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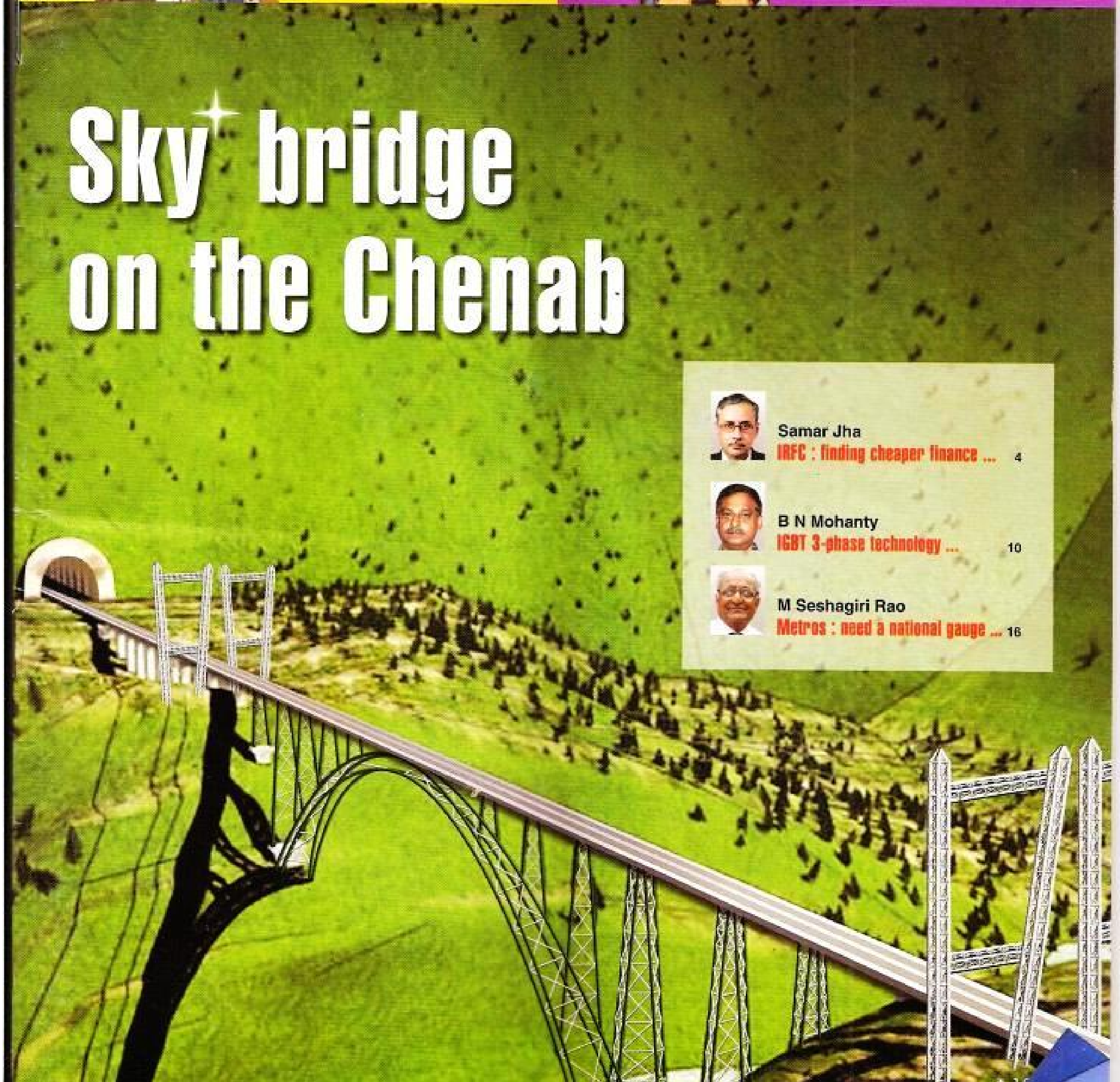

Sky bridge on the Chenab

Chenab Sky*bridge : marvel in the making

View of the ropeway pylons from a fabrication yard

R K Gupta, Chief Administrative Officer (Cons), Northern Railway

The new railway line from Katra in Jammu to Banihal in Kashmir is going to be built in geologically untested terrain and is a major project that will tax Indian engineering and project skills. By far, the toughest technological challenge is the design and construction of the steel arch bridge on the Chenab in Reasi district of Jammu and Kashmir. On completion the bridge will be an imposing 384 m above the river level, the highest of its class in the world. Today as the bridge piers and pylons take shape, a view from far way (about 10 km from Reasi town) impresses with the multiplicity of the engineering skills and innovation that will be required. On completion, the bridge should easily be counted as the toughest rail construction job in modern times in India.

Salient features

Length of deck	1315 m
Main arch span	467 m
Crown height	120 m
Approach (Jammu end)	185 m
Approach (Kashmir end)	650 m
Spans 17, Footings 18 : two for arch foundations, 5 steel piers no. 2, 3, 4, 5 & 6; 11 concrete piers and 2 abutments	

The bridge, to span over 11 concrete and 5 steel piers, has been designed to accommodate double track even though tunnelling and rest of the track is at present limited to single track. Just about 250 m of the bridge will be on a mild curve. The arch will be of steel fabrication, to be manufactured at site workshops and transported to launching sites before being lowered into position by ropeway based cranes supported on two pylons. These 'sky high' pylons are already in position, imposing 103/126 m tall and 915 m apart, waiting for the anchorage to be put in place. As the cable cranes are loaded into position later this year, it will be worth travelling many a mile just to take in a bird's eye view from the state highway to Salal.

Each bag of cement and each tonne of steel will have to be trucked over the recently built rough approach roads, one on each side. Requirements are expected to total 43000 cum of concrete, 3200 t of reinforcements and above 25000 t of steel plates. It is not surprising that many doubts have been raised about the long term stability of the bridge: for every pioneering effort there are enough dissenters who watch from the side lines and pass uninformed judgments.

The international team

This portion of the federally funded national project has been assigned to Konkan Railway Corporation Ltd. The bridge will be designed and constructed by a JV Chenab Bridge Project Undertaking, a consortium formed by AFCONS, Ultra Construction and VSI India. The JV has in turn appointed design consultants in WSP Consulting Kortes (Finland) for via duct and foundations and Leonhardt Andra und Partners (Germany) for the main steel arch. D K Kunnar and VJ Pai of AFCONS who manage the project site indicated that the detailed design of the bridge has undergone number of design consultations and reproofing including for wind load. At present consultations are on with DRDO for assessing the capacity of the designed structure in case of a sudden impact as in case of a blast. The worst case scenarios are being simulated and proofed against.

Progress had been retarded on this 2004 contract due to IR decision to suspend work in 2008 for a fresh look at the overall alignment. As of now, the cable crane equipment has been received at site from SEIK Cables, Italy who specialise in such systems at large construction sites. Lowering the arches and the decks over depths up to 80 m, when a piece can weigh almost 30 t, can be a daunting task. Herbert Franzelin and Roland Kasper, commissioning engineers from SEIK, explained that the cable cranes to be mounted in two segments on the cables suspended from the already erected pylons are rated at 20 t each (6 t self weight). Operation is through hydraulic motors and various microprocessor based controls. These cranes are designed for a maximum lift of around 200 m, will have 2 sky tracks and can work in tandem at a maximum lift of 1 m/sec. for main lift. 8 pylon steel cables used will be 54 mm dia.

Construction and design

The 1.315 km long bridge can be divided into three segments: 467 m steel arch in the center, 185 m approach deck from the Bakkal (Kashmir) "B" end and 650 m approach deck from the Kauri (Jammu) "K" end. At both sides the track will emerge from tunnels. The decks will be supported on 11 concrete and 5 steel piers (2 on one side of the steel arch and 3 on the other). The main steel arch is between piers 4 and 5 (counted from Jammu end). The arch consists of various segments selected carefully to match with the 9 spandrel columns (steel trestles) and limited in individual piece weight matching the combined cable crane capacity of around 32 t. The arch segments taper towards the middle for providing adequate stiffness to the structure.

The very size of the piers, steel sections and decks renders one into large flights of imagination: the foundations will require 46000 cum of concrete mix and 6500 t of reinforcement steel supplementing about

25000 t of structural steel used for the arch , the trestles and the decks. Maximum pile cap size is 17.6 x 11.6 x 4.1 m, which is the size of a large hall. Foundations expectedly will be supported on open and pile formations with conventional methods being used for piling. 109 bore cast insert piles of 1 m dia will support various foundations. Considering local conditions, maximum pile depth of 35 m will occur at the last pier location.12 open foundations with a max depth of 10 m will complete the scene.

Not surprisingly the foundations for the arch segments, piers 4 and 5 from Jammu end, defy normal sizes: these will be 38 x 28 m and a height of 22 m (a football field is around 45m wide).

On site facilities

In addition to concrete batching plant that is already functional, 4 steel fabrication yards have already been set up.

Submerged arc welding will be used for most of the structures, with attendant quality control measures. At present the welding sequence and controls are being fine tuned in consultation with RDSO. For this project the nationally recognised Welding Research Institute, Tirucharapalli has been retained as welding consultants.

Incremental launchings

Deck segments will be fabricated in nominated fab yards and handled in the launching yards to be created for this purpose. Three launching yards one at each end and another intermediate after 7th pier will be built. The longer approach from Kashmir end will be accomplished in three stages:

Stage I	Pier 18 to 13
Stage II	Pier 8 to 13
Stage III	Pier 5 to 7

Pre-fabricated deck segments 8.33 m long will be moved to launching pads on either side. Three deck segments will be welded together to a length of 25 m and then connected with launching nose of 27/36 m length. The launching nose helps guide the deck segment in the right path avoiding any errors or damage to the piers. Temporary piers are planned to be constructed at three points: between Piers 17-18, 8-9 & 12-13. Once the first deck reaches the temporary pier, the launching nose will be removed using a specially erected derrick and taken to the launching yard. Stage 3 of the incremental launching process from Pier 7 to 5 uses launching yard between Pier 7 and P 8.

The concrete piers are box sections standardized at 8 m x 3.5 m but with wall thickness varying from 0.5 to 0.8 m with maximam height of 50 m at Pier 14. While decks will be launched by incremental launching in different combinations, it is the launching of the steel arches and trestles which will be visually most appealing when it happens. Considering the weights and depths involved in segmental arch sections, the method chosen is to use two cable cranes, each 20 t capacity, that will be suspended from 54 mm dia steel cables, almost touching the sky (when you describe such a project, some exaggerations are allowed!). For this purpose 2 pylons 120m tall already erected, are awaiting suspension of the cables and the cable cranes, expected to happen later this summer.

From the Jammu end, single stages incremental launching will suffice for the 4 spans to be decked there.

The loading of the arch segments is almost like building a mechanics set: slowly, methodically and with precision. The cable cranes will be used to lower each arch segment from the decks, with symmetrical operation from both ends. Temporary bracing will be used to support the arch segments before individual trestles are loaded and erected. As the trestles get done, decks will follow per plan. Sounds easy but considering the weights and heights involved, just one word describes it: mind boggling.

Site engineers explained the current work scenario. While 9 piers have been cast and fabrication facilities established, a mock up of deck fabrication has been done to permit detailed examination. Geological drilling is currently being done for steel arch foundations and some other locations.

Fab Yard	Workload	Tonnage
Yard 1 Kauri end	Deck structure 4 (part) to 18	7570
Yard 2 Surandi 6 km from launching yard	Steel piers , arch and trestles (50%), temporary structures	7270
Yard 3 Bakkal end	Deck structures, 5 piers	8680
Yard 4 Bakkal yard	Steel piers, arch and trestles (50 %)	7130

Project engineers VVRV Prasada Rao, V J Pai, Herbert Franzelin, Roland Kasper and Shashi Dhara in front of cable crane.

Tough site management

A thought is required for the managerial skills required to obtain highly specialised manpower at various levels at these odd locations and to retain these for the entire project duration. The project team has set up camp in the midst of the wilderness. VJ Pai narrated the experience few years back when they were held up on site for 28 days with no contact with "civilization". It is not a surprise that satellite communication has been installed at site for easing work and loneliness of the project staff from KRCL as well as the JV.

While locally available staff is adequate for low end jobs, almost none are available for the highly specialised jobs. We did meet with few young people from Kauri and nearby villages who have found employment in the fabrication yard and other general jobs. The support to the local economy through the construction of the approach roads and availability of jobs, albeit at the semi-skilled level, is significant. Perhaps the state authorities have to step in with their support for attaching few 'journey men/trainees' to highly specialized gangs for that is the way local skills are developed. This is an opportunity that rarely presents itself but seems to have been missed so far. RB