USE OF “COMPACT” SOFTWARE IN SOLVING COMPACTION PROBLEMS OF BOTH UNTREATED AND ASPHALT MATERIALS

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1. BACKGROUND

The derivation of the formulas used in **COMPACT** was originally done during the research into the compactability of untreated granular roadbuilding materials (Semmelink, 1991). The original models were developed from the properties of 21 different untreated materials, ranging from well-graded G1 crushed stone (maximum particle size 37.5 mm) to black clay. At a later stage the prediction models were adapted for use on asphalt mixes. **COMPACT** determines all properties on a volumetric basis, thus making provision for different types of rock material, with different relative solid densities, to be used. Models were developed to express the compactability properties as a function of the indicator test values (i.e. the grading, Atterberg limits and linear shrinkage of the -0.425 mm fraction, and the apparent and bulk relative densities of the +4.75 mm and -4.75 mm fractions). The r^2-value for the MDD model is 0.965. Two new easy-to-perform tests were developed to quantify the effect of particle shape and texture, namely the Shakedown Bulk Density (SBD) and the Weighted Fractional Density (WFD) tests. These two properties can be used to improve the accuracy of the predicted properties in the case of fine (poorly to well-graded) materials.

Originally the models only made provision for fine to well-graded materials (i.e. on the fine (top) side of the Fuller or Talbot grading curve)(see Figures 1 to 3). Subsequently, however, because coarsely graded materials react differently from fine (poorly to well-graded) materials (see Figure 1), separate models were developed for these materials. The materials used to develop the coarsely models consisted of coarse, untreated crushed stone, SMAs and porous asphalt mixes. (see Figures 4 and 5.)

COMPACT makes provision for three standard metric sieve ranges, namely the European, SA untreated, and SA asphalt sieve ranges. Any of these sieve ranges can be used for both untreated or asphalt materials. The package also makes provision for its use in countries that still use Imperial measuring units, by giving the equivalent British or US imperial sieve ranges and expressing the maximum dry densities in lb/ft^3.

The purpose of the paper is to show through the evaluation of **COMPACT** output of actual site examples how the causes of compaction or mix problems can be identified and rectified.

2. COARSE AND FINE TO WELL-GRADED MATERIALS

The “grading factor” and the “ideal grading factor” are used to distinguish between “coarse” and “fine (poorly to well-graded)” material.

The Grading Factor (GF) is defined as: Ó(percentage passing sieve/nominal sieve size (mm)) /100 for all the sieves in a particular sieve range larger than 0.425mm (i.e. the material fraction on which the Atterberg limits and linear shrinkage are determined). The Ideal Grading Factor (IGF) is the theoretical value of the GF of the Talbot curve for a particular sieve range for a particular sieve size (i.e. the smallest sieve through which 100 per cent of the material passes). The value of the exponent “n” of the Talbot curve is taken to be 0.51. If the GF value of the actual grading is equal to or greater than the IGF value, the material falls in the fine (poorly to well-graded) zone. If the GF value of the actual grading is smaller than the IGF value, the material falls in the coarse zone (see Figure 1). The relevant prediction models are automatically selected, according to this evaluation.

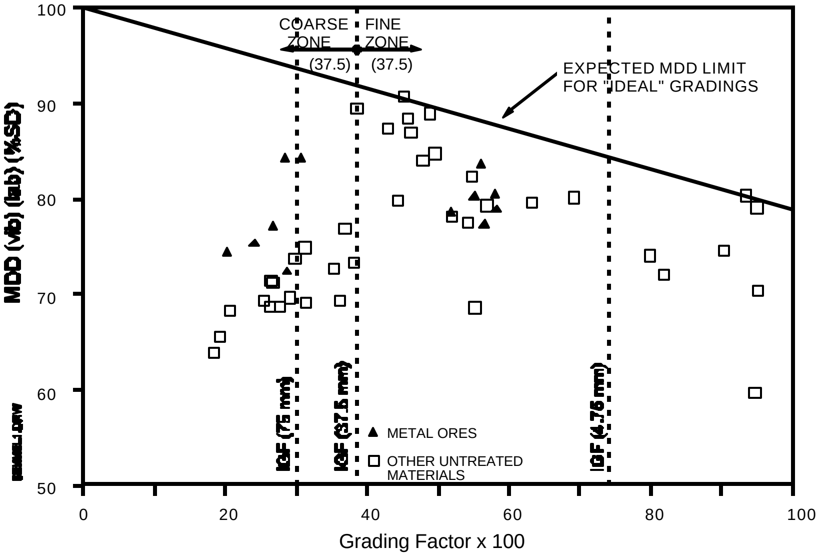


Figure 1: **Maximum dry density values (% of bulk relative density)(% SD) of fine to well-graded and of coarsely graded untreated materials against their grading factors (GF) x hundred**

The results of the models for “fine to well-graded” and “coarse” material are presented in Figures 2 to 5. The limited range of the asphalt properties in Figure 2 is due to the limited range of the gradings for asphalt surfacings. The high asphalt data point is for a Large Aggregate Mix Base (LAMB). The Voids in Mineral Aggregate (VMA) is calculated for maximum aggregate interlock in untreated materials. However, in the case of “fine to well-graded” asphalt mixes the model developed showed that the aggregate matrix opens up slightly (i.e. $MDD_{asphalt\ agg} = 0.97\ MDD_{untreated\ agg}$) to make space for the bituminous binder. These mixes are, therefore, expected to close up a little with time. This is not the case with the coarsely graded asphalt mixes, where $MDD_{asphalt\ agg}$ is equal to $MDD_{untreated\ agg}$.

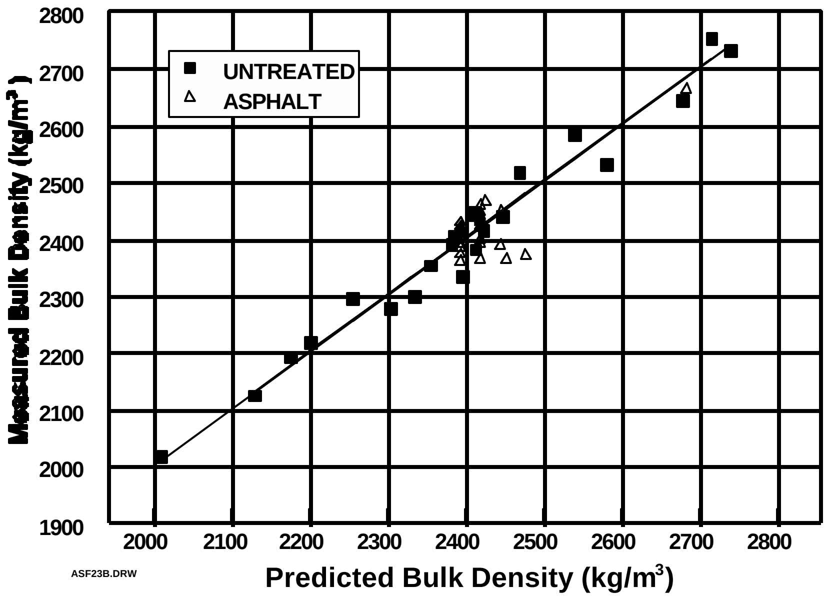


Figure 2: Measured bulk densities against predicted bulk densities of untreated granular materials and of asphalt mixes in the fine to well-graded zone

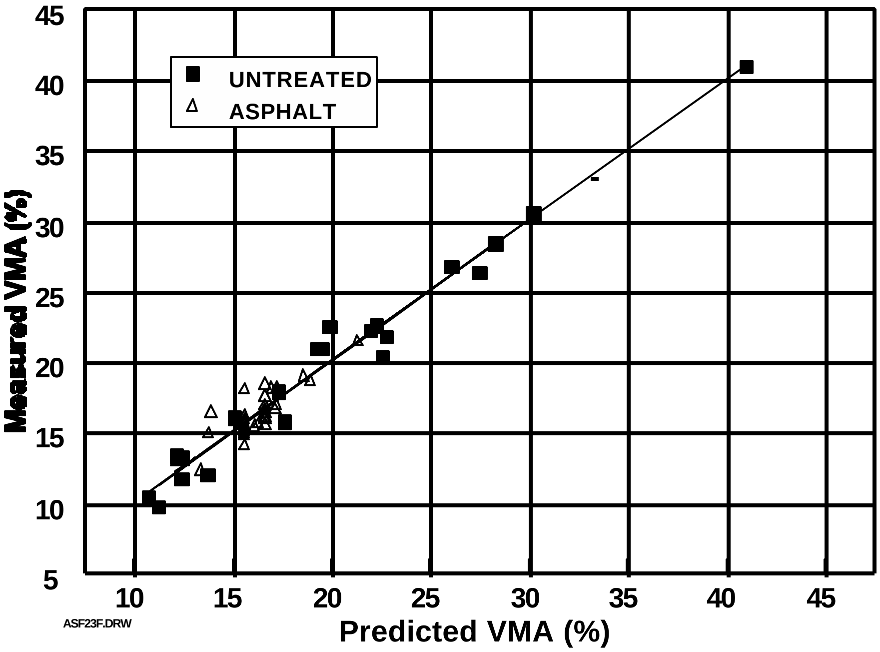


Figure 3: Measured voids in mineral aggregate (VMA)(%) against predicted VMA of untreated granular materials and of asphalt mixes in the fine to well-graded zone

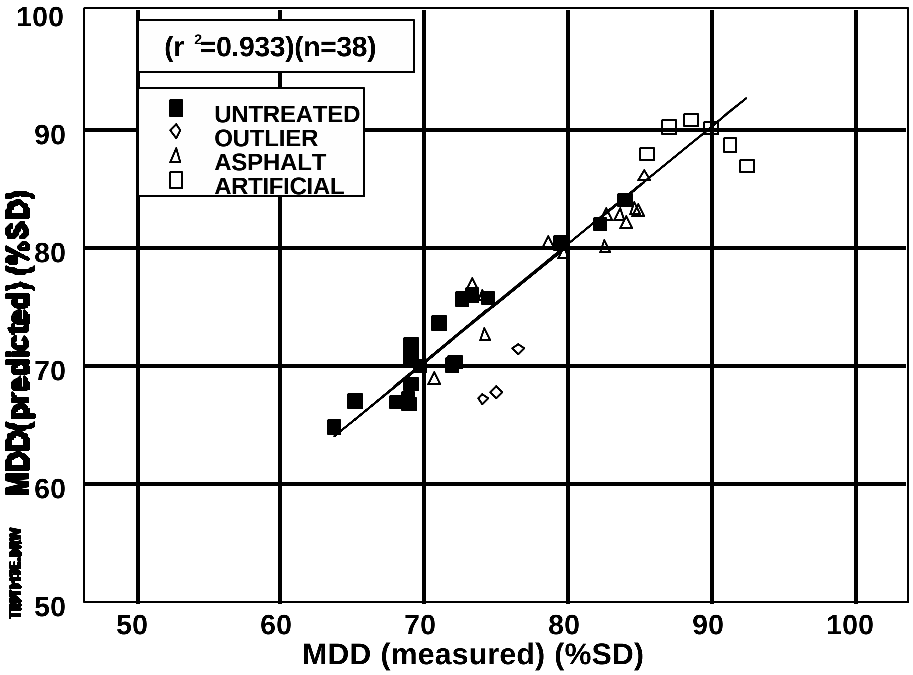


Figure 4: Comparison of predicted and measured maximum dry densities (MDD)(%SD) for untreated granular materials and of asphalt mixes in the coarsely graded zone

The artificial data points in Figure 4 refer to MDDs predicted for "ideal " gradings with different maximum sieve sizes, assuming that the expected MDD limit for "ideal" gradings in Figure 1 is correct. The artificial data points in Figure 5 are the VMAs for these same "ideal" gradings.

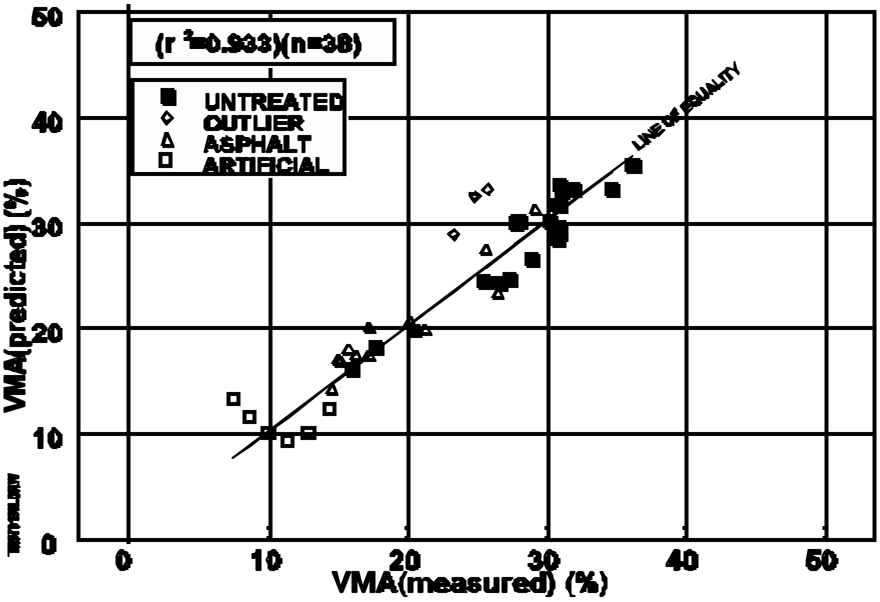


Figure 5: Comparison of predicted and measured voids in mineral aggregate (VMA)(%) for

untreated granular materials and of asphalt mixes in the coarsely graded zone

3. PROBLEMS WITH UNTREATED MATERIALS

COMPACT has been used successfully in a substantial number of cases to determine the causes of compaction problems. For example, on a particular site, problems were being experienced with compacting mechanically stabilized, untreated subbase and base materials to the specified density levels. The **COMPACT** analyses provided densities which were similar to those specified, hence indicating that the contractor should be able to meet the specified requirements. To verify these predictions samples of the specified material blends were then compacted on the TRANSPORTEK vibratory compaction table. The predicted MDD results using **COMPACT** results were between 98 % and 103% of the laboratory MDD results. This indicated that the material was compactable and that reasons for the compaction difficulties should be sought elsewhere than in the material itself. Detailed site investigations showed that the roadbed consisted of a collapsing sand, for which no pretreatment had been specified. Areas where the roadbed had been compacted with an impact roller gave no problems.

In another case a G1 crushed stone base could not be compacted to the specified level of 88 %SD, but only 84,96 %SD. When the material properties of the aggregate were fed into **COMPACT**, it predicted a maximum dry density level of 85,16 %SD. This indicated that, even though the material satisfied the grading requirements of the specification, it would be impossible to compact this material to the specified level of 88 %SD, because it was on the fine side of the grading envelope. The grading was subsequently changed by the supplier to the coarse side of the grading envelope after which 88 %SD was readily achieved. In a substantial number of other cases **COMPACT** has shown that porous crushed stone can also be compacted to levels of 86 to 88 %SD provided the BRD and not the ARD of the aggregate is used in the evaluation process. It has also been used successfully to design rollcrete mixes.

4. PROBLEMS WITH ASPHALT MIXES

COMPACT has been used successfully to determine the cause of problems experienced with asphalt mixes in a number of cases. In one particular case the specified Bulk Relative Densities (BRDs) in terms of the Maximum Theoretical Relative Density (Rice)(i.e. MTRD(Rice)), as determined in the laboratory, could not be achieved. When the predicted values of Maximum Theoretical Relative Density for interparticle air voids (i.e. MTD(AV)) and total air voids (i.e. MTD(TotAV)) were plotted together with the laboratory values of Maximum Theoretical Relative Density (Rice), the MTD(TotAV) and laboratory values were almost identical (see Figure 6). This indicated that the intraparticle voids in the porous aggregate used on this contract had actually been saturated with water during the Rice test, leading to an artificially high MTRD(Rice) value, because the volume of the aggregate was artificially reduced. The intraparticle voids cannot be filled with particle solids or binder in most cases. This artificially high laboratory value led to a density requirement on site which could not be met effectively because the BRD had been specified as a certain percentage of MTRD(Rice). It should also be noted that the laboratory BRD values are of the same magnitude as the predicted MTRD for interparticle air voids (i.e. MTD(AV)) most of the time. This indicates that most of the interparticle voids become saturated with water when the asphalt briquettes are weighed under water to determine their bulk volumes. The laboratory-determined BRD values are, therefore, also artificially high where interconnected voids exist. Weighing them in water, and then immediately after their removal from the water bath will also not be effective, as the voids are relatively large and free-draining. It should also be noted that the predicted BRD values are far more uniform. This is because of the uniform grading of the aggregate.

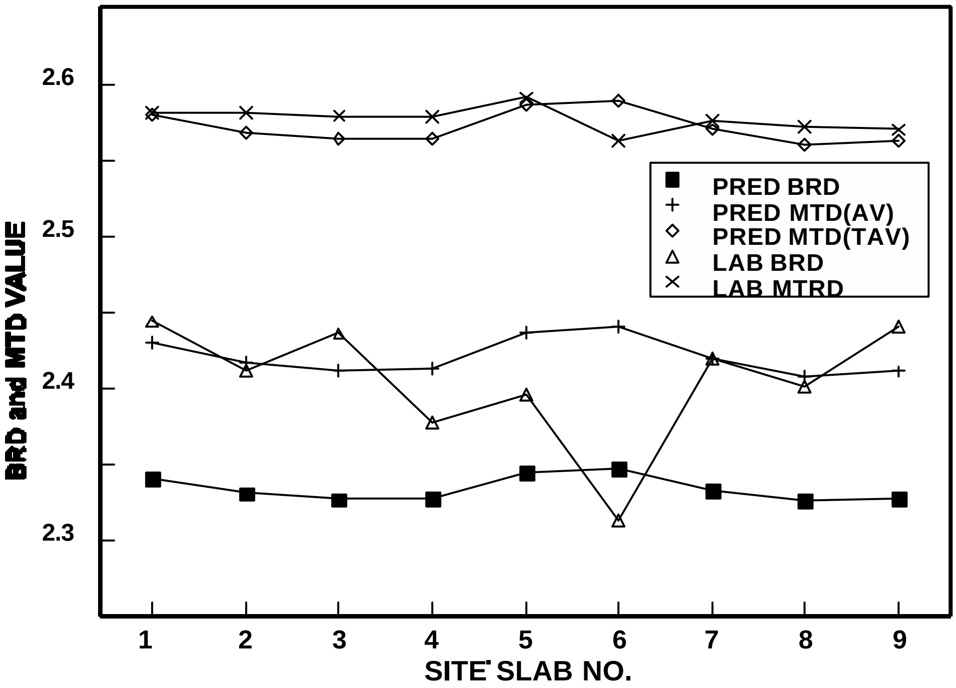


Figure 6: **Graph showing predicted BRD, MTD(AV) and MTD(TotAV) values together with the laboratory-determined BRD and MTRD(Rice) values for porous aggregate**

In another case (Louw et al, 1997) mixes were prepared in accordance with the method specifications of different authorities for SMAs using the specified binder content of 6.5 per cent. However, these mixes were so weak that their Marshall stabilities and flow values could not be measured. The software indicated that the binder content was too high. During in-depth evaluation of the compacted samples, it was found that the three per cent air void content measured with the Rice test was not made up of interparticle air voids, but of intraparticle air voids (see Figure 7). The void space between the aggregate particles was completely filled with binder, leading to the low stabilities of the compacted specimens.

Both problem cases were the result of the incorrect conclusions being drawn from the results of the standard laboratory test, even though the ASTM test methods contain a caution regarding this. This points to some serious shortcomings concerning the execution of the Rice test and the interpretation of its test results. The following aspects of the test need to be addressed seriously in practice:

(i) The rapid weighing of samples in a water bath does not prevent the interconnected interparticle voids from being totally or partially filled with water during the weighing process. This leads to a reduction of the sample volume and thus to excessively high BRD values (see Figure 6). To prevent this from happening effective ways will have to be found to seal the outer surface of the sample so that the true bulk volume is measured accurately. For example, the bulk volume of the sample can be determined by weighing the sample, suspended on a thin wire sling inside a thin plastic bag, open to the atmosphere at the top, in a water-filled container above the scale, and the mass of water displaced by the sample determined, without any of the interparticle air voids being filled with water during the process. This method works very effectively.

(ii) The total or partial saturation of intraparticle voids during the determination of the maximum theoretical relative density, should be acknowledged as a fact. Taking account of the intraparticle voids in porous aggregates will allow higher total void contents than the presently accepted standard of three to four per cent. The proposed value is three to four per cent plus the balance of the intraparticle voids not filled with binder. This seems to be a reasonable assumption, considering the results in Figures 6 and 7.

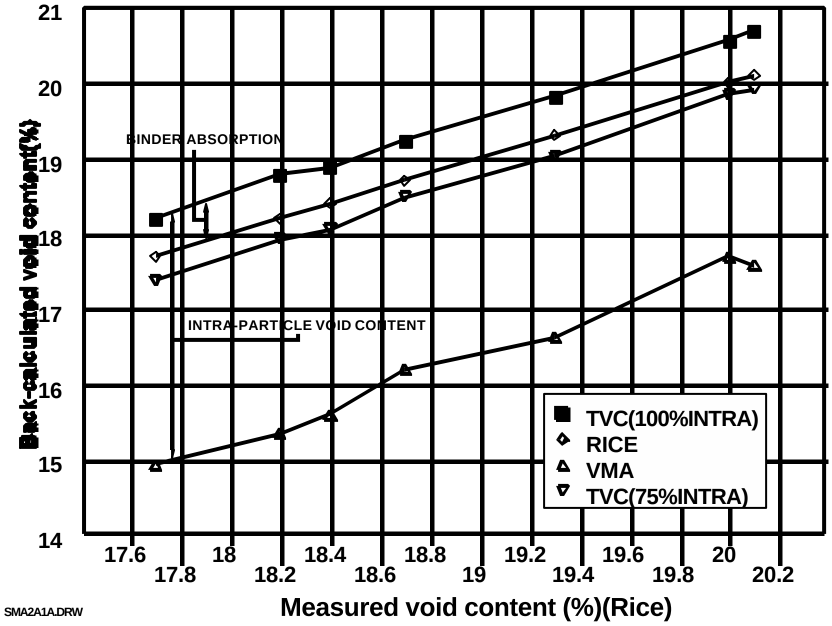
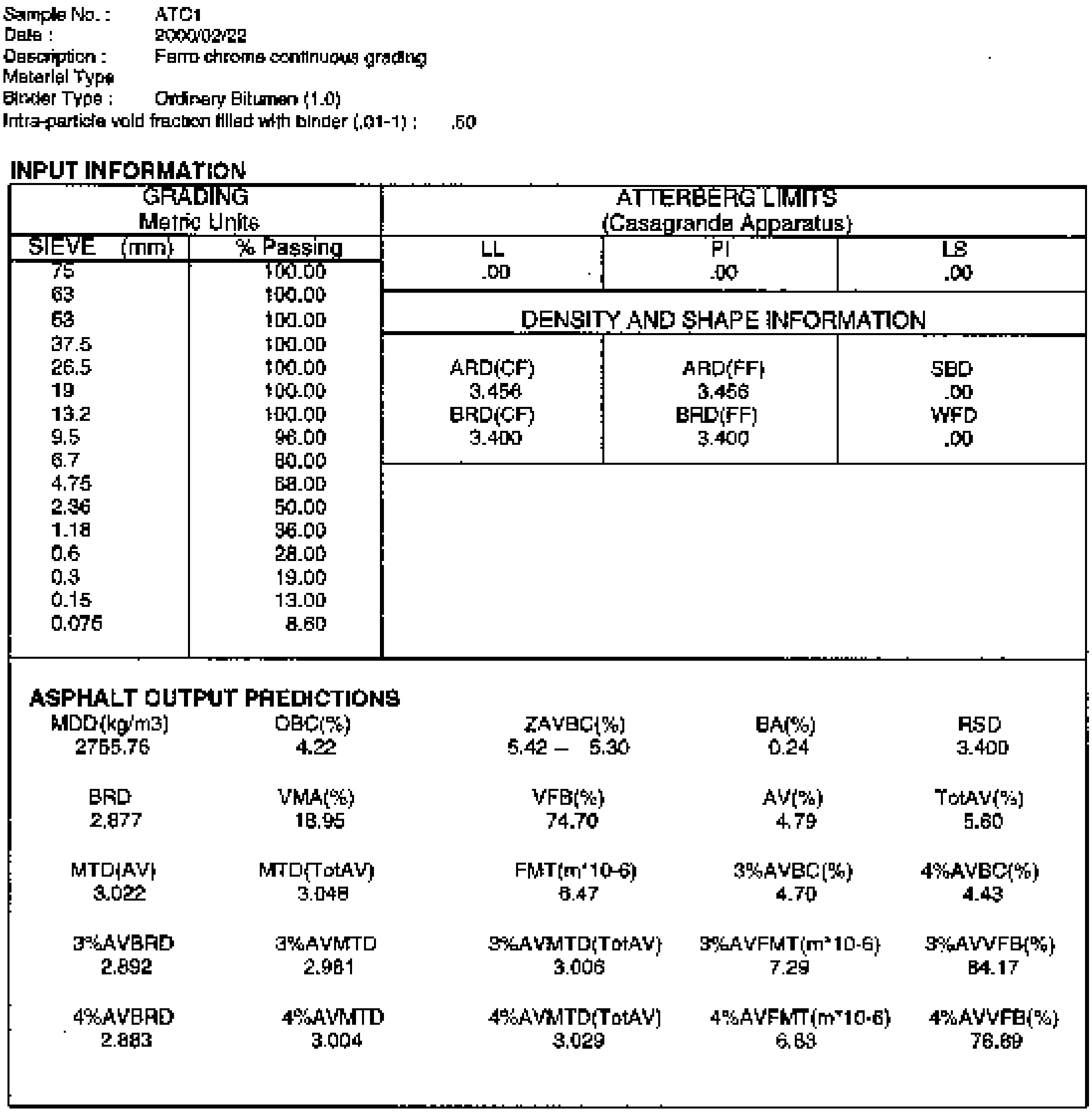


Figure 7: The measured and back-calculated void contents in quartzitic sandstone SMA specimens

In another case an asphalt mix had been designed using ferrochrome slag as aggregate and using the “standard” binder content of 5.5% for the particular grading. However, stability and flow problems were experienced with the Marshall briquettes. Ferrochrome slag has got a high relative density. Because the binder is added as percentage by mass of the total mix the binder content was too high. Because **COMPACT** evaluates the material volumetrically it immediately identified the binder content of the mix as the problem. For a relative density of the aggregate of 2.650 the binder content for the particular grading is 5.7%. For a relative density of the aggregate of 3.400 the binder content should be approximately 4.7% to occupy the same amount of void space in the mix (see Tables 1 and 2 and Figures 8 and 9). Note that the grading envelopes are identical. Beam samples were then manufactured using 4.7% binder content. It was found that the fatigue life was limited. Because a drum mix plant was used on site a method of improving the binder film thickness had to be found. In a **COMPACT** analysis, 3% flue dust was removed to evaluate its effect on binder film thickness (see Tables 3 and 4 and Figure 10). The predicted results showed that by removing 3% flue dust from the mix the binder film thickness would increase from 7.29µm to 8.90µm for a binder content of about 4.7% by mass. This would lead to a substantial increase in fatigue life.

In the case of asphalt mixes three levels of each of the important properties are predicted, making it possible to interpolate between these values, if required. For example, if one would like to know what the binder content would be for a specific binder film thickness, this can be determined by plotting the three levels of binder content against the three binder film thicknesses.

Table 1: Properties of asphalt mix with BRD equal to 3.400



Sample No. : ATC1
Date : 2000/02/22
Description : Ferro chrome continuous grading
Material Type
Binder Type : Ordinary Bitumen (1.0)
Intra-particle void fraction filled with binder (.01-1) : .60

INPUT INFORMATION

GRADING
Metric Units

SIEVE (mm)	% Passing
75	100.00
63	100.00
53	100.00
37.5	100.00
26.5	100.00
19	100.00
13.2	100.00
9.5	96.00
6.7	80.00
4.75	68.00
2.36	50.00
1.18	36.00
0.6	28.00
0.3	19.00
0.15	13.00
0.075	8.60

ATTERBERG LIMITS
(Casagrande Apparatus)

LL	PI	LS
.00	.00	.00

DENSITY AND SHAPE INFORMATION

ARD(CF)	ARD(FF)	SBD
3.456	3.456	.00
BRD(CF)	BRD(FF)	WFD
3.400	3.400	.00

ASPHALT OUTPUT PREDICTIONS

MDD(kg/m3)	OBC(%)	ZAVBC(%)	BA(%)	RSD
2755.76	4.22	5.42 – 5.30	0.24	3.400
BRD	VMA(%)	VFB(%)	AV(%)	TotAV(%)
2.877	18.95	74.70	4.79	5.60
MTD(AV)	MTD(TotAV)	FMT(m*10-6)	3%AVBC(%)	4%AVBC(%)
3.022	3.048	6.47	4.70	4.43
3%AVBRD	3%AVMTD	3%AVMTD(TotAV)	3%AVFMT(m*10-6)	3%AVVFB(%)
2.892	2.981	3.006	7.29	84.17
4%AVBRD	4%AVMTD	4%AVMTD(TotAV)	4%AVFMT(m*10-6)	4%AVVFB(%)
2.883	3.004	3.029	6.83	76.69

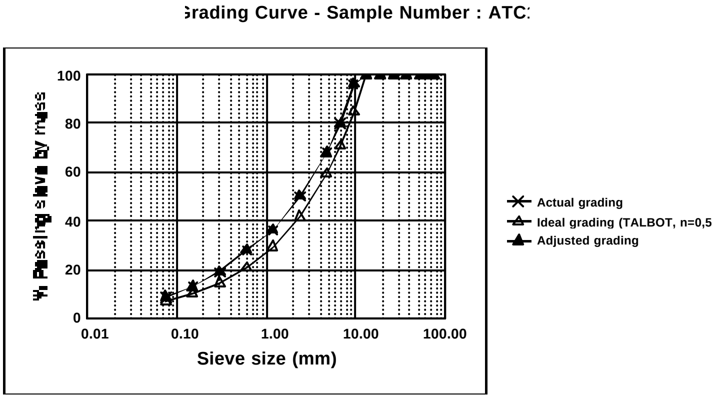
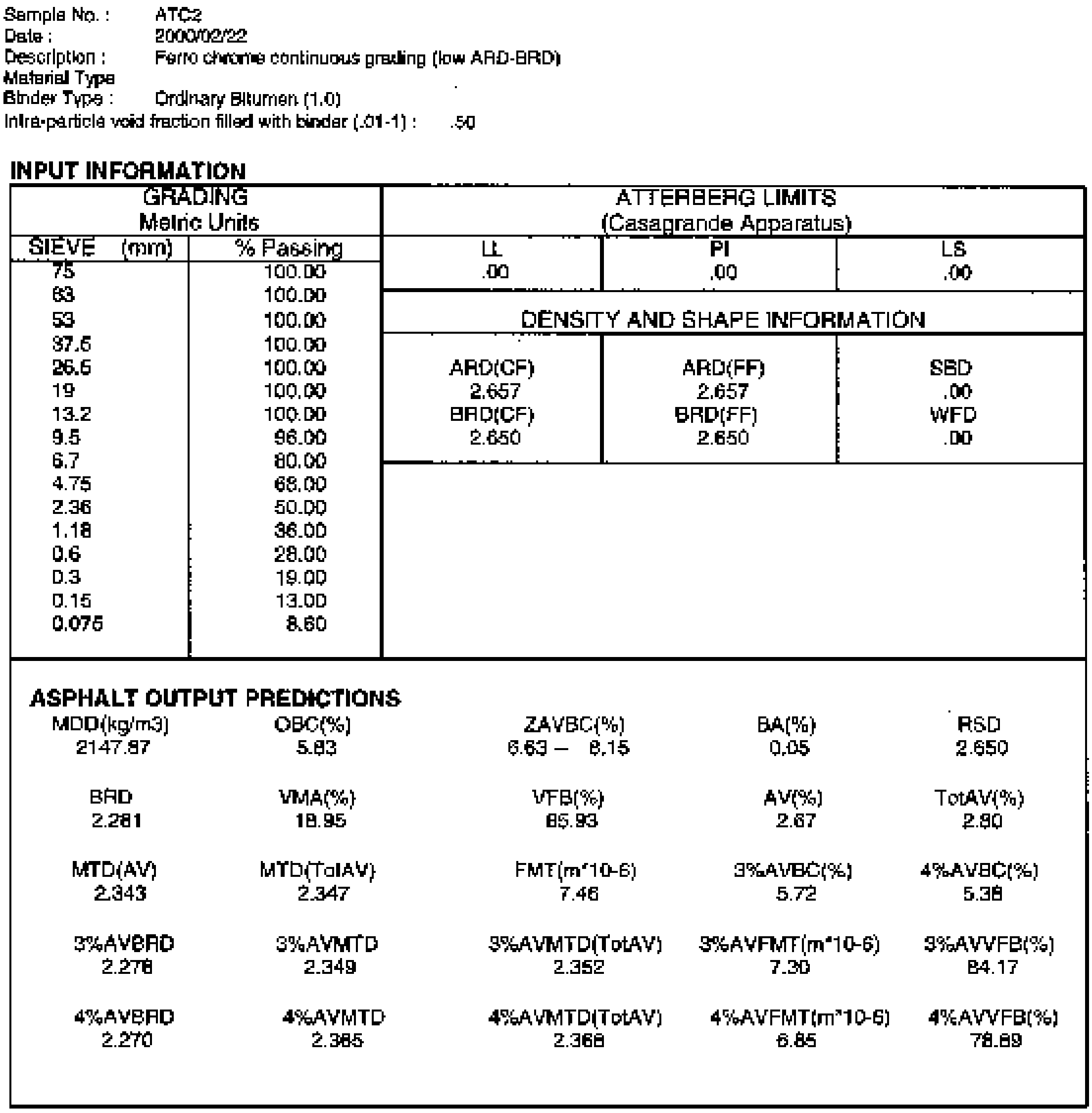


Figure 8: Grading curve of ATC1 shown graphically

Table 2: Properties of same mix with BRD equal to 2.650



Sample No. : ATC2
Date : 2000/02/22
Description : Ferro chrome continuous grading (low ARD-BRD)
Material Type
Binder Type : Ordinary Bitumen (1.0)
Intra-particle void fraction filled with binder (.01-1) : .50

INPUT INFORMATION

GRADING
Metric Units

SIEVE (mm)	% Passing
75	100.00
63	100.00
53	100.00
37.5	100.00
26.5	100.00
19	100.00
13.2	100.00
9.5	96.00
6.7	80.00
4.75	68.00
2.36	50.00
1.18	36.00
0.6	28.00
0.3	19.00
0.15	13.00
0.075	8.60

ATTERBERG LIMITS
(Casagrande Apparatus)

LL	PI	LS
.00	.00	.00

DENSITY AND SHAPE INFORMATION

ARD(CF)	ARD(FF)	SBD
2.657	2.657	.00
BRD(CF)	BRD(FF)	WFD
2.650	2.650	.00

ASPHALT OUTPUT PREDICTIONS

MDD(kg/m3)	OBC(%)	ZAVBC(%)	BA(%)	RSD
2147.87	5.83	6.63 – 8.15	0.05	2.650
BRD	VMA(%)	VFB(%)	AV(%)	TotAV(%)
2.281	18.95	85.93	2.67	2.80
MTD(AV)	MTD(TotAV)	FMT(m*10-6)	3%AVBC(%)	4%AVBC(%)
2.343	2.347	7.46	5.72	5.38
3%AVBRD	3%AVMTD	3%AVMTD(TotAV)	3%AVFMT(m*10-6)	3%AVVFB(%)
2.278	2.349	2.352	7.30	84.17
4%AVBRD	4%AVMTD	4%AVMTD(TotAV)	4%AVFMT(m*10-6)	4%AVVFB(%)
2.270	2.365	2.368	6.85	78.89

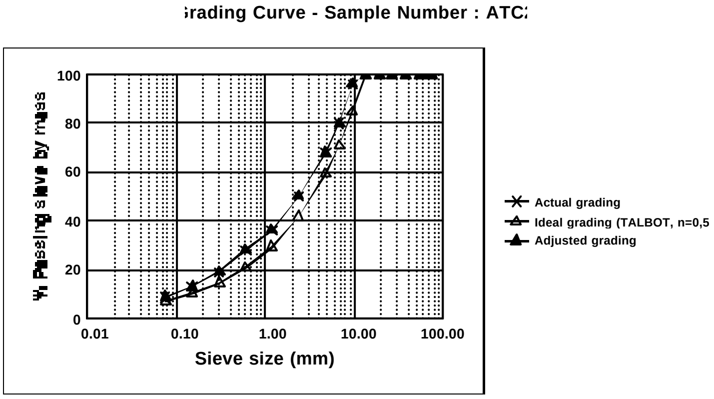
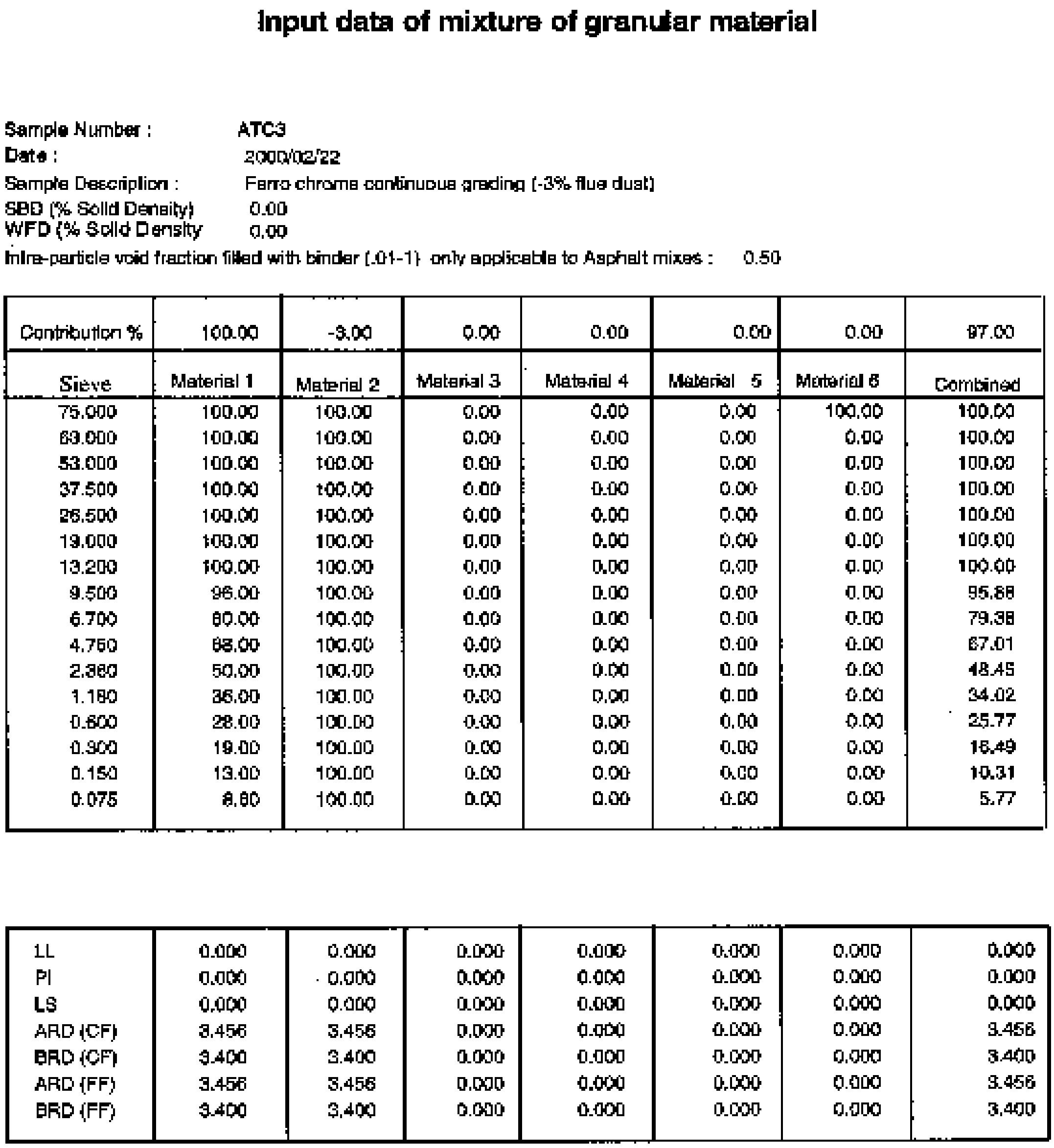


Figure 9: Grading curve of ATC2 shown graphically

Table 3: Effect of adjustment of flue dust content of mix



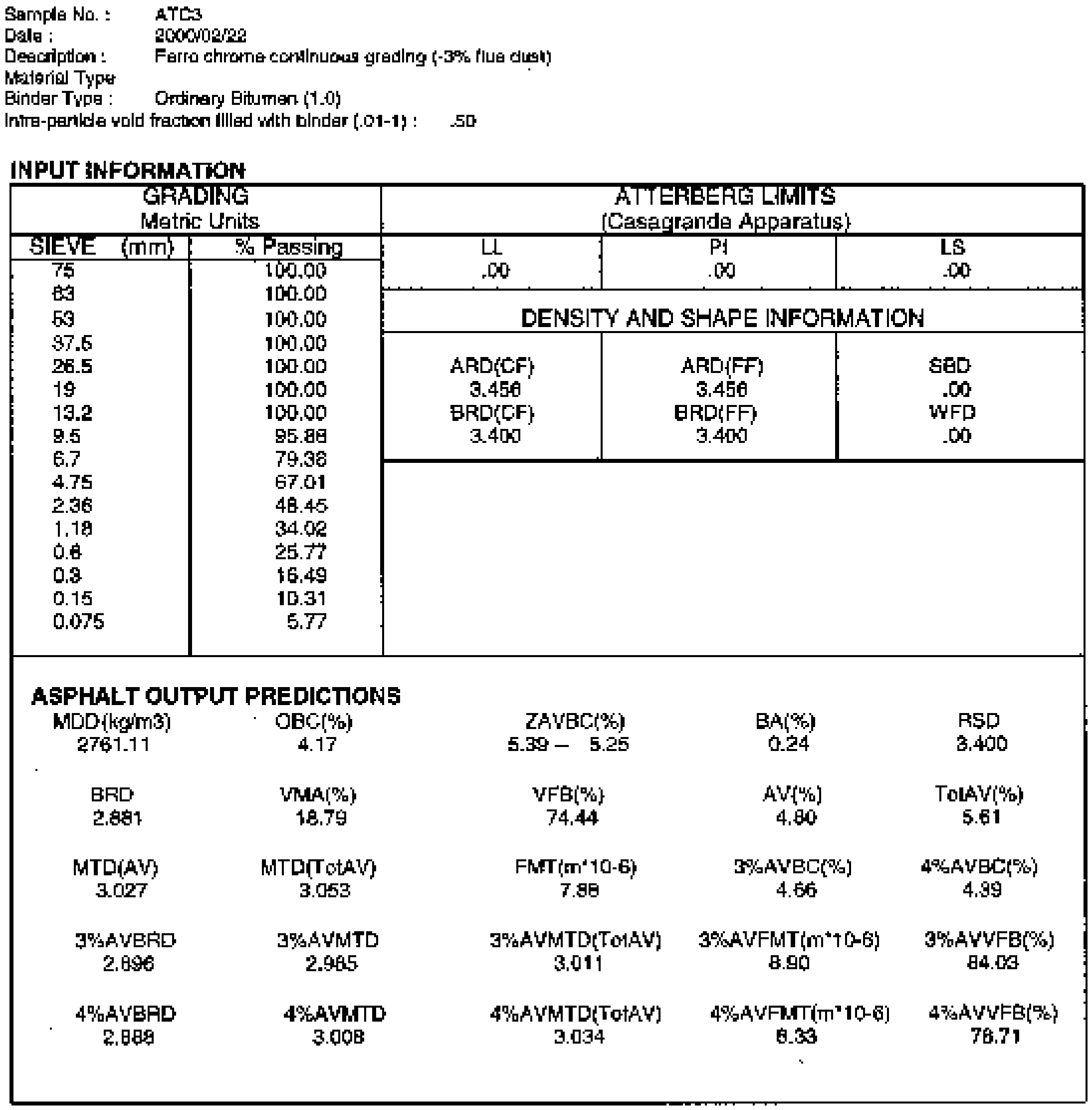
Input data of mixture of granular material

Sample Number : ATC3
Date : 2000/02/22
Sample Description : Ferro chrome continuous grading (-3% flue dust)
SBD (% Solid Density) 0.00
WFD (% Solid Density 0.00
Intra-particle void fraction filled with binder (.01-1) only applicable to Asphalt mixes : 0.50

Contribution %	100.00	-3.00	0.00	0.00	0.00	0.00	97.00
Sieve	Material 1	Material 2	Material 3	Material 4	Material 5	Material 6	Combined
75.000	100.00	100.00	0.00	0.00	0.00	100.00	100.00
63.000	100.00	100.00	0.00	0.00	0.00	0.00	100.00
53.000	100.00	100.00	0.00	0.00	0.00	0.00	100.00
37.500	100.00	100.00	0.00	0.00	0.00	0.00	100.00
26.500	100.00	100.00	0.00	0.00	0.00	0.00	100.00
19.000	100.00	100.00	0.00	0.00	0.00	0.00	100.00
13.200	100.00	100.00	0.00	0.00	0.00	0.00	100.00
9.500	96.00	100.00	0.00	0.00	0.00	0.00	95.88
6.700	80.00	100.00	0.00	0.00	0.00	0.00	79.38
4.750	68.00	100.00	0.00	0.00	0.00	0.00	67.01
2.360	50.00	100.00	0.00	0.00	0.00	0.00	48.45
1.180	36.00	100.00	0.00	0.00	0.00	0.00	34.02
0.600	28.00	100.00	0.00	0.00	0.00	0.00	25.77
0.300	19.00	100.00	0.00	0.00	0.00	0.00	16.49
0.150	13.00	100.00	0.00	0.00	0.00	0.00	10.31
0.075	8.60	100.00	0.00	0.00	0.00	0.00	5.77

LL	0.000	0.000	0.000	0.000	0.000	0.000	0.000
PI	0.000	0.000	0.000	0.000	0.000	0.000	0.000
LS	0.000	0.000	0.000	0.000	0.000	0.000	0.000
ARD (CF)	3.456	3.456	0.000	0.000	0.000	0.000	3.456
BRD (CF)	3.400	3.400	0.000	0.000	0.000	0.000	3.400
ARD (FF)	3.456	3.456	0.000	0.000	0.000	0.000	3.456
BRD (FF)	3.400	3.400	0.000	0.000	0.000	0.000	3.400

Table 4: Properties of mix after removal of 3 per cent flue dust



Sample No. : ATC3
Date : 2000/02/22
Description : Ferro chrome continuous grading (-3% flue dust)
Material Type
Binder Type : Ordinary Bitumen (1.0)
Intra-particle void fraction filled with binder (.01-1) : .50

INPUT INFORMATION

GRADING Metric Units	
SIEVE (mm)	% Passing
75	100.00
63	100.00
53	100.00
37.5	100.00
26.5	100.00
19	100.00
13.2	100.00
9.5	95.88
6.7	79.38
4.75	67.01
2.36	48.45
1.18	34.02
0.6	25.77
0.3	16.49
0.15	10.31
0.075	5.77

ATTERBERG LIMITS (Casagrande Apparatus)		
LL	PI	LS
.00	.00	.00

DENSITY AND SHAPE INFORMATION		
ARD(CF)	ARD(FF)	SBD
3.456	3.456	.00
BRD(CF)	BRD(FF)	WFD
3.400	3.400	.00

ASPHALT OUTPUT PREDICTIONS

MDD(kg/m3)	OBC(%)	ZAVBC(%)	BA(%)	RSD
2761.11	4.17	5.39 – 5.25	0.24	3.400
BRD	VMA(%)	VFB(%)	AV(%)	TotAV(%)
2.881	18.79	74.44	4.80	5.61
MTD(AV)	MTD(TotAV)	FMT(m*10-6)	3%AVBC(%)	4%AVBC(%)
3.027	3.053	7.88	4.66	4.39
3%AVBRD	3%AVMTD	3%AVMTD(TotAV)	3%AVFMT(m*10-6)	3%AVVFB(%)
2.896	2.985	3.011	8.90	84.03
4%AVBRD	4%AVMTD	4%AVMTD(TotAV)	4%AVFMT(m*10-6)	4%AVVFB(%)
2.888	3.008	3.034	6.33	78.71

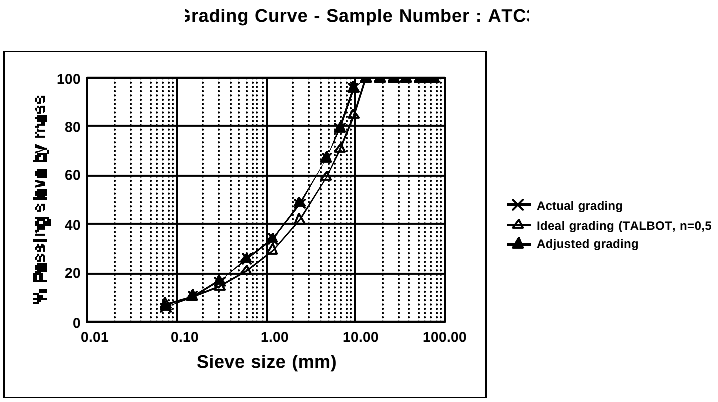


Figure 10: Grading curve of ATC3 shown graphically

5. CONCLUSION

The paper has demonstrated that it is possible to solve compaction problems of both treated and untreated materials as well as to design asphalt mixes by means of the **COMPACT** software package. This handy tool can assist in enhancing asphalt mix design in a cost-effective manner, as well as in solving site problems rapidly and effectively.

6. ACKNOWLEDGEMENT

The author would like to thank the Director of the Division for Transport and Road Research of the CSIR for allowing the publication of this paper. He would also like to acknowledge the assistance of Mr P B Botha in the development of the procedure to deal with the effect of binder stiffness on the VMA of the mix, and Mr C H Coetzee and Mrs V M P de Franca for their assistance with the programming of the **COMPACT** software.

7. REFERENCES

Semmelink C J. 1991. **The effect of material properties on the compactability of some untreated roadbuilding materials**. Ph.D thesis, Department of Civil Engineering, University of Pretoria, Pretoria, South Africa.

Louw L, Semmelink C J, and Verhaeghe B M J A. 1997. **Development of a stone mastic asphalt design method for South African conditions**. Proc of 8th International Conference on Asphalt Pavements, University of Washington, Seattle, Washington, U.S.A. pp 535-554.

8. MEANING OF ABBREVIATIONS

Input information

LL	Liquid limit (Atterberg limit)
PI	Plasticity index (Atterberg limit)
LS	Linear shrinkage
ARD(CF)	Apparent relative density of coarse fraction
BRD(CF)	Bulk relative density of coarse fraction
ARD(FF)	Apparent relative density of fine fraction
BRD(FF)	Bulk relative density of fine fraction
SBD	Shakedown bulk density
WFD	Weighted fractional density
S-a(CF)*	Apparent specific gravity of coarse fraction (same as ARD(CF))
S-s(CF)*	Saturated, surface dry specific gravity of coarse fraction (same as BRD(CF))
S-a(FF)*	Apparent specific gravity of fine fraction (same as ARD(FF))
S-s(FF)*	Saturated, surface-dry specific gravity of fine fraction (same as BRD(FF))

* These parameters are with the USA sieve size range on the data sheets

Asphalt output predictions

MDD	Maximum dry density of aggregate fraction only (kg/m^3 or lb/ft^3)
OBC(%)	Optimum binder content (percentage by mass of total mix)
ZAVBC(%)	Zero air voids binder content (percentage by mass of total mix)
BA(%)	Binder absorption (percentage by mass of total mix)
RSD	Relative solid density (i.e. weighted bulk relative density of aggregate particles)
BRD	Bulk relative density of mix at OBC
VMA(%)	Voids in mineral aggregate (percentage of total space occupied)
VFB(%)	Percentage of interparticle voids filled with binder
AV(%)	Percentage of interparticle air void space
TotAV(%)	Percentage of total air void space (i.e. interparticle voids plus intraparticle voids not filled with binder)
MDT(AV)	Maximum theoretical relative density, assuming void loss in Rice test is equal to AV(%)
MTD(TotAV)	Maximum theoretical relative density, assuming void loss in Rice test is equal to TotAV(%)
FMT	Binder film thickness for OBC (µm)
3%AVBC	Binder content for 3% interparticle air voids (percentage by mass of total mix)
4%AVBC	Binder content for 4% interparticle air voids (percentage by mass of total mix)
3%AVBRD	Bulk relative density of mix at 3% AVBC
3%AVMTD	Maximum theoretical relative density, assuming void loss in Rice test is 3% at 3% AVBC
3%AVMTD(TotAV)	Maximum theoretical relative density, assuming void loss in Rice test is 3% plus intraparticle voids not filled with binder at 3% AVBC
3%AVFMT	Binder film thickness for 3% AVBC (µm)
3%AVVFB	Percentage of interparticle voids filled with binder at 3% AVBC
4%AVBRD	Bulk relative density of mix at 4% AVBC
4%AVMTD	Maximum theoretical relative density, assuming void loss in Rice test is 4% at 4% AVBC
4%AVMTD(TotAV)	Maximum theoretical relative density assuming void loss in Rice test is 4% plus intraparticle voids not filled with binder at 4% AVBC
4%AVFMT	Binder film thickness for 4%AVBC (µm)
4%AVVFB	Percentage of interparticle voids filled with binder at 4% AVBC

Untreated output predictions

MDD(VIB)	Maximum dry density (vibratory compaction)(i.e. undisturbed grading)(kg/m^3 or lb/ft^3)
OMC(VIB)	Optimum moisture content (vibratory compaction)
ZAVMC(VIB)	Zero air voids moisture content at MDD(VIB)
WA	Water absorption by porous aggregate
CMC	Critical moisture content (point where suction forces peak)
MDD(mod)	Maximum dry density (mod. AASHTO compaction)(i.e. disturbed grading) (kg/m^3 or lb/ft^3)
OMC(mod)	Optimum moisture content (mod. AASHTO compaction)
ZAVMC(mod)	Zero air voids moisture content at MDD(mod)
RSD	Relative solid density (i.e. weighted bulk relative density of aggregate)
MDD(VIB)(%SD)	Percentage of space occupied by aggregate particles (i.e. percentage solid density)
CBR	California bearing ratio
OMC(smallest)	Smallest value of either OMC(VIB) or OMC(mod)
ZAVMC	Zero air voids moisture content at a particular density level in CBR prediction table
3%AVMC	3% air voids moisture content (predicted for coarse-graded materials)
4%AVMC	4% air voids moisture content (predicted for coarse-graded materials)

USE OF "COMPACT" SOFTWARE IN SOLVING COMPACTION PROBLEMS OF BOTH UNTREATED AND ASPHALT MATERIALS

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CurriculumVitae

Dr Chris Semmelink has extensive research experience in the field of road engineering. He has done research on Statistical Quality Assurance for Road Construction, Design of Surfacing Seals, Compactability and Compaction of Roadbuilding Materials, Determination of the Elastic and Shear Properties of Roadbuilding Materials (K-mould), Special Road Construction Techniques for Defence Force, Feasibility of Labour-intensive Construction Techniques, Impact Roller and Alkali-Aggregate Reaction in Concrete. He developed the Modified Tray Test as well as the Shakedown Bulk Density and Weighted Fractional Density Tests, designed the Transportek K-mould and developed the **COMPACT** software package. He was author or co-author of a substantial list of reports and papers on these subjects, which were presented both at local and international conferences.