Composite steel bridges: Present and future prospect in Bangladesh

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ABSTRACT: Traditionally lime or cement mortar based brick masonry circular arch bridges were extensively used for small canal in Indian sub-continent. Later on, steel truss or rolled steel I section bridge with lime mortar filled trough plate bridge deck was used. Bridge structures of such types were built during the British period in India. After that, RCC and pre-stressed concrete bridge was used in East Bengal (the then East Pakistan) and in Bangladesh. In the last 1990s few steel composite bridges were built under foreign assistance. Recently environmental and sustainable bridge system is becoming popular. In steel composite construction, naturally available aggregates and other construction material like steel is less used. In this paper advantage of steel composite system, how it reduces dead load of bridge superstructure, thereby reduces the foundation cost. Better earthquake resistance is often attained. It is faster in construction and its future prospects in Bangladesh are the main feature of this paper.

1 INTRODUCTION

Bangladesh was known as East Pakistan after the independence in 1947. At the end of 1947 there were a few roads and bridges in this part. The total length of paved road was 460.0 Km. At that time communication was based on waterways and railways. Composite Steel Bridge construction history of Bangladesh can be divided into three parts. First part is before the independence from British Raj in 1947, second part is before the independence of Bangladesh in 1971 and the third part is after the independence of Bangladesh in 1971.

Bangladesh is a riverine country. It is necessary to build bridges over the rivers to develop road network. The high strength and light weight of steel will minimize the structural weight of superstructures and results less substructure costs, which is particularly beneficial in ground conditions like Bangladesh. It reduces structural size and as a consequence less use of naturally available aggregates. These are discussed in the following.

2 COMPOSITE STEEL BRIDGES IN BRITISH PERIOD

During the British period few roads existed in Bangladesh. In that road network small span bridges i.e. span 5 m are made of circular brick arch and medium span i.e. span 10.0 m bridge becks are made of steel trough plate resting on steel joist. Steel trough plates are covered with lime mortar. But there were not any composite connection/action between steel joists, trough plates and lime mortar. The photograph of steel trough plate bridge deck is shown in Figure 1.

Figure 1. Steel through plate Bridge at Modhupur-Mymensing Highway

3 COMPOSITE STEEL BRIDGES IN SIXTIES AND SEVENTIES

The bridges built before the independence in 1971 were mainly RCC balanced cantilever, RCC deck girder and very few of them were single lane prefabricated Japanese plate girder and composite steel bridge. At that time small to medium gaps of river were connected by RCC balanced cantilever bridges. Wide river gaps were connected by ferry services. End of 1970, the total length of RHD road network was 3,865 km and total length of bridges/culverts was 40,200 m (132,000 ft). At that period composite steel bridges were made of RCC deck over rolled steel joist, basically steel I-section. Usually two steel joists were used for single lane bridge. A typical section and photographs of steel composite bridge deck are shown in Figure 2a and in Figure 2b.

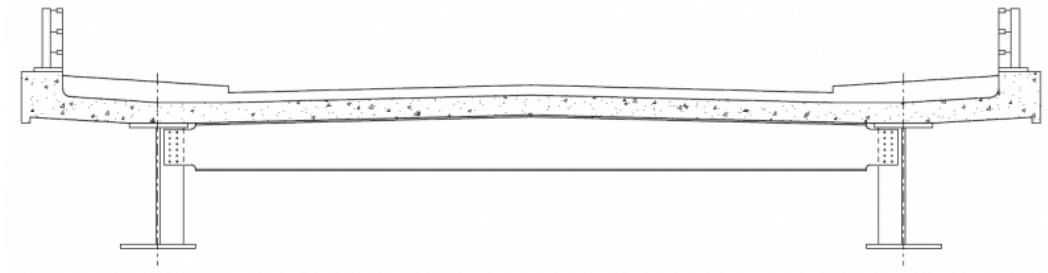

Figure 2a. Cross section of composite I-girder deck bridge

4 COMPOSITE STEEL BRIDGES IN BANGLADESH PERIOD

In the nineties of last century, few steel composite bridges were built by foreign assistance. These bridges are in Dhaka-Khulna and in Dhaka-Sylhet Highways. These bridges were multi-girder and the most common types of medium span composite bridge. The bridge deck were constructed by a number of similar sized longitudinal steel girders arranged at uniform spacing across the width of the bridge, as shown in Figure 3.The RCC deck slab spans transversely between the longitudinal girders and cantilevers transversely outside the outer girders. The girders are braced together at supports and at some intermediate positions. Composite action between the reinforced concrete deck slab and the longitudinal girders is achieved by means of shear connectors welded on the top flanges of the steel girders.

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Figure 2b. A composite steel girder bride at Dhaka-Tangail Highway.

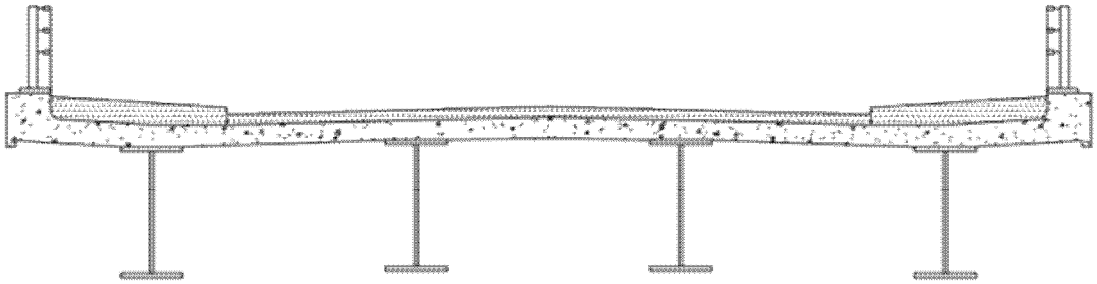

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Figure 3. Cross section of a multi-girder highway bridge

5 ADVANTAGES OF COMPOSITE STEEL BRIDGES

Steel is widely used around the world for the construction of bridges from the very large to the very small span. It is a versatile and effective material that provides efficient and sustainable solutions. Steel has long been recognized as the economic option for a range of bridges. It dominates the markets for long span bridges and medium span highway bridges. Now its choice is increasing for shorter span highway structures as well. Society gains in many ways from the benefits delivered by steel bridge solutions.

5.1 *Composite Steel Bridges Sustainable on Environment*

Most part of Bangladesh is composed of alluvial deposit carried by the rivers. Aggregate for construction is mainly derived from burned clay brick with low strength and very few natural stone aggregate with medium to low strength. All these aggregate put threat to the environment. Light weight superstructure reduces the consumption of aggregate and helps to provide a sustainable environment.

5.2 *Sustainability of Composite Steel Bridges*

Steel scores well on all the sustainability measures, and offers a broad range of benefits addressing the economic, environmental, and social priorities of the ‘triple bottom line’ of sustainability. The high strength to weight ratio of steel minimizes the structural weight of superstructures and thus minimizes the substructure

costs, which is particularly beneficial in poor ground conditions. Minimum self-weight is also an important factor in the cost of transporting and handling components. Use of steel facilitates shallow construction depths, which overcomes problems with headroom and flood clearances, and minimizes the length and cost of approach embankment.

Steel is the most recycled construction material and choosing it for bridge represents a sustainable management of natural resources. When a steel bridge reaches the end of its useful life, the girders can be cut into manageable sizes to facilitate demolition, and returned to steelworks for recycling. Component parts of steel bridges can be reused in other structures; entire bridges have been relocated and bridges can be designed with ease of future relocation in mind.

Steel has broad architectural possibilities. Steel bridges can be made to look light or reassuringly solid, and can be sculptured to any shape or form. The high surface quality of steel creates clean sharp lines and allows attention to detail. Modern fabrication methods can easily provide curvature in plan and elevation. The painting of steelwork introduces color and contrast, and repainting can change or refresh the appearance of the bridge.

6 DIFFERENT FORM OF STEEL COMPOSITE BRIDGE

6.1 *Multiple Girder Steel Composite Bridge*

Multi-girder steel composite bridges are one of the most common types of medium span. These types of bridges were constructed in Bangladesh during the nineties by the financial assistance from ODA UK. The bridges are Abdullahpur, Hashara, Pachchar, Salildia on Dhaka-Khulna highway and Binagao, Layercol, Bilashi, Sadhupati, Jointapur on Dhaka-Sylhet-Tamabil highway. Multi-girder construction is used for single spans and for continuous multiple spans, and it is particularly effective where construction depth is limited.

6.2 *Composite Steel Box Girder*

Steel and concrete composite box girders are used for long spans, where the self-weight of the bridge needs to be minimized, and for situations where their excellent high torsional stiffness is of particular benefit. The clean lines of box girders bridges, usually with no visible external stiffening, is generally considered to give excellent appearance and durability, since there are no traps for dirt and moisture. An example of Composite Box Girder Bridge with rectangular steel box section is shown in Figure 4.

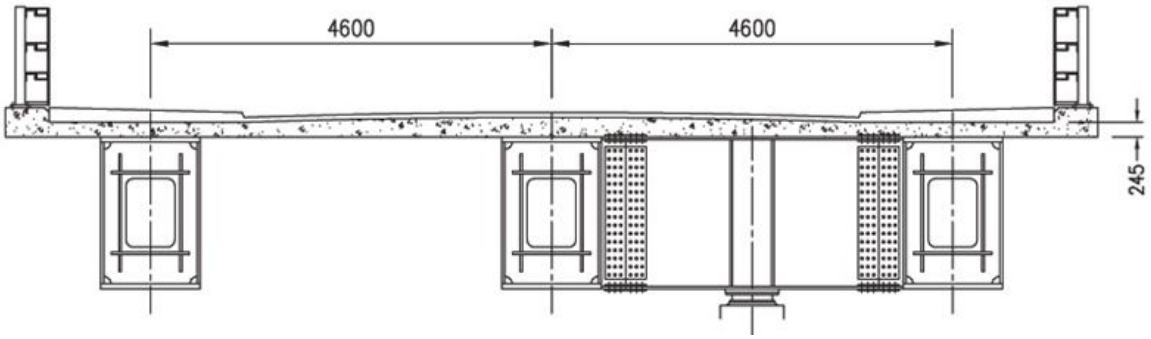

Figure 4. Composite Box Girder Bridge with rectangular steel box sections

7 FUTURE POSSIBILITIES OF STEEL COMPOSITE BRIDGES

Long span bridges are prime necessary for Bangladesh. Unlit now concrete and pre-stressed steel has been used in construction of long span bridges. High strength and light weight steel superstructure will reduce foundation cost. Superstructure construction of long span bridges by steel box section is easy and less time consuming. Earlier time steel composite bridges were discouraged due to foreign exchange shortage. Now the scenario has changed. By spending some foreign exchange our environment can be saved. .

8 CONCLUSIONS

The lightweight nature of a steel bridge means that it leaves the lightest possible footprint. Minimum foundation works is desirable not only for cost reasons, but also to minimize the environmental impact. The

excavation, transportation and disposal arising from substructures require less energy and produce less CO_2. Low maintenance weathering steel is available now. So it is a time to think for an economic sustainable solution.