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11. East Jeddah Airport Roads: Jeddah By-pass (Saudi Arabia)

Owner: Kingdom of Saudi Arabia, Ministry of Communication

Consulting Engineers: Dar Al-Handasah Consultants, Shair and Partners, London, UK

Contractors: EPE (Engineering Projects Establishment), Riyadh and CORIB (Consorzio Romagnoli, Irces, Bettoni), Milan, Italy

Designers of alternative bridges: Cepas Plan Ltd., Zürich, Switzerland

Prestressing work: BBR (Middle East) Ltd., Jeddah, Saudi Arabia

Construction period: 1977-1980.

Introduction

In the course of developing the new Jeddah Airport and for by-passing the city of Jeddah, a ringroad with dual carriageways has been constructed. This motorway section of about 40 km length necessitated a series of interchanges, wadi and channel crossings, requiring a total of 47 bridge structures. After various project changes, 35 bridges have been built according to an alternative design proposal prepared by Cepas Plan Ltd.

The tender in 1976 was won by a Saudi Arabian contractor–EPE–, with an Italian group–Corib–, which has been awarded the contract for the bridge and road work. Subsequently EPE approached Cepas Plan Ltd. to study the feasibility of alternative design proposals for the bridges. The studies included firstly precast post-tensioned concrete box girders, secondly fully cast-in-place post-tensioned bridges and thirdly a solution combining cast-in-place concrete for the bottom slab and webs with precast deck slab elements. The evaluation yielded that the second and third solution offered savings to the contractors particularly, because the cross-sections of the various bridges could be standardized, resulting in a multiple use of the formwork, and savings in concrete and prestressing steel were possible.

Finally the consulting engineers Dar Al-Handasah Consultants, Shair and Partners accepted and approved the alternative bridge design proposals by Cepas Plan, as will be shortly described hereunder.

General description of the bridges

Three basically different types of bridges have been executed:

Channel crossings

These 8 crossings consist of skew concrete slabs with non-prestressed reinforcement. The slab thickness varies from 0.6 m to 0.85 m depending on the spans of 12.3 to 25 m.

Wadi crossings

They have been designed as cast-in-place post-tensioned continuous girders with 5 to 9 spans of equal length of 20 m. The bridge cross-section consists of 3 resp. 4 trapezoidal, 1.3 m deep, 1.4 m wide girders, each with one hollow core dia. 0.9 m. The girders are spaced at 5.9 resp. 5.3 m for a bridge deck width of 18.05 m resp. 21.7 m.

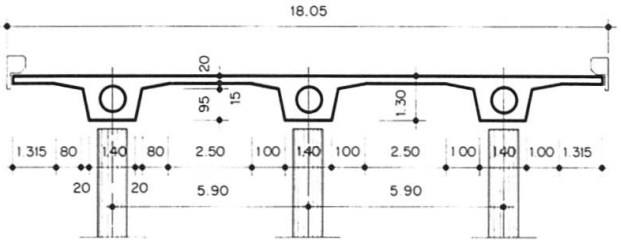

Fig. 1 Cross-section of the wadi crossing

Interchange bridges

These 24 multiple box girder bridges were constructed using post-tensioned cast-in-place concrete for the bottom slab and webs and precast elements for the deck slab. The bridges consist of 3 to 12 spans, 24 m to 45 m long, resulting in overall lengths of the structures between 120 m and 332 m. The depths of the cross-sections are 1.25 m, 1.5 m or 2.2 m, depending on the length of the spans. The number of traffic lanes determines the widths of the bridge decks which are 11.4, 14, 18 or 21.7 m wide.

The clear distance between the webs could be made identical for all the different cross-sections. This permitted an economical production of only one type of precast deck slab element.

Fig. 2 Nearly completed interchange bridge, before mounting the precast parapet elements

Design

All the bridges have been designed according to the British Codes. In particular, the following requirements had to be met:

- full prestress with limited concrete tensile stress for all load combinations incl. the stress due to temperature gradient
- computation of all the members of the bridges assuming a heavy truck load of 4 axles at 45 tonnes in the most severe load arrangement
- verification of the required reinforcing steel according to a crack width criteria.

Construction procedure of the superstructure of the interchange bridges

The falsework for bridges up to 120 m length was entirely in place, before the concreting of the superstructure was carried out span by span.

Fly-overs, longer than 120 m were built in stages. Generally, the falsework for two spans was erected. At the construction joints of each second span all prestressing tendons were tensioned and coupled after the concreting in stages of both spans was completed.

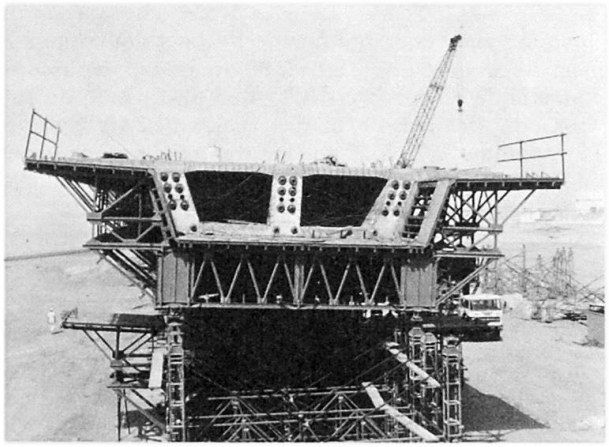

Fig. 3 Construction joint with stressed tendons

The construction procedure of the superstructure was chosen as follows:

- erection of the falsework for at least two spans
- concreting of the trough incl. the pier diaphragm and adjacent deck slab sections (as far as the tendons have completely dipped into the web)
- tensioning of the cables to 20% of the initial prestressing force
- placing of the precast deck slab elements, concreting of the cantilever deck slab and the element joints
- increase of the prestress to 60% of the initial force
- lowering of the falsework and subsequently
- prestressing of the tendons to 100% of the required initial force.

Fig. 4 Placing of the precast deck slab elements after concreting bottom slab and webs and applying a partial prestress

Construction procedure of the superstructure of the wadi bridges

Precast deck slab elements were not practical for this type of cross-section and the sequence of construction was adjusted as follows:

- erection of the falsework for the whole bridge up to 5 spans
- concreting of the entire cross-section incl. diaphragm over the pier and deck slab, span by span
- after hardening of the concrete partial prestress of the tendons to 60% of the required initial prestressing force
- lowering of the falsework and subsequently
- increase of the prestress to 100% of the finally required tendon force.

Prestressing

All the bridges are post-tensioned by means of the BBRV buttonheaded wire system. Three tendon sizes consisting of 24, 32 and 42 dia. 7 mm high tensile steel wires have been used. Depending on the cross-section of the bridge 5 to 10 tendons are arranged in each web. The tendons of the shorter bridges were tensioned from both sides. The tendons of the bridges built in stages were stressed at the construction joints and coupled. In total 1,200 tonnes of high tensile prestressing steel wire was used resulting in a mean consumption of 18 kg per m^2 of bridge deck slab.

(N. Winkler)