LOOSE SUBBASE MATERIAL WILL CONTAMINATE G1 MATERIAL

85

G1 AGGREGATE CONTAMINATED WITH CLAYEY MATERIAL

86

TOO MUCH FINES!

87

G1 AGGREGATE CONTAMINATED WITH SOLUBLE SALT

88

SOLUBLE SALT CONTAMINATION

89

MIXED AGGREGATE READY TO BE SHAPED TO LAYER DIMENSIONS

90

STEP 8: SHAPE THE MIXED AGGREGATE TO LEVEL AND WIDTH

91

STEP 8: SHAPE MIXED AGGREGATE LEVEL AND WIDTH

92

AVOID ADDING TOO MUCH WATER

93

SIDE VIEW OF G1 AGGREGATE LAYER - READY FOR INITIAL COMPACTION

94

SURFACE OF G1 AGGREGATE LAYER - READY FOR INITIAL COMPACTION

95

In-spec grading material delivered to site

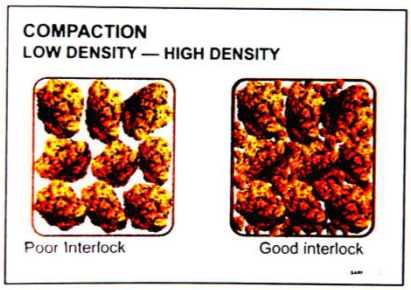
Grading destroyed by recycling/tamping!

G1 AGGREGATE GRADING DESTROYED ON SITE

96

COMPACTION CYCLE

97



HIGHER DENSITY = HIGHER STRENGTH

98

THE EFFECT OF COMPACTION

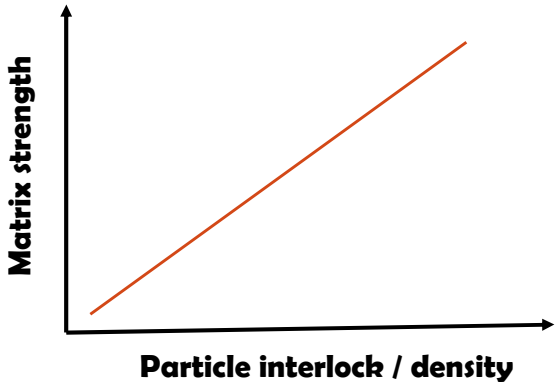
The strength of a layer of road building material depends on:

- **The intimacy of interlock of the particles**
- **The strength of the particles themselves**
- **The micro and macro texture the particles**

Hence:

Tighter interlock of strong and roughly textured aggregate will provide a stronger layer

99



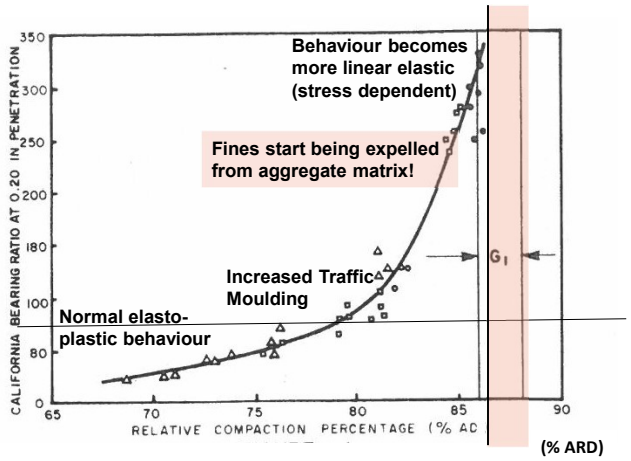
BETTER PARTICLE INTERLOCK = INCREASED MATRIX STRENGTH

100

BETTER PARTICLE INTERLOCK = INCREASED MATRIX STRENGTH

- **However, not every one knows how dramatic this effect can be**
- **It is utilised with great success in achieving G1 Crushed Stone base quality**
- **So, what makes G1 Crushed Stone so different?**

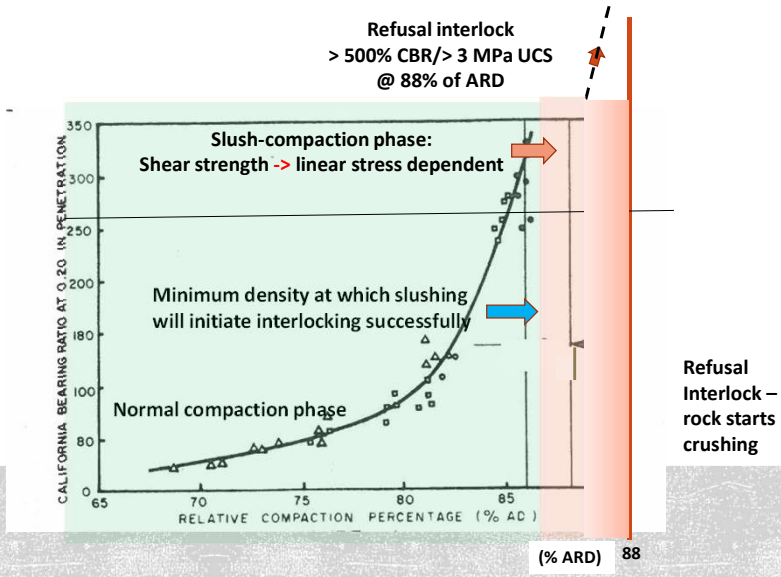
101



THE EFFECT OF INTERLOCK ON G1 MATERIAL

(FROM "COMPACTABILITY OF CRUSHED STONE ROAD BASECOURSE MATERIAL" BY VAN DER MERWE, KLEYN & SAVAGE – ATC 1985)

102



CURRENT G1 INTERLOCK REQUIREMENT

(FROM "COMPACTABILITY OF CRUSHED STONE ROAD BASECOURSE MATERIAL" BY VAN DER MERWE, KLEYN & SAVAGE – ATC 1985)

103

THE ACTION OF VIBRATORY ROLLERS

- **Fixed amplitude/frequency vibratory rollers have a cyclic compaction/de-compaction action on non-cohesive material!**
- **Monitor the effect of the roller with every pass!**
- **If the desired increase in density/interlock is not achieved within 3 to 4 passes the roller is probably too light – continuing will only crush the aggregate!**
- **If self-regulatory, the vibration amplitude should decrease while the frequency should increase with each pass such that "densification/de-densification" cycles are largely avoided.**

104

COMPACTION EQUIPMENT NECESSARY

Rollers:

- **Medium static/vibratory, steel/pneumatic tyred (15-17 ton) with adjustable frequency and amplitude.**
- **Heavy pneumatic tyred (27 - 37 ton) to finish slush-compaction cycle.**

- **No grid roller!**
- **No pad foot roller!**
- **No "till the cows come home" rolling!**
- **No "give it hell" vibratory rolling!**

105

OPTIMUM THICKNESS FOR A <37,5 mm G1 CRUSHED STONE LAYER

Was empirically determined over the years.

- **125 mm layer too thin to allow for:**
  - **absorb stabilisation reflection cracks.**
  - **orientation space for larger aggregate during slushing**
  - **shear strength stability - layer very deflection sensitive –> de-densifies**
- **150 mm layer optimum to:**
  - **interlock larger particles maximally**
  - **Inhibit stabilisation crack reflection to surface**
  - **slush entire layer towards linear-elastic behaviour – to make muscle**

106

OPTIMUM THICKNESS FOR A <37,5 mm G1 CRUSHED STONE LAYER

Was empirically determined over the years.

- **150 mm layer optimum to:**
  - **interlock larger particles maximally**
  - **Inhibit stabilisation crack reflection to surface**
  - **slush entire layer towards linear-elastic behaviour – to make muscle**
- **>175mm layer cannot be slush-compacted fully:**
  - **fines drain down – lack of stable compaction anvil**
  - **aggregate do not interlock fully**
  - **layer behaviour does not approach linear-elasticity – cannot make muscle**
  - **layer starts falling within tensile stress zone (below neutral plane)**

107

INITIAL COMPACTION

108

G1 AGGREGATE GRADING DESTROYED ON SITE

- Note tyre track marks and segregated areas

109

Start at edge of road and compact as for a gravel (15 – 17 ton optimum)

INITIAL COMPACTION

110

DON'T CRUSH THE MATERIAL!

111

INITIAL COMPACTION

112

DON'T CRUSH THE MATERIAL!

113

LAYER READY FOR SLUSH-COMPACTION

114

FINAL OR SLUSH-COMPACTION CYCLE

115

TWO SLUSHING METHODS (COLTO)

1. **"Watering and slushing process: – rolled and slushed by means of steel-wheeled rollers with a mass of not less than 12 tons each, and/or pneumatic–tyred rollers - - shall continue until all excess fines are brought to the surface of the layer - - and its specified density has been reached - - excess fines shall then be swept from the surface".**

2. **"Water or slurry rolling: – the final surface of the base shall be watered and subjected to additional rolling - - in order to obtain a firm, even, well-knit surface - - shall continue until all excess fines on the surface have been distributed over the surface of the base".**

116

SUGGESTED ROLLER APPLICATION FOR SLUSH-COMPACTION AT OMC

1. Start at edge / lower end of cross section
2. Use about half-a-drum overlap
3. 1-2 roller passes no vibration
4. 1 pass at low frequency & high amplitude vibration
5. Correct levels if necessary and start again at #3
6. 2-3 passes at high frequency & low amplitude vibration
7. Continue with static steel & pneumatic tyred rollers to complete slush-compaction to 88% AD and tightly interlocked aggregate mosaic
8. NB! If crushing of aggregate starts taking place, remove steel tyred roller/s and finalise with heavy pneumatic/s

117

SLUSH-COMPACT WITH LOTS OF WATER CLOSELY FOLLOWING WATER TANKER

118

ROLLERS FOLLOW WATER TANKER CLOSELY !

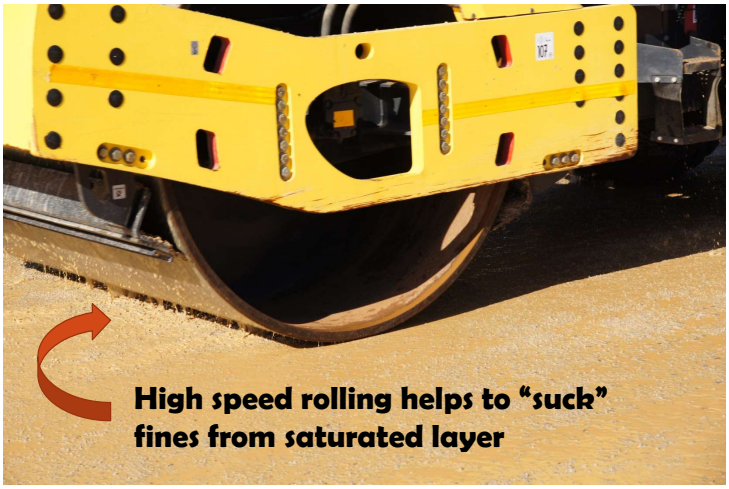
119

DON'T CRUSH THE MATERIAL!

120

EXCESS FINES BEING EXPELLED AS SLUSH FROM LAYER

121



EXCESS FINES BEING "SUCKED OUT"

122

EXCESS FINES BEING "SUCKED OUT"

123

27 – 37 ton

HEAVY PNEUMATIC ROLLER FOR FINAL SLUSH-COMPACTION PHASE

124

AIR BEING EXPELLED FROM LAYER DURING SLUSH-COMPACTION

125

DON'T CRUSH THE MATERIAL!

126

SPREAD INITIAL SLUSH/SAND TO DEFICIENT AREAS

127

EXCESS SAND BEING SLUSHED OUT PRIOR TO <0,075 mm FINES

128

SAND SLUSHED OUT - NOT FINES!

129

VERY IMPORTANT!!

- **Remove steel drum roller when crushing of aggregate is observed and use only heavy pneumatic tyred roller until required interlock/density is achieved!**

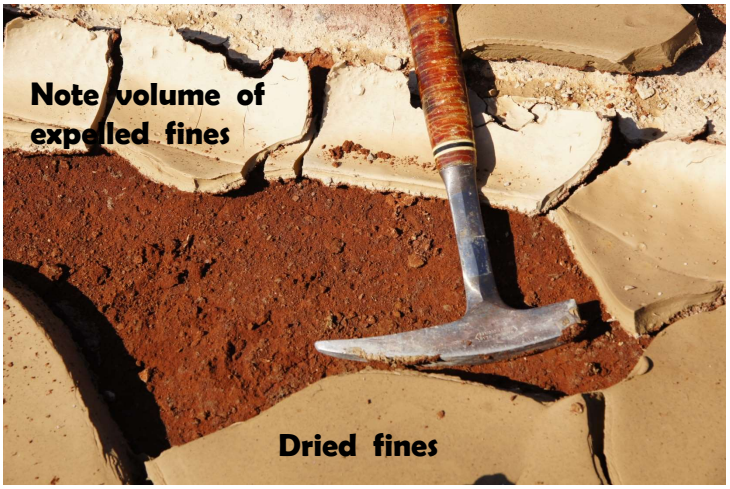
130

SLUSHED OUT FINES (<0,075 mm) RUN-OFF ALONG ROAD

131

SLUSH RUN-OFF ESCAPE FURROW IN WINDROW

132



DRIED SLUSH RUN-OFF

133

TOO LITTLE SLUSH RUN-OFF

134

WATERING DURING SLUSH-COMPACTION

135

WATERING DURING SLUSH-COMPACTION

136

TOO LITTLE FINES BEING SLUSHED OUT

137

COURSE SAND GENERATED BY EXCESSIVE ROLLER APPLICATION

138

EFFECT OF OVER-ROLLING WITH ROLLER THAT IS TOO LIGHT

139

EFFECT OF AGGRESSIVE VIBRATORY ROLLING

140

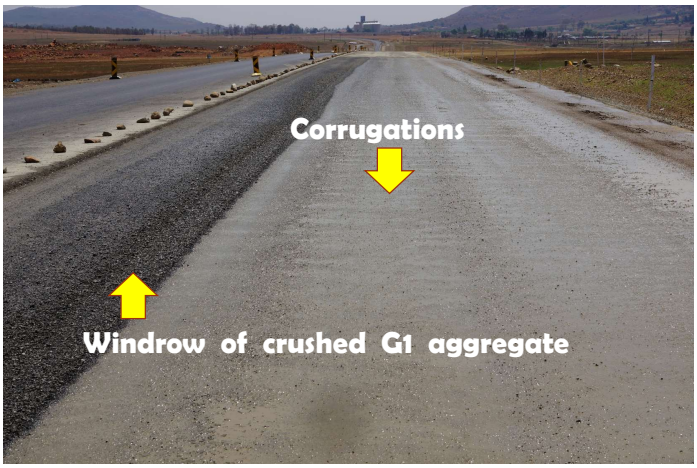
EFFECT OF AGGRESSIVE VIBRATORY ROLLING

141

EFFECT OF AGGRESSIVE VIBRATORY ROLLING

Crushed G1 aggregate being broomed off!

142



EFFECT OF AGGRESSIVE VIBRATORY ROLLING

143

EFFECT OF AGGRESSIVE VIBRATORY ROLLING

- Crushed G1 aggregate windrow

144

EFFECT OF LACK OF LARGER AGGREGATE IN MATRIX

- No mosaic

145

AGGREGATE MOSAIC FORMING

- Aggregate interlock still too open

146

SIGNS THAT OPTIMUM INTERLOCK HAS BEEN ACHIEVED

The signs that refusal interlock (and probably the minimum specified density) has been achieved are:

- **No more air bubbles escaping during slushing.**
- **Expelled water clearing up substantially.**
- **Well-knit mosaic visible through surface water.**
- **Road surface does not heave under heavy roller.**
- **Do interlock and density acceptance control – Visual and Ping Tests!**

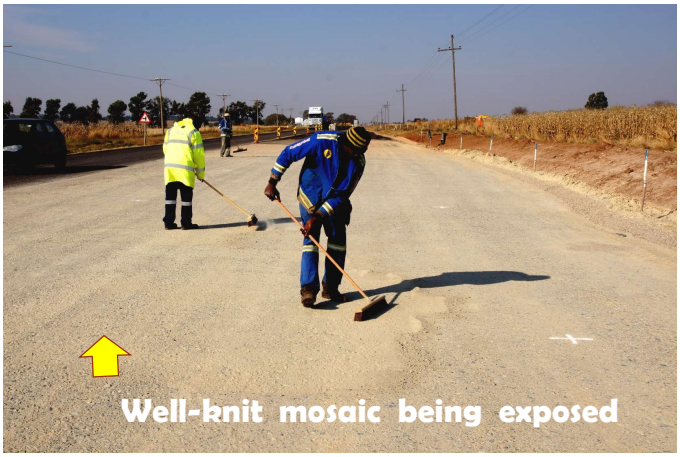
Make sure first time round – re-wetting aggregate is very time consuming!

147

WELL SLUSHED G1 CRUSHED STONE (PRIOR TO FINAL BROOMING)

- Note minimal inter-aggregate fines

148



BROOM ROAD SURFACE 1 DAY AFTER FINAL SLUSH-COMPACTION

149

BROOM ROAD SURFACE DAY AFTER FINAL SLUSH-COMPACTION

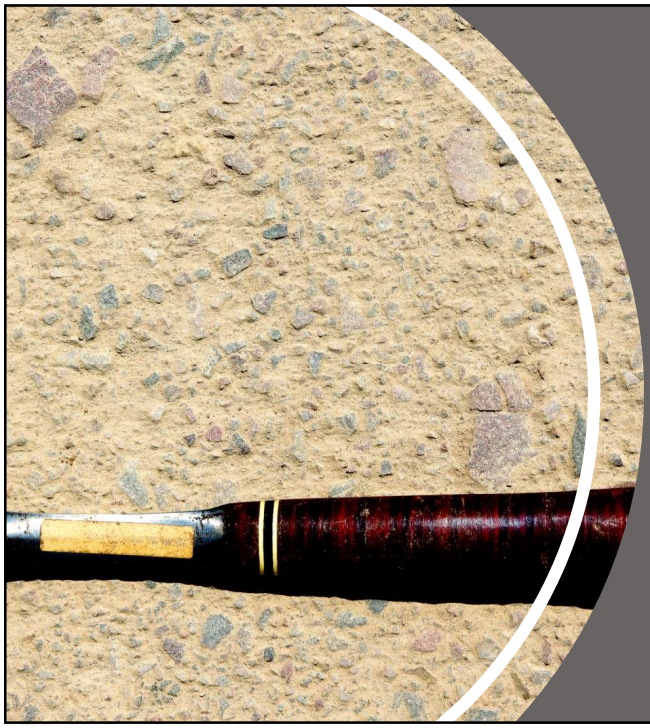
Bristles of broom should just touch surface

150

FINAL SURFACE TOO HEAVILY BROOMED!

- Loss of larger aggregate -
- variable surface texture !

151



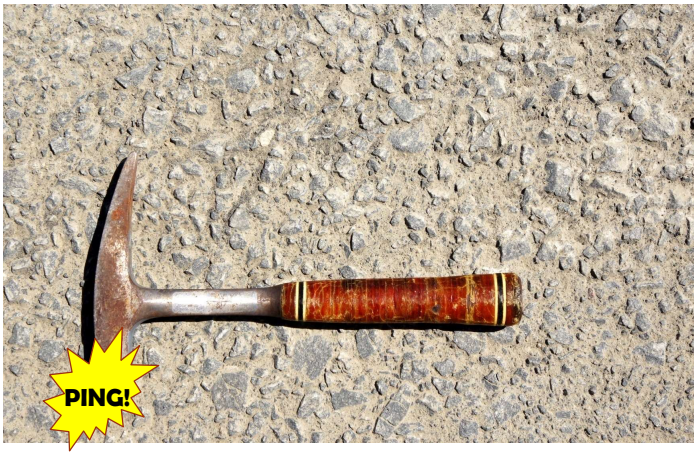
POOR MOSAIC OBTAINED WITH RECYCLED G1 MATERIAL

- Lack of larger aggregate component
- -> poor performance

152

ONE PASS FINAL ROLL TO RE-KNIT SURFACE AGGREGATE

153



G1 CRUSHED STONE READY FOR "PING-TEST" !

154

WHY REFUSAL INTERLOCK MAY NOT BE ACHIEVED

- Support value of subbase not sufficient
- Deflection of pavement too high
- Grading of aggregate not continuous
- Aggregate crushed / too soft
- Moisture content of layer incorrect for equipment
- Material not slush-compacted
- Roller/s too light
- Over-vibrating of material
- Material grading altered during compaction
- Slush-compaction stopped too soon

155

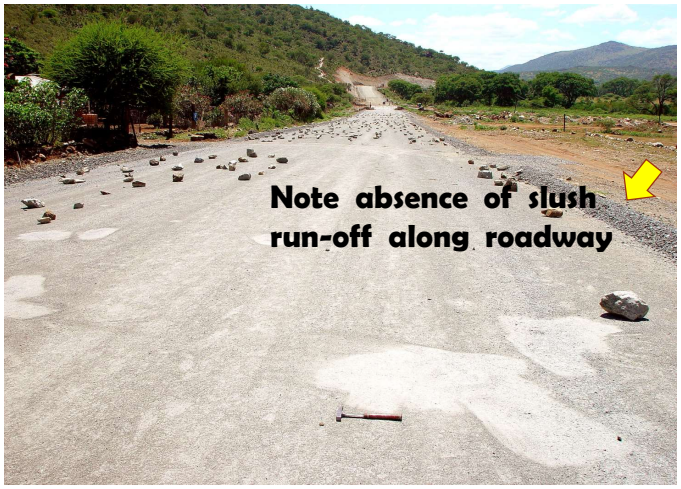
ADDITIONAL INFORMATION

156

ADDITIONAL INFORMATION REGARDING G2 CRUSHED STONE

- **G2 at 85% Bulk Density (BD) may be sufficient for the bearing capacity required**
- **Some road authorities prefer a G2 Crushed Stone with a water or slurry roll final finish to 85% of Bulk Density (BD)**
- **BD usually reserved for more weathered material to allow for voids and cracks in in the aggregate**

157



SURFACE AFTER WATER OR SLURRY ROLL

158

BROOMED SURFACE AFTER WATER OR SLURRY ROLL

159

BROOMED SURFACE AFTER WATER OR SLURRY ROLL

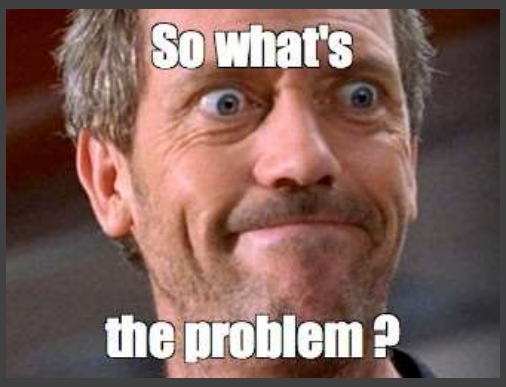
160

VISUAL DIFFERENCE BETWEEN SLUSHED AND SLURRIED G1 CRUSHED STONE

Slurry rolled

Slush rolled

161



162

163