Bridge reinstated to its

Bridge No 422 over the Orange River near Zastron in the Free State was constructed in 1934. It is a magnificent feat of engineering and concerted efforts should be made to preserve it for posterity. The bridge, which was seriously damaged by vehicular impact, was recently repaired. Innovative answers were found for the challenging demands of structural stability, safety and economy

DESCRIPTION

Bridge No 422 is located on Route P53/1 (R726) between Zastron and Sterkspruit, where the road crosses the Orange River near Sterkspruit on the farm Mayaputi. It was constructed in 1934 from pre-manufactured steel imported from the United Kingdom and erected in South Africa. Seen from the point of view of a structural engineer, the construction of these types of bridges involves magnificent feats of engineering. The bridge also plays a major role in accommodating traffic from the bustling local community as well as long-distance traffic between the Free State and Eastern Cape and is in effect an indispensable link.

The superstructure consists of two simply supported, steel truss spans of 61 m each supported by a concrete substructure with a roadway width of 3 m. The truss members consist of laced, riveted sections. The bridge was seriously damaged as a result of vehicular impact to certain of its structural members. This can mainly be attributed to the reckless speed at which vehicles (particularly heavy vehicles) cross the narrow single-lane bridge.

THM Engineers Free State were appointed to evaluate the deficiencies, find structural solutions and compile contract documentation for the repair and rehabilitation of the bridge.

STRUCTURAL DAMAGE TO THE BRIDGE

The photographs demonstrate the seriousness of the structural damage to the bridge. Photo 1 shows a vertical member completely ripped out. This vertical member acts as a hanger to support the longitudinal deck beams. Without it the span of the longitudinal deck beam was doubled, which had a very detrimental effect on the load-carrying capacity of the bridge.

Photos 2, 3 and 4 show the local damage to compression members. The compression resistance of these members was seriously reduced due to a breakdown of composite action between the laced members.

DESIGN APPROACH

Being a narrow single-lane bridge, the bridge had to be closed for the whole construction period. The contractor had no other room than the bridge deck to work from for scaffolding, rigging equipment, welding machines, etc. Closure of the bridge would have had a major impact on the local community and long-distance haulers.

In a statically determinant truss bridge the removal of any compression or tension member for repair will lead to an immediate and complete collapse of the bridge. The traditional engineering solution would have been to construct costly cofferdams and prop the complete bridge 30 m high from the riverbed to make the removal of the damaged members possible. Considering the risk of the frequent flash runoff of the Orange River the traditional approach was not an option.

The challenge was to find a repair method that allows for the safe removal and replacement of damaged structural members while the damaged bridge supports the contractor's workers and construction loads. THM displayed innovation and engineering ingenuity with a unique 'repair in the air' design solution satisfying the challenging demands of structural stability, safety and economy.

REPAIR TECHNIQUE

A 'repair in the air' technique was followed to replace all damaged vertical compression members while they were carrying the full loads due to the bridge's own dead load and applied construction loads. Two temporary compression struts capable of supporting the full load due to dead weight and the construction loads were installed adjacent to each damaged member. To ensure that the full load was carried by the temporary struts a simple but effective and functional support bracket was designed to prestress the struts in a very controlled manner before the damaged vertical laced member was removed. Prestressing was introduced by applying torque to the adjustable nuts. Owing to the complexity of the riveted

1


2


3


1 Vertical hanger ripped out
2 Badly twisted members
3 Twisted vertical member
4 Buckling problem
5 Temporary vertical struts
6 Support with pre-stressing ability
7 Complex riveted connections

former glory

connections it was not possible to install a replacement member as a unit, and the four angle iron legs of the laced member had to be built up one by one.

The diagonal laced members are tension members and do not need composite action for stability as each angle iron leg of the member is in tension. Tension force influence lines that were obtained from analyses were used to cleverly position heavy construction loads such to reduce the forces in the member under repair. The result was that it was possible to replace the damaged diagonals by removing and replacing the legs one by one without the use of expensive temporary tension cables while they had to resist the influence of the full dead weight and construction loads. Photo 9 shows the damaged diagonal with the lacing cut off and only two legs carrying the dead load and construction load. Photo 10 shows the finished new diagonal tension member.

The vertical hanger that was ripped out resulted in a permanent 10 mm settlement of the deck at that point. It was important to recover this deflection as the new member had to be fitted using the same gusset plate holes the rivets used before.

This was easily accomplished by using temporary adjustable tension ties to pull the members together. Two temporary ties were used to pull the settled deck back into position. The ties consisted of angle irons welded to 25 mm diameter bolts with adjustable nuts that were used to safely recover the deflection in a controlled manner.

The contractor designed a functional and unique moveable scaffolding system suspended from the deck to make possible the 'repair in the air' solution.

COMMUNITY RELATIONS

Because the bridge is a single-lane structure with limited work space, repair could not take place under traffic conditions. Long-distance traffic could pre-plan for this eventuality, but the busy taxi industry between the two destinations would have been seriously affected by the closing of the bridge.

For construction purposes the closing of the bridge was a *fait accompli*, therefore the engineer and contractor made a concerted effort to find a more acceptable alternative. The only practical alternative was to accommodate pedestrian traffic over the bridge at certain stipulated times and under certain conditions, as determined by prevailing construction activities.

The assistance of the Officer in Command of

BRIDGE NO 422 REPAIRS

Category Technical Excellence

KEY PLAYERS

Client Free State Department of Public Works, Roads and Transport
Consulting engineers THM Engineers Free State
Main contractor Tanekk
Sub-contractor Rand Sandblasting Projects

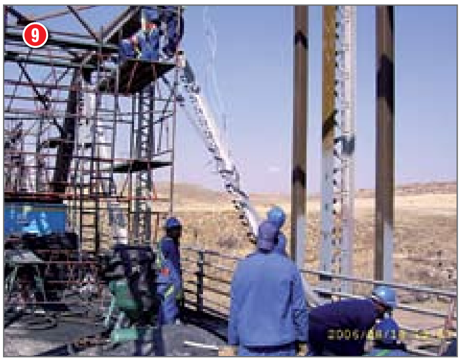
the Police in Sterkspruit was enlisted and a meeting was arranged with the taxi associations of Zastron, Sterkspruit and Aliwal North to discuss the implications and eventual advantages of the project. The meeting took place in a spirit of understanding and cooperation, with all parties concerned indicating their willingness to abide by the proposed temporary arrangements.

Well in advance of the closure of the bridge notices were distributed among the locals and placed at various points of rendezvous. Zastron Bridge was subsequently closed to vehicular traffic for a period of 3½ months, during which not a single incident took place.

PROJECT MANAGEMENT PHILOSOPHY

This project is a good example of the definition of project success, namely – on time, within budget, according to specification, the first time right! It was indeed an out of the ordinary technical project, but also one with close ties with the local community. ☐

8 *Damaged member removed*
9 *Repair of diagonal member*
10 *Finished diagonal member*
11 *Temporary adjustable ties*
12 *Adjustable nuts on tension tie*
13 *'Repair in the air' scaffolding*
14 *Safety was not negotiable*
15 *Vehicle 'terminus'*



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