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SEGMENTAL CANTILEVER BRIDGES AT KAROTE AND KOHALA

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SUMMARY

Key features of analysis, design and construction are presented for two major prestressed concrete segmental cantilever bridges on river Jhelum at Karote and Kohala in Pakistan. Features of design called for by the high seismicity of the sites, very high velocities of flow and exceptionally difficult geotechnical conditions are discussed. Construction of the two bridges, that was let out on a turn-key (design-and-construct) basis, is briefly described.

INTRODUCTION

Bridges at Karote and Kohala have traditionally provided major fixed-crossings over river Jhelum for general traffic and trade convoys. Previous bridges at these locations failed during the record floods in September 1992. National Highway Authority, under a credit from World Bank, invited international bids for reconstruction of both the bridges on a turn-key basis in July 1993. Contract for construction of the bridges was awarded in August 1994.

SITE CONSTRAINTS

The orientation, arrangement of spans (Fig. 1) and structural design were largely dictated by site constraints, particularly hydraulic, geotechnical and seismic parameters.

Hydraulic Parametres

Flow in river Jhelum is seasonal and water levels rise dramatically during floods. The flood season discharge at Karote is around 11,000 cumec and at Kohala around 17,000 cumec which is accompanied by high flow velocities and rapid rise in water levels, upto 35m, from low flood.

For this reason deck levels for the new bridges were raised considerably. Also the value of free board was also increased by one metre from previous values.

Geotechnical Parametres

River Jhelum flows through a deep gorge at Karote with steeply sloping banks Preliminary geotechnical investigation indicated the presence of sound hard Sandstone underneath an overburden of about 5 to 6m mainly comprising gravel and small boulders.

Conditions at Kohala were vastly different and treacherous. The whole area is in a constant state of drift since many centuries and both banks are prone to frequent landslides. The problem was particularly aggravated in 1992 by the receding flood waters that created a rapid draw-down and activated a series of major land-slides even at locations that had been dormant recently. Top soil comprised mostly gravel, boulders and debris from landslides. Subsoil comprised flaky shale interlayered with clay, boulders and gravel. Hard brown shale was available at lower depths.

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Seismic Environment

The sites lie in a high risk seismic zone. Tender documents categorized both sites to correspond to Seismic Performance Category-C of AASHTO and stipulated detailed three dimensional dynamic Response Spectrum Analysis not only during service but also during erection. A base spectral acceleration of 0.22g was specified. The designer used the AASHTO response spectrum as the basic spectral input. The spectral acceleration was applied in the two orthogonal horizontal directions with a simultaneous vertical component [1].

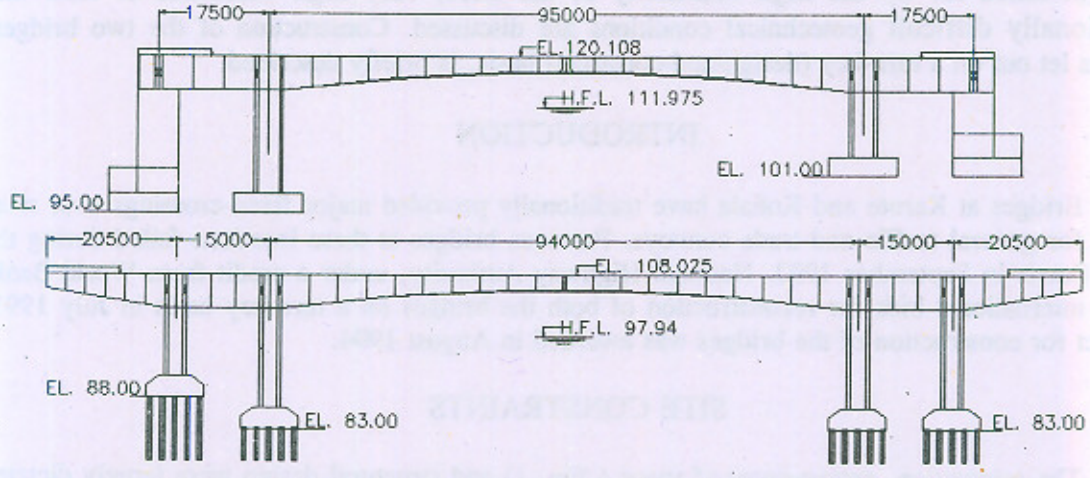


Figure 1: Bridge elevations for Karote (top), Kohala (bottom).

BRIDGE AT KAROTE

Superstructure

A fully continuous 3 span superstructure employing single cell box girders with straight webs was provided. It was envisaged that full continuity would provide long term advantages and significantly add to riding quality. Structural advantages under permanent and transient loads were also envisaged. Detailed analysis confirmed that full continuity of the superstructure significantly attenuated earthquake induced efforts in the substructure.

An important feature of design was the standardization of the prestressing cable profiles. All cables followed straight profiles. Standardized curved were introduced only within the segments in which the cables were anchored. Many of the cables were anchored in blisters provided in the top slab. This feature of design facilitated on-site management and significantly improved the construction cycle.

It was realized that the design of major bridges essentially relates to the method and sequence of construction. A closely integrated design process was therefore developed that ensured constant interaction between the engineering teams of the designer and the contractor at all stages of work.

Substructure

Open foundations were provided with heavy counterweights installed on top of both abutment foundations to resist uplift caused by permanent static loads and transient environmental loads. Piers comprised single cell hollow square shafts of constant cross section. Adequate wall thickness was provided to guard against local failure from boulder impact. Abutments comprised twin solid shafts separated 4.35 m to provide a spill through arrangement, particularly considered advantageous In view of the 25 m height of fill on the left bank.

BRIDGE AT KOHALA

Superstructure

The 5-span superstructure for Kohala in many ways is similar in concept to that of Karote. However, to be noted is the absence of integral connections with abutments at both banks, a feature of design that was dictated by the adverse geotechnical nature of the site as will be discussed later. The superstructure, like that of Karote bridge, does not have any expansion joint and is connected integrally with the piers. Diaphragms are provided at supports only.

Substructure

Detailed study involving physiography, geological mapping, seismic surveys, interpretation of rock profiles and study of probable slide mechanisms confirmed that only the top soil participated in a landslide. Sub-soil and bedrock were stable and dormant. Location of piled foundations, and hence the arrangement of spans, was derived from this logic. No integral abutments were provided on either bank. In the event of a major landslide the abutments, constructed in stone masonry, would de-stabilise and fail without causing any permanent damage to the main structure. Piers, deriving their stability from the paired arrangement and located sufficiently away from either bank would thus not sustain any serious damage. To guard against maximum scour in high flood, uplift during earthquakes and drag from moving top soil in a landslide, piles were socketed at least 4m into sound bedrock. Piers comprised hollow nosed rectangular shafts of a constant cross section.

CONSTRUCTION

Construction began at Karote in April 1995 [2]. It was envisaged that construction at Kohala would start simultaneously, however due to a number of problems, mostly related to acquisition of land and compensations, construction could not commence until November 1995.

Closure of the main span for Karote (Fig. 2.) was achieved in June 1997. Insitu segmental construction of the superstructure using specially designed form travelers proceeded at a rate of one pair of segments every 10 days. Strict geometry control ensured that final tolerance in levels at closure of main span did not exceed 9mm. This tolerance in levels was rectified by maneuvering the position of the construction gantry on the proud cantilever. Earthwork for approaches is currently in progress, the bridge is expected to open to traffic in December 1997.

The bridge holds the national record for the longest fully continuous bridge span constructed by the segmental cantilever method.

The bridge provides a major departure from traditional segmental construction in the country by incorporating a number of innovative features that include the following:

- ☐ Single cell box girder construction
- ☐ Full continuity for live loads and environmental loads
- ☐ Diaphragms at supports only
- ☐ Use of full scale response spectrum analysis to AASHTO 1992



Figure 2: Main cantilevers nearing closure at Karote.

Construction work at Kohala, after initial setbacks from massive land-slides on the left bank, is at an advanced stage (Fig. 3). Table-spans at both banks have been cast and 12 segments of the main span, out of a total of 20 have been cast and stressed. The bridge is expected to open to traffic in May 1998 after earthwork on the approaches has been completed.



Figure 3: Bridge at Kohala under construction

CONCLUDING REMARKS

Design and construction of bridges at Karote and Kohala provided a major activity in the field of bridge engineering in the country and inspired great interest in the professional community. The bridge at Karote holds the record for the longest fully continuous bridge span in Pakistan constructed by the segmental cantilever technique.

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