG) system, as it effectively addresses the most critical site-specific and structural challenges identified by the expert panel.

3.2 Identification of design Factors for Special and Normal Spans

3.2.1 Analysis of Influential Factors on Special Span Selection

The selection of a special span type, such as SBG, was based on three main criteria: span length, site constraints, and vertical clearance requirements. At Bridge 18, the span length exceeds 43 meters, which cannot be achieved reliably using conventional RC beams due to structural limitations. Furthermore, the presence of steep slopes and an active expressway limits the space available for staging, making the installation of large falsework infeasible. SBG, however, can be constructed from above using traveler formwork, which significantly reduces the need for ground-level support. Additionally, it can maintain the required clearance over the highway, meeting regulatory requirements for vertical and horizontal geometry.

3.2.2 Evaluation between Span Selections

A comprehensive technical evaluation was conducted to compare three types of span structures suitable for Bridge 18: the Normal Reinforced Concrete (RC) Beam and Segmental Box Girder (SBG). This comparison focused on three core dimensions: construction process, structural integrity, and operational efficiency. Based on the findings, the Segmental Box Girder emerged as the most advantageous option.

Table 1: Comparison between Special and Normal Spans on Construction Process

Criteria	Normal Span (RC Beam)	Segmental Box Girder (SBG)
Construction Duration (days)	120	90
Traffic Disruption (1–5 scale)	4.5	2.0
% Precast Elements Used	40%	0% (fully in-situ)
Number of Workers On-Site (avg)	35	28
On-Site Equipment Hours	480 hrs	360 hrs
Site Setup Footprint (m ²)	1300	950
Falsework Requirement	High	Low (traveller form)
Maximum Span Length (m)	30	45
Load Capacity (kN/m)	180	300

From the perspective of construction practicality, the SBG offers the shortest construction duration at 90 days, owing to its in-situ traveler form method which facilitates segmental construction without the need for large-scale scaffolding or extensive staging areas. In contrast, the RC Beam requires a significantly longer duration of 120 days, largely due to the need for ground-level falsework, conventional casting, and labor-intensive processes. Additionally, the SBG system requires fewer workers on-site and consumes fewer equipment hours, making it a more efficient solution logistically.

Table 2: Comparison between Special and Normal Spans from Structural Perspective

Criteria	Normal Span (RC Beam)	Segmental Box Girder (SBG)
Vertical Deflection @ Midspan (mm)	45	18
Concrete Grade (typical)	C35/45	C50/60
Structural life Expectancy (years)	50	100
Fatigue Resistance Rating (1-5)	3.5	4.8

Structurally, the SBG provides superior performance metrics. It can accommodate longer spans up to 45 meters, which aligns with the site's topographical and geometric needs, especially over the LATAR expressway. Its load-bearing capacity is the highest among the three systems at 300 kN/m, with the lowest midspan deflection recorded at only 18 mm. These figures reflect both strength and stiffness under service loads, outperforming the RC Beam alternatives. The RC Beam is limited to shorter spans and experiences higher deflection values. Furthermore, the SBG employs high-strength concrete (typically C50/60), which enhances durability and increases its projected structural lifespan up to 100 years, surpassing the 50-year design lives of the RC Beam respectively.

Table 3: Comparison between Special and Normal Spans in terms of Operational Efficiency

Criteria	Normal Span (RC Beam)	Segmental Box Girder (SBG)
Maintenance Frequency (per year)	2	1
Inspection Time per span (hours)	6	3
Noise/Vibration Level (dB)	85	72
Track Alignment Flexibility (m)	+/-0.5	+/-1.5

In terms of operational performance, the Segmental Box Girder once again proves its superiority. It requires only one inspection or maintenance intervention per year, compared to two for the RC Beam. Its internal hollow section also allows for safer and faster inspections, reducing the need for external scaffolding or

heavy equipment during maintenance. The SBG system also generates lower noise and vibration levels during train operation, improving environmental performance, particularly in sensitive or urban-adjacent areas. Furthermore, it offers better alignment flexibility, which is valuable for achieving smooth curvature transitions in viaduct alignment.

In conclusion, the Segmental Box Girder demonstrates a clear advantage across all technical parameters evaluated. Its efficient construction method, high structural performance, and long-term operational benefits make it the most viable and sustainable span option for the Bridge 18 viaduct under the ECRL project. This conclusion is strongly supported by both qualitative insights from industry experts and quantitative comparison across span types.

3.3 Design of Segmental Box Girder

The proposed structural solution for Bridge 18 adopts a Segmental Box Girder with a span of 45 meters and a deck width of 12.3 meters, which accommodates dual railway tracks. The girder is to be constructed fully in-situ using traveler formwork, which facilitates the balanced cantilever method. This technique allows construction from the pier without ground-based falsework, making it ideal for confined, high-traffic sites. In addition, the use of high-strength concrete (C50/60) enhances the structure's durability and capacity to withstand dynamic rail loads and long-term stress.

3.4 Impact of SBG on Construction Method

The use of traveler form significantly improves construction safety and efficiency. Unlike RC beams, which require extensive temporary supports or heavy lifting equipment, SBG can be constructed without obstructing traffic beneath. Its methodical segment-by-segment construction leads to consistent quality control. The internal hollow design of the girder allows for easy access during inspections and reduces reliance on external scaffolding. From both a logistical and structural perspective, SBG offers substantial advantages in the context of the Bridge 18 project.

3.5 Analysis Summary

The overall findings affirm that the Segmental Box Girder (SBG) is the most suitable and feasible span type for Bridge 18 under the ECRL project. It not only meets the structural and site constraints, but also contributes to a safer, faster, and more compliant construction process. The system's long-term benefits, including minimal maintenance, high durability, and compatibility with rail loading requirements, make it the most sustainable choice across technical, regulatory, and operational dimensions.

Recommendations

Based on the study, it is recommended that the Segmental Box Girder method be adopted for Bridge 18, using full-span launching supported by bored pile foundations. Future projects of similar nature should incorporate early-stage 3D simulation and digital planning tools such as Building Information Modelling (BIM) to assess spatial limitations and optimize construction sequencing. Additionally, closer engagement with regulatory agencies like LLM and APAD is advised during the design phase to ensure alignment with road clearance and safety requirements.

3.6 Limitations & Future Research

This study is limited in several aspects. Firstly, it does not include a full seismic performance evaluation or long-term monitoring data for the proposed structure. Secondly, while the qualitative insights are robust, they are based on a limited pool of experts and may not fully represent broader industry perspectives. For future research, it is recommended to conduct a life-cycle cost analysis of SBG versus alternative solutions and to explore the application of automated construction technologies for segment launching in space-constrained environments. Furthermore, integration of environmental impact modelling would strengthen the sustainability dimension of such viaduct projects.

4. Conclusion

This study successfully demonstrates that a Segmental Box Girder viaduct with a special span of approximately 80 meters is the most technically feasible solution for Bridge 18 over LATAR. By addressing soil stability, vertical clearance, and spatial constraints, the proposed design ensures regulatory compliance and minimizes traffic impact. The findings contribute to the body of knowledge for railway infrastructure development in constrained environments.

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References

- [1] Eurocode 2. (2004). *Design of concrete structures – Part 1-1: General rules and rules for buildings* (EN 1992-1-1). European Committee for Standardization.
- [2] Jabatan Kerja Raya Malaysia. (1987). *ATJ 11/87: Manual for the Design of Bridges*. Kuala Lumpur: JKR.
- [3] Malaysia Rail Link (MRL). (2023). *Bridge 18 Construction Drawings & Alignment Layouts* [Unpublished internal documents]. Retrieved from Aconex Project Platform.
- [4] China Railway Design Corporation. (2018). *Technical Standards for Railway Bridge Engineering (CRDS)* [Translated excerpts]. Beijing: CRDC Publications.
- [5] CIDB Malaysia. (2020). *Manual for Segmental Box Girder Construction in Railway Projects*. Kuala Lumpur: Construction Industry Development Board.
- [6] Department of Environment Malaysia. (2019). *Environmental Impact Assessment Guidelines for Infrastructure Projects*. Putrajaya: DOE.
- [7] Department of Environment Malaysia. (2019). *Environmental Impact Assessment Guidelines for Infrastructure Projects*. Putrajaya: DOE Malaysia.
- [8] Azman, M. N. A., & Rahman, I. A. (2021). Application of Segmental Box Girder in Urban Rail Projects: Challenges and Solutions. *Journal of Sustainable Construction Engineering and Technology*, 12(3), 42–51.
- [9] Ismail, Z., & Wahab, N. (2020). BIM adoption in Malaysian infrastructure projects: Benefits and barriers. *Malaysian Construction Research Journal*, 8(1), 15–27.
- [10] Lau, Y. K., & Wong, W. H. (2018). Managing Traffic Impact During Elevated Railway Construction: Case Study of MRT SSP Line. *Proceedings of the International Conference on Transportation Engineering*, 233–241.
- [11] Mahadi, A. F., & Nasir, M. A. (2019). Comparative Analysis of Railway Viaduct Foundation Systems in Malaysia. *Journal of Civil Engineering Research*, 7(4), 112–120.
- [12] Ministry of Transport Malaysia. (2021). *ECRL Project Overview and Technical Framework*. Putrajaya: Government of Malaysia.
- [13] Tan, S. H., & Yap, T. C. (2022). Optimization of Viaduct Pier Layout for Expressway Crossings. *Journal of Bridge Engineering*, 27(2), 04022003.