Advance Technical Construction of Bridges

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Abstract

It is intended to develop bridge construction technique in Sudan to enhance traffic flow, through their model types, service type, construction techniques and materials, such as: Accelerated Bridge Construction [ABC], Incremental Launching Method [ILM]. (Soba) bridge construction was taken as case study and evaluated. Analysis and results had been carried out to develop ideal methods for the various types.

Introduction

Sudan's population rapid increase in cities especially Khartoum, raises traffic problem that the government try all possible measurement to maintain the smooth sailing of traffic. Therefore, it was intended to develop bridges construction by importing the latest techniques that will satisfy the following:

- Enhance the construction progress
- Minimize the cost
- Maintain the HSE requirement

That could be achieved through selecting suitable construction equipment, material and technique. Several items had been detailed through section State of the Art, such as: Bridge model, service, materials and construction technique. Further details for Accelerated Bridge Construction [ABC], Incremental Launching Method [ILM] and (Soba Bridge) construction was taken as Case study.

Discussion for the application of the advance techniques in comparison to what is running for superstructure geometry and equipment involved. It was concluded to the bellow recommendation:

- Apply ABC techniques
- Import advanced equipment
- Apply Box-girder & Segmental techniques
- Apply Moving scaffolding system [MSS]

State of the art

The most famous latest advanced bridge types are:

- Suspension bridge
- Cale-stayed bridge
- Cantilever Bridge

All of those are long span bridge, Suspension have light material deck such as Kaikyo bridge in Japan with span 1991m.

Cable-stayed has been affected by the advancement in computer technology to develop long and efficient span. Tatara bridge in Japan span is 900m.

Cantilever bridge construction has been favorable for its simplicity in construction, but requires adequate calculation for the supporting and erection system.

According to bridge service type can be classified in to Highway, Railway and Pedestrian bridge. It depends on the service live load intended, they are different in shape and size. Precast units, Cast on place and Steel & Composite frames are different techniques that passes through different ways of fabrication method, transportation & erection and construction material.

The Precast units bridge construction passes through casting on formwork, prestressing and curing, moving to stock yard, transporting to site and erection. They were applied for both Substructure [Columns & x-head beam] and Superstructure [Girders & Deck slab]. Precast segmental pier was one of the smart ideas. It allows constructing hollow segments that reduces material consumption and leaves ducts especially for Cable-stay bridge towers. Transporting girders to site for erection is through different kinds of equipment such as trucks, trolley and girders transporter. Span by span, balanced cantilever and cable crane [Cable way] were popular erection technique using different equipment like under-slung girder supported on false-work, over head gantry, cranes on floating barge or mounted on bases and lifting frames. The construction sequence was usually segments deliver, epoxy jointing, prestressing and grouting.

Cast on place was through Moving Form Traveler [MFT]. The segment needs to have developed at least the specified strength to be prestressed to the previous elements and support the subsequent one.

Cable way is also being used on the steel arch bridge. In this case the design and construction must go hand-in-hand for successful conclusion.

Innovative materials were involved such as Fiber Reinforced Polymer [FRP], High Performance Concrete [HPC] and Ductal. They were higher in strength, lighter in weight and durable for their service life.

Accelerated Bridge Construction [ABC] with its different techniques takes most of the construction stages in fabrication yard. It has been implemented by the USA Department of transportation [DOT]. Full span erection was with Transporter or Launcher. The following table reflects their capacities.

Table. (1): Equipment capacities

Equipment	Rolling speed	Load Carrying Capacity
Transporter	100 m/min	450 ton
Launcher	3 m/min	500 ton

ABC advantages were as bellow:

- Safety: reduce work zone accidents
- Mobility: reduce congestion; improve flow
- Innovation: new equipment & procedure
- Leadership: new standards, used by local agencies

Incremental Launcing Method [ILM] for concrete bridges were cast in stationary forms behind an abutment, meanwhile steel bridges were completely assembled (typically one span or more at a time), including steel cross frames and bracing, prior their launching operations. It is worthy in consideration for project sites which face challenges such as:

- Steep slopes or deep valleys that make delivery of materials difficult.
- Deep water crossings.
- Environmental restrictions that prevent severely limit access.
- Access to area beneath bridge limited b heavily traveled roadway or railways.

The case study was (Soba Bridge) construction. Crossing the Blue Nile to connect Khartoum with Khartoum North, it is one of the Ring Road elements that was aimed to withdraw the traffic out of the town center.

Basic information:

- **Client: Ministry of Infra-structures**
- **Consultant: TECNOCON + KHATEEB & ALME**
- **Contractor: A&A**
- **Project duration: 30 month**
- **Start date: December, 3, 2012**
- **End date: June, 3, 2015**
- **The basic contract value 38,000,000 USD, for length of 820 m.**
- **The design was modified according to the contractor's proposal to reduce the length to 570m and 27m width. The contract value decreased to 31,000,000 USD.**

Bridge substructure was casted in place on formwork, meanwhile superstructure girders were pre-casted and launched using Pin-mover, Trolly and Gantry launcher. The tables indicate girder erection equipment and their launching speed.

Table. (2): Girder erection equipment

Equipment	Capacity	Job description
Pin mover	60 ton	Moves girders to stocking yard and handle it to Trolley
Trolley	60 ton	Transport the girders and deliver it to Gantry launcher
Gantry	70 ton	Locate the girder in right position.

Table. (3): Equipment speed and loading duration

Equipment	Rolling speed	Average Loading & Offloading duration
Pin mover	4 m/min	(55) min
Trolley	5 m/min	
Gantry	6 m/min	(75) min

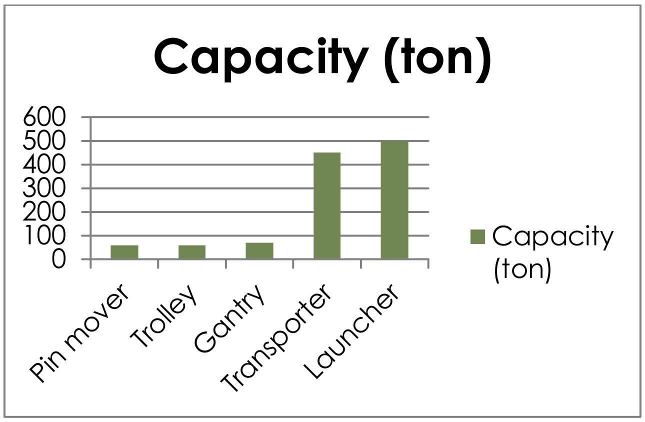
Evaluating the equipment performance through the tables, reflect clearly that the superstructure construction technique was slow. According to Trolley speed it takes almost 5 hours to transport girder from stoking yard to launcher within 1.2 km. Picking the girder by pin-mover set, both sides were not linked to be operated together in timing, but depend on the operators' communication for move and stop.

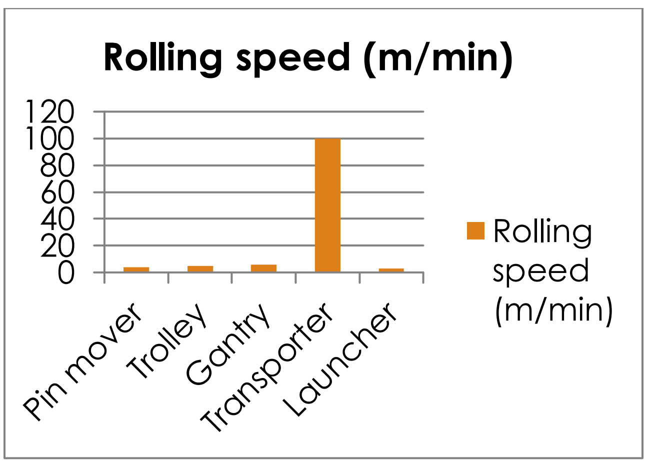
Results & Discussion

Taking Soba Bridge construction as case study representing the bridge construction industry in Sudan and measuring it with advance techniques, we had derived the following results:

- Girder type is T-section girder that requires much casting yard and long preparation period. Most of the latest bridges were Box-girder that were economical, smart and highly in construction progress.

- Pin-mover, had low speed and rolling on rail (not flexible), meanwhile Girder-lifter had high speed and rolling on wheels.
- Trolley is very slow in comparison with Girder-transporter see the chart.
- Trolley transport only one girder and that means only 10% of full span width, without deck and diaphragm construction.
- Transporting & Launching equipment vary in capacity according to construction requirement.





Conclusion

Precast units' construction progress was over the cast onsite and even the quality was more adjusted.

Movable launchers or girder transporter were quicker especially those who carry full span.

FRP and Ductal as construction material will minimize the section, decrease the weight, extend the span and increase the strength. Therefore, and efficient structure with aesthetic model could be achieved. But it's usage should meet feasibility and environmental requirements.

Incremental Launching method [ILM] requires adequate calculation for the supporting system to avoid negative impact, such as collapse.

Accelerated Bridge Construction [ABC] was and efficient system, but requires further study to select and adopt the suitable techniques.

Bridge construction requirements for geometry, material, construction equipment and tools had to specified. It was recommended categorizing them according to their suitability to our conditions as mentioned below:

- Applying ABC technique was the most fruitful method, because it saves time, shorten the construction duration and minimize the disturbance especially in the cities.
- Import the equipment that moves on wheels to speed up the delivery of the units to the launcher for erection
- It was preferable to make use of the advantage of the box-girder since it was economical and easy to control.
- Moving scaffolding and jacking system for the false-work was applicable and will highly speed the construction progress.

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