Challenging bridge repairs earn a commendation

THE C H MITCHELL BRIDGE is a local landmark in the Port Edward area and crosses the Mtamvuna River close to the Wild Coast Sun. The bridge is a double steel arch structure with cross bracing, supporting two systems of cable hangers from which the deck is suspended. The arch springing points are supported on four cast steel bearings, two on each end of the bridge.

The bridge was refurbished in 2000/01 when, among other items, the expansion joint configuration was modified. A computer model was prepared to analyse the effects of the modification to the expansion joint system at the time.

Several weeks before the Christmas holidays of 2002, explosive devices were detonated at the Eastern Cape side of the bridge causing severe damage to the steel arch structure at its two supports. The sabotage attempt was only partially successful, but left the bridge precariously perched on its crippled supports.

The bridge was closed causing major disruption to the local community and tourists with access to the Eastern Cape effectively cut off. A ferry shuttle service provided by the Wild Coast Sun to the community was the only means of access for pedestrians during emergency repairs.

During this time, the computer model mentioned above was of great help in assessing the redistribution of forces caused by the explosions. Emergency contractors worked long hours in consultation with the design engineer for several weeks to temporarily secure the bridge.

The bridge was opened to traffic just in time for the holiday season – to the great relief of all.

PURPOSE
The consultant was commissioned to prepare and implement a scheme to replace the damaged legs of the arch without disrupting traffic. In addition, the bridge was to be strengthened to accommodate heavy loads envisaged for the proposed toll road at the time. This article focuses on the repair of the arch supports.

DESIGN APPROACH
After assessing the damage and the temporary repairs, it was decided that the practical way to repair the bridge without disruption to traffic was to provide temporary supports attached to the arch above the damaged areas and to replace the latter with pre-fabricated members to the exact shape of the original.

The arch had been repaired by makeshift methods resulting in a structural configuration significantly different from the original design. As a result, the distribution of forces in the arch members was different from the original design with several members possibly overstressed. This problem was approached by designing the temporary supports to the same shape in elevation as the original arch in order to generate the same dead load reaction in both magnitude and direction. This would re-instate the original force distribution in the arch.

In addition, the stability of the bridge against wind forces had to be maintained throughout. This required the design of temporary wind bracing while the various members were being replaced.

CONSTRUCTION PROCEDURE
In broad terms, the methods adopted in the design were based on the following procedures:

- Fabrication of temporary supports and permanent arch members in the workshop
- Installation of clamps to the downstream arch above the damaged area for the attachment of the temporary supports. This support had been the most severely damaged
- Construction of two reinforced concrete bases on either side of each arch support bearing
- Installation of the two temporary supports placed symmetrically about the downstream support, attached to the pre-installed clamps on the arch and supported by a total of two bearings each on the two concrete bases
- Jacking of the temporary supports complete with the attached bearings off their seats to allow a gap of 7 mm for grouting with epoxy mortar
- Releasing the jacks after the epoxy mortar had set to allow the temporary legs to take up full support of the bridge
Removing the damaged member and refurbishing the cast steel arch bearing
Installing the new permanent member onto the refurbished cast steel bearing and splicing it to the arch
Jacking the temporary supports to release pressure on the temporary bearings and removing the bearing top adaptor plates
Releasing the jack to allow the permanent member to take up the full load of the bridge
Removing the temporary legs and bearings and repeating the whole process for the upstream arch member

DESIGN ELEMENTS
Five elements had to be designed as follows:
- **Temporary bases** The reinforced concrete temporary bases were founded on rock and made provision for a centrally placed hydraulic jack and two line rocker bearings, one on either side of the jack, to support the temporary supports
- **Temporary bearings** These were designed as standard fixed line rockers with top plate adaptors to provide room for removal of the bearing once the replaced arch supports were supporting the bridge
- **Temporary legs** The temporary legs were designed as frames built up of heavy steel sections. The legs were designed to be constructed in segments for ease of transport and handling and for final assembly on site
- **Attachment of the temporary legs to the arch** These clamps were designed to accept the top ends of the temporary legs and were subject to meticulous analysis because of the high localised forces required to be transferred to the existing structure
- **Permanent legs** The original legs were constructed by a shipbuilder employing riveting methods. The expertise to manufacture large riveted joints is not available locally and it was decided to weld the joints and to use M30 and M36 High Strength Friction Grip bolts at the splices between the new and existing members. The legs were detailed to the exact measurements as per the original design using Grade 300W steel

CONSTRUCTION PROBLEMS
The main construction problems arose from the confined working space. This was exacerbated by the following:
- The stringent safety requirements demanding extensive scaffolding to provide safe access to elevated working areas
- The maintenance of wind bracing
- The close proximity of various structural elements hampering the tightening of bolts

The scaffolding proved to be a time-consuming factor during the rigging of the large structural elements. The elements were lowered from the top of the bridge and moved through the scaffolding, which had to be dismantled and reassembled to provide a path for the rigging operation. This also applied to wind bracing, which could only be modified during periods of light wind.

The tightening of bolts was also very time consuming because of cramped working space. Initially a flogging spanner was used, but when this proved to be too slow, a geared torque spanner was employed.

TRANSFER OF LOADS
The transfer of loads from the crippled structure to the temporary supports and back again to the new supports was the highlight of the project and, due to meticulous planning and dress rehearsals, went off without major problems.

Jacking was done manually with a central, 70 MPa hydraulic pump which required the full strength of an extremely powerful man to operate. This is equivalent to a column of water 7 km high.

During each jacking operation, movements were monitored with dial gauges and force-deflection curves were compared with expected results. It was gratifying to observe the flattening off of the curve exactly when the calculated dead load was read off the pressure gauge. The only problem arose when a hydraulic seal started leaking. Once repaired, the system worked perfectly.

CLOSING REMARKS
The project was satisfying to client, consultant and contractor alike in that the brief for replacing the arch springing points of a bridge with a span of 160 m was achieved with minimal disruption of traffic.

REPAIRS TO THE C H MITCHELL BRIDGE OVER THE MTAMVUNA RIVER
Commendation in the category Technical Excellence in 2006
Submitted by Pietermaritzburg Branch

KEY PLAYERS
- **Client** South African National Roads Agency Ltd
- **Consultant** SNA Civil and Development Engineers (Pty) Ltd
- **Main contractor** Erbacon Construction cc
- **Sub-contractor (steel construction)** SHM Engineering (Pty) Ltd