Improvements to Ballito Interchange (km 6.66) on National Route 2 Section 27

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INTRODUCTION

SANRAL appointed SMEC South Africa in 2009 for improvement works to the Ballito Interchange, situated 45 km north of Durban. The upgrading of this interchange became necessary due to capacity limitations and poor operational efficiency at the existing interchange configuration.

The original scope of services for improvements to the Ballito Interchange included signalising the existing ramp terminals, as well as the design and construction of a single-loop ramp for the east-to-north right-turn movement. To accommodate the envisaged loop ramp, the western bridge jackspan required reconstruction.

STRUCTURAL CAPACITY ANALYSIS

A structural capacity analysis was carried out on the existing bridge over the N2 at Ballito. The results showed that the deck lacked sufficient shear reinforcement, and that significant deck strengthening would be required in terms of the design loading code. The bridge deck also required modification or lengthening for the proposed loop ramp. This could only be achieved in half-width construction, with significant traffic accommodation complications. Despite the lengthening and strengthening of the deck, the bridge width was also found to be inadequate for the required number of traffic lanes and pedestrian walkways. Improving

Photo 1: The Partial Cloverleaf Type A2 design for the Ballito Interchange allows for free-flow movements on the dominant approach and departure ramps

pedestrian safety in and out of Ballito was an integral part of the design.

In addition, as part of the initial investigations as per the original scope of works, the traffic study showed that the originally proposed improvements did not make adequate provision for existing traffic demands, or for future traffic demands that would be generated by the planned developments surrounding the Ballito area and the expected growth associated with the new King Shaka International Airport.

It was established from the traffic study that two free-flow loop ramps, as well as additional lanes, would be required on the bridge over the N2. The terrain and road reserve constraints were such that it would not be possible to provide the loop ramps at the required 50 m radius within the existing interchange configuration. A number of layout options were investigated by the geometric design team.

MOVING THE INTERCHANGE

It was agreed with SANRAL that shifting the interchange approximately 90 m to the south was required to accommodate the new north-east quadrant loop ramp. The provision of a new interchange position would also provide a new structure over the N2 with adequate lane capacity on the overpass arterial. In addition, the dominant traffic movement ramps would be designed as two-lane ramps, and the tie-ins to the existing N2 would be designed to cater for the future N2 capacity upgrade from a four-lane dual carriageway freeway to an eight-lane divided-carriageway freeway. These benefits were fully compatible with the traffic study recommendations and ensured that the improved interchange would adequately cater for the existing traffic demands and be well-suited to accommodate the anticipated changes in this bustling north coast development node.

Photo 2: Approach arterial MR445 was also widened as part of the interchange upgrade

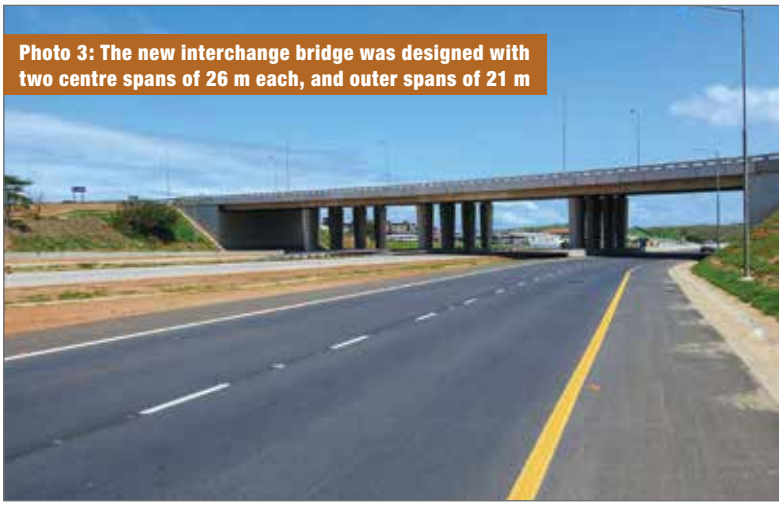

Photo 3: The new interchange bridge was designed with two centre spans of 26 m each, and outer spans of 21 m

Photo 4: The piers of the new bridge consist of four columns per pier, one under each voided slab beam, and each supporting two bearings

GEOMETRIC DESIGN

The preferred geometric layout for the Ballito Interchange was a Partial Cloverleaf Type A2 Interchange System, allowing for free-flow movements (Photo 1) on the dominant approach and departure ramps.

In addition, the approach arterial, MR445 (Photo 2), would also be widened as part of the interchange upgrade to accommodate the traffic demand in and out of Ballito, and to ensure that the approach lane configurations are in balance with the future interchange itself.

The new interchange bridge (Photos 3 and 4) was designed with two centre spans of 26 m each, as determined by the existing N2 and provision for future capacity improvements, and outer spans of 21 m. With a maximum span of 26 m and no vertical clearance issues, the optimum deck design was a cast in-situ, 1.3 m deep voided slab. The slightly deeper deck, with a slenderness ratio of 20 instead of the more conventional 23, meant less deflections and less pre-stressing.

As the proposed MR445 roadway width would total 32 m, it was decided to accommodate the arterial roadway on two decks rather than a single very wide deck. This option reduced the amount of reinforcement required in the deck and simplified the construction sequence. Two separate 16 m wide decks presented further challenges – as this is still very wide for a single-voided slab deck, the chosen cross-section consisted of two voided slab beams, joined with a thin slab, and with cantilevers on the outside.

The new bridge is 95 m long with a vertical clearance over the N2 of more than 7 m. The proposed construction method was a cast in-situ staged construction method, with a construction joint at the quarter point of one of the main spans. The contractor had more than 2 m available for staging above the 5.2 m clearance envelope to the deck soffit, and the temporary works could span the N2 carriageway, allowing two lanes open to traffic at all times.

The piers consist of four columns per pier, one under each voided slab beam and each supporting two bearings. To improve the appearance, the columns were tapered in both directions, widening to 3.6 m at the top transversely, and varying in thickness from 900 mm at the foundation level to approximately 1 500 mm at the pier top. Large chamfers were placed in the corners of the piers to further improve the aesthetic appearance of the bridge.

As the new bridge was on a new alignment, the construction of the bridge did not have an impact on the existing overpass and therefore did not impede the traffic flow, which was critical in maintaining a smooth flow of traffic through the interchange during construction.

A geotechnical investigation for the bridge foundations and lateral support design confirmed that the interchange area is underlain by deep, unconsolidated sediments of the Berea Formation, and overlying weathered sandstone, shale and mudstone bedrock of the Vryheid Formation at depths in excess of 25 m below the existing ground level.

Eight boreholes were drilled, two at each foundation. These indicated that the bridge would be founded in the Berea Formation, which varies from dense, clayey, fine-to-medium sand, to stiff, slightly-sandy clay. Settlement analyses indicated that shallow founding on spread footings would have resulted in settlements greater than 80 mm, which would have been unacceptably high. A piled deep foundation was considered, but deemed too expensive. To reduce settlements to more acceptable levels of 40 mm to 60 mm using spread footings, it was recommended that the abutments be founded at 5 m below ground level on pre-treated foundation platforms and the pier footings at 2 m below existing ground level respectively.

Due to the site constraints and level differences between the ramps, a retaining structure was required to provide lateral support for the area between the north-to-east off-ramp and the west-to-

Photo 5: An anchored contiguous retaining pile wall provides lateral support for the area between the north-to-east off-ramp and the west-to-south loop on-ramp

Photo 6: The Ballito Interchange was officially opened by the Minister of Transport, Ms Dipuo Peters, and Mr Mxolisi Kaunda, MEC for Transport, Community Safety and Liaison, on 1 July 2016

south loop on-ramp. An anchored contiguous pile wall with a reinforced concrete panel façade was proposed to allow for 'top down' construction, as the north-to-east ramp would carry traffic close to the wall during construction (Photo 5).

Although the heavy vehicle traffic on the opposing ramps was significantly less, a single uniform pavement was recommended for all the interchange ramps and the MR445, which would be suitable for an ES10 traffic class. It was recommended that an asphalt base/cemented sub-base type of pavement be constructed for the interchange, as it would be the most suitable for construction where traffic must be accommodated through multiple phases of staged construction which also included many turning movements. The pavement allowed traffic to be accommodated on the asphalt base during construction, with final surfacing to be constructed at the end once all major road sections had been completed. The recommended surfacing comprised 45 mm continuously-graded medium asphalt with rolled-in chippings to provide adequate surface texture for skid resistance at the lower speeds (less than 80 km/h) anticipated within the interchange.

The extension of the east-to-south ramp on the N2 required the construction of a section of rigid concrete pavement adjacent to the existing concrete pavement. The recommended design matched the existing jointed concrete pavement of the N2 main carriageway.

PEDESTRIAN SAFETY

In addition to the high volume of vehicular traffic, the existing interchange also carried significant pedestrian movement. Pedestrian traffic through the interchange, along the MR445 in particular, was mainly on unsafe and informal pathways, either in the narrow verges behind the guardrails or adjacent to drainage channels. Pedestrian counts confirmed the need for pedestrian footways. Provision was therefore made for formalised footways on both sides of the MR445 crossing the N2, as well as formalised footways linking the new bus/taxi embayment on the N2 to the facilities on the MR445 in a manner which minimises pedestrians crossing ramps and the N2 median. The ramp terminals off the N2 were provided with traffic signals which offer gap opportunities for pedestrians to cross the ramp terminals. The new formalised concrete footpaths linking the bus/taxi embayments on both carriageways of the N2 were positioned behind the cast in-situ reinforced concrete barriers around the outside of the loop ramps, further facilitating the safer movement of pedestrian traffic through the interchange.

STREET LIGHTING

To increase safety and visibility at night, verge street lighting was provided on the outer edges of the ramps and the provincial cross-road. High-mast lighting was not considered, due to the close proximity of a private housing estate.

RELOCATION OF SERVICES

As with any urban upgrade project, relocation of services had to be carefully planned during the construction phasing, including the jacking of a 1 800 mm diameter concrete pipe culvert some 52 m in length under both carriageways of the N2. The controlled demolition of the existing interchange bridge on completion of the new works also required careful programming. To ensure sustainability on SANRAL projects, the concrete from the demolished bridge was crushed by the contractor and re-used in an adjacent road contract.

IN CLOSING

The complexities associated with this project are to be expected from a retrofit type interchange upgrade within a constrained environment. The solution provided by SMEC South Africa and implemented by SANRAL, with construction undertaken by Stefanutti Stocks, has been well received by the Ballito community. Construction was completed in September 2015 and the Interchange was officially opened by the Minister of Transport, Ms Dipuo Peters, and Mr Mxolisi Kaunda, MEC for Transport, Community Safety and Liaison, on 1 July 2016 (Photo 6). □

KEY PLAYERS

Client	SANRAL (South African National Roads Agency Limited, Eastern Region)
Project team	SANRAL Ravi Ronny, Design and Construction Manager Stewart Wilson, Retired Design and Construction Manager Zandile Nene, Project Manager: Design & Construction
Consultant	SMEC South Africa
Contractor	Stefanutti Stocks