REVERSE ENGINEERING A BLEEDING SEAL IN THE LABORATORY

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INTRODUCTION

The bulletin describes the forensic investigation of a bleeding double seal on a crushed stone base in southern Africa. It presents a structured methodology for investigating a bleeding surfacing. The paper is intended to be instructive on a topic that little has been written about. It gives data and methods which would be of use to other practitioners and post-graduate students.

Unusual laboratory methods are used to determine the actual application rates. The reverse engineering in the laboratory involves recovery of binder, separation of stone from the different layers, measuring binder and stone quantities per unit of area, testing stone and binder, and checking embedment. . Actual field and laboratory results are presented to illustrate the approach. Some surprisingly useful results can be had using this method.

The body of the presentation follows as slides.

REVERSE ENGINEERING A BLEEDING SEAL

BACKGROUND

- Bleeding occurred on a new construction 13/6 double seal, over a primed crushed stone base.
- The seal was designed using TRH 3 (1986) for a traffic of 2000 equivalent light vehicles (2 way).
  - *cool climate location, with hilly terrain*
  - *150/200 was the main binder used. A short section was built in autumn using MC3000 and has performed satisfactorily.*
- Bleeding was evident from in the first summer and was corrected by blinding with 6,7mm stone. Bleeding reoccurred in second summer prompting a full investigation.

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COMMON CAUSES OF SEAL BLEEDING

- Wet precoat
- Contamination by tar prime
- Wrong binder grade
- Too much binder
- Traffic too heavy
- Wrong stone size
- Stone too soft
- Excessive steel wheel rolling
- Stone punching down/embedment
- 2nd seal too quick after 1st seal
- Wrong application rates in construction
- Design

WARNING: usually more than one cause is present, which can confound the effect.

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REVERSE ENGINEERING /1

- Reverse engineering involves:

Field

- inspection and checking traffic level *(which here was close to the design traffic that was used)*
- strength testing of the basecourse *(which here was DCP-CBR 150-400, which is strong. Embedment was not suspected).*
- sampling *(which was done here. Square surfacing samples were removed by pickaxe, the samples sealed in plastic to limit volatile loss, and the area measured. The car boot smelt of tar upon return).*

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REVERSE ENGINEERING /2

Laboratory

- recovery of binder, and separation of stone from the different layers *(this was done, and was difficult. Some contamination of surface by base is inevitable; careful work minimizes it).*
- measuring binder and stone quantities per unit of area
- testing stone and binder.

Design/construction

- checking design *(possible problem here)*
- check time between first and second seal *(not a problem here).*

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FIELD TESTING - INSPECTION

- Observe traffic
  - *especially slow moving or turning trucks*
- Look at pattern of bleeding:

  <u>Hills and climbing lanes only</u>

  - *design failed to reduce application rate*

  <u>Wheeltracks only</u>

  - *possible punching/embedment*
- Smell the surfacing from close-up
  - *any smell of tar is a good indication of contamination by prime or precoat*
- Check for any stone crushing

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FIELD TESTING - BASE STRENGTH

- Strength testing checks for **embedment potential**.
  - *DCP is an excellent tool for this.*
  - *Only the first 100mm need be tested.*
  - *Reading for first few millimetres ignored due to seating of the cone. It is rare that the very top of the basecourse is loose prior to sealing.*
  - *Embedment will occur in soft bases, usually indicated by in-situ DCP CBRs of less than 80-100. Where the in-situ DCP-CBRs are as low as 25-45, embedment is more certain.*
  - *Embedment is extremely difficult to see, even if cores are taken. Often the only undisputed guide is base strength.*

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FIELD TESTING - SAMPLING

- Samples are taken from several areas
  - *try to sample both bleeding and adjacent non-bleeding areas*
  - *square slabs of surfacing are cut by pickaxe and sealed in plastic; 500mm by 500mm is a good size, but record the actual area accurately*
  - *note the adhesion of the base to the surfacing, any prime, and dampness of base*
- Cores are very difficult to interpret, and often misleading
  - *especially when trying to assess how much embedment has occurred.*
  - *their use is not recommended here*

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LABORATORY TESTING - BINDER RECOVERY

- An unusual technique was used due to the suspected tar contamination.
  - *common recovery techniques use toluene or melt the sample in the oven. They would drive off tar volatiles such as benzene derivatives, naphthalene, etc.*
  - *distillation employing a fractionating column was used with chloroform, which boiled about 20^{o}C lower than the tar volatiles.*

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LABORATORY TESTING - RECOVERED BINDER

- Penetration and softening point (R&B) check for contamination or wrong binder grade;
  - *an MC3000 had R&B of 54 °C after 2 years (normal)*
  - *a bleeding 150/200 had R&B of 22-29 °C after 1 year (effect of tar contamination)*
- Low temperature ductility checks suspect binder
  - *very low values indicate unstable bitumen*
- RTFOT tests show contamination and suspect binder
  - *high mass loss shows contamination*

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LABORATORY TESTING - GAS CHROMATOGRAPH

- Small samples (2 grammes) of binder can be tested using the gas chromatograph to check for tar or diesel contamination
  - *testing the top and bottom of the seal separately*
  - *the prime 'signature' can be identified at the bottom, and its presence at the top of the seal checked (there should be none)*
- Note that quick drying prime can easily cause contamination
  - *during construction, it can appear to be surface-dry while still containing a large amount of tar solvents.*
- Other contaminants such as diesel can also be detected

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RECOVERED BINDER AND STONE

- Total application rates are determined in laboratory
  - *very hard to separate into layers*
  - *some inaccuracy expected (say up to 0.3 l/m²)*

Example from bleeding section

	SRT LAB	**DESIGN**
Total binder cold on flat (l/m^2)	2,81	2,60
Total binder cold on hills (l/m^2)	2,32-2,40	2,45
Total stone (m^3/m^2)	0,0094	0,0148

- Conclusions: binder applied normally (variation less than 0,3 l/m^2. Stone was under-applied

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RECOVERED STONE

- Stone ALD and FI checks that the stone tested for the design was the same one actually used onsite (surprisingly common problem).
- Example from bleeding section

	SRT Laboratory	**Actual Design used here**
ALD 13,2mm (mm)	8.4	8,6
FI 9,5mm (%)	6,6	9
ALD 6,7mm (mm)	3,9	3,8
FI 4,75 mm (%)	12,6	17

- Conclusion: stone was in accordance with design