SUCCESSFUL G1 CRUSHED STONE CONSTRUCTION

by
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July 2022

Dennis Rossmann

a simple "padmaker"

50 years in roads business.

- **11 years with KZN Provincial Roads Dept.**
- **17 years with N-DOT (Dep. Director Materials & QA)**
- **19 years with SANRAL as Specialist Materials & QA Engineer.**
  - **Chaired Sanral's Materials Focus Group**
- **4 years post "retirement" as private consultant.**

PRESENTATION CONTENTS

1. INTRODUCTION
2. HISTORY AND DEVELOPMENT OF G1 BASES
3. CRITICAL ITEMS TO CONSIDER BY
   - CLIENTS,
   - DESIGNERS,
   - MATERIAL SUPPLIERS,
   - CONTRACTORS AND
   -SITE SUPERVISION.
4. CSRA SPECIFICATIONS
5. CONSTRUCTION
6. MAINTENANCE!

NB!

1. We're NOT going to cover pavement design (stresses/strains, resilient response etc)
2. This is covered by appropriate pavement design courses offered by higher learning Academia Institutions going to look at G1 Crushed Stone construction.
3. Objective is to share personal experiences over decades
4. The plant shown in this presentation is solely used to illustrate an activity.
5. The aims & sequences of the activities are important.

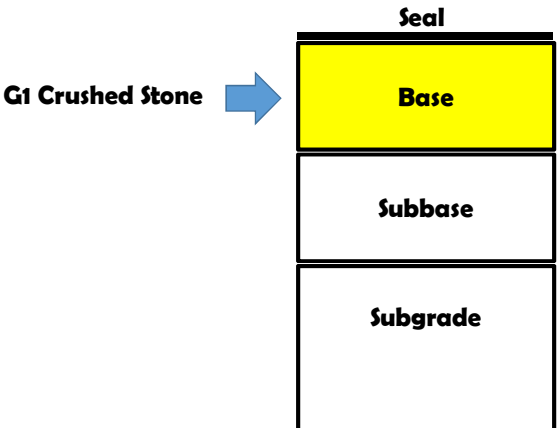
Please interrupt me to clarify something for you.

I welcome questions, queries etc in order to stimulate discussion for the benefit of all delegates

THE AIM WITH THE CONSTRUCTION OF G1 CRUSHED STONE

STOCKPILED AGGREGATE → **INTERLOCKED AGGREGATE**

THE POSITION OF G1 CRUSHED STONE IN THE PAVEMENT



"G1 CRUSHED STONE"?

It is the name of a LAYER of:

1. **Continuously graded (Fuller/Talbot grading),**
2. **Minus 27,0 or 37,5 mm crushed aggregate,**
3. **Slush-compacted to refusal interlock.**

"G1 CRUSHED STONE" CONTINUED

At a minimum density of:

- **86% of Apparent Relative Density (ARD) for unblemished G2 high quality rock**
- **88% of Apparent Relative Density (ARD) for G1 high quality rock**

(Relative Density is the mass of the particles compared to the mass of an equal volume of water.)

WHY AT SRD/ARD AND NOT MOD AASHTO DENSITY?

Because G1 aggregate is:

- **Non-cohesive, high quality, crushed rock that cannot be impact (hammer) compacted (AASHTO method) to a consistent maximum density;**
  - **The aggregate will break down**
  - **The grading will change**
  - **The final interlock will be variable**
- **It has to be "guided" (slush-compacted) into position to achieve consistent maximum interlock.**

ATTRIBUTES OF G1 CRUSHED STONE

- **High load dependent E-modulus**

  bearing capacity increases to meet the demand of the traffic load – it "makes muscle" as it is loaded.

- **High durability**

  equal to that of the parent rock.

- **Low permeability**

  because of continuous grading at maximum particle interlock.

- **Low moisture sensitivity**

  because material is non-cohesive (has no PI).

G1 CRUSHED STONE SENSITIVITIES

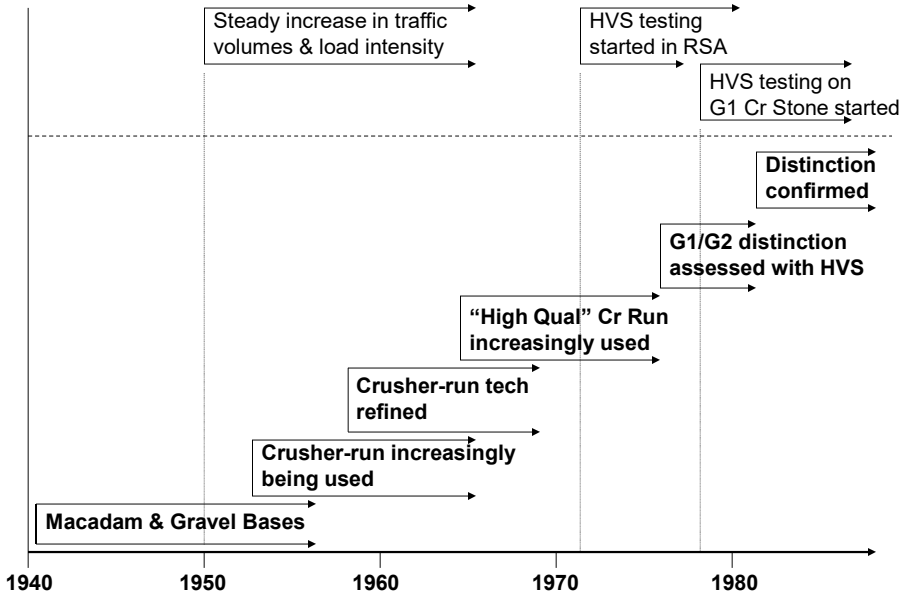
- **E-modulus at rest is much lower than under load – leads to bearing capacity miscalculations!**
- **Deflection that causes tensile stresses will lead to de-interlocking – operate layer under compressive stresses – on a highly supportive subbase/pavement!**
- **Lack of edge restraint will lead to edge de-interlocking and raveling.**
- **Traffic over unsurfaced layer will lead to contamination and de-interlocking of layer.**
- **Any PI will lead to a jump in moisture sensitivity.**

EVOLUTION OF G1 CRUSHED STONE

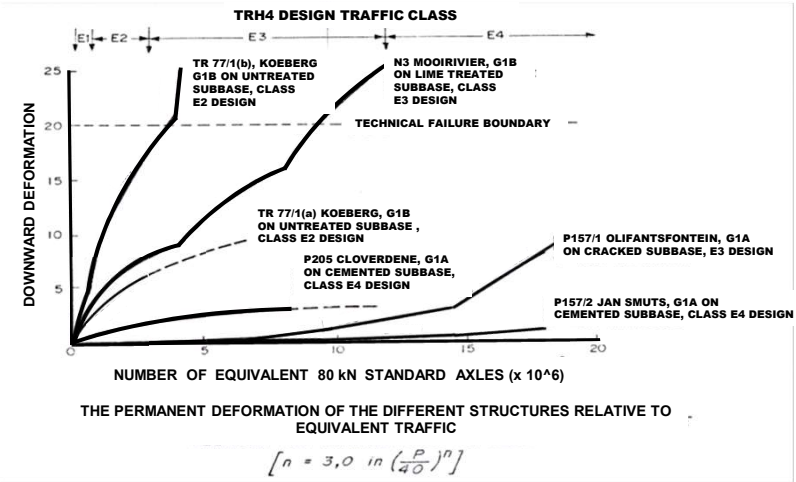
EVOLUTION OF G1 CRUSHED STONE

- Was originally single stage crushed rock with no specific grading, called Crusher-run.
- Observed in 50's that unintentional washing out of fines under compaction helps to interlock layer matrix.
- Realisation: Better interlock -> better performance!
- Realisation: Better grading -> better interlock!
- Hence, HVS investigation on provincial roads (1972-1984)
- Hence, adoption of continuous grading.
- Hence, stricter grading and material specifications.
- Hence, more precise construction guidelines.

THE EVOLUTION OF G1 CRUSHED STONE

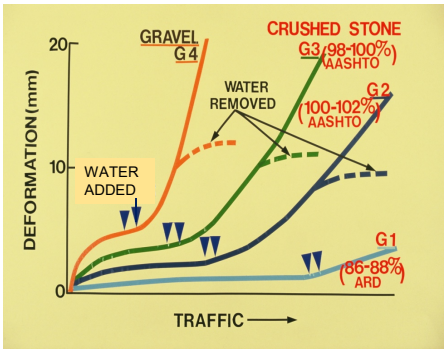


BEHAVIOUR OF DIFFERENT PAVEMENT COMPOSITIONS UNDER THE HVS

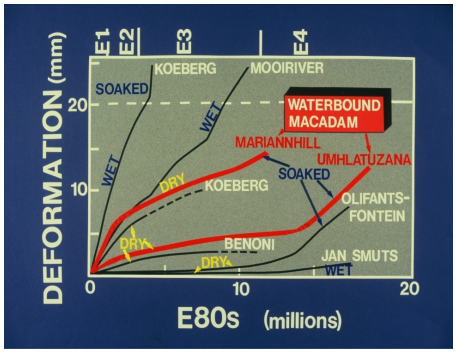


COMPARATIVE HVS TEST ON EXISTING ROADS

Various crushed stone & gravel base-courses



Various crushed stone & Waterbound Macadam



Note low moisture sensitivity of G1 Crushed Stone

SUPERIORITY OF G1 CRUSHED STONE RECOGNISED

- **G1 Crushed Stone construction process and quality control incorporated into COLTO specifications.**
- **Heavy Vehicle Simulator (HVS) and Long-term Pavement Performance (LTPP) monitoring resulted in application for heaviest traffic loads in SA – up to 50 MISA (Million Standard Axles).**
- **Overseas countries enquiring about and investigating the "South African Inverted Pavement Design" ! (2016 TRB International Conference in Washington, USA)**

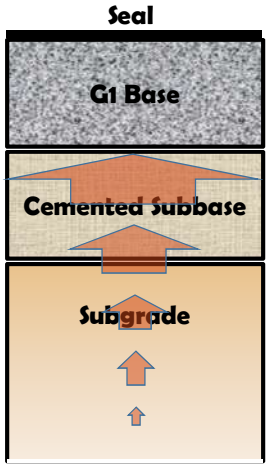
BASIC G1 CRUSHED STONE PAVEMENT COMPOSITION

BASIC G1 CRUSHED STONE PAVEMENT COMPOSITION

To ensure that the G1 Crushed Stone base will respond positively to a load increase ("make muscle") and operate under compressive stresses:

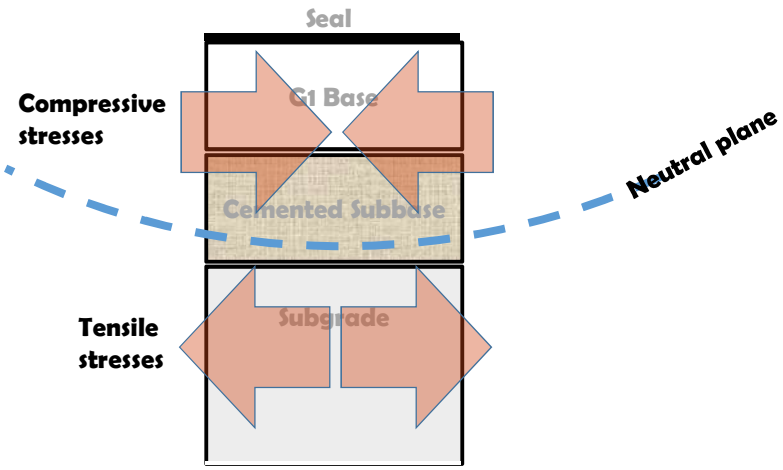
- **Select a relatively deep pavement composition to ensure that the neutral plane is below the base.**
- **Cement stabilise the subbase/s to assist in keeping the neutral plane below the G1 base course -**
  - **also to ensure a sound anvil upon which the G1 base course may be slush-compacted without softening or disintegration,**
  - **also to inhibit cutting/mixing of sub-base material into the G1 material during construction.**

TYPICAL G1 CRUSHED STONE PAVEMENT COMPOSITION



Sound, water-resistant, support -> deep pavement

SOUND SUBBASE / SUBSTRUCTURE KEEPS BASE UNDER COMPRESSION



TOWARDS DELIVERING WHAT IS EXPECTED

PREREQUISITES TO SUCCESS

Success basically depends on:

1. **Having the correct specification**
2. **Having the correct material**
3. **Having the correct equipment**
4. **Applying the equipment correctly**

Commitment !

THE CORRECT SPECIFICATION & TECHNOLOGY

- **It is that which when applied results in the wanted end-product**
  - **The Client's vision of the end product,**
  - **conveyed to you through his communications,**
  - **guided by mutually agreed upon specifications (materials, equipment, method & process).**

THE CORRECT SPECIFICATION & TECHNOLOGY

The correct specification and technology may be obtained through a combination of:

- **COLTO specifications**
- **Major Provincial Road Authority manuals**
- **SARF courses**
- **Experience from successful construction**

(not construction on which one was not caught out on!)

CONSTRUCTION MOANS AND GROANS

SITE LAMENTS!

Heard on site:

- **"It's too time consuming"!**
- **"It's too expensive"!**
- **"Nobody knows how anymore"!**
- **"My way is just as good – even without slushing"!**
- **"Why should I worry – they'll never find out"!**
- **"I learned from your father – now YOU want to tell me"!**
- **"The crusher told me to go fly a kite"!**
- **"The recycler/pad foot does not change the grading"!**
- **"I didn't tender for this !#*@*! Process"!**
- **Etc, etc, etc!**

SPECIFICATIONS FOR G1 MATERIALS

"COLTO" SPECIFICATIONS

Originally commissioned by the

"Committee of Land Transport Officials"

Given in Section 3600: "Crushed Stone Base" of the Standard Specifications for Road and Bridge Works for State Road Authorities - referred to as "COLTO".

QUALITY SPECIFICATIONS FOR G1 AGGREGATE

Aspects that have to be controlled (COLTO 3600):

1. **Aggregate type**
2. **Additional Fines**
3. **Soluble salt content**
4. **Strength**
5. **Durability**
6. **Flakiness**
7. **Fractured faces**
8. **Atterberg Limits**
9. **Coarse sand ratio**
10. **Particle grading**

DENSITY SPECIFICATION FOR G1 CRUSHED STONE

The minimum density for G1 Crushed Stone is:

- **88% of Solid Relative Density (SRD) for unblemished high quality rock**
- **85% of Apparent Relative Density (ARD) for high quality rock containing internal voids**

(Relative Density is the mass of the particles compared to an equal volume of water.)

WHY SRD/ARD AND NOT MOD AASHTO DENSITY?

Because G1 aggregate is:

- **Non-cohesive, high quality, crushed rock that cannot be impact compacted (AASHTO method) to consistent refusal-interlock;**
  - **The aggregate will break down**
  - **The grading will alter**
  - **The interlock will be variable**
- **And has to be "guided" (slush-compacted) into position to achieve consistent maximum interlock.**

ADDITIONAL CARE

The following cautions should be observed when considering rock for G1 aggregate:

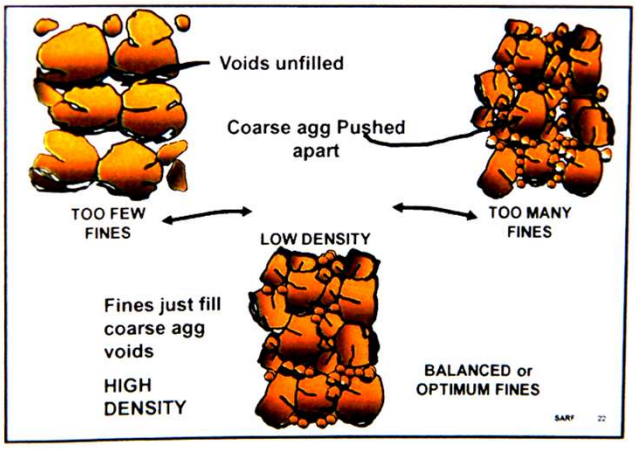
- **Rock that is too soft will break down further under construction - and even normal service – check hardness.**
- **Basic crystalline rock such as dolerite and basalt have a tendency to produce relatively little fines – add in.**
- **Basic crystalline rock may contain smectite which decomposes to a heavy clay, especially where N < 5 (coastal areas and eastern Freestate) – pre-treat with lime.**
- **Sedimentary rock such as gritstone, sandstone, ferricrete, calcrete, etc, normally has low crushing/shear strength – sensitive to high tyre contact stresses (high inflation) on upper part of base – check.**

ADDITIONAL CARE - CONTINUED

- **Crushed blast furnace slag has a tendency to be porous or glassy, and high variability, if not selected carefully.**
- **Smooth riverwash will deliver poor shear strength - should be crushed to specification.**
- **Be weary of G1 aggregate that stains the skin – sign of clayey fines - check.**
- **Be weary of otherwise sound granite containing muscovite (mica) – highly elastic and also expansively disruptive under wet/dry cycles.**

GRADING OF G1 MATERIAL

BETTER PARTICLE SIZE DISRIBUTION

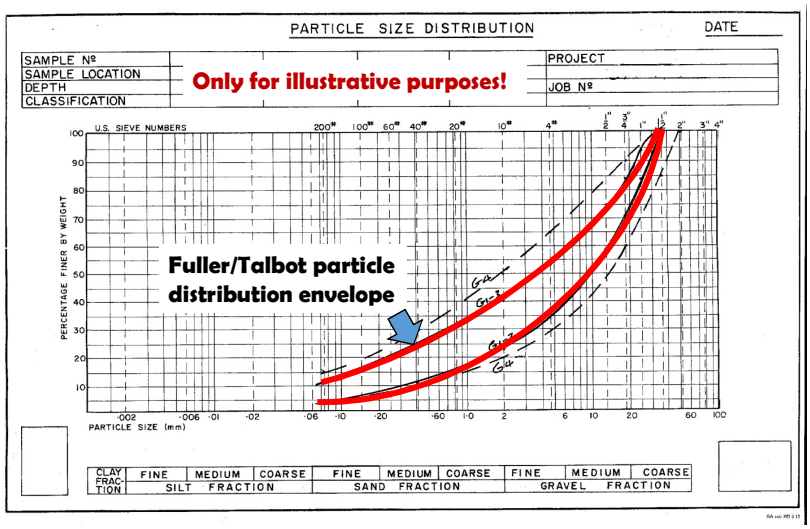


THE PRE-COMPACTION TARGET GRADING FOR G1 AGGREGATE

In order to minimise the construction effort necessary to obtain maximum particle interlock:

- **A target grading is specified by COLTO –**
  - **to be fine-tuned by way of an acceptable test section**
  - **to be adhered to by crusher and contractor thereafter**
- **Any crusher/aggregate changes necessitate another test section and target grading!**

TRADITIONAL PARTICLE GRADING FOR G1 AGGREGATE (COLTO 1998)



THE FULLER/TALBOT FORMULA

$$P_d = 100[d/D]^n$$

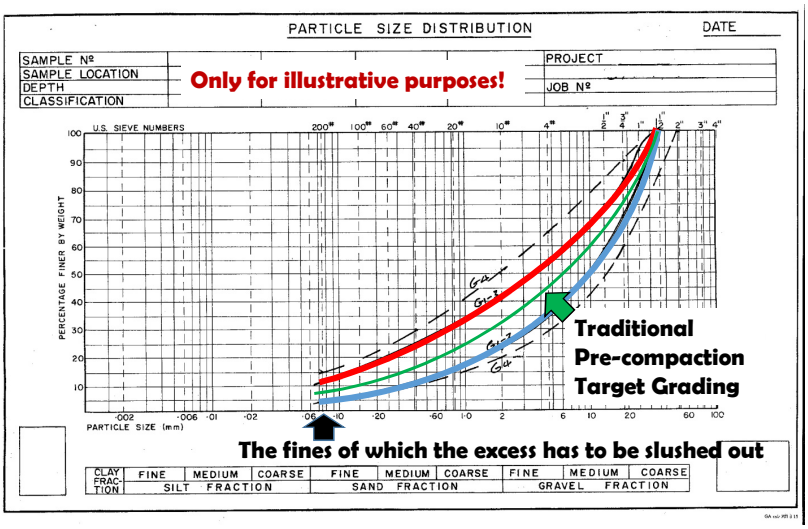
Where

- P_d = percentage material by mass passing the sieve size with opening "d"
- D = maximum particle size (37,5 mm)
- n = a constant governing the overall grading type of the aggregate matrix

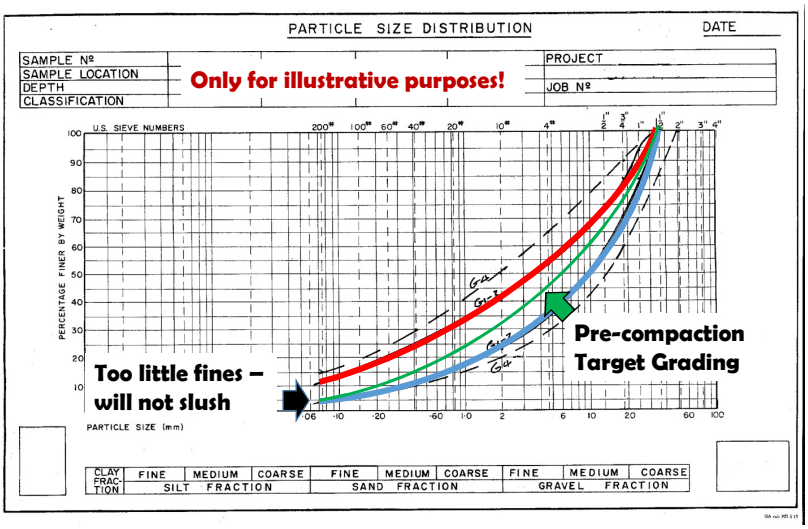
  fine boundary n ≈ 0,3

  coarse boundary n ≈ 0,5

TRADITIONAL GRADING FOR G1 AGGREGATE (COLTO 1998)



GRADING ANNOMALIES AND THEIR EFFECT ON CONSTRUCTION



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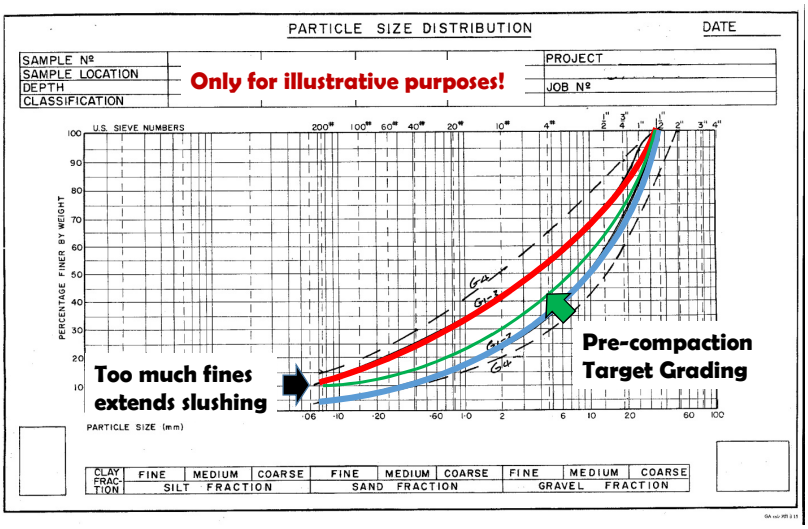
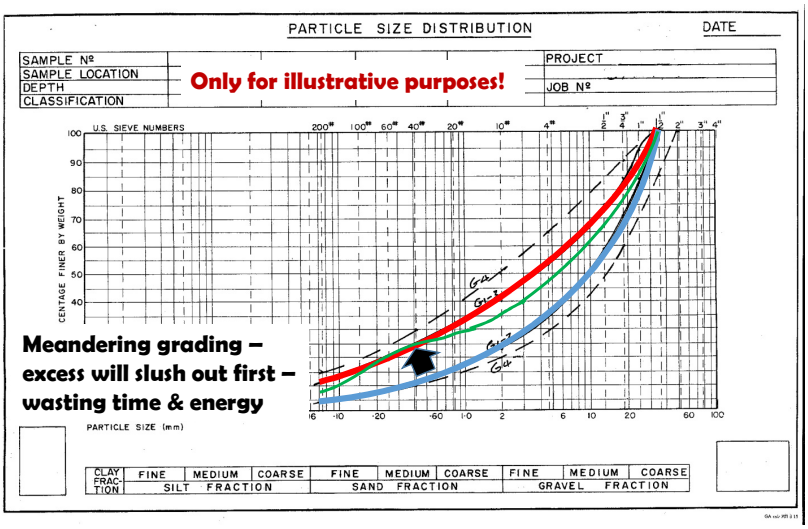
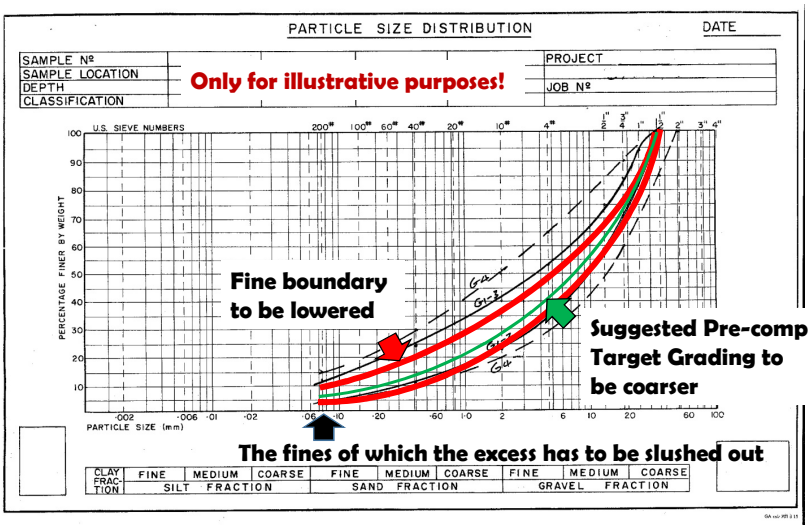
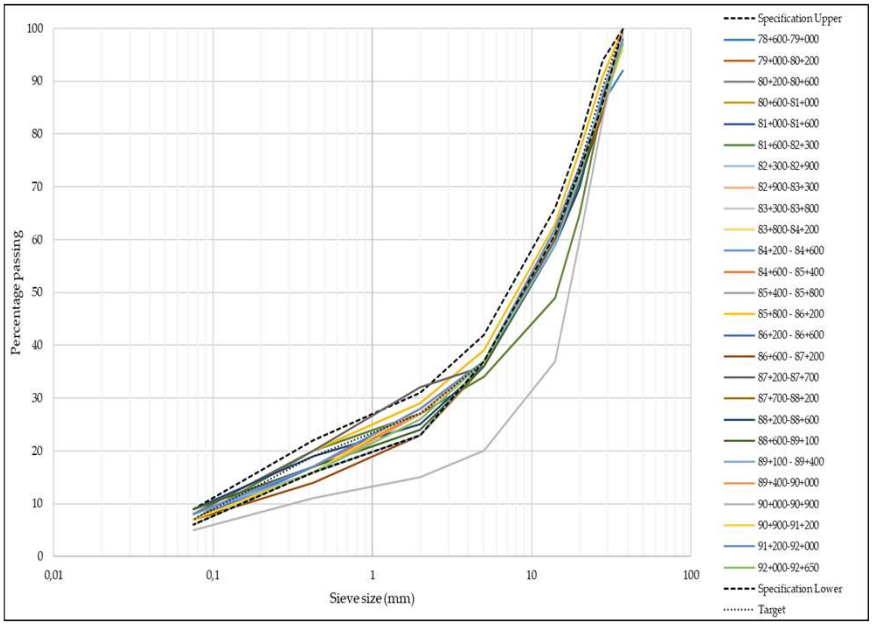


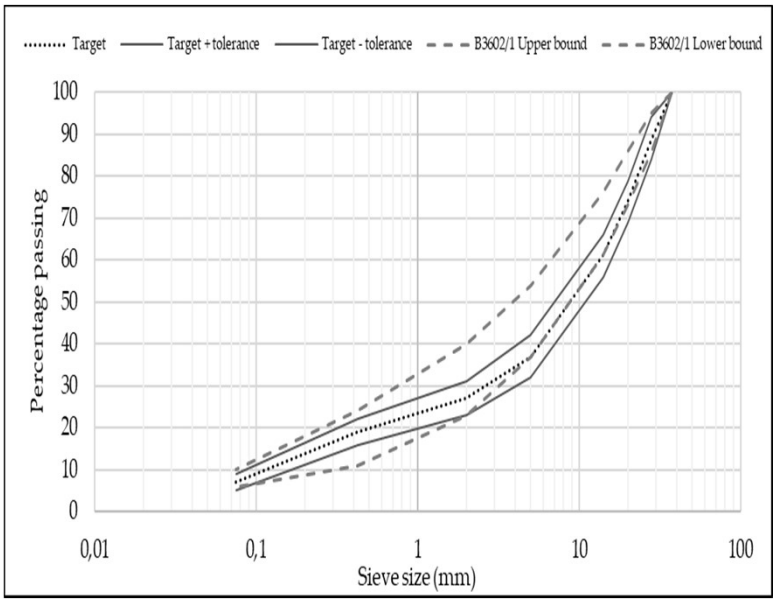
GRADING ANNOMALIES AND THEIR EFFECT ON CONSTRUCTION



SUGGESTED NEW PRE-COMPACTION GRADING TREND FOR G1 AGGREGATE




Percentage passing
Sieve size (mm)
0,01
0,1
1
10
100
0
10
20
30
40
50
60
70
80
90
100
Specification Upper
78+600-79+000
79+000-80+200
80+200-80+600
80+600-81+000
81+000-81+600
81+600-82+300
82+300-82+900
82+900-83+300
83+300-83+800
83+800-84+200
84+200 - 84+600
84+600 - 85+400
85+400 - 85+800
85+800 - 86+200
86+200 - 86+600
86+600 - 87+200
87+200-87+700
87+700-88+200
88+200-88+600
88+600-89+100
89+100 - 89+400
89+400-90+000
90+000-90+900
90+900-91+200
91+200-92+000
92+000-92+650
Specification Lower
Target

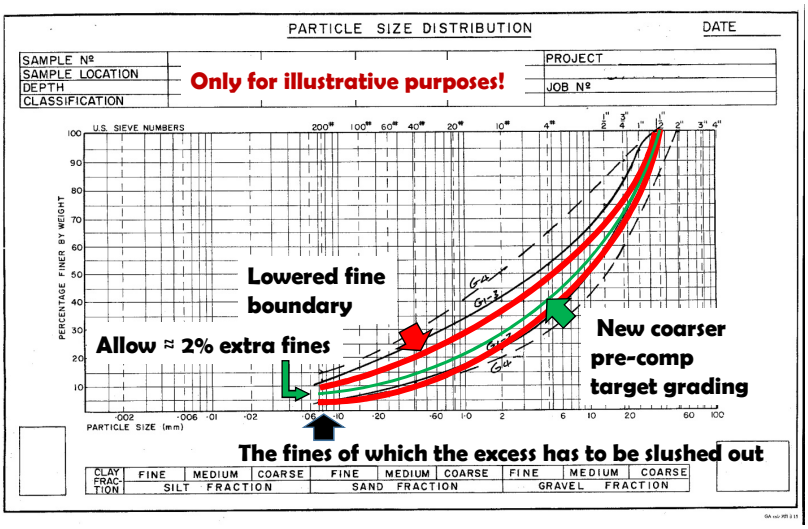

Target
Target + tolerance
Target - tolerance
B3602/1 Upper bound
B3602/1 Lower bound
Percentage passing
Sieve size (mm)
0,01
0,1
1
10
100
0
10
20
30
40
50
60
70
80
90
100

SUGGESTED ADDITIONAL FINES FOR RELATIVELY COARSE GRADING

- **Allow about 2% additional fines (<0.075 mm) to relatively coarse Fuller/Talbot grading to assist initiation of slush-compaction process .**

This only changes the toe of the pre-compaction target grading curve and must of course be slushed out completely.

CURRENTLY SUGGESTED PRE-COMPACTION GRADING TREND FOR G1 AGGREGATE



BEFORE AND AFTER GRADING OF G1 AGGREGATE

- Since only the excess fines (<0,075 mm) is slushed out,
- only the toe of the grading curve changes slightly,
- only negligible change in grading occurs during slush-compaction.
- Hence, the "before-" and "after-" construction grading of G1 aggregate is shown as being the same.

G1 MATERIAL ACQUISITION

PREREQUISITE 1:
HAVE THE CORRECT G1 MATERIAL

- **Order** only in-spec aggregate - per crusher QC
- **Accept** only in-spec aggregate – per contractor QC
- **Pay** only for in-spec aggregate!

Execute strict quality control -
you'll pay for good quality whether you have it or not!

INSPECT THE SOURCE

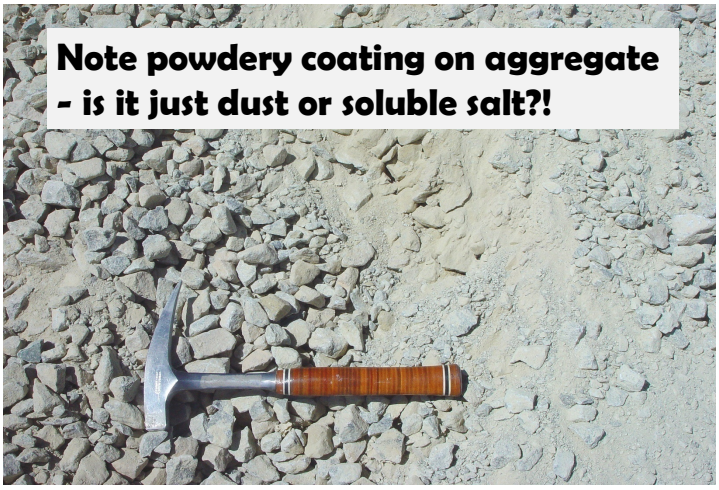
DOES IT LOOK LIKE G1 MATERIAL OR JUST SOME TYPE OF GRAVEL!?

G1 material

Same type of Gravel

INSPECT THE SOURCE

INSPECT THE SOURCE



SAMPLING FOR TESTING

NB:

- **Stockpiled G1 aggregate can be highly segregated.**
- **Stockpile base is usually totally non-representative.**
- **Sample from trenches cut into stockpile.**
- **Sample at various positions around stockpile.**

So

- **Sample off the conveyor belt at the crusher!**

SAMPLING G1 MATERIAL

TRANSPORTATION OF G1 AGGREGATE

Ensure that ALL the aggregate that left the crusher arrives on site!

- **Fines can be lost through:**
  - **careless handling,**
  - **rough transport,**
  - **wind & rain,**

  to the point of non-constructability!
- **Transport damp aggregate.**
- **Minimise transport distance.**
- **Cover the aggregate if necessary.**
- **Dump as near as possible to point of application.**
- **Load clean aggregate – don't pick up in situ soil.**

CONSTRUCTION

RESPONSIBILITY OF CONTRACTOR

- **Per COLTO 3603: Approval of the crushed-stone material for the base will not relieve the contractor of his responsibility to produce a finished crushed-stone base constructed according to the specifications.**

NEW COTO SPECIFICTIONS

CHAPTER 4 - MATERIALS

CHAPTER 5 – FINAL PRODUCT

PREREQUISITE 2:
HAVE THE CORRECT WHEREWITHALL

1. **Have the correct site**
2. **Have the correct material**
3. **Have the correct equipment**
4. **Have the correct operators (not drivers)**
5. **Have the correct specifications/plans**

PREREQUISITE 3:
BUILD A TEST SECTION

- **Per COLTO 3603: Approval of base material will be granted only after the successful construction of a trial section, or sections, complying in all respects with the specifications, including density and grading.**

NB: SANRAL intends adding visual, sound and accelerometer interlock requirements for slush and slurry compaction.

THE REASON FOR A TEST SECTION

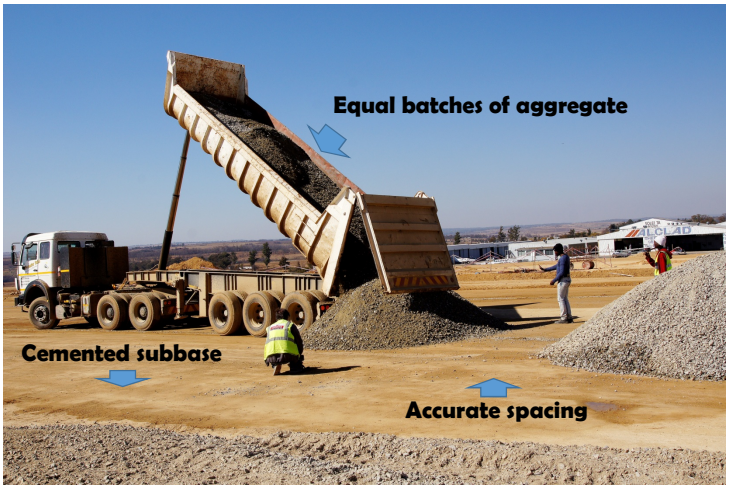
It ensures that:

1. **The crushing plant can deliver to specification.**
2. **The Contractor has the right equipment.**
3. **The Contractor team knows what to do.**
4. **The specified end result can be achieved with the delivered material.**
5. **Corrections can be made timely to the material, plant, specifications or process, if necessary.**
6. **Pre-compaction target grading to be delivered on site is established.**

STEP 1: DAMPEN SUBBASE PRIOR TO DUMPING OR SPREADING AGGREGATE

STEP 2: SET OUT THE DUMP FREQUENCY

STEP 3: DUMP THE AGGREGATE EVENLY



STEP 3: EVENLY SPACE DUMPED G1 AGGREGATE

STEP 4: FLATTEN DUMPED AGGREGATE SLIGHTLY (AVOID SEGREGATION)

STEP 5: DAMPEN DUMPED AGGREGATE BEFORE SPREADING

STEP 6: SPREAD DAMP AGGREGATE TO INHIBIT SEGREGATION

STEP 6: SPREAD DAMP AGGREGATE IN PREPARATION TO MIXING

STEP 7: ENSURE AGGREGATE IS EVENLY MIXED

Equipment needed:

- **Operative fine-spray water tanker.**
- **Powerful grader with unworn blade/links.**
  - **No disc harrow!**
  - **No makouvoet!**
  - **No plough!**
  - **No rotovator!**
  - **No recycler!**
- **Competent operator – not driver!**

STEP 7: WATER AGGREGATE TOWARDS OMC IN PREPERATION TO MIXING

STEP 7: WATER AGGREGATE TOWARDS OMC IN PREPERATION TO MIXING

NB!

- **Compacting / slushing overly wet G1 Material will promote long-wavelength deformation of layer and poor IRI results!**

IMPACT OF WEATHER

- **Working in heavy rain means that the fines can be washed away prior to slush-compaction.**
- **Working under very cold conditions means that the water can freeze on contact with the aggregate – in which case slush-compaction cannot be done until water melts.**
- **Working under very hot /dry conditions means that moisture content has to be corrected more frequently.**

Be observant!

STEP 7: MIX AGGREGATE BY CUTTING IT ACROSS (LEFT/RIGHT)

TINES/RIPPERS/MAKOUVOET CANNOT MIX G1 MATERIAL!

STEP 7: OBSERVE MOISTURE CONTENT WHILE CUTTING AGGREGATE ACCROSS

AVOID "NIPING" SUBBASE THROUGH COWBOY TACTICS WITH GRADER

CONTAMINATING G1 MATERIAL WITH SUBBASE MATERIAL

CONTAMINATING G1 MATERIAL WITH SUBBASE MATERIAL

LOOSE SUBBASE MATERIAL WILL CONTAMINATE G1 MATERIAL

G1 AGGREGATE CONTAMINATED WITH CLAYEY MATERIAL

TOO MUCH FINES!

G1 AGGREGATE CONTAMINATED WITH SOLUBLE SALT

SOLUBLE SALT CONTAMINATION

MIXED AGGREGATE READY TO BE SHAPED TO LAYER DIMENSIONS

STEP 8: SHAPE THE MIXED AGGREGATE TO LEVEL AND WIDTH

STEP 8: SHAPE MIXED AGGREGATE LEVEL AND WIDTH

AVOID ADDING TOO MUCH WATER

SIDE VIEW OF G1 AGGREGATE LAYER - READY FOR INITIAL COMPACTION

SURFACE OF G1 AGGREGATE LAYER - READY FOR INITIAL COMPACTION

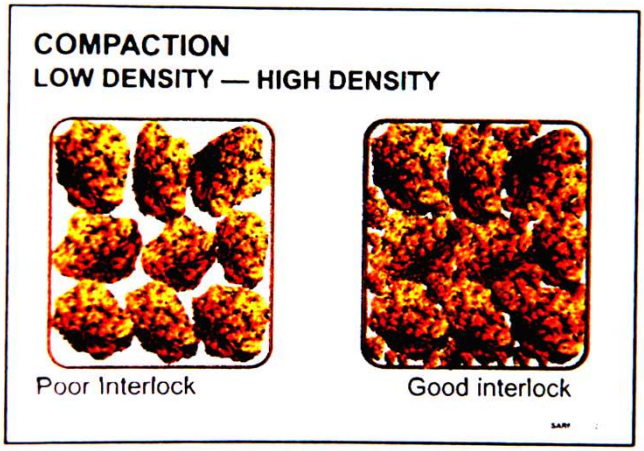
G1 AGGREGATE GRADING DESTROYED ON SITE

In-spec grading material delivered to site

Grading destroyed by recycling/tamping!

COMPACTION CYCLE

HIGHER DENSITY = HIGHER STRENGTH



THE EFFECT OF COMPACTION

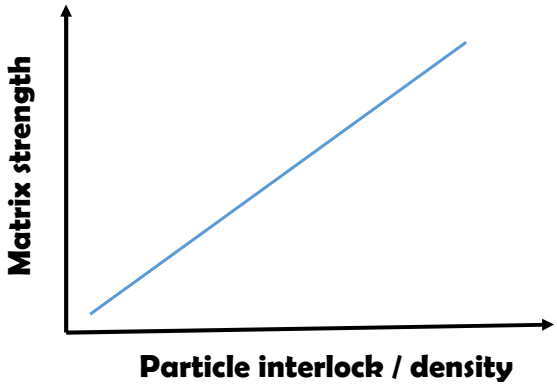
The strength of a layer of road building material depends on:

- **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

BETTER PARTICLE INTERLOCK = INCREASED MATRIX STRENGTH

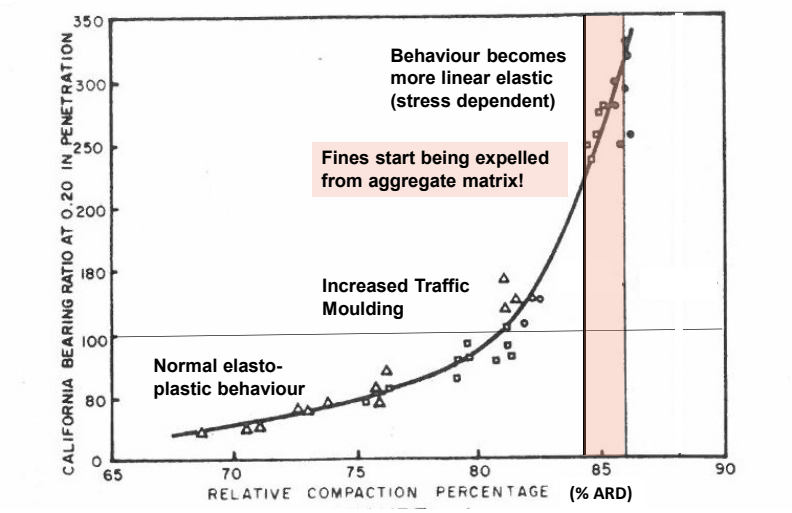


BETTER PARTICLE INTERLOCK = INCREASED MATRIX STRENGTH

- 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?

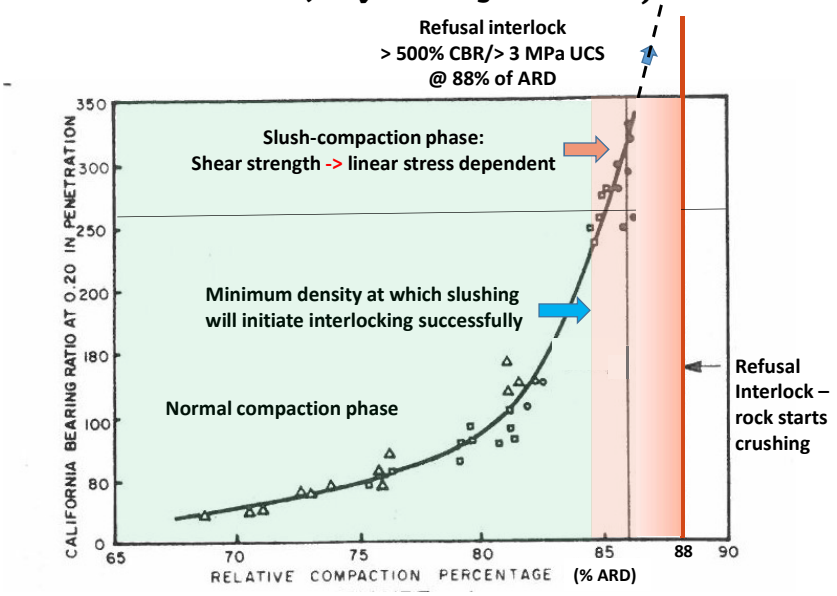
THE EFFECT OF INTERLOCK ON G1 MATERIAL

(from "Compactability of Crushed Stone Road Basecourse Material" by van der Merwe, Kleyn & Savage – ATC 1985)



CURRENT G1 INTERLOCK REQUIREMENT

(from "Compactability of Crushed Stone Road Basecourse Material" by van der Merwe, Kleyn & Savage – ATC 1985)



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.**

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!**

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**
- **>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)**

INITIAL COMPACTION

LAYER STILL TOO LOOSE TO START SLUSH-COMPACTION (< 85% SRD)

INITIAL COMPACTION

- **Don't crush the material!**

INITIAL COMPACTION

- **Don't crush the material!**

LAYER READY FOR SLUSH-COMPACTION

FINAL OR SLUSH-COMPACTION CYCLE

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".**

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% SRD/ ARD 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

SLUSH-COMPACT WITH LOTS OF WATER CLOSELY FOLLOWING

ROLLERS FOLLOW WATER TANKER CLOSELY !

- Don't crush the material!

EXCESS FINES BEING EXPELLED AS SLUSH FROM LAYER

EXCESS FINES BEING "SUCKED OUT"

EXCESS FINES BEING "SUCKED OUT"

HEAVY PNEUMATIC ROLLER FOR FINAL SLUSH-COMPACTION PHASE

27 – 37 ton

AIR BEING EXPELLED FROM LAYER DURING SLUSH-COMPACTION

- Don't crush the material!

SPREAD INITIAL SLUSH/SAND TO DIFFICIENT AREAS

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

SAND SLUSHED OUT - NOT FINES!

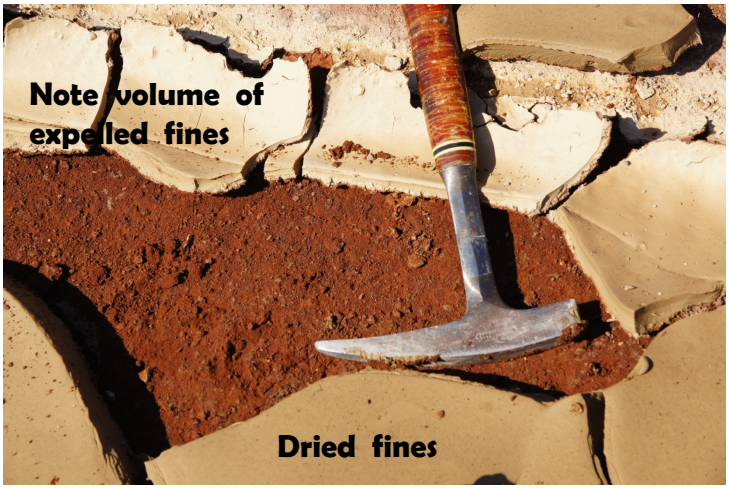
NB!

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

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

SLUSH RUN-OFF ESCAPE FURROW IN WINDROW

DRIED SLUSH RUN-OFF



TOO LITTLE SLUSH RUN-OFF

WATERING DURING SLUSH-COMPACTION

Too little water and roller too far behind

WATERING DURING SLUSH-COMPACTION

Slushing rollers too far behind water applicator (and too slow in this case)!

TOO LITTLE FINES BEING SLUSHED OUT

COURSE SAND GENERATED BY EXCESSIVE ROLLER APPLICATION

EFFECT OF OVER-ROLLING WITH ROLLER THAT IS TOO LIGHT

EFFECT OF AGGRESSIVE VIBRATORY ROLLING

EFFECT OF AGGRESSIVE VIBRATORY ROLLING

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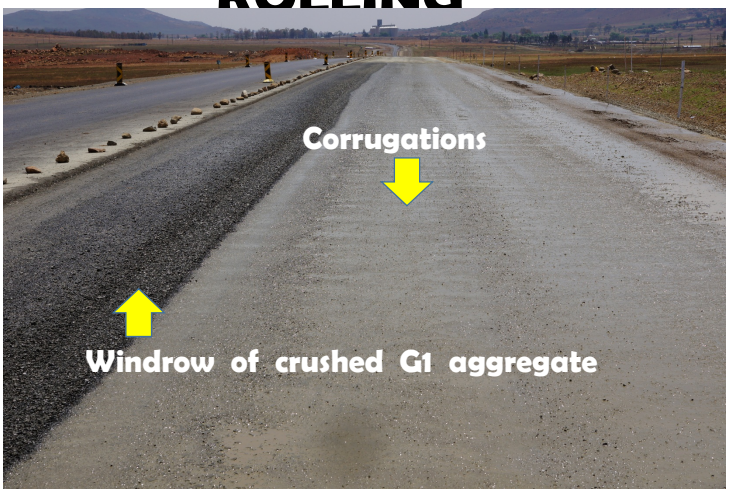
EFFECT OF AGGRESSIVE VIBRATORY ROLLING



EFFECT OF AGGRESSIVE VIBRATORY ROLLING

EFFECT OF LACK OF LARGER AGGREGATE IN MATRIX

AGGREGATE MOSAIC FORMING

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!

WELL SLUSHED G1 CRUSHED STONE (PRIOR TO FINAL BROOMING)

BROOM ROAD SURFACE 1 DAY AFTER FINAL SLUSH-COMPACTION

BROOM ROAD SURFACE DAY AFTER FINAL SLUSH-COMPACTION

FINAL SURFACE TOO HEAVILY BROOMED!

POOR MOSAIC OBTAINED WITH RECYCLED G1 MATERIAL

ONE PASS FINAL ROLL TO RE-KNIT SURFACE AGGREGATE

G1 CRUSHED STONE READY FOR "PING-TEST" !

WHY REFUSAL INTERLOCK MAY NOT BE ACHIEVED

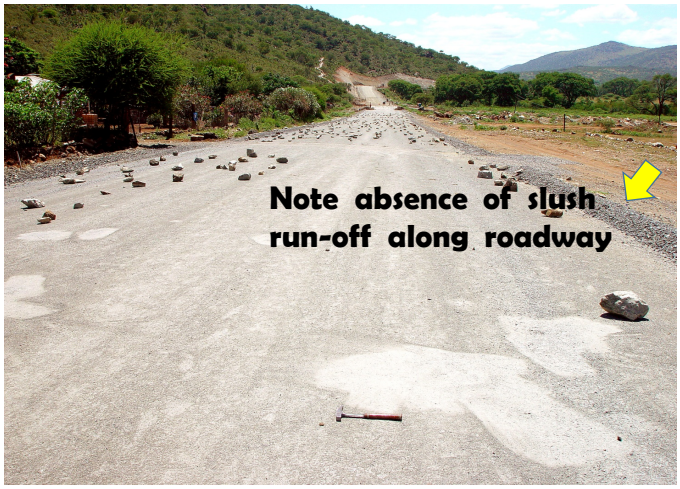
- Support value of subbase not sufficient
- Deflection of pavement too high
- Grading of aggregate not continuous
- Aggregate crushed / too soft
- Moisture content of layer incorrect for equipment
- Material not slush-compacted
- Roller/s too light
- Over-vibrating of material
- Material grading altered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

ADDITIONAL INFORMATION

ADDITIONAL INFORMATION REGARDING G2 CRUSHED STONE

- G2 at 85% Bulk Relative Density (BRD) 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 Relative Density (BRD)
- BRD usually reserved for more weathered material to allow for voids and cracks in in the aggregate

SURFACE AFTER WATER OR SLURRY ROLL



BROOMED SURFACE AFTER WATER OR SLURRY ROLL

BROOMED SURFACE AFTER WATER OR SLURRY ROLL

VISUAL DIFFERENCE BETWEEN SLUSHED AND SLURRIED G1 CRUSHED STONE

Slurry rolled

Slush rolled

Problem? – what problem?

END OF G1 CRUSHED STONE TRAINING SLIDE SHOW

Thank you!