

<<Insight>>

Can we build it? Yes we can!

<bylines>

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<intro>

The employer's objectives of this case study was to upgrade gravel roads in the Brandwag Community to surfaced standard, with preference to Ultra-Thin Reinforced Concrete Pavement, constructed by means of labour intensive construction methods to maximise the use of local labour

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From the onset it was clear that the design and documentation needed to be adapted in order to maximise the interest of the community as well as ensuring a quality product. Well balanced use of equipment and local labour was vital to the success of the project as extensive training was done before the specific tasks were programmed to commence. On-site design changes were possible due to the flexibility of the "Spin Screed" being used, with resultant innovative techniques that result both in time saving as well as improved constructability and quality. Quality control of both virgin and modified materials before, during and after construction needs a higher level of supervision, which must not be underestimated.

A direct cost comparison was possible to conventional methods as this was part of the project scope. Crucial to the success and sustainability of this method, however, is long-term commitment from authorities, with guaranteed financial and technical support.

Short project description

The project scope of this project was the upgrading of some gravel roads in Brandwag to surfaced standards using Ultra-Thin Reinforced Concrete Pavement (UTRCP), constructed by means of labour-intensive construction (LIC) methods, to maximise the use of local labour.

Project location

The Brandwag community, Part of Ward 7, is situated approximately 11 km north of the N2 and Trunk Route 33, section 2 (TR33/2) and the intersection en route to Oudtshoorn as shown in Figure 1.



Figure 1: Location of Brandwag Community

Road numbers

The roads are numbered in Table 1 for ease of reference with the following approximate lengths constructed:

ROAD No.	LENGTH (m)
Road 1	230
Road 3	180
Road 4	60

Table 1: Road numbers and lengths

Project specifications

The road was upgraded to a surfaced standard to the widths, alignment and structural capacity as specified for low volume roads taking local conditions into account:

- existing material was reused and reworked to form part of the support layers to the cemented base

- the base was constructed using mainly existing material and consisted of a 100 mm thick cement stabilised layer to C3/C4 standards by means of labour-intensive construction methods
- this was followed by an application of a bituminous emulsion application to improve durability and limit the water susceptibility of the stabilised layer
- the surface layer consisted of a 50 mm thick UTRCP (mesh 200 x 200 x 5.6 mm nominal reinforcing) with batch mixing of the concrete on site with concrete mixers
- as part of the works, kerbs and channels were removed and reused, where those could be successfully salvaged.

Documentation

Works specifications: Variations and additions to the standardised specifications were included to distinguish between machine- and labour-intensive methods. The following items were included for quantifying the type and amount of works carried out by means of LIC:

Construction of stabilised base

Payment Items	Activity
P106	Mixing of gravel, cement and water
P107	Wheelbarrow haulage
P108	Spreading and levelling
P109	Construction of sub-base
P110	Screening of sub-base

This section covers the construction of a layer of concrete, 50 mm thick continuously reinforced with 200 x 200 x 5.6 mm welded mesh (Ref 193) on an emulsion cured stabilised layer.

Materials

- aggregate to comply with relevant SANS
- 32.5 CEM I cement complying with SANS requirements
- concrete to be used after submission and approval of trial mix* to 30 MPa after 28 days
- welded wire mesh fabric conforming to SANS 1024 – 1991 (6 x 2.4 m sheets)
- water to comply with relevant SANS
- curing compound or plastic sheeting for curing
- emulsion for treatment of joints
- cold applied polymer modified emulsion with 8% rubber on bitumen for treatment of joints or similar approved
- granular rubber crumbs to Sabita Manual 4 for slurry for sealing of joints or similar approved.

** On-site batch mixing on site was used and if the desired consistency was not achieved, ready-mix would be used.*

Equipment

- wheelbarrows, shovels, steel squeegees
- mixer for batch mixing/ready-mix concrete
- Spin Screed to replace vibrating screed beam for compaction of the concrete
- movable bridge to prevent walking on mesh for placing and screeding concrete
- broom with extended handle to provide texture
- concrete saw with a blade of suitable width for cutting longitudinal and construction joints
- equipment for sealing joints
- bull float.

Construction procedure

- set up side forms/shutters to specified line and levels on the prepared support layer
- placement of welded mesh on cover blocks as specified
- concrete placement ensured adequate area for truck to turn without damaging the constructed layers
- spread concrete evenly between shutters using steel squeegees/rake
- compact concrete with Spin Screed
- once the concrete was compacted, a bull float was used to achieve required surface finish
- once concrete had set sufficiently, the surface was broomed transversely to provide the required texture finish
- covered with plastic sheeting to cure concrete
- saw-cut joints as instructed
- seal joints as instructed, with approved sealant.

Quality control

A slump test had been conducted on each batch and cubes prepared as requested by the engineer. For tender purposes, the slump test for hand vibration was to be between 70 and 120 mm and for vibration beam was between 30 and 70 mm. After the trial section, the tolerances on slump test had been specified at 100 mm for the Spin Screed. Design requirements were:

- 28 days cube strength: 30 MPa
- cement to water ratio not more than 1:9
- minimum cement content 310 kg/m³
- flexible strength 3.8 MPa (mix)

Construction tolerances

- Thickness of concrete: 5 mm (minimum 45 m)
- Level and grade: 5 mm over 10 m
- Top cover to mesh: 2 mm (Minimum cover 15 mm)

Payment Items	Activity
P306	Placing of shutters
P307	Placing and fixing of welded mesh
P308	50 mm ultra-thin reinforced concrete
P309	Extra over for construction of bell mouths and intersection
P310	Anchor beams

P311	Sawing of joints
P312	Sealing of joints

Late amendments

After consultation with the CSIR, the latest techniques and methods were implemented as far as possible. This included the adjustment of the concrete design. The following photos (1 to 4) show the aggregate, fibres, plasticizer and mesh used.



Photo 1: 9.5 mm aggregate for concrete



Photo 2: Polypropylene fibres



Photo 3: P900 plasticizer



Photo 4: Ref 200 steel mesh (100 x 100 mm)

Another change was the use of a Spin Screed (Photo 5) instead of the vibrating beam (Photo 6) to compact and finish-off the concrete layer.

The Spin Screed consists of an aluminium pipe, up to 6.4 m in length, with an electric power head that spins the pipe in the opposite direction to the direction it is being advanced so that concrete rolls up in front of the screed, cutting off high spots and filling

in low spots. The aluminium pipe screed can be purchased or cut into any length up to 6.4 m, making screeds tailor-made for various jobs.



Photo 5: Spin Screed

Photo 6: Vibrating beam

The advantages of using the spin-screed

- handles easily and quick to assemble
- lightweight, only two persons to handle
- no vibration means shutters stay in place, ensuring accurate layer thickness

- position of steel reinforcing is not negatively impacted as with the vibrating beam
- no excessive fines brought to the surface, no segregation
- length of the Spin Screed eliminates half-width construction.

Contractors can switch from one length of pipe to another in just a matter of seconds by means of quick disconnects. See photos 7 and 8 below.



Photo 7: Spin Screed attachment

Photo 8: Operating the Spin Screed

The TRH4 catalogue design was used as reference design for comparison with the CSIR approach for the UTRCP. The design pavement structure is shown in Figure 2 as well as the amendment made during construction:

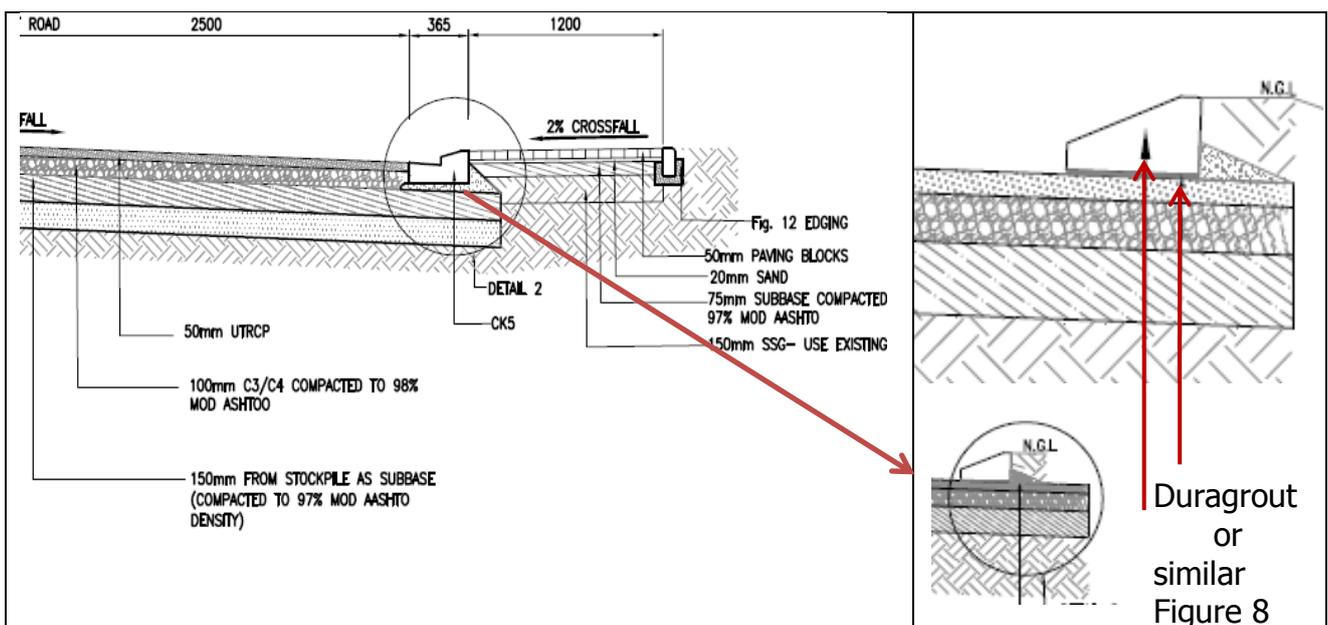


Figure 2: Design and amended cross section for UTRCP

Construction

Due to the quality of the material on Road No 3 and guidance from CSIR, the existing layer was tested with the in-situ densities exceeding the required values needed as the supporting layer.

With the use of the spin screed that exceeds the width of the road, it was decided to construct the road in full width with no longitudinal joint on the centre line.

A further change came in with the decision taken to construct both the base and UTRCP to a width that the kerbing would be constructed on top of the finished UTRCP. This was due to the time consuming efforts in fixing the shutters to the correct horizontal alignment. An added advantage was the elimination of a longitudinal joint along the road and kerbing.

The kerbing were then changed from a CK5 (combination) to a Figure 8 (mountable kerb).

Stabilised C3/C4 layer

Utilising the existing layer works resulted in a higher finished road level than designed by 100 mm. The imported G4 material stabilised with cement was mixed off-site, transported, spread by hand and compacted by walk-behind rollers.

Shuttering was placed to construct the layer to very tight vertical tolerances.



Photo 9: The emulsion being applied

The layer was finished off with the application of a diluted emulsion as shown in Photo 9.

50 mm UTRCP

To maximise local labour, mixing of the UTRCP was done by on-site batch mixing as shown in Photo 10. For this operation, eight workers were employed.

Due to the properties of the mixture, placement needed to be as soon as possible and therefore was tipped into a TLB. The mix is then carefully distributed onto the prepared surface with the reinforcing in place and well supported by spacers. Note the bridge to prevent stepping onto the reinforcement in Photo 11.



Photo 10: Batch mixing in progress



Photo 11: Off-loading the concrete mixture

Spreading with squeegees (Photo 12), prevents segregation and compacting with the Spin Screed (Photo 13), provided the quality finish needed. For this process 11 trainees were employed.



Photo 12: Spreading with squeegees



Photo 13: Spin Screed at work

Once the broom finish has been completed, the layer was covered with a canopy of plastic (Photo 14), for the curing process. This is one of the most critical aspects and the layer should be kept moist for at least seven days. This was done by watering the layer with a hosepipe (Photo 15), but unfortunately no record of this has been kept.



Photo 14: Plastic covering being placed



Photo 15: Hosepipe used to water the layer

Kerbing and sidewalks

With the construction method used, kerbs were constructed on the finished UTRCP by using a water-cement paste and screed. This gives the following advantages.

Eliminating longitudinal joints next to the kerbing, no sealing to be done

Cost saving by using Figure 8 instead of CK5

Aesthetically pleasing

Reduce routine road maintenance

The previously used method, as shown in Photo 16, needs to be sealed properly, whereas the implemented construction strategy as shown in Photo 17 does not need to be.



Photo 16: Kerbs constructed using previous method



Photo 17: Implemented kerbing construction

Once the kerbing had been, the sidewalk layerworks were constructed as shown in Figure

18. Figure 19 shows the completed sidewalk and finished road.



Figure 18: Sidewalk in progress



Figure 19: Sidewalk completed

One month after construction, some sections showed cracking similar to that of a stabilised base and it is suggested that cores be drilled to establish the extent as well as the reinforcement position. Photos 20 show typical cracks observed.



Figures 20: Typical crack patterns

Training and job creation

A well-structured training programme was initiated and supported by the provincial government of the Western Cape, Chief Directorate EPWP: CIIE. A special acknowledgement to Yolanda Ngcongca and Mzwandile Dlammanzi for their contribution to ensure that training of the highest standard was achieved.

SAVE (South African Value Education) was awarded the training project for 20 learners with the contractor Urhwebo e-Transand, which added valuable experience to the project.

A development objective of Mossel Bay Municipality regarding unemployment, poverty rate and skills shortage is to reduce it by 2% per annum and this will lead to the achievement of the 2014 millennium goal of reducing these three issues by 50%.

Structure of the technical support

- The training consisted of a theoretical as well as a practical component.
- The venue for theoretical component was provided by the community.
- The practical component was provided at the Brandwag site.

- The practical component included an on-site mentor for the learners provided by the contractor.
- Mentors provided were on-site for the first two weeks of practical implementation and operations as well as quality control of the UTRCP technique.

Training content

The theoretical training covered the following topics:

- calculations of quantities for consumables and material
- equipment required, hired and non-hired
- construction cost
- preparation of mix designs
- team balancing
- preliminaries.

Practical training initially made provision for a 20 m strip, but eventually 80 m were constructed due to changing of the reinforcing and climatic conditions prevailed at the first section. The practical training covered the following activities:

- concrete mixing
- shuttering work
- steel fixing
- using the spin-screed
- finishing of the UTRCP
- protection and curing of the layer
- kerbing.

All learners were provided with a training manual that covers the topics under the training. The learner is allowed to keep the training manual for future reference.

Quantity of learners and their skills areas

The number of learners was 20 and they received the following group training:

- 1 x skilled person from the main contractor
- 1x concrete hand
- 1x shutter hand
- 1x steel fixer
- 1x supervisor for the construction process.

Project costs

By providing a business plan and with persistent communication by the Mossel Bay Municipality, the project was approved a budget of R1.8 million for professional fees and construction.

Mossel Bay Municipality contributed an additional R330 000 towards the project.

Table 2 below gives the summary of the project cost.

Budget Item	Amount	% of Project Cost
Total construction cost	R1 635 444	76.7%
Professional fees	R497 556	23.3%
Total project cost (approved budget)	R2 133 000	

Table 2: Percentages spent of approved budget.

As mentioned elsewhere, extensive training was provided and the document was drafted to distinguish between labour and plant needed for labour-intensive construction. Table 3 below indicates spending as a percentage of the construction cost.

Pay Item	Amount	% of Construction Cost
Training of local labour including wages	R 81 600	5.0%
Labour Section 100 : Stabilised layer	R 59 606	3.6%
Labour Section 300: UTRCP	R 50 086	3.1%
Plant for labour-intensive construction	R 88 058	5.4%
Sub-total	R279 350	17.1%
Total construction cost	R1 635 444	

Table 3: Percentages spent of construction cost

It must be emphasised that a portion of this project was done conventionally and this has an influence on the percentages shown above. This, however, made a comparison between conventional and labour-intensive construction more realistic. Table 4 shows a comparison between conventional (S13) surfacing and 50 mm UTRCP done labour intensively.

Table 4: Conventional vs. UTRCP

UPGRADING : BRANDWAG PROJECT		
ACTIVITY / ITEMS	CONVENTIONAL	UTRCP
	Rate / m ²	Rate / m ²
In-situ Compaction	R 6.15	R 0.00
Cut to spoil from:	R 8.95	R 0.00
Supply of G5 material from commercial quarry	R 32.86	R 0.00
Natural G4 - Unstabilised (150 mm)	R 10.80	R 0.00
Natural G4 - Stabilised (100 mm LIC) (incl. Plant and Labour)	-	R 44.59
Construct base with graded crushed stone (G4)	R 36.90	
Application of diluted emulsion	-	R 5.00
Prime coat:	R 15.00	-
CAPE SEAL (S13)	R 60.00	-
ULTRA THIN REINFORCED CONCRETE PAVEMENT (incl. Plant and Labour)	-	R 124.48
<i>Extra Over for CSIR Design</i>		R 9.00
TOTAL	R 170.65	R 183.07

The direct construction cost of UTRCP only, is 7.3% more expensive than that of a Cape Seal. This compares well with other literature showing an 8.6% difference.