APPENDIX E: TEST METHODS USED

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E.1 INTRODUCTION

The basic test methods used to determine specific characteristics of the concrete used in the experiments are as follows:

a) SABS test method 863: 1994 – Compressive strength of hardened concrete.
b) SABS test method 864: 1994 – Flexural strength of hardened concrete.
c) SABS test method 1085: 1994 – Initial drying shrinkage and wetting expansion of concrete.
d) BS1881: Part 121: 1993 – Method for determination of static modulus of elasticity in compression.

The scopes of each of these test methods, as well as the prescribed procedure of expressing results are summarised below.

E.1.1 SABS 863: 1994 – COMPRESSIVE STRENGTH OF HARDENED CONCRETE

This test describes a method for determining compressive strength of test specimens of hardened concrete.

The test specimens consist of 150 mm x 150 mm x 150 mm concrete cubes, cured under water for 3, 7, 28 days, etc. depending on the specifications.

Each specimen has to be tested while still saturated. Prior to testing the mass of each specimen is determined to an accuracy of 1%.

During testing, a compression load is applied to each specimen without shock at 0,3 MPa/s + 0,1 MPa/s to failure. The maximum load applied, is recorded, and the compressive strength calculated as follows:

$$f_{cc} = \frac{F}{A_c} \tag{E.1}$$

Where:

f_{cc} = Compressive strength (MPa);
F = Maximum load at failure (N); and
Ac = Cross-sectional area of specimen on which compressive force acts (mm^2).

The average compressive strength is recorded to the nearest 0,5 MPa. Test results are considered accurate if a result does not exceed 15% of the average.

To report the apparent saturated density of each specimen, calculate it by dividing the mass by its volume.

E.1.2 SABS 864: 1994 – FLEXURAL STRENGTH OF HARDENED CONCRETE

This test method describes a:

a) Two-point loading method that produces a constant bending moment along the central part of a test specimen – standard method.
b) Centre-point loading method – alternative method.

The dimensions of the moulds depend on the maximum nominal size of the aggregate in the concrete. A 100 mm x 100 mm x 500 mm mould could be used for 19,0 mm aggregate, but the 150 mm x 150 mm x 750 mm mould, used for 37,5 mm aggregate, is the preferred size.

The compression-testing machine consists of two pairs of steel rollers of nominal diameter 38 to 40 mm, and length at least 10 mm more than the width of the specimen. One pair of rollers is used to support the specimen, and the other two to apply the load.

Each specimen has to be tested while still saturated. Determine dimensions to 1 mm accuracy, and mass to 1%.

Increase the load continuously at a constant rate of between 0,03 MPa/s ± 0,01 MPa/s to failure. Measure the distance between the line of fracture and the position of the nearer supporting roller, along the centre-line of the bottom surface.

The flexural strength for two-point loading is calculated as follows:

$$f_{cf} = \frac{Fl}{bd^2} \tag{E.2}$$

Where:

Fcf = Flexural strength (MPa);
F = Maximum load at failure (N);
l = Distance between axes of supporting rollers (mm);
b = Width of specimen (mm); and
d = Depth of specimen (mm).

The flexural strength for centre-point loading is calculated as follows:

$$f_{cf} = \frac{3Fl}{2bd^2} \qquad \text{(E.3)}$$

Where the parameters are as defined for Equation D.2.

Calculate the average of the results to the nearest 0,05 MPa. The difference between the highest and the lowest result should not exceed 15% of the average. The apparent saturated density of each specimen is the mass divided by the volume.

E.1.3 SABS 1085: 1994 – INITIAL DRYING SHRINKAGE AND WETTING EXPANSION OF CONCRETE

This test describes a method of determining initial drying shrinkage and wetting expansion of freshly cast concrete. It is not applicable to matured or hardened concrete or to concrete containing expansion inducing agents or to pre-cast concrete products.

The mould dimensions for nominal aggregate sizes of 37,5 mm and less, are 100 mm cross-section x 300 mm length.

Cure the test specimens for 20 to 24h in the moulds, covered with impervious sheeting at 22 to 25°C at a relative humidity of 90%. De-mould the specimens, and calculate the gauge length L_0 to the nearest mm. Cover with an impervious sheet and store for a further 24h ± 0,5h. Submerge specimens for 5 days in clean, potable water at 22 to 25°C.

Remove specimens from water, 7d ± 2h after moulding. Measure L_1 to nearest 2μm (always measure in the same direction). Store in a drying facility for 7d. Remove and allow to cool to between 22 to 25°C. Measure L_2. Repeat drying for periods of 48h and measuring, until two successive readings do not exceed 2μm/100 mm of specimen length. Take lowest reading as final dry measurement.

The percentage drying shrinkage is calculated by:

$$\frac{L_1 - L_2}{L_0} x100 \qquad \text{(E.5)}$$

Where:

L_1 = Measurement after initial wet curing (mm);
L_2 = Measurement after drying (mm); and
L_0 = Distance between innermost faces of anvils (mm).

The wetting expansion of the specimen is determined after storing the specimen in a drying facility for 7d, by immersing it in water for periods of 48h, and measuring L3, until the difference between successive measurements is less than 2μm/100 mm of specimen length. Take the highest reading as the final wet measurement.

The percentage wetting expansion is calculated by:

$$\frac{L_3 - L_2}{L_0} x100 \qquad \text{(E.6)}$$

Where:

L_3 = Final wet measurement (mm);

L_2 = Measurement after drying (mm); and

L_0 = Distance between innermost faces of anvils (mm).

Record the drying shrinkage and wetting expansion to the nearest 0,001% for individual values, as well as the mean value.

E.1.4 BS1881: PART 121: 1993 – METHOD FOR DETERMINATION OF STATIC MODULUS OF ELASTICITY IN COMPRESSION

This test describes a method for determination of the static modulus of elasticity in compression of hardened concrete.

The static modulus of elasticity in compression is the secant modulus = $\Delta\sigma/\Delta\varepsilon$, where $\Delta\sigma$ and $\Delta\varepsilon$ are the differences in stress and strain, respectively, between a basic loading level of 0,5 MPa and an upper loading level of 1/3 the compressive strength of the concrete.

The test specimens consist of 150 mm diameter x 300 mm long concrete cylinders. The specimens are subjected to 3 loading and unloading cycles, during which the strain ε_a is recorded for stress σ_a (= $f_{cc}/3$), and strain ε_b is recorded for stress σ_b (= 0,5 MPa).

Calculate mean stress ε_a and ε_b, respectively.

The static modulus of elasticity in compression, is given by:

$$E_c = \frac{\Delta_\sigma}{\Delta_\varepsilon} = \frac{\sigma_a - \sigma_b}{\varepsilon_a - \varepsilon_b} \qquad \text{(E.7)}$$

Where:

E_c = Static modulus of elasticity (MPa);

σ_a = Upper loading stress (MPa);

σ_b = Basic stress (0,5 MPa);

ε_a = Mean strain under upper loading stress; and

ε_b = Mean strain under basic loading stress.

Express results to nearest 500 MPa for values over 10 000 MPa, and to nearest 100 MPa for values below 10 000 MPa.

APPENDIX F: MATERIAL TEST RESULTS

APPENDIX F: MATERIAL TEST RESULTS

F.1 INTRODUCTION

The materials used to manufacture the concrete for the experiments were supplied by Alpha Stone, Lyttleton (Pty) Ltd, and Lafarge Readymix, as summarised in Table F.1.

Table F.1: Summary of concrete material sources

Material	Supplier	Source
Cement – Duratech CEM I 42,5	Lafarge Readymix	Lafarge Readymix
Granite sand	Lafarge Readymix	Rossway Quarry
19 mm granite aggregate	Lafarge Readymix	Rossway Quarry
37,5 mm granite aggregate	Alpha Stone	Jukskei Quarry
Dolomite sand	Lyttleton (Pty) Ltd	Lyttleton Quarry
19 mm dolomite aggregate	Lafarge Readymix	Mooiplaas Quarry
37,5 mm dolomite aggregate	Lafarge Readymix	Mooiplaas Quarry

The properties of the various materials as tested in the laboratory at the University, as well as by the laboratories of Alpha Stone, Lyttleton (Pty) Ltd, and Lafarge Readymix and are given below.

F.2 MATERIAL PROPERTIES

F.2.1 CEMENT

The cement properties (summarised in Table F.2) were determined by Lafarge Readymix in accordance with SABS ENV 197-1:1992, in their laboratory on a split sample of the cement supplied by them.

Table F.2: Properties of Duratech CEM I 42,5 cement

Description of test	Result number TSD 00/493/2
Consistency (%)	25.3
Initial setting time (min)	213
EN prism 2 day (N/mm^2)	14,9
EN prism 28 day (N/mm^2)	49,1

F.2.2 GRANITE SAND

Granite washed crusher sand from Rossway Quarry was supplied by Lafarge Readymix. The grading of the sand was determined in the laboratory at the University, prior to using it in the concrete mix, as summarised in Table F.3. Further properties of the granite sand as reported by Lafarge Readymix are summarised in Table F.4.

Table F.3: Granite washed crusher sand grading analysis

Sieve sizes (µ)	Weight retained (g)	% Weight retained		Total % actual	Specification	
		Individual	Cumulative		Lower	Upper
9 500				100,0	100	100
6 700	1,8	0,2	0,2	99,8	90	100
4 750	48,0	4,1	4,2	95,8	75	100
2 360	231,7	19,7	23,9	76,1	55	85
1 180	242,8	20,7	44,6	55,4	35	65
600	200,7	17,1	61,7	38,3	20	45
300	171,6	14,6	76,3	23,7	10	30
150	116,0	9,9	86,1	13,9	5	20
75	65,3	5,6	91,7	8,3	0	10
Pan	97,7	8,3	100,0	0,0		
Total	1175,6					
Fineness modulus		2,97				

Table F.4: Properties of granite washed crusher sand

Test method	Description of test	Result
SABS 835	Water demand (liter)	198
SABS 844	Relative density	2,63
SABS 843	Water absorption (%)	1,1
SABS 845	Uncompacted bulk density (kg/m^3)	1590
SABS 845	Compacted bulk density (kg/m^3)	1740
SABS 1243	Methylene blue value	0,2

F.2.3 DOLOMITE SAND

The grading of the dolomite crusher sand, obtained from Lyttleton Quarry, is summarised in Table F.5. Further properties of the dolomite sand as reported by Lyttleton Dolomite (Pty.) Ltd. are summarised in Table F.6.

Table F.5: Dolomite crusher sand grading analysis

Sieve sizes (µ)	Weight retained (g)	% Weight retained		Total % actual	Specification	
		Individual	Cumulative		Lower	Upper
9 500				100,0	100	100
6 700	0,0	0,0	0,0	100,0	90	100
4 750	14,0	0,0	0,0	100,0	75	100
2 360	175,0	17,5	17,5	82,5	55	85
1 180	315,0	31,5	49,0	51,0	35	65
600	227,0	22,7	71,7	28,3	20	45
300	130,0	13,0	84,7	15,3	10	30
150	77,0	7,7	92,4	7,6	5	20
75	48,0	4,8	97,2	3,6	0	10
Pan	28,0	2,8	100,0	0,0		
Total	1000,0					
Fineness modulus		3,15				

Table F.6: Properties of dolomite crusher sand

Test method	Description of test	Result
SABS 835	Water demand (liter)	185
SABS 844	Relative density	2,82
SABS 843	Water absorption (%)	1,2
SABS 845	Uncompacted bulk density (kg/m^3)	1671
SABS 845	Compacted bulk density (kg/m^3)	1845
SABS 1243	Methylene blue value	0,05

The volume of 19 mm and 37,5 mm aggregate in both the granite and the dolomite concrete mixes had to be the same, in order to obtain more or less the same aggregate interlock contact areas. In other words, the coarseness of the joint area formed by the 19 mm granite aggregate had to be the same as for the 19 mm dolomite aggregate. The same applied to the 37,5 mm aggregate concrete mixes. To achieve this, the grading of the granite sand and the dolomite sand had to be more or less the same. Figure F.1 shows the grading of the sands used in the concrete mixes, within the grading envelope.

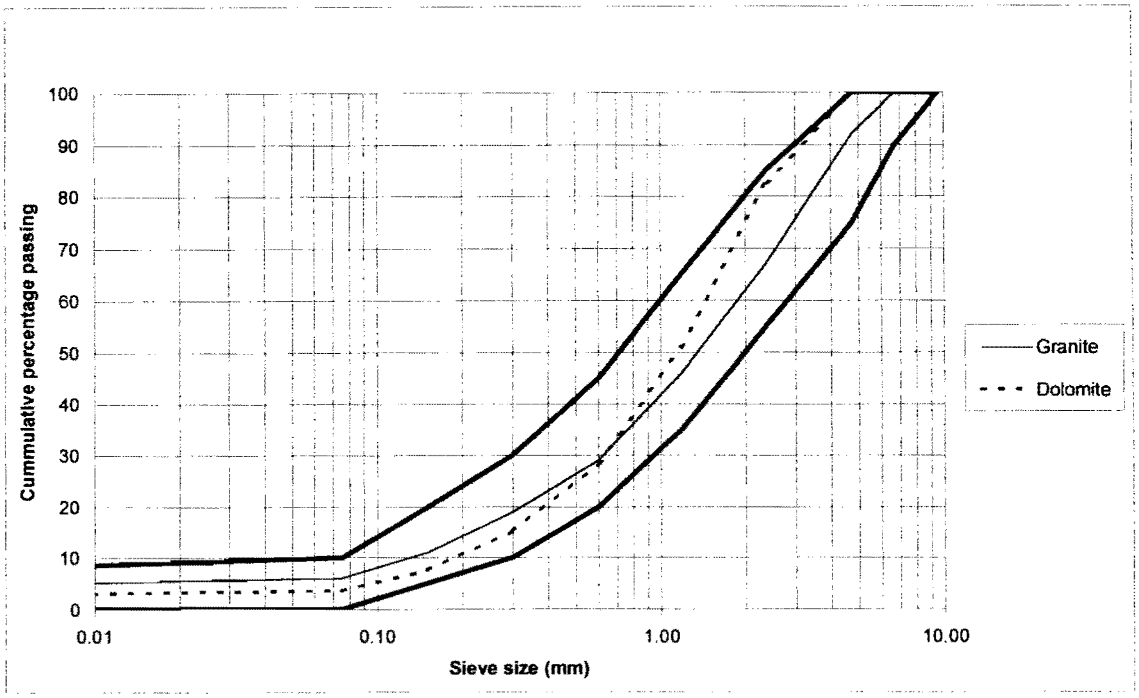

Figure F.1: Sand grading

F.2.4 19 mm GRANITE AGGREGATE

19 mm granite aggregate from Rossway Quarry was supplied by Lafarge Readymix. The properties of the aggregate are summarised in Table F.7.

Table F.7: Properties of 19 mm granite aggregate

Test method	Description of test	Result
SABS 841	Aggregate crushing value (%)	25
SABS 842	10% Fines aggregate crushing value (FACT) (kN)	130 (wet) 150 (dry)
SABS 844	Relative density (kg/m^3)	2,65
SABS 843	Water absorption (%)	0,33
SABS 846	Los Angeles abrasion value (%)	33

F.2.5 37,5 mm GRANITE AGGREGATE

Normally quarries do not produce 37,5 mm concrete aggregate. It was therefore necessary to approach another supplier to obtain the 37,5 mm granite aggregate used in the research. Fortunately a stockpile was located at the Jukskei Quarry operated by Alpha Stone, where production of this stone size was also discontinued. The typical aggregate properties for the 37,5 mm granite aggregate are summarised in Table F.8.

Table F.8: Properties of 37,5 mm granite aggregate

Test method	Description of test	Result
SABS 841	Aggregate crushing value (%)	27
SABS 842	10% Fines aggregate crushing value (FACT) (kN)	122
SABS 844	Relative density (kg/m^3)	2,65
SABS 843	Water absorption (%)	0,33
SABS 848	Polished stone value	47
SABS 846	Los Angeles abrasion value (%)	33

F.2.6 19 mm and 37,5 mm DOLOMITE AGGREGATE

Dolomite aggregates were obtained from Mooiplaas Quarry. The 19 mm aggregate was from their standard concrete aggregate production line, and the 37,5 mm was from their so-called "Metallurgical leg" where they produce a –40 - +20 aggregate. The properties of the dolomite aggregate are summarised in Table F.9.

Table F.9: Properties of dolomite aggregate

Test method	Description of test	Result
SABS 841	Aggregate crushing value (%)	15
SABS 842	10% Fines aggregate crushing value (FACT) (kN)	275
SABS 844	Relative density	2,86
SABS 843	Water absorption (%)	0,2
SABS 846	Los Angeles abrasion value (%)	21

F.3 MATERIAL TEST RESULTS

A total of four concrete beams were cast, using the materials as summarised in Table F.10. In all instances the design strength of the concrete was a minimum 28-day compressive strength of 35 MPa for water-cured cubes. For control purposes a fifth beam was cast using a bubble plastic sheet (supplied by Hyson Cells) to act as joint former. Ordinary Portland Cement - Duratech CEM I 42,5 cement was used for all five beams.

Table F.10: Composition of experimental beams

Experiment number	Materials	Crack inducer
1	Granite sand & 19 mm granite aggregate	Angle iron
2	Granite sand & 37,5 mm granite aggregate	Angle iron
3	Dolomite sand & 19 mm dolomite aggregate	Angle iron
4	Dolomite sand & 37,5 mm dolomite aggregate	Angle iron
5 (control)	Granite sand & 19 mm granite aggregate	Bubble plastic sheet

To ensure that a 28-day compressive strength of 35 MPa would be obtained with the granite sand and 19 mm granite aggregate, used in Experiment 1, test cubes were made up beforehand, using water/cement ratios of 0,59 and 0,63. The test cubes were crushed after 7 days, and the 28-day strengths were calculated from the assumption that the 7-day compressive strength is approximately two-thirds that of the 28-day compressive strength (Fulton, 1994). The average 7-day compressive strength values obtained for water/cement ratios of 0,59 and 0,63 were 21,5 MPa and 20,5 MPa, respectively, which indicated that the corresponding 28-day compressive strength would be 32,5 MPa and 30,5 MPa. From these results it was determined that a water/cement ratio of 0,56 should be used to obtain a 28-day compressive strength of 35 MPa. The actual strengths obtained were 38,7 MPa and 30,0 MPa for the water-cured cubes and the air-cured cubes, respectively.

The concrete mix designs used are as summarised in Table F.11.

Table F.11: Concrete mix designs

Experiment number	Materials ($/m^3$)			
	Water (l)	Cement (kg)	Sand (kg)	Stone (kg)
1 & 5	201	360	775	1025
2	185	335	800	1075
3	201	360	830	1115
4	185	335	854	1160

Apart from the beams, a number of cubes, beams and cylinders were also cast for testing purposes, as summarised in Table F.12. The test methods used are described in Appendix E.

Table F.12: Basic information on cubes, beams and cylinders cast for testing purposes

Test specimen	Dimensions (mm)	Number	Time of test
Compressive strength cubes (SABS 863: 1994 / ASTM C39/C39M-01, 2001*)	150 x 150 x 150	18	At 7 and 28 days after casting slab, and at end of 2 million load cycles.
Modulus of rupture beams (SABS 864: 1994 / ASTM C133-97, 1997)	750 x 150 x 150	6	At 28 days after casting slab, and at end of 2 million load cycles.
Shrinkage beams (SABS 1085: 1994 / ASTM C426-99, 1999)	300 x 100 x 100	4	Measure gauge length L_0 before casting specimen, and L_1 after 7 days in curing bath. Place in drying oven with temperature 50°C, and relative humidity 25%, and measure L_2 at 48 hour intervals thereafter, until difference in length less than 2μm/100 mm.
Modulus of elasticity cylinders (BS1881: Part 121: 1993 / ASTM C469-94, 1994)	300 x 150 diameter	3	At 28 days after casting.

*NOTE: ASTM test methods give equivalent test results, although the test methods are not necessarily the same.

The results obtained for the tests conducted on the cubes, beams and cylinders mentioned above are summarised in Table F.13.

The complete set of tests to determine the properties of the concrete, described above, were not conducted for the fifth experiment with the bubble plastic joint, as these results for this specific mix design were already obtained during Experiment 1. However, six cubes were cast for control purposes to calculate the 28-day characteristic strength of the concrete. The average 7-day strengths obtained for the air-cured cubes and the water-cured cubes were 29,0 MPa and 32,0 MPa, respectively. The calculated 28-day strengths for the air-cured cubes and the water-cured cubes were therefore 43,5 MPa and 48,0 MPa, respectively.

Table F.13: Material test results

Experiment number	Curing method	Compressive strength (MPa) at:			Modulus of Rupture (MPa) at:		Shrinkage (%)	Modulus of elasticity (GPa)
		7 days	28 days	Time of test*	28 days	Time of test*		
1	water	24,5	38,7	50,0	4,75	4,90	0,019	21,0
	air	20,0	30,0	36,7				
2	water	27,2	45,0	57,5	4,40	5,00	0,018	29,0
	air	29,0	41,7	50,0				
3	water	27,7	41,5	55,0	5,00	5,10	0,016	41,0
	air	27,7	38,5	48,2				
4	water	29,8	43,5	49,3	4,80	5,03	0,035	48,0
	air	27,5	39,3	45,0				

*NOTES:

1. The **Time of test** for experiments number 1 and 2 was after the application of 2 million dynamic load cycles, at 66 days and 138 days after casting, respectively. For Experiments 3, and 4 it was at the commencement of the testing at different crack widths, at 133 days, and 120 days after casting, respectively.
2. The slab for Experiment 5 was cast using the same concrete mix design as for Experiment 1. Only the 7-day cube compressive strength was determined, and a forecast made of the 28-day results. This was only for control purposes as the properties of the concrete for this specific mix design has already been determined through the results listed above.

F.4 VOLUMETRIC SURFACE TEXTURE

In an attempt to establish a method of quantifying the decrease in load transfer efficiency with an increase in crack width, and to provide an estimate of the abrasion that has taken place since fracture, Vandenbossche (1999) developed a volumetric surface texture (VST) test at the University of Minnesota. The test apparatus consisted of a spring-loaded probe with a digital readout, mounted on a frame over a computer-controlled microscope of the type typically used to obtain linear traverse and other measurements of concrete air void systems.

As mentioned before, dolomite and granite sand with approximately the same grading was used for both the 19 mm and 37,5 mm maximum sized aggregate concrete mixes. This was in order to obtain equivalent crack surfaces for both 19 mm and 37,5 mm beams, respectively. A milling machine was modified to measure the VST of representative samples of each of the first four experiments. The milling machine had an automatic longitudinal feed, with a manual transverse feed. A laser-measuring unit was mounted at the required standoff distance of 200 mm from the sample. A 24 Volt DC power supply needed by the laser unit was built for the measurements (See Photo G.25).

The volumetric surface texture ratio (VSTR) of the crack faces of the experimental beams, as well as crack faces formed during modulus of rupture testing of concrete beams, was determined to:

a) Quantify whether the 19 mm granite and dolomite crack face volumes similar, and also the 37,5 mm granite and dolomite crack face volumes.

b) Quantify whether the crack faces formed by breaking beams during modulus of rupture testing could be taken as representative of the crack surface in the experimental beams itself. In other words, whether it may only be necessary to cast a beam, break it and measure the VST, to determine the VSTR of a crack inside a pavement.

c) Compare the VST results from this study, obtained using the high quality South African crushed aggregates, with the results obtained from crack faces of concrete constructed with typical USA aggregates, published by Vandenbossche (1999).

Prior to measuring the VST of the crack faces with the laser, a total of 20 longitudinal scans were done in one location on a sample chosen at random to determine the accuracy and/or repeatability of the laser scans, as shown on Figure F.2. All 20 lines were superimposed, with an average standard deviation of 0,02 mm.

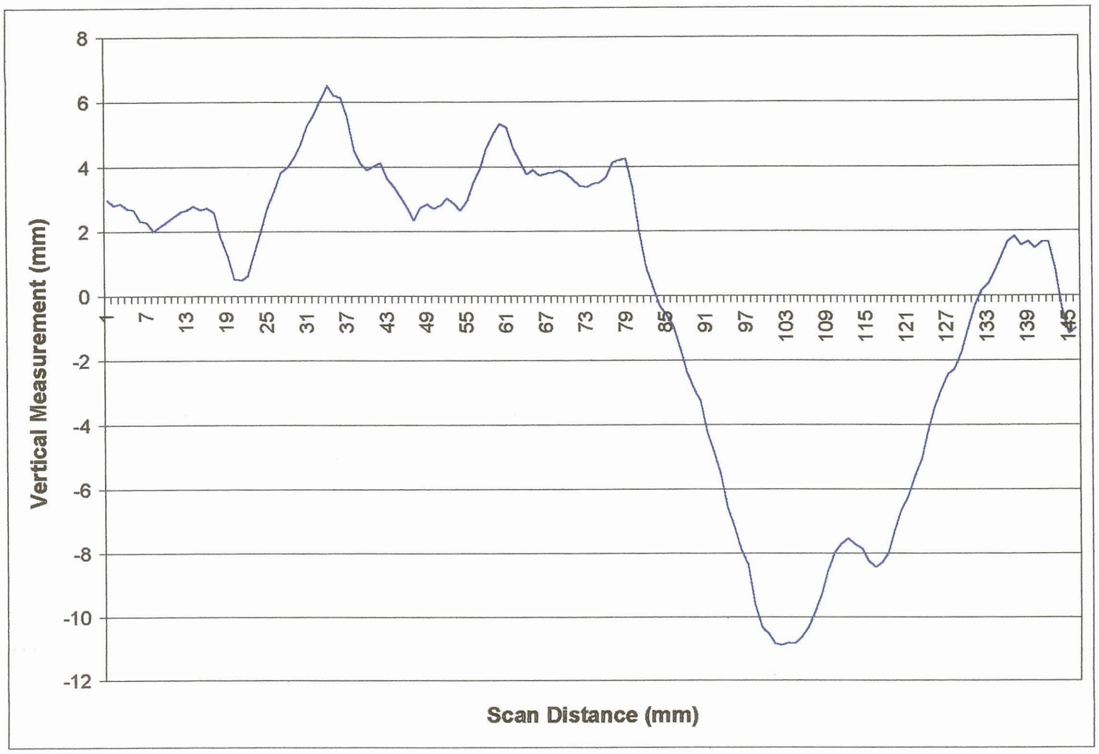

Figure F.2: Repeatability and/or accuracy of laser scans

The average measurement area in the study by Vandenbossche (1999) was about 161 cm^2 at an optimum grid of 3,18 mm (0,125 inch). The samples in this study were scanned on a 1 mm grid over a 100 mm x 100 mm (100 cm^2) area. By sub-dividing a block of data into four equal sized blocks, and calculating the average VSTR of the four blocks the effect of the smaller measurement area was determined. In each case the VSTR so calculated was less than the initial value. This indicated that the results would not be biased to give values larger than the comparative study.

The influence of the size of the grid was determined to verify whether the 3,18 mm grid used by Vandenbossche (1999) is indeed the optimum grid size. The VST of a sample at a grid of 1, 2, 3, 4, 5, 10, and 20 mm was measured, and the VSTR at each grid calculated. The results, with an exponential trend line fitted through the data points are shown on Figure F.3. The VSTR increased gradually with an increase in grid up to 4 mm, where after the increase was more marked, which confirmed that the smaller the grid, the more accurate the results. However, it is not clear from Figure F.3 whether the grid reported by Vandenbossche (1999) is indeed the optimum, as the VSTR of the 1, and 2 mm grid was less than for the 3 mm grid. On the other hand, the figure does show that the 1 mm grid used in this study will give a lower result for the area measured than for, for example if a 3 mm grid was used. A typical surface plot of a crack face, as measured with the laser is shown on Figure F.4.

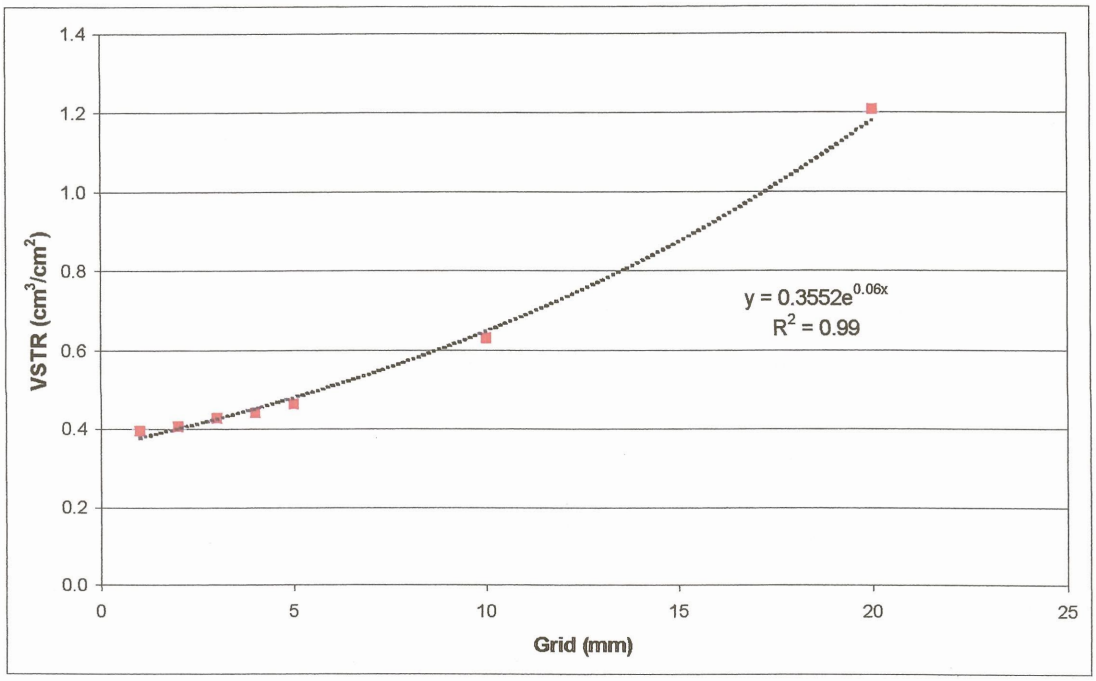

Figure F.3: Verification of optimum grid size

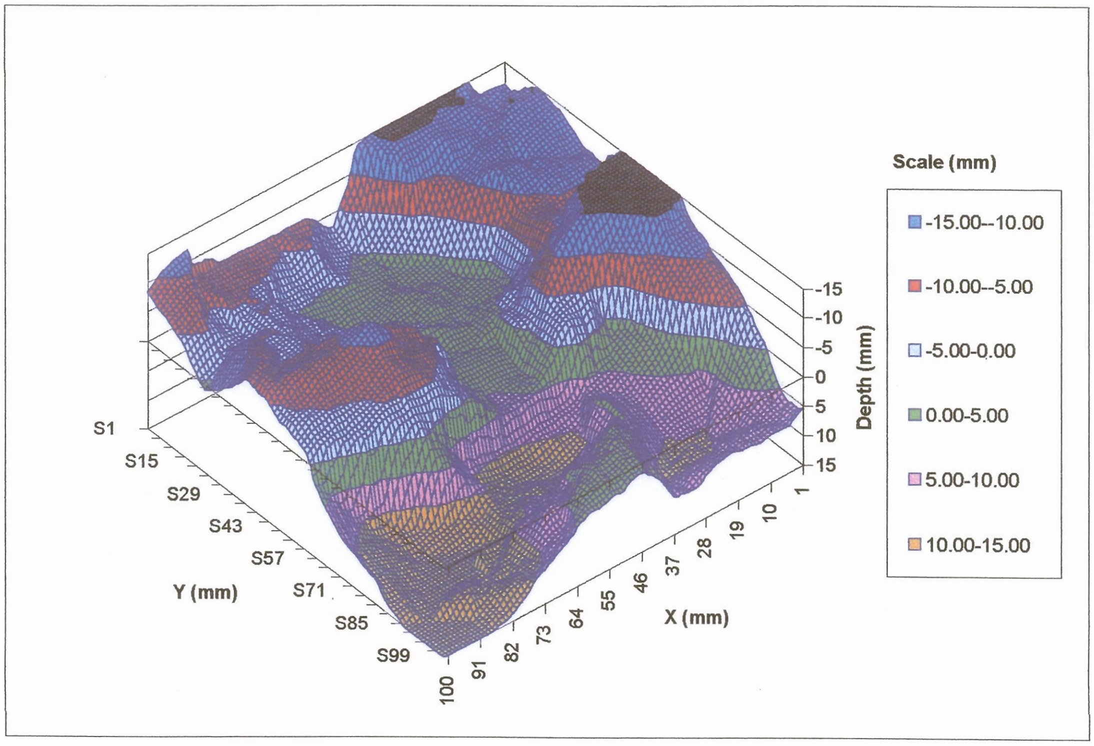

Figure F.4: Typical surface plot of VST data

The results published by Vandenbossche (1999) based on VSTR measurements made with cores from 16 different doweled joints are reproduced in Figure F.5, together with the results obtained in this study. Although the joints considered in this study were aggregate interlock joints, the volume of the aggregate interlock crack face itself could still be compared.

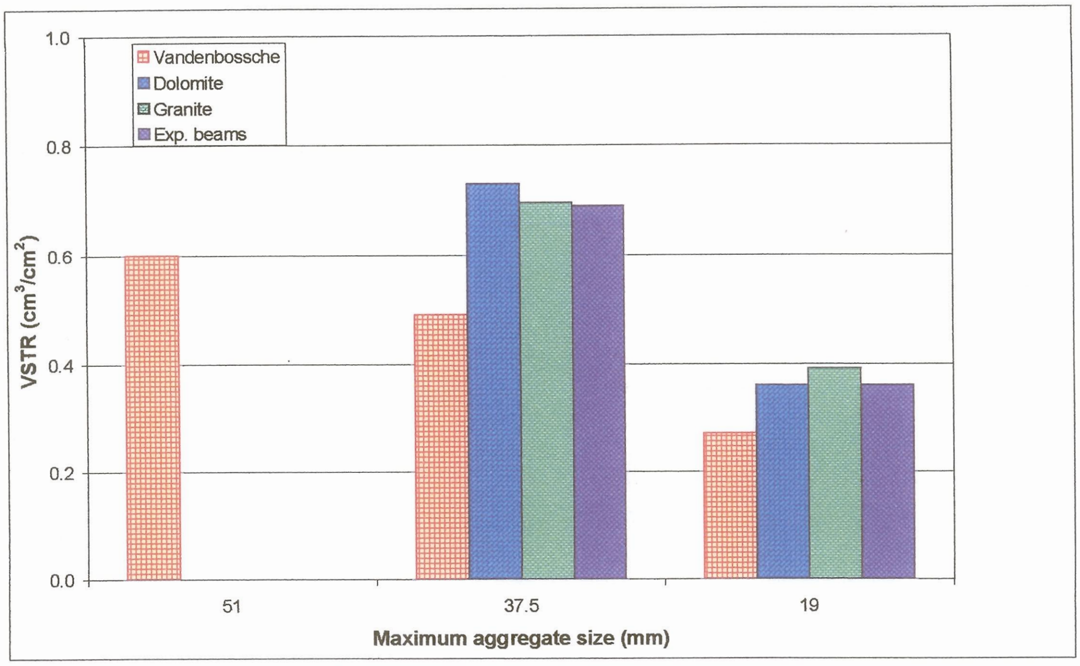

Figure F.5: Effect of maximum coarse aggregate size on VSTR - comparison between USA and South African aggregates

The objectives for determining the VST of the concrete samples were mentioned above. From Figure F.5 it is obvious that all the questions have been answered, as the VSTR of both the 19 mm granite and dolomite crack face volumes, as well as the 37,5 mm granite and dolomite crack face volumes differed less than 10% from each other. Furthermore, the VSTR of the crack faces of both the 19 mm and 37,5 mm coarse aggregate experimental beams were also approximately the same as the crack faces formed by breaking 28-day beams during modulus of rupture testing. It can therefore be assumed that the crack face formed when conducting modulus of rupture testing on test beams can be taken as representative of the VSTR of the crack inside the road pavement.

When comparing the VSTR results from this study with the results obtained from crack faces of concrete constructed with typical USA aggregates, published by Vandenbossche (1999), it is obvious that the South African aggregates have a far greater aggregate interlock potential. The VSTR results obtained for the concrete constructed with 19 mm and 37,5 mm coarse aggregate were 37% and 44%, respectively, higher then the USA results.

Although not shown on Figure F.5, the VSTR of the pre-deformed plastic joint was 0,63cm^3/cm^2. Bearing in mind that the "bubbles" in the plastic sheet were formed with a hot light bulb, with a circular radius of approximately 22 mm, the aggregate interlock size would then be approximately 44 mm. It could therefore be compared with the results obtained for 37,5 mm coarse aggregate concrete. The smooth surface finish, however, also influenced the VSTR value, which was only 89% of the average of the VSTR results for 37,5 mm coarse aggregate.

Although the VSTR was effective in determining the volume of the crack face, it could not quantify the smoothness of the surface of the pre-deformed plastic joint face. Various methods were investigated to quantify the smoothness of this surface. The simplest method of showing the smoothness of the pre-deformed plastic joint surface, was to plot an extract from the VST laser data, and compare it with the VST laser data obtained from a randomly selected aggregate interlock crack face. The obviously smoother pre-deformed plastic joint surface data is shown on Figure F.6 and the rougher aggregate interlock crack face data on Figure F.7. The shiny, smooth crack face created with the plastic sheet is also clearly visible on Photo G.24.

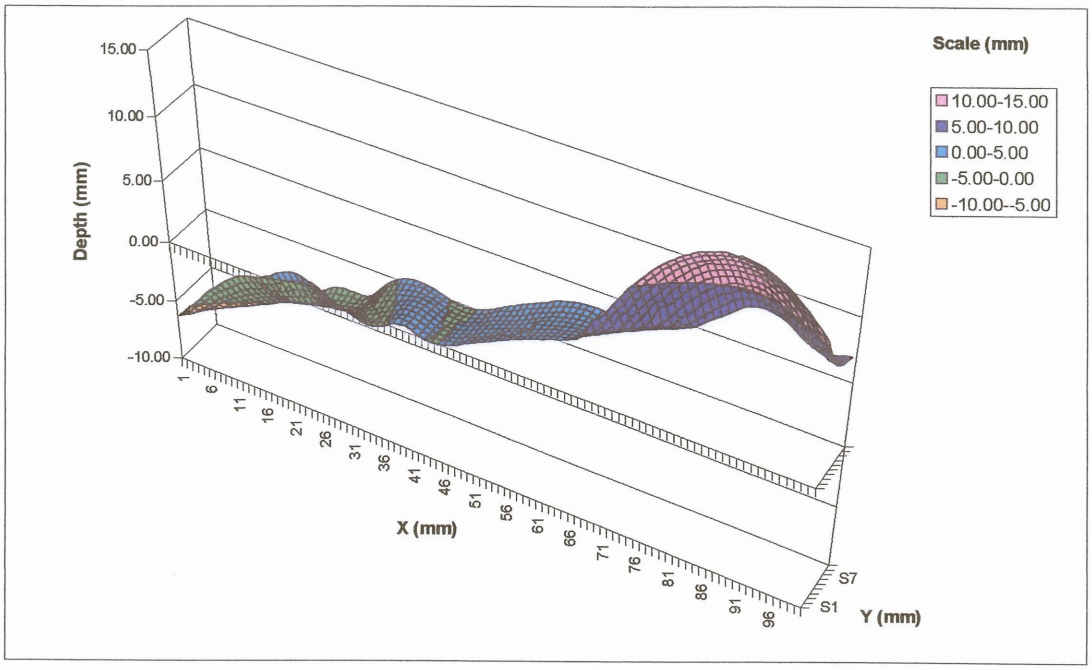

Figure F.6: Extract from pre-deformed plastic joint VST data

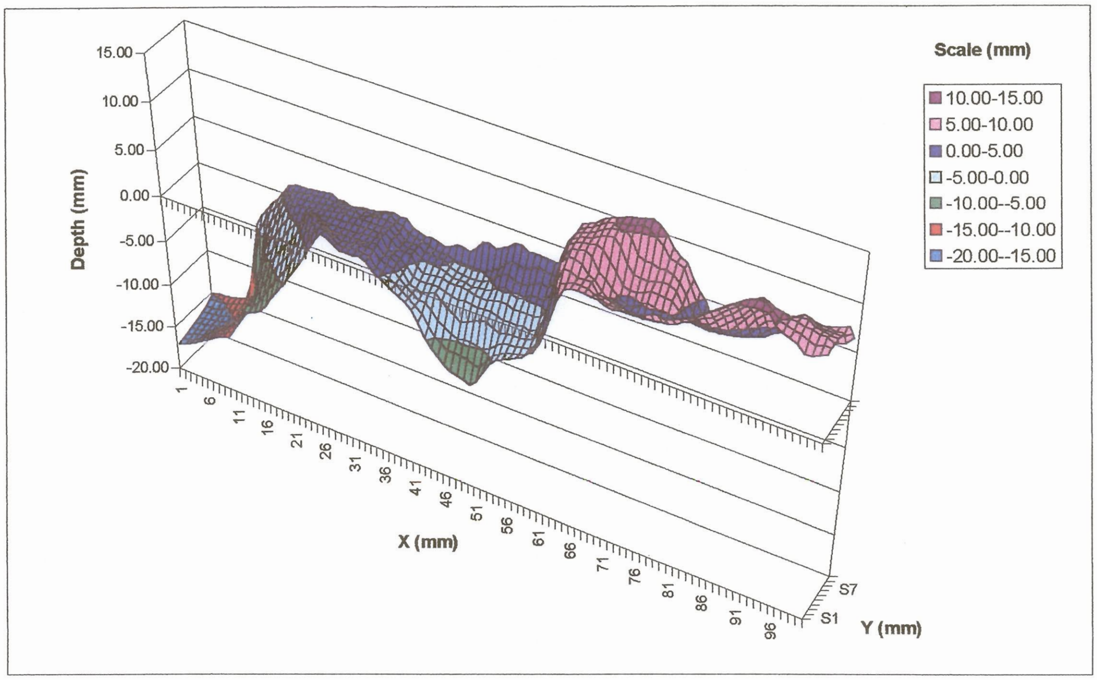

Figure F.7: Extract from randomly selected aggregate interlock joint VST data