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Padma Bridge Rail Link Project with Special Emphasis on Padma Multipurpose Bridge, its Technological Uniqueness

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ABSTRACT

The South and Southwestern part of the country is devoid of direct communication with the central part of Bangladesh due to the presence of the most important tributaries of Lower Ganges i.e. Padma River. To establish direct communication with those areas Government of Bangladesh Constructed Padma Multipurpose Bridge with the provision of road and rail traffic at the upper and lower deck of the bridge respectively. The Padma Bridge Rail Link Project (PBRLP) is the main passage connecting the East and the West of Bangladesh and is also a part of the Bangladesh-China-India-Myanmar corridor. This line is a single-track passenger-freight railway with a total length of 168.6 km. For the first time in Bangladesh, State of the Art technology ballast less tracks in Padma Bridge, its approach to viaducts and other viaducts are being adopted for providing a smooth operation for both freight and passenger traffic. Precast and prestressed long sleeper embedded in cast in-situ track slab ensures a maintenance-free track system for the railway. PBRLP, once completed will restore the missing link with the Trans-Asian railway and will provide a platform for connecting with the Dedicated Freight Corridor (DFC) of India in future. It will also contribute to the Gross Domestic Product (GDP) of the country by 1.0%.

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1. INTRODUCTION

The Government of Bangladesh (GoB) has taken a project to construct a Multipurpose Bridge over the mighty river Padma. The objectives for constructing the said multipurpose bridge over river Padma is to connect Dhaka with South-West part of the country. The upper deck of the Padma Multipurpose Bridge (PMB) will provide four lanes for road traffic while its bottom deck will provide a single-track Broad Gauge (BG) line for rail traffic. Though the PMB has been designed based on the Dedicated Freight Corridor loading which is axle load 32.5 t but its Ballast less Track (BLT) structure been designed considering 25 t axle loading. Because of the lack of matured application of track structure considering 32.5 t axle loading, Bangladesh Railway (BR) has adopted the design of BLT with 25 t axle loading. However, based on the requirement of the BR and its connectivity with regional and sub-regional network, this track structure can be upgraded to 32.5 t axle load.

The Padma Bridge Rail Link Project (PBRLP) is a new rail route that will connect Dhaka with Jashore through the lower deck of PMB. It is a mixed passenger and freight rail routes and will pass through Dhaka, Naraynganj, Munshiganj, Shariatpur, Madaripur, Faridpur, Gopalganj, Narail and Jashore. With a view to connect Dhaka with South-west part of the country within shortest possible period, constructing of a rail link between Dhaka and Jashore earned prime importance. The new railway route will provide a substantially shorter route by reducing the travel distance between Dhaka-Jashore, Dhaka-Khulna and Dhaka-Darsana by 184.72km, 212.05 km and 44.24 km respectively. This rail link will become a vital railway corridor in terms of national as well as regional railway traffic demand (CANARAIL, SMEC, DB, & ACE, 2015).

This rail link passes through the flood plain and low-lying areas of the South and South-West part of the country. Running through the alluvium soil deposits and flood affected areas of the country entails a design level of embankment to be very high and needs extensive soft soil improvement. In this project, different methods of soft soil improvement techniques were applied based on the soil conditions. Drainage was another important issue which

was addressed properly by provisioning of sufficient bridges and drainage culverts. The railway embankment divided the people of surrounding area socially and culturally which entails the construction of adequate underpasses throughout the alignment.

2. PROVISIONS OF RAILWAY TRACK OVER PADMA BRIDGE

Padma Railway is the main passage connecting the east and the west of Bangladesh, and is also part of the Bangladesh-China-India-Myanmar corridor. This line is a single-track passenger-freight railway with a total length of 168.6km, a wheelbase of 1676 mm and a designed axle load of 25 t.

Figure 1: Padma Bridge under construction

Among them, Padma Bridge, its truss bridges at both ends and some viaducts adopt ballast less track of about 30km long. Padma Bridge, with a total length of 6.15km, is composed of 41 spans of $6 \times (6 \times 150)m + 5 \times 150m$ double-layer steel-concrete composite continuous beams (NIPPON KOEI CO., LTD & CONSTRUCTION PROJECT CONSULTANTS, INC., 2005). The upper layer is a two-way four-lane highway bridge, and the lower layer is a single-track broad-gauge railway bridge. The bridge deck of upper layer is a precast slab, which is connected with I-shaped longitudinal beam at the lower layer using embedded connectors. Meanwhile, Π-shaped reinforcements known as shear connectors are reserved on lower bridge deck slab to connect with the track slab.

Figure 2: Shear Connectors provided at the lower deck of the Padma Bridge

3. LOCATIONS AND ALIGNMENT OF THE PBRLP

The PBRLP is the second largest infrastructure project ever taken in Bangladesh after Rooppur Nuclear Power Plant.

Division	District	Upazila/Thana
Dhaka	Dhaka	Motijheel, Sabujbag, Sutrapur, Demra, Keraniganj
	Narayanganj	Fatulla
	Munshiganj	Serajdikhan, Sreenagar, Louhajang.
	Shariatpur	Janjira
	Madaripur	Shibchar
	Faridpur	Bhanga, Nagarkanda, Saltha
	Gopalganj	Muksudpur, Kashiani
Jessore	Narail	Lohagara, Narail Sadar
	Jessore	Bagharpara, Jessore Sadar

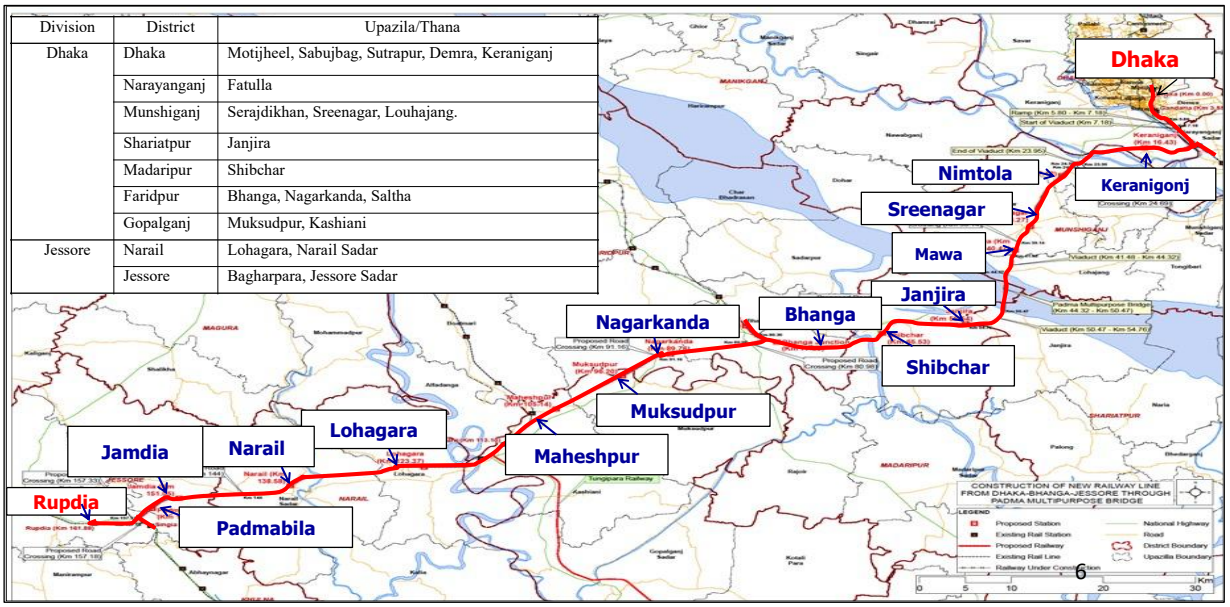

Figure 3: Alignment of Padma Rail Link Project (PBRLP)

4. SCOPE OF THE PROJECT

- Construction of new Broad Gauge 172 Km route main line and 43.22 km loop & siding line. Total track is 215.22 km including loops & siding.
- Construction of 23.377km viaducts, 60 major bridges, 230 minor bridges/ culverts/ underpass, 1 road overpass (at Mawa approach) and 29 level crossings
- Construction of 14 new station buildings and remodeling of 6 exiting station buildings along with Platforms, Platforms Shed, approach roads, functional and residential building for O&M personnel and other allied works
- Installing Computer Based Relay interlocked signaling System along with Telecommunication System of 20(Twenty) stations
- Supply of 100 BG Passenger Coaches
- Supervision Consultancy Services
- Acquisition of 1940.96 Acres private land and requisition of 206.5 Acres land from RHD and 59.32 acres from BBA including implementation of RP & EMP

5. OBJECTIVES OF THE PROJECT

- To connect Dhaka with South and South Western region of the country by rail road.
- To establish another sub-route of Trans-Asian Railway Network in Bangladesh.
- To cover new areas of Munshiganj, Shariatpur, Madaripur and Narail districts under railway network
- To create opportunity to construct second line in this route and connect Barisal and Payra Deep Sea Port in future.
- To contribute Gross Domestic Product (GDP) growth of approximately 1%.

6. TECHNOLOGICAL UNIQUENESS

- Introduction of Ballast Less Track in Bangladesh Railway.
- Initiation of railway track on elevated viaduct.
- Minimized at-grade crossing by providing road underpasses.
- Adoption of State-of-the-Art Technology in railway track, bridges and stations construction.
- Universal design for physically challenged people.
- Provision for carrying double stack containers.
- Introduction of transitional embankment at major bridge approaches
- Provision of future electric traction in railway.

7. CONSTRUCTION OF EMBANKMENT

A. Geological Strata

The whole embankment is mainly located on an alluvial plain which is flat. Except few areas nearest to the town, it has marshy area, paddy field and pond distributed on both sides of the embankment. The surface is made up of thick loose soil which provides poor bearing capacity, high compressibility and poor compression strength. The overlying layer is thick. From top down, the soil gradually changes from fine-grained cohesive soil into silty-fine sand. With the increase of depth, the soil becomes stronger and has higher bearing capacity. The ground water table is very high and close to the surface. The area also experiences frequent flood in changes climate change scenario. The foundation soil along the embankment gets soaked and the mechanical strength of the surface soil decreases seasonally.

B. Typical Embankment Cross Section

Figure 4 and 5 present Typical cross section of embankment with height $\leq \mathbf{4.0}\ \boldsymbol{m}$ and $\geq \mathbf{4.0}\ \boldsymbol{m}$.

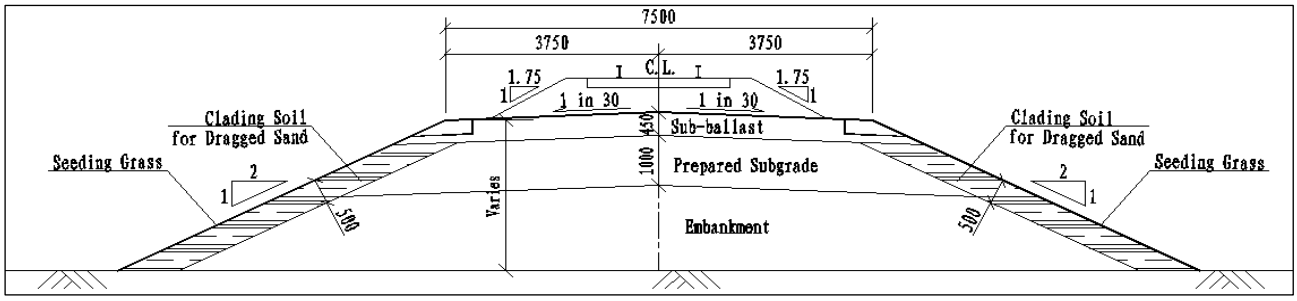

Figure 4: Typical cross section of embankment with height ≤ 4.0 m

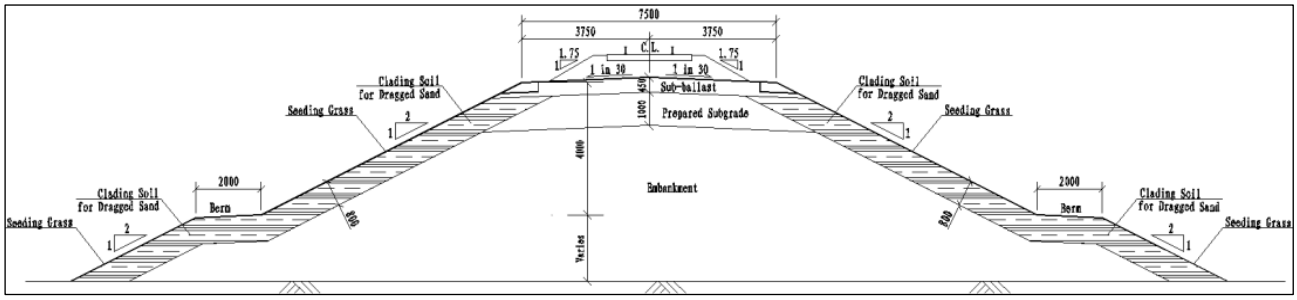

Figure 5: Typical cross section of embankment with height ≥ 4.0 m

C. Ground Treatment

i. Clearing, Grubbing and Stripping

After completion of the topographic survey, all trees, roots, stumps, weeds, and rubbish from the existing ground are to be removed. Removal of topsoil of 150mm thickness containing above rubbish are termed as clearing, grubbing, and stripping. All pits resulting from uprooting of trees and stumps are also backfilled again with required compaction.

ii. Removal and Replacement

Based on geological investigation, if the California Bearing Ratio (CBR) is less than 4.0 and bearing capacity is less than 100 KPA, then it is considered as soft soil. Soft material is fully removed and backfilled with suitable embankment materials, if the depth of soft soil and highly compressible soil is within 3m from the top of existing ground.

iii. Prefabricated Vertical Drain (PVD)

PVD, also known as Wick Drains or Band Drains are prefabricated geotextile filter-wrapped plastic strips with molded channels. It acts as a drainage path to take pore water out of soft compressible soils that consolidate faster under a constant surcharge load (Turukmane, Gulhane, Kolte, & Chaudhary, 2019). If the depth of soft soil exceeds 3m, the treatment of soft soil is done by PVD. To install PVD up to design depth, mandrel operation is adopted. The entire procedure of installation of PVD is recorded with digital corder having print out facilities. Surcharge or preloading is a must to ensure that the settlement has ceased before prepare subgrade is to be constructed in case of a railway embankment.

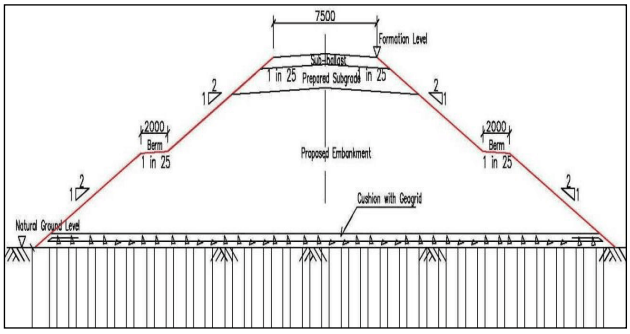

Figure 6: Cross section of soft ground treatment with PVD

Figure 7: PVD being installed in the embankment

iv. Cement Mixing Pile

Cement Mixing piles are an effective way for soft soil treatment using cement as the main curing agent. Mixing pile machine is used to inject cement into the soil body and to fully mixed with the soil. After a series of physical and chemical reaction between cement and soil, soft soil become hardened which will increase the strength of the foundation (Zotsenko, Vynnykov, & Zotsenko, 2015).

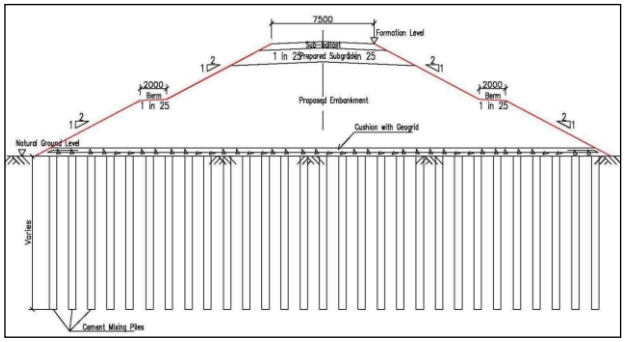

Figure 8: Cross section of embankment with Cement Mixing Piles.

Figure 9: Cement Mixing Piles after construction

Cement mixing piles are mainly provided at transition sections of both end of bridges, culverts, underpasses, and the underneath of these structure if there are soft soils. When there is a constraint of time, cement mixing piles are being used as it does not require preloading as settlement is not being expected once cement mixing piles are being used.

8. CONSTRUCTION OF RAILWAY TRACK

Two types of tracks are being used in Padma Bridge Rail Link Project. Though most of the tracks are of ballasted but for the first time BLT is being used in Padma Bridge, it's approach viaducts and other viaducts including steel bridges within the viaduct. The BLT has a definite advantage over ballasted track in terms of its high durability, stability, smoothness, and light dead load. It is normally applied in case of high-speed railway, heavy axle load, mixed freight and passenger railway track, urban rail transit, bridge, and tunnel etc.

A. Construction of BLT over PMB

The main bridge of Padma bridge is a 6×150m through steel truss bridge. The upper layer is a two-way four-lane highway and the lower layer is a single-track railway with a total length of 6.15km. The bridge layout is $\mathbf{150}\boldsymbol{m} + \mathbf{6} \times \mathbf{150}\boldsymbol{m} + \mathbf{6} \times \mathbf{150}\boldsymbol{m} + \mathbf{6} \times \mathbf{150}\boldsymbol{m} + \mathbf{6} \times \mathbf{150}\boldsymbol{m} + \mathbf{6} \times \mathbf{150}\boldsymbol{m} + \mathbf{5} \times \mathbf{150}\boldsymbol{m}$ continuous steel trusses. The layout of each span of main bridge of Padma Bridge.

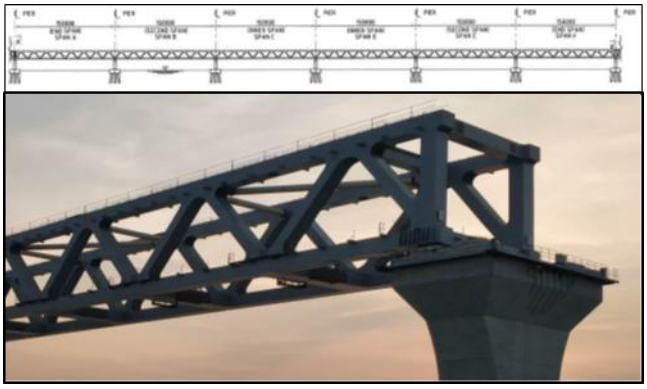

Figure 10: Spans of PMB

The span of Padma Bridge is 150m and consists of 8 sections, each of which is 18.75m long. The lower railway load-bearing system is composed of a bridge deck, longitudinal beams and lower transverse beams. The longitudinal beams are 15.9m in length and are supported on the lower transverse beams by supports and corbels. The bridge deck is a precast slab, which is connected with the longitudinal beam and lower transverse beam using shear studs.

B. Typical Cross Section of Padma Main Bridge

The top chord, bottom chord and diagonal members of the main truss are in the form of a hollow steel box. Plate thicknesses of the boxes vary depending on the location of the member. Box section is also adopted for other members including the lower cross beams and upper cross beams.

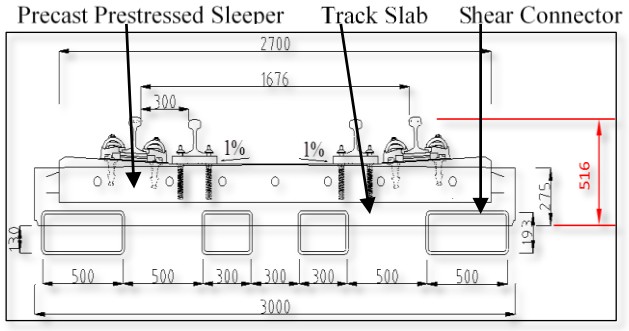

Figure 11: Cross section of Padma main bridge composite steel truss

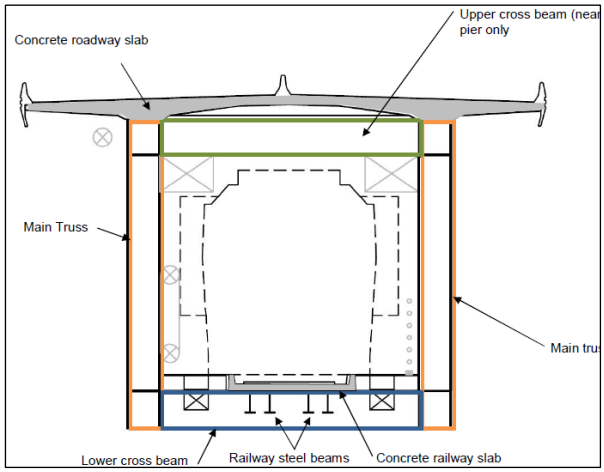

Figure 12: Deck slab over I Stringer

C. BLT Over Padma Bridge

Padma Main Bridge constitutes the Precast Sleepers Embedded Track Slab system. It is a type of BLT system which has less maintenance, and more stability since PSC sleepers are used at 600mm centres and are easy to construct. The sleepers are manufactured in the sleeper factory with high-quality standards and embedded (Cast in Situ) in M50 concrete. The track slab, deck slab and sleepers are connected by taking the bottom reinforcement of the slab through the shear connectors in the deck slab and the top reinforcements pass through the holes in the sleepers. The track structure consists of f 60Kg/meter E1 rail of R32 0. The fastening is s WJ12 system with a 32mm rail pad. The depth of the track slab from rail top to deck slab is 516mm.

Figure 13: Long Sleeper Embedded BLT over Padma Bridge

Figure 14: Semi precast cast in situ BLT

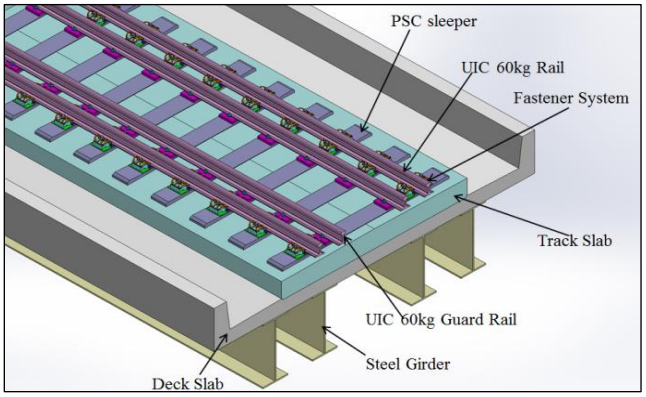

Figure 15: All components of BLT over I type Stringer

D. Construction Methodology of BLT over Padma Bridge

The track panel is assembled in the base; it is then hoisted to the bridge. The track panel is then transported to the construction site (Padma Bridge) by a gantry crane or platform wagon. Then, the track panel was lifted by the track panel laying gantry crane and laid over the lower deck. The steel bar was then placed and welded before the final adjustment of the track. The next step is the installation of mold for pouring the concrete to complete the construction of BLT.

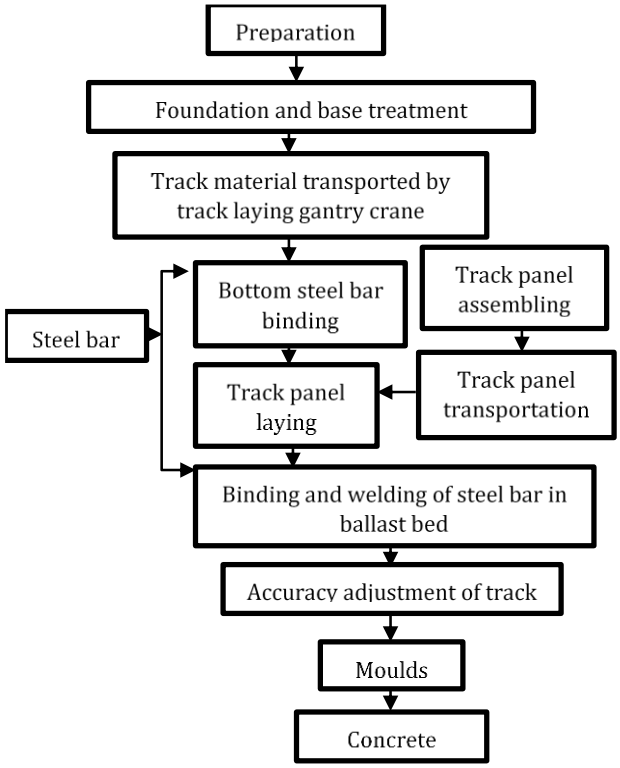

Figure 16: Schematic diagram of BLT Construction over Padma Bridge

Figure 17 Placing of precast sleeper over Padma Bridge Rail Deck by using Mechanical Layer is in progress

9. CONCLUSIONS

The Padma Bridge Rail Link Project (PBRLP) is the second-largest infrastructure project in the country. It is running through the lower floodplain of the country which is prone to flood every year. Soft soil improvement, numerous drainage culverts, bridges, grade separation and elevated viaducts including elevated stations made it a unique civil engineering project in the country. Besides, BLT and ballasted track construction with an axle load of 25 t gave exposure to Bangladesh Railway and other experts associated with it, a proper learning ground for future development and construction of the railway in Bangladesh.

ACKNOWLEDGEMENTS

The paper is written based on the author's personal involvement with the project as Deputy Chief Coordinator of the consultant team at present and Project Manager in the past. Besides, the author has consulted different documents of PBRLP as was involved in the design review, supervision, and implementation of the project.

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