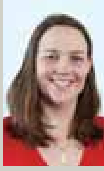
Project management of the design of the

Mount Edgecombe Interchange upgrade



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INTRODUCTION

The Mount Edgecombe Interchange on the N2 Section 26, Durban, is one of the largest interchange projects in South Africa. The design of this interchange posed additional project management challenges compared to those encountered in smaller projects. This article aims to discuss the way in which these challenges were overcome to achieve the successful completion of the design.

BACKGROUND

Vela VKE Consulting Engineers (now SMEC South Africa) were appointed in 2009 by SANRAL Eastern Region (South African National Roads Agency Limited) to provide consulting engineering services for the upgrade of 21 km of the N2/26 from the Mount Edgecombe Interchange to the Tongaat Toll Plaza.

The initial traffic study on the capacity improvements of the N2, and site observations, revealed that the northbound off-ramp to the Mount Edgecombe Interchange was a major safety concern as traffic backed up onto the N2 during peak periods. Similar delays were experienced on the crossroad (M41) during peak periods. An in-depth traffic demand and micro-simulation study revealed that major improvements were required at the Mount Edgecombe/M41 Interchange, beyond the scope of the works originally envisaged. This would entail the design and construction of a free-flow interchange facility catering for high traffic volumes, as well as a grade-separated pedestrian bridge and footway facilities to meet the demands of a large number of pedestrians.

TECHNICAL INFORMATION

Improvements to the Mount Edgecombe Interchange are shown graphically in Figure 1 and include the following:

- A new free-flow, two-lane directional ramp, catering for the west-north movements. The ramp comprises a 443.3 m long viaduct, approximately 18 m high. This will be constructed using the incremental launch method.
- A new free-flow, two-lane directional ramp, catering for the east-south movements. The ramp comprises a 947 m long viaduct, approximately 26 m high. This will also be constructed using the incremental launch method, and will be launched from two ends, joining over the M41.
- A new free-flow, three-lane ramp, catering for the north-east movement which requires a new underpass structure under the M41 and a loop ramp to accommodate the directional movement.
- A new free-flow two-lane ramp, catering for the east-north movement which requires a 50 m long bridge to span the future Cornubia link.

- A new free-flow two-lane ramp, catering for the west-south movement which requires a 120 m long bridge to span the stormwater attenuation area in the south-east quadrant of the interchange.
- A new free-flow loop ramp, catering for the north-west movement in the south-east quadrant of the interchange.
- Widening of the existing M41 bridge over the N2 on the westbound carriageway to allow for the merging of the north-west movement off the loop ramp from the north.
- Retaining walls within the interchange to accommodate level differences between the ramps and adjacent roadways.
- Widening of an existing underpass on the M41 eastbound carriageway.
- Widening of the M41 in the median to accommodate an additional lane on the existing loop ramp from Armstrong Avenue.
- A new median barrier wall along the M41.
- Pedestrian facilities at the interchange, including a new pedestrian bridge over the N2 and over the new south-to-east loop ramp.
- Additional overhead sign gantries.

- Street-lighting.
- Relocation of Telkom, Electrical, ITS, Neotel and Dark Fibre Africa services.
- Rehabilitation of the M41 pavement.
- Land acquisition.

PROJECT MANAGEMENT OF THE DESIGN PROCESS

The overall project management of the design used the SMEC South Africa ISO 9001 certified in-house Quality Management System (QMS). This QMS incorporates the ten areas of project management knowledge. Familiarisation with and use of this system by all design team members facilitated a seamless design process.

PROJECT TEAM

The multi-disciplinary capabilities of SMEC South Africa allowed the entire design to be completed by the company. Most of the bridges were designed in Cape Town, the geotechnical investigation and foundation design were done in Pretoria, and the traffic modelling was undertaken by the traffic specialist in Bloemfontein. Pavement and geometric design, as well as overall project management, was carried out from the Durban office. In total, 76 staff members were involved from concept to detail design phase, spending almost 39 000 man-hours on the project.

COMMUNICATION MANAGEMENT

Communication management is an essential component of project management and was particularly important due to the geographical spread of the design team. Clear and effective lines of communication were critical to the success of the project. Communication therefore took place in several forms:

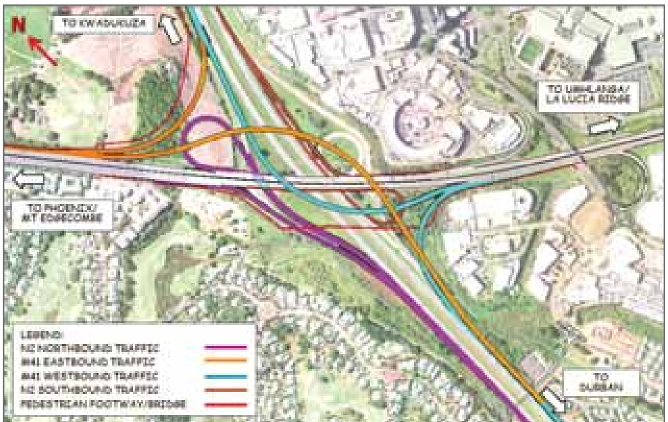

Figure 1: The upgraded Mount Edgecombe Interchange configuration

Figure 2: The geographical spread of the design teams

E-mail

Extensive communication took place via email. In each office, all correspondence went through one responsible person who ensured that the appropriate person received and acted on the information. The practice of copying e-mails to the entire project team was strongly discouraged in the interests of maximum efficiency.

Commercially available document-management software was initially used to control document revisions during concept design. However, this had a number of draw-backs, such as slow data transfer rates over the internet and a lack of automatic notification of changes to drawings. Other measures were then adopted for preliminary and detailed design.

In the Cape Town bridge design team a dedicated project manager and lead-draftsperson controlled incoming and outgoing information. This measure, combined with a rigid server directory structure and strict document control procedures, ensured a full history of communication and access control for all to revision-controlled documents.

Monthly meetings

During the concept design and preliminary design stages, monthly meetings were held with the client, followed by additional meetings as required. Prior to each meeting an agenda was drawn up highlighting major decisions required or matters approved. These were circulated before the meeting, giving the attendees the opportunity to prepare for the meeting. Minutes of meetings were circulated within a few days of the meeting documenting decisions made. In this way meetings were kept effective and decision-focused. This was particularly important to ensure efficiency, as attendees had to travel from various centres. These decision-making meetings played a crucial role in the project management process during the design development and towards achieving project milestones.

Internal weekly conference calls and ad hoc meetings

Apart from monthly meetings with the client, weekly conference and internal ad hoc meetings were also held when key decisions affecting the progress had to be made.

The internal design process was managed through weekly teleconference calls between geometric design and structural specialists to ensure design compatibility and programme monitoring and updating.

The ad hoc meetings included the client's Bridges Network Manager. These meetings were mostly technical and dealt with bridge design decisions. Subjects covered included structural forms, geometry, deck sections, piers, parapets, expansion joints, bearings, services, durability, deck drainage, bridge lighting, tender documentation and cost estimates. Initially these meetings dealt with general issues such as potential bridge options for the different sites, bridge loadings and types of concrete. Later meetings dealt with more specific issues such as parapet details and deck lighting. These meetings enabled decisions to be made timeously and ensured optimisation of the programme and efficiency of the design team.

The use of telephone-conferencing (and at a later stage video-conferencing) between the internal design teams was a particularly effective way of workshopping issues and reaching a consensus on the way forward with the design.

STAKEHOLDER MANAGEMENT

From the outset, the SANRAL team was intimately involved with the decision-making process and selection of the final concept layout that was carried through to the detailed design phase. Their input in regular meetings ensured a smooth transition between activities in the design process, as well as a staged sign-off of decisions.

ENVIRONMENTAL ASSESSMENT

The Environmental Authorisation for the N2 widening had already been granted in February 2011. With the inclusion of the Mount Edgecombe Interchange upgrade, a separate application had to be submitted as an amendment to the original authorisation. Specialist studies and the public participation process had to be repeated in order to inform the public of the magnitude of this interchange upgrade. The Department of Environmental Affairs granted the amended authorisation in March 2013.

PROGRAMME MANAGEMENT

The conceptual design phase of the interchange was completed at the end of September 2011. The preliminary design phase commenced in October 2011 with the tender advertised in mid-May 2012. Initially, construction was scheduled to commence in November 2012. However, this was delayed due to the Land Acquisition process and the amended Environmental Approval. Construction recently commenced (in May 2013) with a 36 month contract period.

The control of abortive work, and preserving staff focus, were key elements of the project management process, due to the appointment for this project being at a reduced fee. During the design phase, the largest expense was for staff hours. This expense was controlled through close monitoring of the programme, decision-making, design reviews and staff management to avoid abortive or inefficient work, and to keep the project on schedule.

A later addition to the scope of works was the provision of safe and efficient pedestrian access across the systems interchange. The design and decision-making process took much longer than anticipated. However, sufficient information was provided for tender purposes. The lesson learnt in this is that provision for pedestrian movements at complex interchanges need to be resolved early in the project concept stage.

PROJECT EXECUTION AND INTEGRATION MANAGEMENT

Careful planning was paramount due to design tasks being interlinked across disciplines. Detailed programming of the design process guaranteed that information was available at an appropriate time for each design component. Adequate regular monitoring of progress of the design against this baseline programme was the key to ensuring that interim milestones were met in line with the main tender documentation dates.

The flow of information to achieve design efficiency is shown in Figure 3, and the details of the flow of information for design efficiency are shown in Table 1.

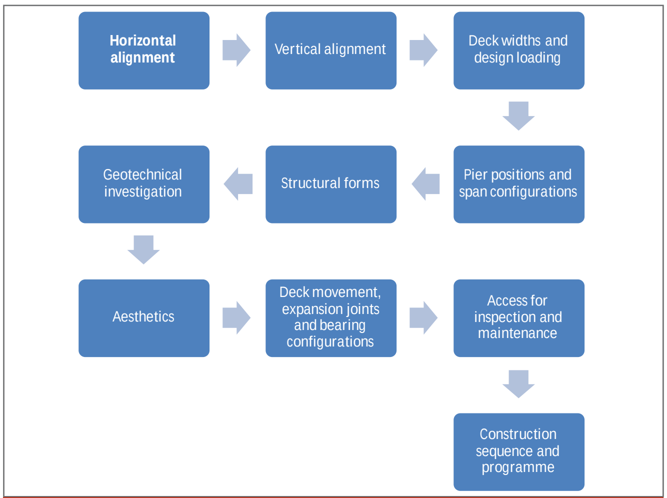

Figure 3: Flow of information applied for design efficiency

QUALITY MANAGEMENT

The internal review process involved verification carried out on a component by component basis to ensure the elimination of abortive work. Strict control of this process safeguarded the quality of the design and ensured timely completion of the design deliverables.

The tender document compilation was particularly challenging, as the schedule of quantities comprised 15 schedules and particular specifications that had been specified by the various design teams. Planning of this involved careful pre-planning of the compilation process and the implementation of clear procedures. Ultimately, through effective communication, strict version control, implementation of the checking process and time management, the document was compiled successfully.

On a project of this magnitude, it is important that the client is assured of a design of a suitable standard that will ensure appropriate work cost. Various independent reviews were done by other consulting firms to make sure that the client was getting the best possible product. These included the following reviews:

- Interchange layout: This was reviewed in July 2011.
- Pile design: This was reviewed twice – the first time during the design of the piles, and the second time during the

Table 1 Details of flow of information required for design efficiency

Order	Information required	Comments
1	Horizontal alignment	This has a large impact on the preliminary design and needed to be finalised at an early stage.
2	Vertical alignment	The incremental launching method (ILM) is highly dependent on both the horizontal and vertical alignment. Finalising a vertical alignment compatible with the ILM was a critical path item.
3	Deck widths and design loading	This had to accommodate future traffic growth demands. Experience with other systems interchanges indicates that increasing capacity on viaduct ramps can be costly and disruptive.
4	Pier positions and span configurations	This affects other works, temporary works, traffic accommodation and the cost effectiveness of the structural components.
5	Structural forms	Several structural forms were used. The process of choosing structural forms was closely managed to reduce construction costs, especially with regard to ensuring repeatability.
6	Geotechnical investigation	Early in the project it was identified that the larger structures would require piled sub-structure foundations. Suitable pile designs meeting the stiffness and settlement criteria of ILM bridges had to be undertaken.
7	Aesthetics	This was very important to both the client and the design team. Various options, including the shapes of the piers and the overall visual impact of the systems interchange, were modelled in 3-D and discussed. This process was managed so that all parties agreed to these aesthetic decisions early enough in the preliminary design process to avoid abortive work.
8	Deck movement, expansion joints and bearing configurations	These all greatly influence the durability and maintenance cost of the structures. The design team examined the various options and obtained client approval at the appropriate time to avoid abortive work.
9	Access for inspection and maintenance	This included access through the abutments and deck soffit. Access to expansion joints, bearings and piers becomes difficult on very high viaducts. Appropriate design decisions therefore had to be made and approved by the client.
10	Construction sequence and programme	This had to give the contractor as much leeway as possible so that he could complete the works within the construction period. Where a specific construction sequence could adversely affect the contractor's critical path, this was examined more closely and alternative designs investigated. Construction space, especially for components such as ILM casting yards and temporary piers, was carefully assessed to ensure that it enhanced constructability.

tender evaluation period where several alternatives had been received. Several independent geotechnical engineers were involved in this process to ensure that the client's risk was mitigated.

RISK MANAGEMENT

Risks were managed in several ways during this project. The first tool used was peer review. With respect to the interchange design, a peer review was carried out by an independent consultant during the concept design phase.

Another major risk during the design phase of this interchange upgrade was the founding conditions for the ILM viaducts and other bridges. On this project the cost of the piles made up a substantial portion of the construction cost. Initial boreholes were drilled at concept design stage to corroborate what was suspected for foundations, based on prior knowledge of the area. This investigation confirmed that the bedrock was some 50 m below the current N2 level. To mitigate the settlement risk, a comprehensive drilling investigation was undertaken with boreholes at each bridge pier position. Close liaison was maintained between the geotechnical specialist, the bridge designers, SANRAL's bridge network manager and SANRAL's regional project team, in order to provide a safe, cost-effective founding design.

A large number of boreholes, 40 in total, were drilled in the interchange precinct. The geotechnical drilling contractor was only appointed once pier positions had been finalised. As a result, the design team had to make assumptions with regard to the piling of the structures in order to progress the design at an adequate rate to achieve milestone dates. These assumptions were later verified once the borehole logs and geotechnical report had been completed. This highlights the need on projects of this size to call for tenders and appoint a geotechnical contractor so that drilling commences as soon as the pier positions have been finalised.

CONCLUSION

This project was an unusually large project involving several disciplines across various offices. Many techniques contributed to the success of the design phase. However, by conscientiously applying good project management principles throughout the design phase, the team was able to deliver tender documentation to the client's tight programme. ☐

KEY PLAYERS

Client South African National Roads Agency SOC (Ltd)
Consultant SMEC South Africa
Project team
Ravi Ronny (Design and Construction Manager)
Stewart Wilson (Retired Design and Construction Manager)
Zandile Nene (Project Manager: Design)
Corné Roux (Project Manager: Construction)