HydroSurveyor Enables Rapid Indian Railways Bridge Surveys

Acoustic Technology Makes Railways Safer

Every day, Indian Railways (IR) carries 23 million travelers and 3 million tonnes of freight on routes covering 95,981 kilometres (km). Maintaining one of the world’s largest railway systems—with more than 1,23,500 km of track spanning deserts and jungles, crowded cities and empty landscapes, mountains and coastlines—IR must maintain constant surveillance of the condition of its 1,47,523 bridges to keep its network running.

IR runs more than 13,500 passenger trains daily, from Mail or Express trains chugging at an average speed of 50.6 kilometres per hour to premium passenger trains running 140 to 150 km/h and the flagship Gatman Express between New Delhi and Jhansi topping out at speeds of 160 km/h. At the same time, more than 9,000 freight trains carry goods that fuel one of the world’s most dynamic economies. More than 12,000 locomotives, 2,89,185 wagons and 74,000 coaches keep Asia’s largest railway—and the world’s second-largest railway under single management—rolling.
In a system as crowded and vital as IR’s, bridge failure can be
catastrophic. The threat is heightened because 37,689 of IR’s bridges
are more than 100 years old. Though the Ministry of Railways notes that
age is not an indicator of soundness, it also points out that a century
ago, bridges were designed for lighter loads than they are today.
Regardless of the age or even the condition of a bridge, the biggest
concerns in bridge safety is scour, the removal of sediment from
around bridge abutments and piers caused by swiftly flowing water.

The resulting scour holes can comprise the integrity of the structure.
Bridge scour is one of the three main causes of bridge failure (the
others being collision and overloading). It has been estimated that
60% of all bridge failures result from scour and other hydraulic-related
causes. It is the most common cause of highway or railway bridge
failure.

Water normally flows faster around piers and abutments, making them
susceptible to local scour. At bridge openings, contraction scour can
occur when water accelerates as it flows through an opening that is
narrower than the channel upstream from the bridge. Degradation
scour occurs both upstream and downstream from a bridge over large
areas. Over long periods of time, this can result in lowering of the
stream bed and, finally, weakening of the bridge structure.

Gathering data on the bridge scour over a period of years is the only
way that early warning can be issued to direct measures to strengthen
endangered piers and abutments. Bathymetry surveys that measure
depth and velocity near the bridge pier are considered the best
technique to gather long-term data around the bridge piers.

The HydroSurveyor-M9 system from SonTek, a Xylem brand, is an
instrument/technology that Indian Railway has employed to rapidly
measure bathymetry data along with velocity data. The HydroSurveyor
is a multi-frequency acoustic Doppler current profiling system (ADCP)
equipped with nine acoustic beams, five of which are used to survey
at any one time; four slanted beams provide a velocity profile from
up to 128 cells as well as measure depth, and then there is a vertical
beam with an 80m range which measures the depth directly below the
system. The HydroSurveyor thus provides a detailed profile of velocity
with depth as well as providing a detailed bathymetric map that can
identify scour holes. A moving boat survey is conducted using the
HydroSurveyor to measure the velocity around the piers and surveys
from 100 meters upstream and downstream of the piers provide the
data for studies on the changes occurring pre and post monsoon
season.

The monsoon season occurs in parts of India from June to September,
and several changes occur during the monsoon due to high velocity of
water carrying heavy sediment loads.
The HydroSurveyor system’s slanted beams are mounted at a 25 degree off-axis angle, providing a 50 degree ‘swath’ for the depth measurement. This means that the time spent “driving” the boat is minimized in comparison with single beam instruments. The HydroSurveyor also incorporates built-in navigation, and compensation for speed of sound and integrated RTK GPS positioning.

Rajiv Bhatia, a SonTek Application Specialist at Xylem Analytics, says “the HydroSurveyor is unique because it is the only product on the market that is able to make real-time corrections for thermoclines, saline stratification and the effects of boat pitch and roll.” User-friendly software provides a central recording and processing platform that enables users to develop bathymetric maps and velocity maps, using properly gridded data points—a function that is automated and fully embedded in the software.

The HydroSurveyor can be easily deployed in the water with a HydroBoard-II floating platform, towed by a user supplied boat, or remotely using a rope from a bridge. The instrument is also capable of measuring discharge and cross section area from one bank to the other.

Bathymetric survey data is recorded on HYPACK software that integrates all the data and then can be processed into various products in 3D graphical formats and tabular formats for further assessment.

The technology is extremely helpful for Indian Railway engineers to study the changes occurring on the bridge piers before and after the monsoon season, helping keep millions of IR passengers and millions of tonnes of freight moving quickly and safely.