Unique Structural Design and Construction Challenges for Al Bustan South Project in Qatar

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ABSTRACT

The Al Bustan Street South (ABS) Expressway Project features the longest dual carriageway bridges in Qatar spanning 2.6 km each, with a minimum of four lanes in each direction from south of Al Waab Street to south of Rayyan Road. These twin mainline bridges carry the ABS Expressway forming a three-level interchange at Al Waab Street and two-level crossings at Al Rasheeda Street and Snay Bu Hasa. The Al Waab Interchange consists of multiple structures; namely, the mainline bridges at Level +1, the West-South directional ramp at Level +2, and the East-North directional ramp at Level +2. In addition, there are six other on/off ramp structures that tie into the mainline bridges at various locations. While the current construction maintains Al Waab Street at Level 0, in its ultimate configuration, Al Waab Street will contain an underpass at Level -1, resulting in Level +4 interchange. This underpass due to its proximity to the bridge supports requires unique design considering future constructability. The ABS Expressway is part of the prestigious Sabah Al Ahmad Corridor which once constructed will provide a separate north to south route from the Landmark Mall to Hamad International Airport. The appearance of the bridges along the Sabah Al Ahmad Corridor will contain aesthetically pleasing cladding attached to the parapets with artificial green walls running down select piers and MSE Walls. This paper summarizes recent developments in the design and build for the future underpass, which requires special attention in the bridge design while also considering aesthetic features.

Keywords: Design and build; Al Bustan South; Structural design; Construction challenges

1 INTRODUCTION

The Design and Construction of the "Al Bustan Street South (ABS) Expressway Project - P007 C5 P1" commenced on September 2017 and comprised of the following key team members:

- Client: Public Works Authority (ASHGHAL)
- Authority's sub-representative: Parsons International Limited (PIL)
- Construction Contractor: Hyundai Engineering and Construction (HDEC)
- Designers: Parsons International Limited (PIL) & WSP

2 PROJECT DESCRIPTION

The scope of the ABS Expressway Project includes upgrading of ABS from an existing dual carriageway at-grade to dual carriageway at-grade and flyover, with a minimum of 4 lanes in each direction for approximately 3.1 km from south of Al Waab Street to south of Rayyan Road (Junction R6), including 2 to 3 lane service roads running parallel to the mainline bridge along both sides. The 2.6 km twin mainline bridges carry the ABS Expressway forming a three-level interchange at Al Waab Street and two-level crossings at Al Rasheeda Street and Snay Bu Hasa.

The ABS/Al Waab interchange consists of multiple structures; namely, the twin mainline bridges at Level +1, the East-North directional ramp (Ramp 5) at Level +2, and the West-South directional ramp (Ramp 6) at Level +2. The two ramp bridges combine for the total length of 1.5 km. In addition, there are six other on/off ramp structures that tie into the mainline bridges at various locations (Refer to Figure 1 for the Project Layout). While the current construction maintains Al Waab Street at Level 0, in its ultimate configuration, the ABS/Al Waab interchange will have an underpass along Al Waab Street, allowing the free-flow of traffic along Al Waab Street and converting the interchange to become a four-level interchange (Refer to Figure 2 for the Ultimate Design Layout and Figure 3 for Current Interim Construction).

Figure 1 Project Layout.

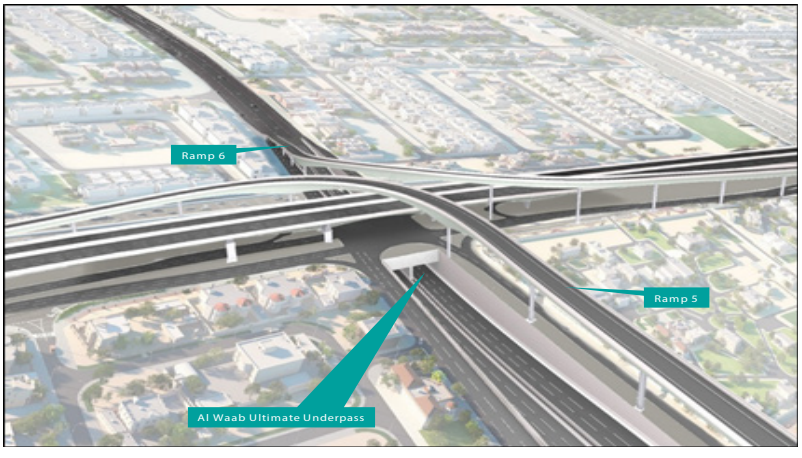

Figure 2 Ultimate Design.

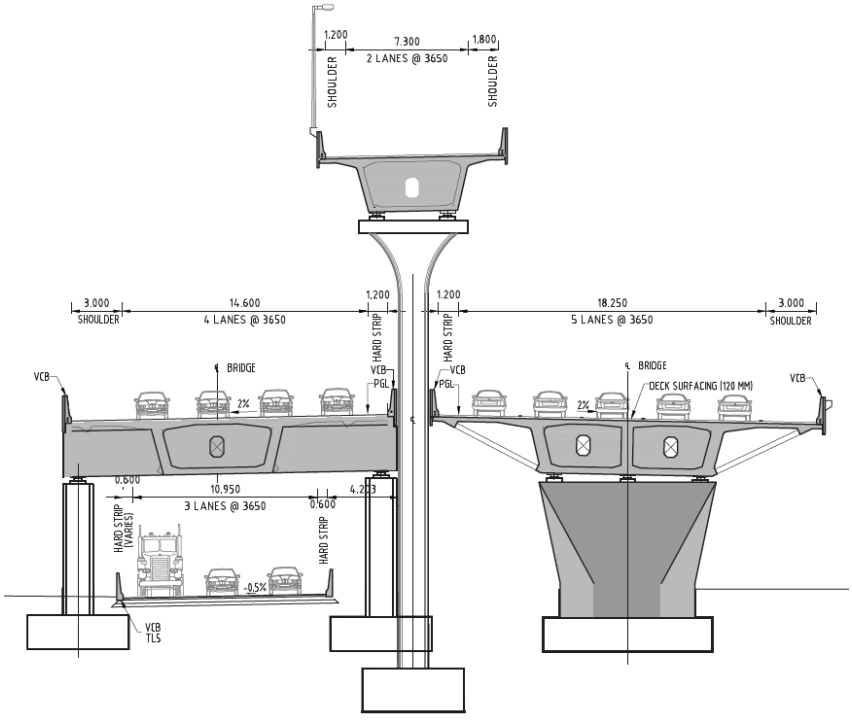

Figure 3 Current Interim Construction.

3 DESIGN

Due to its proximity to the bridge supports, the construction of the future underpass will require special attention in the design. The following measures were taken into account during the development of the bridges' design to allow a safe future excavation of the Al Waab Underpass adjacent to the bridges.

3.1 Pre-Installed Diaphragm Walls

Mechanically Stabilized Earth (MSE) wall embankments are used to support the approaches of the ramp bridges, primarily to fit the ramps in the limited space within the interchange. The alignment of the ramps necessitates the placement of these embankments along the edges of the future underpass. One of such embankments is particularly close to the underpass edge, to the extent that there is no space to install the shoring to support the embankment at the time of the future underpass construction. For this reason, the diaphragm wall will be installed during ongoing construction beneath the MSE wall embankment. As the future excavation takes place, the pre-installed diaphragm will be exposed and retain the MSE wall embankment above during the underpass construction (Refer to Figure 4 for the details of the Pre-installed Diaphragm Walls).

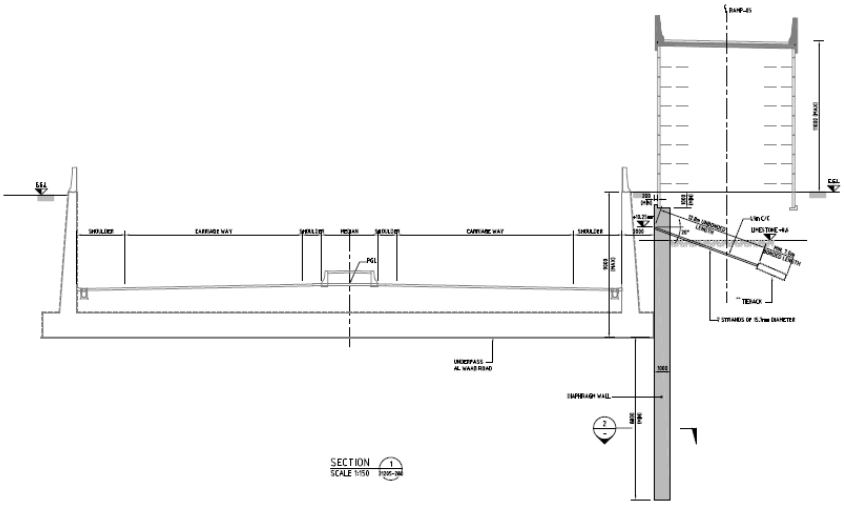

Figure 4 Details of Pre-installed Diaphragm Walls.

3.2 Ramp Bridge Piles Adjacent to the Future Underpass

Some of the ramp bridges' foundations are located closely behind the edges of the future underpass. These piles are close to the extent that their capacity will be impacted by the loss of supporting material due to the underpass excavation. As such, the design of the ramp bridges considers the conditions encountered before, during and after the construction of the underpass. In order to account for these conditions, the bridges are analyzed with variable pile support conditions to represent the various stages throughout the life of the structure. The piles are designed such that their ultimate capacities during and after the construction of the future underpass are derived only from the embedment below the bottom of the future underpass structure (Refer to Figure 5 for the details of Piles Adjacent to the Future Underpass).

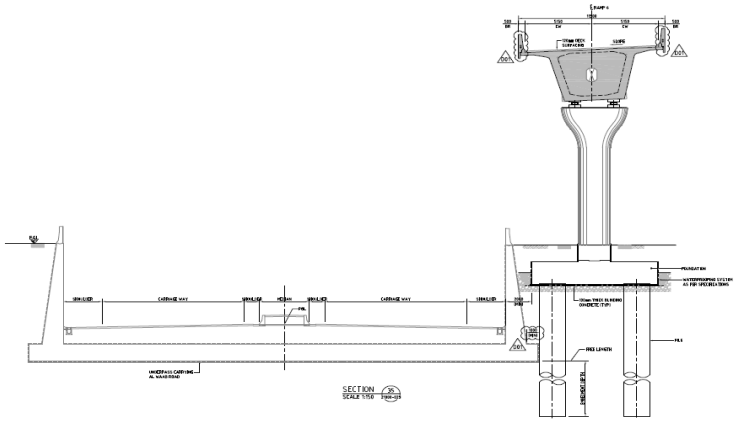

Figure 5 Details of Piles Adjacent to the Future Underpass.

3.3 Foundation Located at Median of Al Waab Street

One foundation, each of Ramps 5 and 6 bridges is located in the median of Al Waab

Street. Similar to the ramp foundations located behind the future Al Waab underpass as described in the preceding section, these foundations will also be exposed due to the future underpass construction. Accordingly, the design of these foundations also incorporates similar considerations regarding the pile analysis and capacities, which are compatible with conditions before and after the underpass construction. In addition, since the underpass construction would expose the piles permanently, the design of these foundations has been made to allow for construction of underpass walls adjacent to the exposed piles. These underpass walls will serve two purposes, one of which is to provide water-tightness to the underpass, which is located below the design ground water level, and the other to visually conceal the exposed piles with smooth walls for aesthetic reasons (Refer to Figure 6 for the details of Foundations at the Median of Al Waab Street).

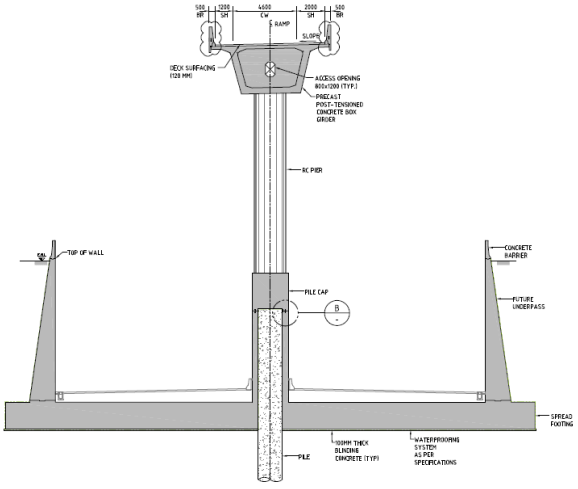

Figure 6 Details of Foundations at the Median of Al Waab Street.

4 CONSTRUCTION

To achieve the fast track delivery method directed by the Client, the Contract mandated all bridge structures to be of precast box-girder construction. This was the method implemented during the construction with the only exception being the spans tying with the ramp bridges that required a variable width box-girder. Balanced cantilever erection method was selected to be the most suitable and efficient method considering the time and site constraints. With a total exceeding 1,100 precast segments of an approximate total length of 4.0 km and the utilization of more than 65 types of formworks, the production, storing, transportation and erection of the segments within a limited time frame and space posed a significant challenge. Further, the scale of the precast segments exceeding a width of 23.0m and a weight of 155 tons for the mainline bridges increased the degree of difficulty of the logistics exceeding the conventional size and weight of precast box-girder segments. In addition, the limited Right of Way availability was also an important consideration, as well as the continuous and uninterrupted traffic flow of Al Waab Street, which was the Clients firm instruction.

Working closely, the Designer and the Contractor approached the Client's Traffic Management Authority and obtained the approval of several Traffic Management Plans,

which allowed the Contractor to divert the traffic and gain access to specified areas to commence construction activities. The complexity of the traffic management plans as well as the short execution duration in coordination with the overall construction schedule formed a difficult challenge for the traffic management team. One of the major Traffic Management Schemes was the four-lane signalized roundabout that replaced the existing at-grade Al Waab junction. However, securing approval of this scheme through the authorities proved difficult and required the upgrade of Mehairja Street, which provided another route to avoid the roundabout. This roundabout allowed the Contractor to construct the +1 level and +2 level substructures and superstructures without impeding traffic flows along Al Waab Street (Refer to Figure 7).

Figure 7 Temporary Traffic Management Map – Al Waab Roundabout & Mehairja Diversion.

5 BRIDGE AESTHETICS ACROSS THE SABAH AL AHMAD CORRIDOR

The Sabah Al Ahmad Corridor is a 25 km stretch of Expressway that provides a new north to south route parallel to Doha Expressway and comprises of the following key projects:

- P008-C2 – E-Ring Road
- P008 C3 - Mesaimeer Road
- P007 C5 P1 - Al Bustan Street South
- P007 C7 P2 - Al Bustan Street North
- P007 C7 P1 – Duhail Interchange and Al Gharrafa Street

Upon completion of the ABS Expressway Project, the Sabah Al Ahmad Corridor will boast the longest bridge in the State of Qatar spanning 2.6 km over Al Waab Street, Al Rasheeda Street, and Snay Bu Hasa (Refer to Figure 8).

Figure 8: Sabah Al Ahmad Corridor.

One of the primary design goals of the bridge designer is to unite the bridge with its immediate environs or set the architectural tone for future development. This approach provides the designer with direction and guidance in the design process and helps assure that the aesthetic properties of the bridges are appropriate and effective. Many of the superstructures in Qatar are used to enhance the appearance of each area by utilizing aesthetics to brighten the visual effect the structure has with the surrounding area. As such, the bridge along the Sabah Al Ahmad Corridor will be enhanced by applying aesthetically pleasing cladding attached to the parapets and MSE Walls. This will be supplemented with decorative lighting along the bridges. In addition, the MSE walls and specific mainline bridge piers will contain arch type cladding that would be decorated with artificial grass and specialized lighting (Refer to Figure 9).

Figure 9: Arch Cladding at Select Piers of Sabah Al Ahmad Corridor.

6 CONCLUSION

In summary, the ultimate challenge of the successful execution of ABS Expressway Project and the greater Sabah Al Ahmad Corridor which features the longest bridge in the State of Qatar spanning 2.6 km, requires the constant coordination of all subcontractors, suppliers and site personnel for the safe execution of this unique project, within the limited time and approved budget by the Client. The collaboration of the experienced personnel from the Designer, Contractor, Authority's sub-representative and Client are

essential for the delivery of a Project of this scale and magnitude. The commitment of the project personnel along with the Client's support resulted in unique design and construction elements that accounted for the Ultimate Al Waab Underpass while proving aesthetically pleasing structures.

REFERENCES

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