CONSTRUCTIBILITY ASPECTS OF ULTRA THIN CONTINUOUSLY REINFORCED CONCRETE PAVEMENT

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ABSTRACT

Ultra Thin Continuously Reinforced Concrete Pavement (UTCRCP) is a new rehabilitation technique for roads which was originally imported from overseas and redesigned for South Africa conditions. Initial development involved accelerated pavement testing (APT) with the Heavy Vehicle Simulator (HVS) on experimental sections at the Heidelberg Traffic Control Centre. The success of these short experimental sections shifted the emphasis to constructability issues and associated design issues on a larger scale.

A test section of 50 mm thick UTCRCP was constructed in 2008 at the Heidelberg Traffic Control Centre (screener lanes for heavy vehicles). The main challenges of construction of the UTCRCP were examined, with the objective of achieving a methodology for the roll out on full scale projects. The construction aspects examined included the mixing technique of the concrete components, the position of the reinforcing mesh within the overall 50mm thickness of concrete layer, the compaction and vibration techniques of the fresh concrete, and the use of a pan mixer. Indicators such as slump values during construction and the normal mix design criteria such as water cement ratio were recorded, as well as flexural strength and compressive strength of this ultra strong concrete, were monitored. Additional test results such as the new composite centrally loaded round panel deflection test were also recorded.

Initial conclusions and recommendations regarding constructability are made to help further technology development of the UTCRCP.

INTRODUCTION

Ultra Thin Continuously Reinforced Concrete Pavement (UTCRCP) in South Africa has been developed via technology transfer under the leadership and drive of the South African Roads Agency Limited (SANRAL). The initial technology was developed from “white topping” concrete overlay technology used with bridge deck rehabilitation in Europe. This technology was converted as an ultra thin flexible thin concrete layer for road pavement design and rehabilitation in South Africa. Considerable work has been done with the adaptation of the concrete mix design, the reinforcement and pavement structural analysis and other component changes. Initial technology transfer and development involved various short experimental sections laid at the Heidelberg Traffic Control Centre site. This site is situated approximately 10 km South-East of Heidelberg on route N3-11 in the Gauteng Province.

These experimental sections were subsequently tested with a variety of accelerated pavement testers (APTs). Most of the accelerated pavement testing was done with the Heavy Vehicle Simulator (HVS) of the Gauteng province (Kannemeyer et al, 2007) and the Mobile Load Simulator (MLS) and all sponsored by SANRAL. Very encouraging results from the HVS testing have led to a number of constructability issues to be refined and developed for application on higher order roads on larger contracts for new design and rehabilitation. A number of role-players under the auspices and guidance of SANRAL have recently been involved in various roles to help develop the mix design, structural analysis, construction and material quality control aspects of this unique material. SANRAL therefore recently commissioned a 1.2 km test section of 50 mm thick UTCRCP to be

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constructed as part of a screener lane at the Heidelberg Traffic Control Centre. This forms part of the pavement rehabilitation design of sections of the screener lanes.

The purpose of this document is to describe the construction techniques used during the construction of the UTCRCP, discuss lessons learnt regarding construction joint and longitudinal joint constructability aspects, reflect on the material testing and quality control aspects, comment on the applicability of new test methods and associated test results and comment on the initial performance of these screener lanes thus constructed.

DESIGN OF UTCRCP

Concrete mix design: trial sections

Considerable design work was done regarding the concrete mix on the preceding experimental work. In essence the concrete mix not only involves cement, aggregate and water, but steel fibres, silica sand, polypropylene fibres and admixtures or special product additives (e.g. CSF, PFA and Chryso products). The resulting UTCRCP mix is further reinforced with a 50mm x 100mm high strength steel mesh. As part of this project, three short trial sections were constructed on site next to the old short experimental sections where the APT was carried out in the initial tests. The purpose was to refine the UTCRCP concrete mix design based on the project specifications (SANRAL, 2008). The final mix design was finalised as shown in Table 1 with special attention given to concrete workability. The water cement ratio of about 0.325 was found to be efficient for the workability and also achieved the ultra high strength requirements in terms of flexural strength and compressive strength.

Pavement design: screener lanes test sections

The 50 mm UTCRCP was specified to be constructed as:

- an overlay either over existing asphalt surfaced sections after localized repairs were completed; or
- an overlay on new pavement layers constructed on sections that required rehabilitation action. These new pavement layers were either Bitumen Treated Base (BTB) correction layers of variable thickness over 150 mm Emulsion treated base (ETB) or 50 mm Asphalt (AC) over 150mm ETB;

The function of the asphalt layer underneath UTCRCP was to avoid or to prevent the occurrence of pumping, and to simulate the effect of UTCRCP as an overlay technique

Conventional thickness Continuously Reinforced Concrete Pavement (CRCP) was constructed at the positions where the Weigh In Motion (WIM) and the traffic control loops were installed in the screener lanes. Isolation joints were specified and constructed between UTCRCP and CRCP, longitudinal joints and construction joints were also provided where needed. These joints will be discussed in more detail later regarding constructability.

The UTCRCP was provided with a transverse anchor beam at each end section to ensure good embedment of UTCRCP in the pavement structure and to reduce possible curling effect of the UTCRCP.

Table 1: Concrete Mix Design Adopted After Trial Sections

Component Material		Unit	Qty
Cementitious material	Cement	Kg/m^3	481
	PFA	Kg/m^3	86.6
	CSF	Kg/m^3	72.2
Water (maximum)		l/m^3	175
Water / cementitious materials ratio			**0.325**
Aggregate	6.75 mm	Kg/m^3	972
	Silica sand	Kg/m^3	683
	Steel fibres	Kg/m^3	100
	Polypropylene fibres	Kg/m^3	2
Cement / Aggregate ratio			0.39
Admixture per 100 kg of cementitious materials	Chryso Optima 100	ml	442
	Chryso Premia 100	ml	626
Slump (before steel fibres are added)		mm	
Slump (after steel fibres are added)		mm	150
Compressive Strength	24 h	MPa	40.0
	3 days	MPa	81.0
	28 days	MPa	90.0
Flexural Strength	24 h	MPa	7.0
	3 days	MPa	10.0
	28 days	MPa	11.0

CONSTRUCTION PROCESS

The construction process of the UTCRCP is highly labour intensive as most of the tasks are manual, due to the stiffness of the mix, and the intricacy of placing and anchoring the mesh reinforcing. The various components and construction processes are briefly described in the following sections.

Placement of side-forms

A rectangular metallic tube or a lipped channel, meeting the layer thickness specified (50mm), were used as side-forms. To avoid corner break of a sharp edge of extremely hard overlay in the completed the UTCRCP, corner chamfer (15mmx15mm) was constructed on the side edge of UTCRCP; a piece of wood (with triangle section) was mounted on the side-forms for this purpose. The side-forms were anchored to the asphalt by means of metal pegs and nails.

Placement of mesh

A 50mm x 100mm high strength steel mesh was used as reinforcement in the UTCRCP. This mesh consisted of: 5.6mm diameter longitudinal bars spaced at 50mm; and 5.6 mm diameter transversal bars spaced at 100mm. The mesh was placed with the longitudinal bars in the road traffic direction.

Two challenges in the construction operations were:

- to maintain the mesh at the mid position within the 50 mm concrete layer thickness;
- to control the overlap area of adjacent mesh sections (see Figure 1) so that the total thickness of the steel in the concrete do not exceed 3 mesh bars (one on top of the other), as shown on Figures 1A and 1B, Such a situation would be yielding a total of 16.8mm of reinforcement thickness which represents 34% of the total UTCRCP thickness.

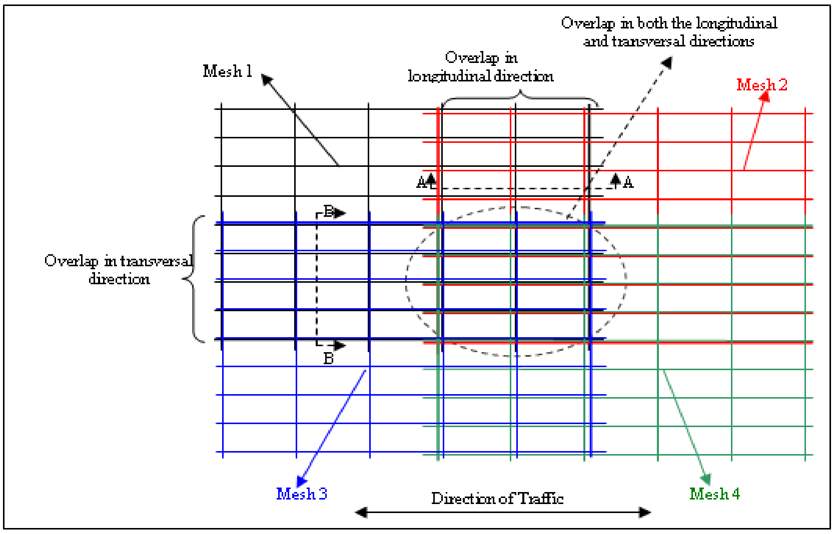

Figure 1: Sketch displaying general overlap between high tensile strength steel meshes

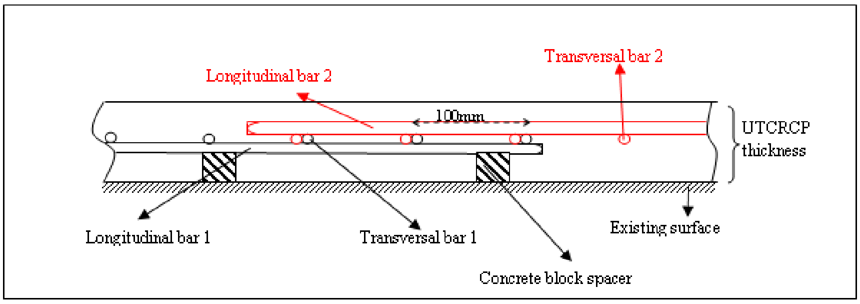

Figure 1A: Section A-A: Overlap in longitudinal direction

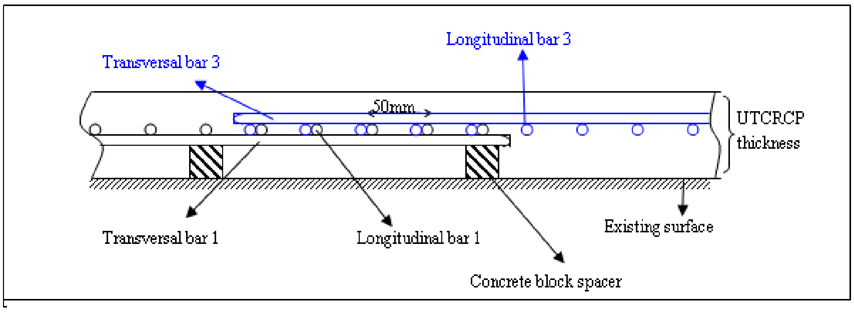

Figure 1B: Section B-B: Overlap in traversal direction

An additional 4th mesh bar would bring the thickness of steel in the UTCRCP thickness to 45%, which does not provide sufficient concrete cover.

The reinforcement position in the middle of the layer thickness required a careful monitoring. The mesh was therefore placed on top of concrete spacer blocs to ensure a 25mm space from the bottom surface, and anchored with nails and pegs in the bottom asphalt surface.
The thickness of steel on the overlap areas had to be controlled. The adjacent meshes were placed alternatively as follows:

- overlap in longitudinal direction; If the first mesh has transversal bars on top, the consecutive mesh should have transversal bars in the bottom (see Figure1A); and
- overlap in transversal direction; If the first mesh has longitudinal bars on top, the consecutive mesh should have longitudinal bars in the bottom (see Figure 1B).

At places where there was overlap in both the longitudinal and traversal directions, as shown in Figure 1, some bars were cut to leave a reinforced thickness of 3 bars as indicated earlier. This operation was done in such a way to ensure a continuity of reinforcement in both longitudinal and traversal directions. Note that an overlap of at least 200mm was allowed in each direction. With this technique, the reinforcing mesh did not show much buckling-up during placement and the concrete cover on top of the reinforcing mesh was sufficient.

The possible use of 100mm X 200mm high strength steel mesh (more readily available in industry than size 50mm X100mm) was investigated on a short sections (300 m) of the test section, Two 100X200mm meshes were superimposed to make up the required 50mmX100mm steel mesh pattern. The same principle as the abovementioned overlap technique was used except for positions of longitudinal and transversal bars that were placed in order to get 50mm and 100mm spacing respectively between each other. In this case the overlap area resulted in a steel reinforcement with at least 5 bars one on top of another. Since the minimum number allowed was 3 bars, this method required that transversal and longitudinal bars had to be removed at overlap areas, either during the manufacturing process or by cutting some bars in the construction process. This process was found to be time consuming due to the detail attention required and nuisance of cutting additionally during construction.

Formwork on longitudinal joints

Two types of longitudinal joints were tested on site:

- Longitudinal joint type 1 which consisted of a joint using Y12 tie bars with a Hex coupling nut to link the two meshes each side of the joint. The link was done through the Hex coupling nut that connected the tie bars of each side of the joint. This joint type sketch is illustrated in Figure 2;
- Longitudinal joint type 2 which consisted of a joint using the continuity or extension of the mesh through the joint Type 2 joint is sketched on Figure 3. In this type of joint, the reinforcing mesh passed between the top and the bottom side formworks. The top and the bottom side formworks were subsequently screwed together. After casting and curing the first side of joint, the top and the bottom side-form were taken out without damaging the reinforcement. The final level of UTCRCP was controlled and to avoid unevenness of the top of side-form due to the screwing operation, it was necessary to use a 25mmX5mm steel plate as correction control plate. The correction plate was placed between the top and the bottom side-form and a sponge was included under the correction plate for water proofing or sealing off purpose during concrete placement and vibration.

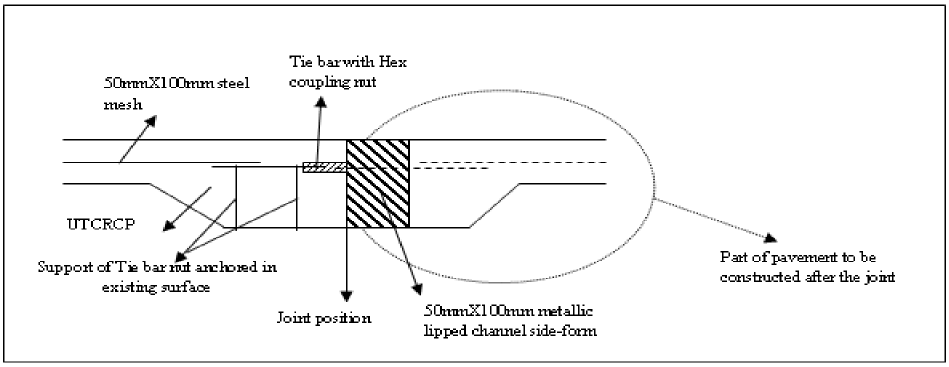

Figure 2: Sketch of form-work of joint using tie bars with Hex coupling nut (Type 1 longitudinal joint)

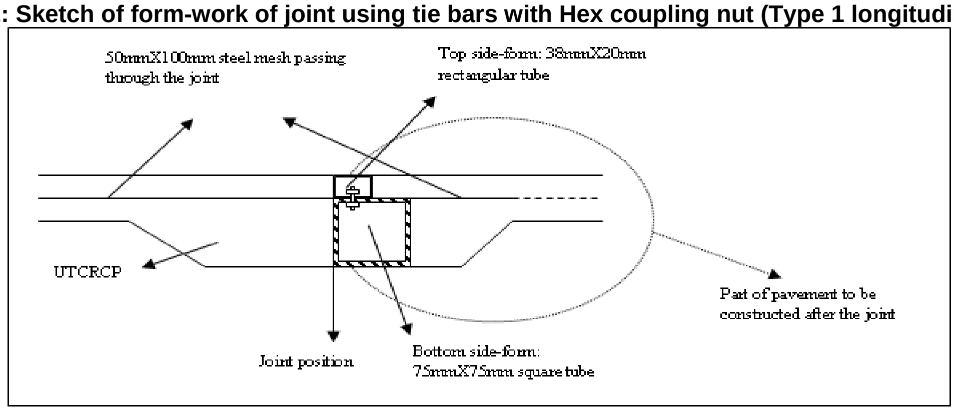

Figure 3: Sketch of form-work of joint with reinforcing mesh trough it (type 2 longitudinal joint)

Preparations and mixing of materials

Mixing equipment and preparation of mixing components

The mix of UTCRCP was done in pan mixer (two units were used i.e.: a small mixer of 400 kg and a large mixer of 720kg. They were mounted on a flatbed truck. The pan mixer was provided with a shearing device (see Figure 4). The pan mixers were key mixing elements by allowing intimate and homogeneous mixing of the different components.

All material components (excluding the water) were prebatched in a factory setting and bagged. This included the sand, cementitious materials (cement, fly ash, condense silica fume) and polypropylene fibres. Workers on site only had to mix the aggregates (also pre-batched and bagged) with the pre-batched steel fibres on site in the pan mixer.

Mixing process

The mixing process was as follows:

- The aggregates, and the pre-batched dry mix, were mixed for 1 to 2 minutes;
- The water, blended with additives (Chryso Optima 100 and Chryso Primia 100), was added and mixed for an additional 2 to 2.5 minutes until the mix appeared workable;
- The steel fibres were added last and mixed for another 1 minute. Steel fibres were spread in the mix progressively in the same direction as mixer rotation to avoid the “balling effect” of steel fibres that tended to cause segregation and non-homogeneity.

	
Figure 4: inside of mixer pan	**Figure 5: Oscillating triple roller screed in action**

Laying and compaction of concrete

The UTCRCP casting process was done as follows:

- The mixed concrete from the mixer was poured and sprayed all over the prepared area by means of a shrivelling shute system. Workers further manually sprayed and distributed the fresh concrete using rakes and shoves;
- Pocker vibrators were used for initial compaction and vibration of the concrete. The pocker vibrator was applied against the mesh to shake the entire area;
- The concrete was then rolled on the surface with an oscillating triple roller screed beam system. This equipment included 2 normal rollers to level and roll the concrete surface, and 1 oscillating roller that provided additional compaction to the concrete. The use of the oscillating triple roller screed increased the production rate significantly. The oscillating triple roller screed is depicted in Figure 5;
- After compaction, a straight edge was pulled over the surface to get a more levelled surface whereafter the surface was hand floated; and finally the surface was textured and covered with curing compound.

It was observed that the pocker vibrator could not achieve sufficient compacting energy especially under the reinforcing mesh in the lower half of the layer. Although the oscillating action of the oscillating triple roller screed provided additional compaction energy, a proper device designed to allow correct compaction under the steel mesh might be required. One of the solutions could be to equip one of the two remaining rollers of the oscillating triple roller screed with a vibrating action in addition to the single third oscillating beam.

Joint detail

Longitudinal Joints

Longitudinal joints were constructed where the total width of the UTCRCP was too large to be placed in one operation. As explained in section **3.3.**, two types of longitudinal joints were constructed: Type 1 longitudinal joint and Type 2 longitudinal joint. Each of these type longitudinal joints was constructed in 2 different cross profiles:

- oblique edge profile, as designed in project specifications (SANRAL,2008).;
- straight edge profile. This was an experimental profile implemented on site.

The longitudinal joint was constructed as follows: the side form work was placing as mentioned in section **3.3.** The first side of the longitudinal joint was cast. The reinforcement of the second side was tied to the reinforcement of first side whereafter the second side of the longitudinal joint was cast.

All the longitudinal joints using Y 12 tie bars displayed cracks a few days after concrete placement while for the same period of observation no noticeable cracks were found on joints using extended mesh of type 2. It is speculated that the presence of cracks in type 1 longitudinal joint could be due to the fact that the continuity of the reinforcement was interrupted between two consecutive tie bars. It should also be noted that the type1 joint was more expensive than the type 2 joint.

Isolation Joints

Isolation joints were constructed between the UTCRCP and the CRCP at the WIM and loop slabs. Mild steel bars (40mm in diameter and 500mm in length) were used as dowels at a spacing of 375mm. A 12mm joint left between the UTCRCP and the CRCP was filled with cold poured liquid self levelling ultra low modulus silicon.

Construction Joints

Construction joints were constructed at the end of day-work sections or where the concrete supply was insufficient. The construction joint was made with a sponge underneath the mesh tied to a piece of wood which was placed on top of the mesh. No groove was made between new and old concrete in the construction joint. The construction joint (without groove) showed a good bonding between the new and the old concrete; and no noticeable cracks were observed. This technique could potentially save the use of the silicon sealant application in the joint as required in the project specifications (SANRAL, 2008) if it proves to perform adequately over time.

Texturing and curing of concrete surface

Two types of concrete surface texturing were experimented with on this project:

- Tinning finish. The tinning or grooving finish was achieved by using a rake to give the required surface texture. The action of the rake could easily result in steel fibres being raked from the surface instead of getting the grooving effect needed. The method also appeared to be more inconsistent.
- The stiff broom finish: It was applied over the last 500m as comparative method. It was found in general for better texture. The brooming finish should take place 15 to 20 minutes after floating to allow initial hardening of the concrete.

The curing of concrete was done using a solvent type resin-based curing compound. This curing application operation was done just after surface texturing was applied. In general white-pigmented resin-based curing compound was applied. Due to a shortage of white-pigmented resin-based curing compound, a small piece of work was constructed using a none-pigmented resin-based curing compound. At some places where none-pigmented curing compound was used, minor transversal micro-cracks appeared. In general, no cracks were observed where white-pigmented curing compound was applied. This could probably be due to the light-reflection of white-pigmented curing compound, which slowed down the water evaporation from fresh concrete.

Curing with plastic sheeting was also tested in addition to curing compound on 40m of road; it was found that:

- The plastic sheeting laid over a fresh curing compound prevented the curing compound tended to stick to the UTCRCP surface.
- The plastic sheeting could easily be blown away by the wind and it was feared to become a hazardous object for the traffic near the highway.

Production rate

The average length of daily placing of UTCRCP, as obtained from the section constructed every day was 55.4m (representing 13.85m^3 of UTCRCP placed per day). Thus, with a mixer of 720kg, a daily production rate of between 55 and 60m can be expected, or a daily UTCRCP volume placed of between 13m^3 and 15m^3.

TEST RESULTS

Concrete compressive strength, concrete flexural beam strength and; concrete flexural toughness tests using centrally loaded round panel were done while consistency and workability testing involved slump tests on the fresh mix before introducing of any of the fibres.
Note that the results of these test presented below, are untreated ("raw results"), without any discard of outliers.

Concrete compressive and flexural strength

The compressive and flexural strength showing average, maximum and minimum for 1, 3, 7 and 28 days UTCRCP are given in Table 2.

Table 2: Compressive and Flexural strength [MPa]

concrete age [day]	Compressive Strength			Flexural Strength		
	average	Maximum	Minimum	average	Maximum	Minimum
1	50	66	34	7.7	10.0	5.5
3	66	84	49	9.1	11.4	7.2
7	83	92	72	10.8	11.6	10.2
28	103	127	72	12.2	13.8	10.2

It could be concluded that:
The 1day compressive strength had an average of 50MPa with a minimum of 34MPa;and at 3 days, the period after which the road was opened to traffic, the average strength was 66MPa with a minimum of 49MPa; while, at 28 days, the average compressive strength was found to be 103MPa with a minimum of 72MPa.

After 1day, the average flexural strength was 7.7MPa with a minimum of 5.5MPa and; at 3 days, the average strength was 9.1MPa with a minimum of 7.2MPa; while, at 28 days, the average compressive strength was 12.2MPa with a minimum of 10.2MPa.
It was noticed a slow gain in flexural strength from 7 days concrete age onwards.

Concrete flexural toughness using centrally loaded round panel

Flexural toughness as defined in ASTM C 1550-05 (2005) was tested on 28 days old UTCRCP. All maximum loads with the correspondent deflections are given in Table 3. It could be seen that the maximum load could go up to 52.26kN with a minimum of 28.50kN and an average of 37.2kN. It was also notice that the deflection reached a maximum of 11.48mm with a minimum value of 1.32mm and an average of 5.64mm. it can be seen that the range of the deflection is wide.

Table 3: Maximum Load with it correspondent deflection

Cast Date	Disc No	Max Load (kN)	Deflection (mm)
23-Jun	2306a	52.260	4.35
23-Jun	2306b	38.092	1.32
23-Jun	2306c	45.537	5.99
21-Jul	kp1	38.944	1.89
21-Jul	kp2	34.474	1.34
21-Jul	kp3	34.674	2.53
21-Jul	kp4	33.341	2.11
21-Jul	kp5	48.516	4.83
21-Jul	kp6	32.463	2.40
08-Aug	kp17a	28.501	10.60
08-Aug	kp17b	29.777	8.60
08-Aug	kp17c	34.138	11.48
17-Aug	kp28a	34.212	9.08
17-Aug	kp28b	37.790	8.29
17-Aug	kp28c	35.301	9.84
	average	37.201	5.643
	Maximum	52.260	11.476
	Minimum	28.501	1.323

Consistency and workability test: Slump test

The slump test on this project was done on concrete before addition of steel fibres, and the results of this test were not consistent. It was difficult to correlate the slump with the UTCRCP strength. However, the slump varied between 90 and 208. As mention in section **2**, the workability of the concrete mix was found to be better with a W/C ratio of around 0.325. This value fluctuated on site between 0.320 and 0.330.

In general compressive strength and flexural strength obtained in this project were higher than those required in the project specifications (SANRAL, 2008), as can be seen in Table 4.

The inconsistency of the slump compared to the concrete strength could possibly be due to the presence in the concrete sample of some steel fibres which remained from the previous mixing. However, the slump should be controlled to avoid voids or segregation in the concrete.

Table 4.: Comparison of designed strength specified and average strength obtained on site

	Design specifications		Site	
	1 day	28 days	1 day	28 days
Compressive strength [MPa]	40	90	50	103
Flexural strength [MPa]	-	10	7.7	12.2

EARLY PERFORMANCE OBSERVATION

Four months after the construction, the UTCRCP constructed was inspected. The performance of the UTCRCP was good in general. However, a few places displayed some minor micro-cracks on the straight sections of the screener lane. No spalling or cracks were observed on the longitudinal joints or construction joints. There is only one section where peculiar behaviour of the UTCRCP was observed. It is an escape link to the screener lane of approximately 80m length in the northern direction where the UTCRCP were placed on a curve with end or anchor beams in short succession skew and perpendicular to the existing roadway and screener lanes. The UTCRCP layer detached from the underlaying pavement structure in only one portion. This expansion seems to be temperature related and tends to expand in hotter temperature to “bridge” by expansion and increase the delamination and lift. More investigation should be done to clarify the cause of this phenomenon. Currently there are no other places on the UTCRCP sections on the straight sections with longer lengths which show any such lifting, delamination or bulging.

CONCLUSION AND RECOMMENDATIONS

The UTCRCP trial section constructed in Heidelberg Traffic control centre can be considered to be successful in terms of the defining of basic construction methodology of this new technology development for South Africa. The UTCRCP was constructed as an overlay on repaired existing asphalt or, where major pavement distresses previously occurred, on top of a new pavement structure which included an asphalt surfacing.

The following were the major findings of this experimental project:

Materials and Mix

- The optimum water /cement (W/C) ratio of UTCRCP concrete mix was in the order of 0.325. In general the UTCRCP construction required a lot of manual, labour intensive operations which was time consuming but could enhance labour intensive construction.
- The thin thickness of UTCRCP did create problems with concrete cover with various options of placement of the reinforcing mesh. The following considerations were addressed:
  - Curling and warping of reinforcing steel mesh led to a reduction of concrete cover. To prevent buckling-up of the reinforcing mesh nails and peg anchored in the existing surface were used in addition to cover blocks to maintain the steel mesh at correct position.
  - An alternative technique of placing steel mesh allowed a maximum of 3 mesh bars (one on top of another) in longitudinal or transversal overlap areas. In cases where overlap occurred in both longitudinal and transversal directions, the extra mesh bars were cut off to leave only 3 bars which assured continuity between consecutive meshes.
- The possibility of the use of 100mm X 200mm high strength steel mesh was experimented with by superposing them to get a same pattern as 50mm X 100mm mesh. This arrangement was found to be difficult to control.
- The average compressive strength and the average beam flexural strength were found to be higher than the required strength in the mix design for the 1, 7 and 28day periods tested. The site average compressive strength at 1 day and at 28 days were 50MPa and 103MPa respectively, while project specifications required respectively 40MPa and 90MPa. The average beam flexural strength on site at 28 day was 12,2MPa while the mix design required 10MPa. Thus the UTCRCP mix design could be regarded as an acceptable mix design. However, one should consider that a very strong concrete is a source of possible cracks

Plant/Equipment

- The pan mixer, using proper shear action during mixing process, seemed to be an appropriate on-site equipment for the UTCRCP.
- The use of the oscillating triple roller screed increased the production rate significantly and provided additional compacting energy to the use of pocker vibrators. However, compaction and vibration techniques needed more refinement such as the addition of a vibration action to the oscillating triple roller screed in addition to the oscillation action.

Joints and Formwork

- The longitudinal joint using Y 12 tie bars with a hex nut was found to be less efficient than the longitudinal joint using mesh extended through it. The presence of cracks in the first type of joint could be due to the fact that the continuity of reinforcement was interrupted between two consecutive tie bars.
- The construction joint made without the specified groove showed a good bound between the new and the old concrete. No noticeable cracks through the thickness of the UTCRCP were observed even four months after construction.

Finish and Curing

- Surface texturing by means of tining appeared to be inconsistent while hard broom finish texturing gave better consistent results. The white-pigmented resin-based curing compound gave good result in terms of crack appearance than none-pigmented resin-based compound.

This could be explained by a lack of light reflexion of the none-pigmented compound which influenced rapid water evaporation from the concrete.

- It was found that the simultaneous use of curing compound and the plastic sheeting as curing method ,as required in the project specifications, (SANRAL, 2008) was difficult because the fresh curing compound tended to stick to the plastic sheet instead of sealing the UTCRCP. Furthermore, curing with plastic sheeting became a potential hazardous object for the traffic near the highway when it was blown by the wind.

Production Rates

- The daily production rate of this labour intensive construction using a 720kg pan mixer was estimated between $13m^3$ and $15m^3$ or in term of length of road constructed; 55m to 60m.

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