

ULTRA THIN REINFORCED CONCRETE PAVEMENT: PRACTICAL APPLICATIONS

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ABSTRACT

Over the last decade considerable research effort has led to the development of Ultra Thin Reinforced Concrete Pavements (UTRCP). The objective of this paper is to present practical refinements to the original concepts and theories. This paper will briefly discuss the development of UTRCP, and problems encountered during the implementation of UTRCP technology. Refinements were proposed and implemented in a number of projects. These projects are discussed and illustrated to demonstrate the usefulness of the UTRCP. This paper also briefly discusses the cost implications of the UTRCP as well as a cost comparison with equivalent surfacings such as 45 mm asphalt and 80 mm block paving. It was found that the refinements which included a different reinforcing mesh, the use of ready mix concrete and a spin roller for compaction and finishing resolved most of the previous problems.

1 INTRODUCTION

Over the last decade considerable research effort has been expended to develop a more economical and maintenance free solution to road construction, by the development of Ultra Thin Reinforced Concrete Pavements (UTRCP). Originally the UTRCP consisted of a 50 mm layer of 30 MPa concrete with Ref 193 welded wire mesh reinforcing (5,6 mm @ 200 x 200 c/c) placed in the centre the slab. The concrete had a slump of 75 mm and was mixed on site. When placed, the concrete was levelled and compacted using a vibratory beam. The surface is given a broom finish to improve aesthetics and skid resistance.

During the research the principles and theory for design of a suitable pavement structure were developed, but during the implementation some problems with construction as well as on certain areas of performance were encountered. Practical solutions for these problems had to be developed. The objective of this paper is to present practical refinements to the original concepts and theories as developed in a number of projects.

The paper briefly reviews the literature, and illustrates the typical problems encountered in the field, and solutions developed on several projects. The performance of these projects is also presented to demonstrate that the solutions are feasible.

2 BRIEF LITERATURE REVIEW

The difference between UTRCP and conventional reinforced concrete pavement is the thickness – 50 mm for UTRCP and between 150 mm and 250 mm for conventional concrete. For low volume roads there is thus a significant saving. UTRCP is not the same as Ultrathin Continuously Reinforced Concrete Pavement (UTCRCP) which uses high strength (80 to 100 MPa) concrete and contains more sturdy reinforcing as well as steel fibres and has been used as an overlay on major freeways in South Africa (Kannemeyer et al, 2007).

The experimental programme consisted of the following:

- Repetitive static testing with two 40 kN wheel loads as shown in Photo 1. After two million repetitions no sign of failure or fatigue was evident and the testing was terminated. The testing was done without addition of water and showed that the pavement, even on a weak structure, performs well if kept dry (Louw et al, 2011).
- The South African Heavy Vehicle Simulator (HVS) was used to apply repetitive rolling wheel loading to three UTRCP sections, as shown in Photo 2. It was found that after the application of 1.3 million standard axles there was minimal cracking and no pumping or other signs of deterioration, which confirmed the structural capability of the structures (Du Plessis et al 2009, 2011).
- The Roodekrans field experiment was probably the most compelling performance that demonstrated the suitability of UTRCP technology. During a 7-year period more than 1 million standard axles were applied on an exit road from the Roodekrans quarry (Louw et al, 2011). Performance exceeded expectations, with only isolated cracking of the concrete.

Besides the experimental programme, a number of demonstration projects were also constructed by the CSIR team to validate the technology. These demonstration projects were as follows (Louw et al, 2011):

- Mthatha Demonstration Project – a 2.4 km access road (constructed in 2008) to a quarry carrying about 250 standard axles per day is still performing well, although some cracking is evident.
- Soshanguve Demonstration Project – a 12 km long road which is a major arterial in the Township.
- Atteridgeville Demonstration Project – 2.5 km of streets in the Township.
- Mamelodi Demonstration Project – 2.5 km of streets that were rehabilitated by the construction of 50 mm UTRCP after the underlying layer was scarified and stabilised with 3% of lime.

The experience gained in the construction of the UTRCP has been incorporated into the Labour Intensive Construction manual published by Gautrans (2008).

Nevertheless some problems were noticed during the demonstration projects done by the CSIR, namely:

- The Ref 193 welded wire mesh seems to induce block cracking (Photo 3).
- The use of the vibrating beam is not the most effective.
- Mixing the concrete on site results in inconsistent results in many cases (Photo 4).



Photo 1 – Static testing by CSIR at UP



Photo 2 - HVS testing done by GAUTRANS



Photo 3 - Block cracks on CSIR test at Mamelodi



Photo 4 - View of CSIR test section at Soshanguve

Solutions to these problems are the focus of this paper. Subsequent to further discussions with the CSIR project team (Adrian Bergh), the following adjustments were made on several further projects which were being constructed:

- The concrete was obtained from a ready mix plant, to eliminate problems with consistency.
- The Ref 193 welded wire mesh was changed to Ref 200 with spacing of 100 x 100 mm and 4 mm thick wire to eliminate the block cracking shown in Photo 3.
- The vibrating beam was replaced with a Spin Screed roller.
- Polypropylene fibres were added to the mix to inhibit shrinkage cracking.

The following sections describe the projects where the proposed changes were implemented, and the performance is discussed.

3 PROJECTS EXECUTED WITH THE DESIGN AND CONSTRUCTION IMPROVEMENTS

3.1 Transnet Capital Park, Pretoria

At Transnet Capital Park the main road carrying truck traffic was upgraded from a badly deteriorated asphalt road to a UTRCP road. The process is shown in Photos 5 to 8. The construction of the UTRCP was relatively easy according to the contractor, and proceeded without undue problems. During construction, the wire mesh was cut so as to allow for the existing grid inlets within the road. After completion it was noted that this caused cracking at the corners of the inlets. It became clear that any disruption in the continuity of the mesh is likely to cause cracking in the finished product because of stress concentration during setting of the concrete and diurnal temperature fluctuations.



Photo 5 - Preparation of base



Photo 6 - Preparation of reinforcing



Photo 7 - Casting of concrete



Photo 8 - Finished product

3.2 South African Breweries Waltloo Depot

At South African Brewery's Waltloo Depot, the asphalt surfacing of the parking area in front of the loading bay was in a bad condition. This was repaired and overlain with a 50 mm UTRCP surface (Photos 9 to 11). The layer works were reconstructed using the in situ material, but stabilised with cement and bitumen emulsion for the lower and upper

150 mm layers respectively. The UTRCP has shown some hairline cracks and the broom finish was not uniformly applied. The performance, however, has been satisfactory.



Photo 9 - Wet concrete



Photo 10 - Finished product



Photo 11 - Broomed finish

3.3 UTRCP at Mosenthal, Road 1, Marikana (near Rustenburg)

This road was upgraded for the Royal Bafokeng Administration from a gravel road to a UTRCP road (Photos 12 to 14). The road serves as a link to the main road for a granite-block exporting quarry, thus carrying very heavy loads. Due to black clay material underlying most of this area, two imported layers were constructed. The sub base layer under the UTRC was stabilised with lime. The heavy trucks are using the road daily and it is performing well.



Photo 12 - Completed sub base concrete

Photo 13 - Casting of ready mix concrete



Photo 14 - Floating of concrete with bull float

3.4 UTRCP road at Matsulu - Jericho Umgwaco road (East of Nelspruit)

This road was upgraded from a gravel road to a UTRCP road (Photos 15 to 17) and was constructed on a high fill and large box culverts, crossing a river. To compensate for the possible settlement of the fill, more anchor beams were installed. Several minor cracks showed up in the UTRCP, but not affecting the functionality of the concrete.



Photo 15 - Preparation of reinforcing



Photo 16 - Casting of concrete



Photo 17 - Spreading of concrete with spin roller

3.5 UTRCP road at Ga-Rankuwa Unit 10

Ga-Rankuwa Unit 10 is a township development for economical housing. The in situ material consists of fair quality material, but with some red clay, as shown in Photos 18 and 19. Instead of removing all the in situ clay material, it was stabilised with lime so as to reach the moderate CBR strengths required. The UTRCP road was constructed as wearing surface. The roads are still holding up well.



Photo 18 - Conditions at Ga-Rankuwa site **Photo 19 - Test pit showing top soil depth**

4 BRIEF COST COMPARISON FOR COMPARABLE SURFACING OPTIONS:

On the introduction of new technologies the first question is always the cost effectiveness. Accepting that the underlying pavement layers would be the same, the construction cost of the alternative comparable surface options are:

45 mm Asphalt	-	R 170 per m ²
80 mm paving blocks	-	R 220 per m ²
50 mm UTRCP	-	R 150 per m ²

Note that the base as needed for the other layer is also omitted for the UTRCP, as is practice for the conventional concrete bases, giving an additional saving of about R 50 per m², to be taken into account with the above.

These cost figures show that the UTRCP is highly cost competitive. Furthermore, in a broader context, concrete (aggregates and cement) is readily available in most areas, whereas bitumen has to be transported over long distances. Recent bitumen supply problems and price volatility, is causing further concerns for the use of asphalt.

The decision of whether to use UTRCP on roads and streets is an easy one; several South African municipalities have already decided to use it. It is no more a question of will it work; these test sections have proven that UTRC is the answer.

5 CONCLUSIONS

This paper is an example where industry has performed additional development of the original research ideas. The development work has shown that using a thinner and more closely spaced reinforcing mesh eliminated the earlier block cracking. Ready mix concrete resulted in a more homogeneous mix and appearance, and the spin roller has eliminated several other operational problems. The performance of the constructed projects is satisfactory, and from a costing perspective it shows that the UTRCP is highly competitive.

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