A Review on Hong Kong-Zhuhai-Macao under Go Bridge

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Abstract: The Hong Kong Zhuhai Macao link can be constructed across the mouth of the Pearl River delta linking Hong Kong Zhuhai and Macao in the south of china. The link can include of dual 3-line with hard shoulder motorway with a total length of around 42km, of which around 30km in mainland territory and around 12km with in Hong Kong territory. The link can comprise of border crossing facilities on reclaimed land in Zhuhai and Hong Kong, around 30km of sea-crossing bridges, around 5km of immersed tunnel, two artificial islands, around 2km of at-grade road and around 2km of cut and cover tunnel.

- HPDI - Lead
- ARUP - Bridges
- COWI - Tunnel
- SHTDI - Island
- FHCL - Electrical & Mechanical

KEYWORDS: Infrastructure, Sea-crossing bridge, cable-stayed bridges, Design, tunnels

DOI of the Article: https://doi.org/10.46501/IJMTST0707037

Available online at: http://www.ijmtst.com/vol7issue07.html

As per UGC guidelines an electronic bar code is provided to seure your paper

To Cite this Article: D. Ajay Kumar; J.Sree Naga Chaitanya; Dr. K. Chandra Mouli. A Review on Hong Kong-Zhuhai-Macao under Go Bridge. *International Journal for Modern Trends in Science and Technology* 2021, *7*, 0707076, pp. 226-230. https://doi.org/10.46501/IJMTST0707037

Article Info. Received: 14 June 2021; Accepted: 12 July 2021; Published: 21 July 2021

INTRODUCTION

The world's longest sea bridge is now formally open for traffic in china. It took nearly a decade to build the Hong Kong Zhuhai Macau Bridge (HZMB), said by CBS News correspondent Ben Tracy. Important transport construction project include in –National High-Speed Road Network Planning‖. This link road below highway departments contract No.HY2011/09. The flyovers in this project consist of 115 spans and can be characterized into different character zones of structures. Regular spans of typical 75km interwind with two 1-way navigation spans of 150m. The bridge total length of 55km .This Bridge was started from 15^{th} Dec 2009.This construction was ended in 6^{th} Feb 2018.This bridge was opened in 24^{th} Dec 2018. Built according to the highway standard of six lanes going each way; it was design speed of 100km/h and design life of 120years. Iconic unique and suddenly identifiable bridge befitting the second decade of the 21^{st} century.

Fig: Map of Hong Kong- Zhuhai-Macau Bridge.

HISTORY

Construction of the HZMB project started on 15^{th} December 2009 on the Chinese side, with then-Politburo Main member and Vice Premier of China Li Keqiang holding a commencement ceremony. Construction of the Hong Kong section of the project started in December 2011 after a delay triggered by a legal challenge regarding the environmental impact of the bridge.

The past bridge tower was founded on 2^{nd} June 2016. The last straighted- element of the 4,860-metre-long (15,940 ft) straight section of the undersea tunnel was installed on 12^{th} July 2016, while the final tunnel joint was installed on 2^{nd} May 2017. Construction of the Main Bridge, consisting of a flyover and an undersea tunnel, was finished on 6^{th} July 2017, and the whole construction project was completed on 6^{th} February 2018. In Throughout construction 19 workers died.

SECTIONS AND ELEMENTS

The 55-km (34 mi) HZMB consists of three main sections: the Main Bridge (29.6 km or 18.4 mi) in the middle of the Pearl River estuary, the Hong Kong Link Road (12 km or 7.5 mi) in the east and the Zhuhai Link Road (13.4 km or 8.3 mi) in the west of the estuary.

Main bridge:-

The largest part of the HZMB project contains with bridge-cum-tunnel system constructed by the mainland Chinese authorities. It can be connected with artificial islands, housing the Boundary Crossing Facilities (BCF) for both mainland China and Macau in the west, to the Hong Kong Link Road in the east.

It includes a 22.9-km (14.2 mi) flyover and a 6.7-km (4.2 mi) undersea tunnel that runs among two artificial islands. The flyover crosses the Pearl River inlet with three cable-stayed bridges with a leg on each side of between 280 and 460 metres (920 and 1,510 ft), permitting transport traffic to pass underneath.

Hong Kong link road:-

Under Hong Kong jurisdiction, the Hong Kong Link Road was constructed by Highways Department[citation needed] to link the Main Bridge to an artificial island housing the Hong Kong Border Crossing Facilities (HKBCF). It includes a 9.4-km (5.8 mi) flyover, a 1-km (0.62 mi) Scenic Hill Tunnel and a 1.6-km (1.0-mi) at-grade road along the east coastline of the Chek Lap Kok.

ZHUHAI LINK ROAD:-

The Zhuhai Connection Road Begins from an artificial island housing the Borderline mutual Crossing Facilities for mainland China and Macau, passes through the established area of Gong Bei via a tunnel towards Zhuhai, and joins to three major expressways, namely, the Jing- Zhu Expressway, Guang-Zhu West expressway and jiang-Zhu expressway.

ENVIRONMENTAL ASPECTS:-

The Pearl River delta is the environment for the waning pink dolphins. Therefore significant that the waters are not artificial by the new link. Bridge piers and basics must not harmfully affect the flow of water and that creation approaches are used that minimize noise in the water and minimize pollution of the water. On- site and in-site construction and minimize off-site of bridge elements.

FLYOVERS

The flyovers cross light water at the Zhuhai and Macao end and over growing depth of water to Lantau. Over the light depth of water the spans studied ranged from 60 – 80m and over profounder water the spans explored ranged from 90 - 120m. A number of long sea and river crossings have recently been created in China such as Sutong Bridge, Donghai Bridge, and Hangzhou Bridge. In all of these bridges two isolated prestressed concrete box girder floors have been used, each reinforced by single column piers. For this bridge, from environmental reflections, it has been decided to use single column piers to support also two isolated decks or a single wide deck. The reason for this is to provide the least block to water flow expressly as the water flow is not always normal to the placement of the bridge. To further minimize obstruction to water flow, the piles are successful to be suppressed in the sea-bed. Long-span flyovers with spans 150m to 180m.

LAND SECTION WITH SPAN LENGTHS FROM 35 M TO 65 M:-

The floor in this area is sitting on cast in situ portal, each column being reinforced on a single pile. The five bridge units lengthways the sea wall are matching decks, and the sixth one have 3 decks joined into the portal structure. The flyovers are designed as shaped segmental erected by the balanced beam method with overhead beginning gantry. To enable suitable structural behavior, side spans are on sliding bearings and midway ones, fully fixed into the portals.

Fig: Hong Kong- Zhuhai-Macau Bridge.

Under Sea Tunnel Design:-

Structural design:-

The immersed tunnel can be considered as one of the most exciting parts of this project and special in a number of ways. The structural design of the immersed tunnel is gritty by various boundary conditions. Since the tunnel has to transfer a three-lane dual carriageway the durations within the cross section are comparatively large with 14.55m. As described earlier the tunnel is placed deep under the present seabed to allow for the future deepening of the shipping channel to billet passage of 300.000 tons vessels. Until the future navigation channel is searched, the immersion trench is permitted to fill with sedimentation up to the present seabed, which may be result in a ground cover on the tunnel of over 20 m. When also considering the changing and poor soil conditions at the project location the cross-section design in reinforced concrete becomes critical, however still feasible. The option of transverse post tensioning has been studied but was not preferred due to a more difficult execution of the works. The geotechnical conditions at the project location are unfavorable and have an important impact on the immersed tunnel design. While the immersed tunnel can be applied in relatively poor soil conditions additional measures are required over a large part of the immersed tunnel arrangement due to settlement/deformation requirements. In the deep sections the geotechnical conditions are moderately good and additional measures are not required. The immersed tunnel is originated on a gravel bed direct on the present soil. To limit settlements and more important difference settlements the extra measures have been taken by means of sand replacement, settlement reduction piles and foundation piles.

Under Sea Bed tunnel :-

The Tunnel also delivers a dual 3-lane carriageway with a design speed of 100 km/h. The Tunnel is of width 2×14.25 m and vertical clearance of 5.1 m. The sub- sea Tunnel is the largest and one of the deepest subterranean tube tunnels in the world, as it has to accommodate three lanes of traffic in each direction and will be have extremely wide spans of nearly 15m. It is placed some 45 m below the sea level, so as to confirm safe passage of 300,000 tonnes shipping vessels on Pearl River. So, the Tunnel is required to resist big hydrostatic and traffic loads. Furthermore, the design has to take into account a design Suitable life of 120 years in a harsh marine environment, and the opposing offshore conditions and complex navigation environment for transportation and absorption of the tunnel tube elements during construction, creation the design and building of the sub-sea Tunnel uniquely challenging. The sub-sea Tunnel basically contains of a set of 33 inter- connected precast concrete 'boxes' of typically180 m long as shown Weighing over 75,000 tonnes, these tunnel tube elements are the main in the world. Having been transported afloat from the production site to the project location, they are linked together on the seabed using special rubber seals to ensure the connection is watertight. The fitting of Tunnel Element E18 is After the temporary tunnel ends have being knocked through, one continuous tunnel structure is generated.

The Tunnel is located in between West Artificial Island and East Artificial Island. The containment constructions of the two artificial islands are constructed of large steel cylinders fitted by vibratory driving as the volumes inside the steel cylinders and the volumes within the containment structures are then occupied with sand as after the fitting of prefabricated vertical drains. The engineering properties of the soft marine deposits in the seabed inside the containment structures are enhanced by surcharging with prefabricated vertical drains. Sand compaction piles are fitted around the perimeters external the containment structures as to support the seawall revetments. A cross-section of the artificial island representative different methods of ground development is depicted the construction method minimizes the searching and dumping of soft marine deposits.

OFF SHORE CONDITIONS DURING TRANSPORT AND IMMERSION:-

Fig: under water tunnel

The immersed part consists of 33 tunnel elements, of which maximum have a length of 180 m. The cross-sectional dimensions of 11.5 * 37.95 m the basics will become the largest concrete tunnel elements in the world. The tunnel elements determination be built in a construction dock located at some 10 km of the project site and will be transported and immersed under seaward conditions. During these stages adverse wave circumstances may be encountered.

TUNNEL CONNECTIONS AND ROAD SAFETY:-

The expansion of a basic safety concept of a bridge-tunnel connection of this size is a true challenge. Especially when three different governments are involved, and several design companies have shared in different parts of the project. For the tunnel a basic safety concept has been developed using cutting- edge design lines resultant in efficient drying systems, safety foods and escape events, also taking account the human factor (behavior and reply of the road employers). In addition for maximum handiness of the tunnel state of the art traffic management systems and tunnel connections will be every day.

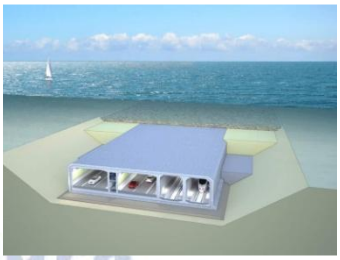

Fig: cross sectional view of underground tunnel

CONCRETE:-

Ika admixtures were used to produce several types of concrete for the ong- huhai- acao bridge project Architectural concrete design, referred to as Brutalist construction or Brutalism was specified for the construction of the wave wall of the artificial island. It is concrete that is left unfinished after being cast, which enables the pattern left by the formwork to be expressed. To achieve the remarkable quality of C30 concrete with a highly aesthetic white look, Sika China and CCCC Shanghai Harbour Engineering Design & Research Institute conducted a 6-month full-scale concrete model test. They chose Sika® ViscoCrete®-3310C high range water reducing and super plasticizing admixture to produce 20,000 m3 of concrete.

Thanks to Sika technology, it was possible to avoid such problems as laitance blackening and bleeding of concrete ika isco rete-3310C was also used to produce 75,000 m3 of marine C45 concrete. It was applied in the hidden section of the artificial island. Through mix design optimization ika super plasticizer ensured concrete cooling and prevented cracking The same admixture was used to produces of site cast in-situ concrete on the artificial island t prevented cold joints occurring during a pour to produce C concrete for the retaining wall project of the artificial island ika isco rete - high-performance water reducer was used ika admixtures were also used to produce about 500,000 m3 of concrete for bridge construction. Thanks to concrete admixtures from Sika, the concrete produced met the high requirements for durability and fit the trends of modern concrete placing and architectural aspects.

ROOFING:-

HKZMB Zhuhai Port is an essential a part of the Hong Kong Zhuhai- Macao bridge task with a complete region of 325,000 m2. To cowl 141,000 m2 of roof region over the passenger inspection regions A and B, Sarnafil PVC single-ply roofing membrane turned into applied. It now no longer most effective supplied secure and dependable waterproofing safety however additionally contributed to the architectural layout of the constructing matching with the aluminium status seam device above it. To obtain this effect, the Sarnafil® S327-15L PVC roof waterproofing membrane turned into custom designed to pearl white colour for the task.

FLOORING:-

For the development of the bridge, Sika supplied a huge variety of outside and indoor floors answers, which includes epoxy terrazzo floors, incredibly wear-resistant polyurethane and dry shake ground hardeners for concrete floors. Sika ground structures had been used on a complete location of over 140,000 m2 in passenger manipulate halls, parking garages, system rooms, workplace regions and pedestrian walkways on breakwaters.

ika's high-appearing floors answers had been a great healthy for this project, as they're designed for the present day traits and necessities and observe all policies and standards. Applied structures ensured durability, safety, sustainability in addition to an attractive look.

CONCLUSION

The layout of the bridge has been primarily based totally on a holistic method to fulfill the necessities of economy, sustainability, maintenance, and aesthetics and could assist in furthering the monetary integration of the Pearl River Delta. Over the final decade the fields of software of immersed tunnels were significantly enlarged. The HZMB Link in China is the today's instance, even greater stretching the boundaries and being an instance of the huge opportunities of immersed tunneling. The flyovers of the Hong Kong Link Road beneath Contract No. HY/2011/09 is precast prestressed concrete systems built the use of segmental balanced cantilever approach with span duration starting from 35m to 180m. About 7km of the viaducts are marine systems and a few unique strategies were hired to address the demanding situations encountered on this environment. Prestressed approach within side the formation of monolithic deck-column connection and pier works is a brand new strive on this assignment pushed with the aid of using the want to limit the in-situ concrete works and to optimize the erection cycle time. Special design and construction considerations for the use of precast concrete shells in the marine pile caps and pier segments of the long-span viaducts are also novel ideas motivated by the construction requirements. Geometric characteristics in the design and on-site geometry control/ erection follow up involve challenging technique adopted in this project particularly for the long-span viaducts of maximum 180m span length using the balanced cantilever erection method.

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