HOW <u>NOT TO</u> ABUSE LOGIC AND RESOURCES IN ASPHALT MIX DESIGN AND ASPHALT COMPOSITE CHARACTERIZATION

PRESENTATION

ABSTRACT

The ultimate purpose behind performing a volumetric asphalt mix design is the optimum proportioning of the right functional constituents in order to provide optimum or requested performance and cost-effectiveness for the project conditions. In asphalt pavement layers – both dense and to considerable extent in gap graded - the skeletal aggregate structure functions as a backbone and is crucially responsible for resisting pavement distresses.

Rational Asphalt Technology Mix Design Method ©, originally invented and field validated in the eighties, as refreshed and fully computerized serves now as the tool for reliable skeletal grading and mix design as well. The method objective is to use spatial 'packing' concepts and relate them to compaction characteristics and optimum asphalt performances.

Dynamic testing simulation and highly correlative regression models indicate that Volumetric Concentration of stone skeleton at 'denied' compaction (VC ss / as max) value MUST BE USED as THE BASE for ANY OPTIMUM mix design, constructability evaluation, and meaningful performance related criteria development.

ASPHALT EXPERT SYSTEM ® software suite is the ideal tool for data processing, various compatible scenario playing and valid analyses.

Keywords:, skeletal 'packing', comparability, Asphalt Expert System ®, rational mix design, performance evaluation

1. INTRODUCTION

Various types of asphalt composites are used on a large scale for different pavement structures. Level of resistance to distress and durability of asphalts depend primarily on the functional constituents. It is widely believed that the surface and structural damages in asphalts are because of heavy traffic and environmental loads. **In fact, the causes of permanent deformation are to be found in structural deficiencies of asphalt composites – i.e. in inadequate proportioning of functional constituents.** Heavy traffic and environmental loads are just critical /'trigger' conditions. <u>Without prolonged exposure to such conditions poorly designed / constructed surface layers usually are not and won't be recognized as inadequate</u>.

The incompetent mix design for the specific project task conditions is the core cause of failures in asphalt paving mixtures. The output inadequacy is because of the following: missing mix design 'know-how', misleading specifications or both. Of course, poor construction can to considerable extent degrade the effects of even optimal design. Needless to mention, some interactive 'phenomena', effective on a micro- and nano-scale, and especially profound within bituminous mortar sub-system, almost not at all investigated in research laboratories, can to some extent affect the asphalt performance.

Common sense and valid research evidence not only support but cannot stress out more the importance of the fact that some crucial properties of asphalt composite - from resistance to permanent deformation to skid resistance - depend mostly on a single factor still not well understood and validated – **the 'packing' of the skeletal part of the aggregate mix expressed in volumetric grading**. <u>Figuring out or better accurately computing the optimum value of volumetric concentration of the skeletal part of aggregate blend with pores included at denied compaction - VC ss (por) /as max - is the crucial step ONE in any professionally successful asphalt mix design</u>. The nature of skeletal 'packing' and the total space occupied by the skeletal aggregate structure, which is in a function of energy transferred to the system, are uniquely defined by two mutually relational physical parameters **– Skeletal Structural Grading (SSG) and VC ss (por) /as max.**

The idea of this presentation is to illuminate and affirm the rational approach to the issue, indicate the existence of the meaningful Quality Assurance (QA) criteria, and emphasize the fact **that intelligent design solutions practically stay out of reach, unless is employed the latest generation of powerful optimization tools 'built in' in already available commercial asphalt software. Simply, the substantially complex optimization procedures CANNOT be carried out successfully / processed within minds even the most gifted asphalt engineers and researchers. The assistance of advanced technology implemented in a daily working asphalt environment is required.**

There is a way out from the substantial abuse of both resources and logic in the asphalt industry. Asphalt composite material CAN BE premium, consistent, high quality, environmentally friendly, comparatively inexpensive, and competitive product, but only by implementation of rational approach, particularly in mix design process.

2. BACKGROUND

2. 1. Conventional in Aggregate Grading and Mix Design

"The design of asphalt paving mixture is largely a matter of selecting and proportioning constituent materials to obtain the desired properties in the finished pavement structure. " (The Asphalt Institute). But, HOW to achieve what we desire when conventional mix design methods are fundamentally experience based and provide us with neither universal guidance nor safe 'procedures' / physically validated criteria for the QCQA during entire asphalt process? The aggregate grading design and evaluation are part of this core issue.

Traditionally, asphalt mixtures have been designed using a trial and error procedure to select the aggregate gradation. The methods are based on the following:

- **The acquired experience with local materials,**
- **Conditional maximum density concept,**
- **Mass proportioning, and**
- **Missing idea for a creation of physical 'separation line' between skeletal aggregate structure & the filler (mix).**

In general, for the aggregate grading the Fuller's maximum density curve is used with some attached warnings such as:

"Stay away from the maximum density line to increase VMA (Voids in the Mineral Aggregate)",
"Stay at the middle of the specs", and
"Keep it well-balanced and go for continuity"

At the most, the above experience may relate only to what types of gradations to avoid so that construction-related problems such as segregation and tenderness of the asphalt mixture are prevented.

Apparently, **there is no relational interpretation for the effect of gradation on key mixture properties**.

Without proper asphalt software optimization tools and without clear guidance for both – the optimization of skeletal structure gradation (includes the functional equation that describes the effective 'space' occupied by SSG) and the optimization of bituminous mortar - most engineers would have just a very limited opportunity to learn, and only through experience, HOW the change in gradation affects the specific mixture properties. **NOT ENOUGH for the skills acquisition and professional competence.**

As result, there are serious unresolved issues in the asphalt field such as:

- COMPARABILITY,
- CONSISTENCY,
- PREDICTABILITY,
- CONSTRUCTABILITY,
- COST-EFFICIENCY

All above indicates the **profound luck of REAL CONTROL in the process**

We should be ALL aware of the fact that almost everywhere in the world next to obvious and less obvious failures lay our successes – the true perpetual asphalt paving layers. Such 'old-fashion' way, without costly modifiers, 'randomly' well designed Dense Graded Asphalt Concrete (DGAC) composites are in impeccable shape and service condition for decades. Despite of multitude increase in traffic loads (tires contact pressures and acceleration / breaking forces) and severe environmental loads there are NO major signs of fatigue – no surface and / no structural damages.

Strictly speaking, so far, with conventional approach **we couldn't get what we 'desire'**, especially when dealing with asphalt composites that represent **a combination of different density aggregate fractions**, **'rich' filler mix, and various purpose modifiers.** Almost any attempt to bring the 'physical order' into aggregate design was futile, including the SHRP initiative when suggested two additional features to the traditional 0.45 power chart: control points and a restricted zone.

However, there are two promising approaches based on fundamental respect for mix physical properties, and reality: The Bailey Method, and The Rational Asphalt Technology Skeletal Aggregate Design Method ©.

2. 2. Rational in Aggregate Grading and Mix Design

2.2.1. The Bailey Method of Aggregate Blending and Evaluation

The Bailey Method for gradation selection considers the 'packing' characteristics of aggregates. The parameters in the method are related directly to Voids in the Mineral Aggregate (VMA), total air voids, and compaction properties.

The Bailey method is a relatively comprehensive 'guess & trial' gradation evaluation procedure to provide "aggregate interlock as the backbone for the aggregate skeleton". In this method is applied 'blend within blend' principle. Fine aggregates are those particles that can fill the voids created by the coarse aggregates and division is not related to the conventional No. 4 sieve (4.75 mm) or European equivalent 4 mm sieve opening. The sieve that separates the coarse and fine aggregates is called the Primary Control Sieve (PCS). It is dependent on NMPS - the Nominal Maximum Particle Size - of the aggregate blend. The PCS is with reasonable accuracy mathematically defined as 0.22 of the NMPS based on two and three dimensional analysis of the packing of different shaped particles. Furthermore, the aggregate blend below the PCS is divided into coarse and fine portions, and each portion is evaluated. The method provides a set of tools that allows the evaluation of aggregate blends indirectly incorporating some other aggregate properties such as internal friction, angularity, etc.

Aggregate ratios, which are based on particle packing principles, and the relative proportions passing certain critical sieves, are used to analyze the particle packing of the overall aggregate structure. The Coarse Aggregate ratio (CA Ratio) is used to characterize the packing and size distribution of the coarse portion of the aggregate blend. The coarse portion of the fine aggregate is evaluated using the Fine Aggregate ratio of the coarse portion (FAc), and the fine portion of the fine aggregate is evaluated using the Fine Aggregate ratio of the fine portion (FAf). All these ratios are calculated using the mathematical equations relating the amount of aggregate passing specific critical sieve sizes.

In summary, the Bailey Method involves the following approach:

- Evaluates packing of coarse and fine aggregates individually
- Contains a definition for coarse and fine aggregate
- Evaluates the ratio of different size particles
- Evaluates the individual aggregates and the combined blend in volumetrics

The Bailey Method represents not a free guessing but a 'free' approximation in attempt to rationalize the aggregate gradation procedure.

2.2.2. The Rational Asphalt Technology Skeletal Aggregate Design Method ©

The most successful rational attempt to solve the key issue of any asphalt mix design - the effective optimization of the skeletal structure of aggregate blend – was partially brought to attention of the international asphalt community in mid eighties (Figure 1). The Rational Asphalt Technology Skeletal Aggregate Design Method © is in compliance with physical reality for asphalt mixtures. It is proven in the field in more then 1,200 highly demanding projects (over 30 million tons of laid down asphalts). It is accepted by all professionals that came across it - from mix design and troubleshooting engineers to diagnostics and status verification consultants and researchers.

The following features should be outlined:

- **A Border Line Establishing Between Filler Mix and Larger Skeletal Aggregate Particles.**

The very first thing that happens during plant mixing process is an immediate mutual attraction between filler mix particles and highly viscous and easily migrating parts of binder. Therefore, a filler mix issues, including the physical and chemical interactivity with bitumen, must be treated separately from the skeletal aggregate structure 'packing'. Such issues clearly belong to domain of bituminous mortar characterization. For each specific case the borderline must be determined within range 63 - 125 microns. Frequently, it is around 90 microns.

- **Skeletal Aggregate Structure Power Grading Design Is Expressed in Volumetric Percentages with Pores Included.**

A sieve, as the prime measuring device, DOES NOT 'recognize' a mass of a particle, but its diameter / volume. Also, a sieve DOES NOT 'recognize' if aggregate particles are with or without pores. (The particles are with 'open' / accessible pores.) Furthermore, the aggregate fractions are often either of different geological origin and / or passing different manufacturing process. This suggests that both porosities and densities could vary significantly. All mentioned above MUST be taken into consideration for valid skeletal aggregate design, including accurately measured and updated spatial physical values of the aggregate sub-fractions - densities with pores included. Power skeletal aggregate grading design expressed in volumetrics with pores included is the only physically correct choice. The general rule is that the optimized 'curve' is always well-balanced and mathematically smoothened especially for dense-graded aggregate structures. The final 'curve' adjustments depend on the required / available space for bituminous mortar functional constituents (less the absorbed part of binder). ALL 'fine-tuning' style computerized adjustments take place at the state of 'denied compaction' as a referent level.

- **Comprehensive and Physically Workable Rational Asphalt Model © (Figure 1a)**

Such asphalt model makes possible COMPARABILITY between two or more asphalt compositions in a process of correct validation and performance evaluation. The theoretical model is field verified. It functions under condition that specific equi-viscous temperatures for selected (un)modified bitumens during mixing and laying down are applied and respected.

- **Low of Skeletal Aggregate 'Packing' (Figure 1b)**

Volumetric Concentration of stone skeleton in the asphalt specimen (layer) at 'denied' compaction - VC ss / as max) [%] is in direct function of mathematical integral representing the surface area 'below' simulated Skeletal Aggregate Grading 'Curve' I [cm^2]. This equation is the cornerstone for OPTIMUM mix design, constructability, and performance criteria development.

This was the real breakthrough. Low of Skeletal Aggregate 'Packing' successfully relates the specific skeletal aggregate grading with the exact volume occupied at the state of 'denied' compaction - when particles are still not prone to re-granulation caused by excessive compaction force. Factors 'A' and 'B' indirectly represent all imaginable physical properties of the skeletal structure particles. It is obvious that presence of rounded particles such as natural send creates troublesome 'spatial' states. Factor 'C' is closely related to that issue.

- **Law of Compaction (Figure 1c)**

Here is brilliantly formulated relation between Volumetric Concentration of stone skeleton with pores included in asphalt layer at 'Denied' Compaction (VC ss (por) / as max) and energy (E) transferred to the system – i.e. the specific asphalt paving mixture. The other functional parameters influences are indirectly incorporated in factors 'A', 'B' and 'C',

- **Rational Behind Skeletal Structure Selection (Figure 1d)**

Theoretically, a 'million' grading 'curves' could be constructed .between 'zero' point, which is filler borderline and NMPS (if NMPS and D max are identical) or 'linearly' extrapolated point value laying between NMPS and D max. The optimization process is carried out by the following criteria:

- **In a case of Asphalt Concrete (AC) paving mixtures those criteria are: Maximum skeletal densification, Minimal cost, and Minimal energy expenditure.**
- In a case of gap-graded skeletal structures, such as per example SMA, the rest of the 'space' available is filled out by bituminous mortar functional constituents (profoundly by added filler and the 'excesses' of bitumen).

The adequate asphalt software solutions make possible and easy the necessary fine 'playing' with both skeletal structure and bituminous mortar functional constituents during final optimization procedures.

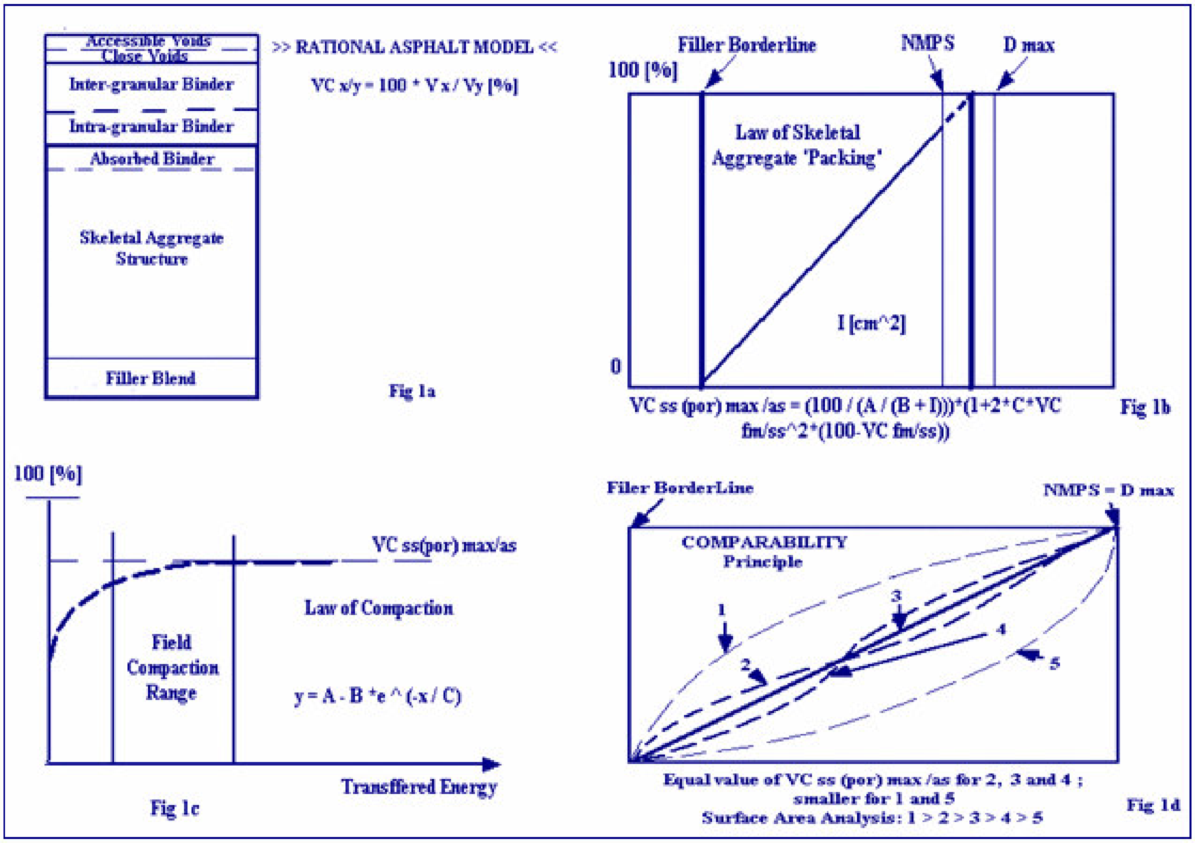

Figure 1 Rational Asphalt Technology © Skeletal Aggregate & Mix Design Features

3. EXPERIMENTAL

3. 1. Objectives

<u>Selected analytical approach and testing methodology in characterization of asphalt paving mixtures could differ. The physical laws and the rational criteria for design and evaluation have universal verifiable validity</u>. Therefore, there is no point in preferring one over any other type of asphalt paving mixture for this study. The choice - DG AC 11s, DG AC 16s, OG SMA 11- was made out of convenience. The selected composites were in frequent use for surface layers all over Europe in the last several decades.

First, the appropriate asphalt software has to be selected for this study. It must have a capability to give out the optimized skeletal aggregate grading according to both The Bailey Method and The Rational Asphalt Technology Skeletal Aggregate Grading Design Method © using the identical input –i.e. mineral material constituents.

- For Asphalt Concretes: crushed aggregate fractions of eruptive origin, with added filler and 'zero' high quality fraction of carbonate origin;
- For SMA: not double crushed, but the same regular eruptive stone fractions plus carbonate added filler.

Second, the chosen software must have as 'built in' feature the Rational Asphalt Technology © algorithms and the other related and relevant QCQA criteria for mix design optimization. The software determines the bitumen type, the bitumen content, and the bitumen functional constituents ratio. All is taken into account: the key material properties, traffic & environment parameters, pavement relevant factors, prices, and the other input that influences workability and compactibility. **Bitumen type selection is not only according to SUPERPAVE Performance Grade criteria, but also includes the origin and the processing characteristics. Strict control must be observed on equi-viscous temperatures for mixing (0.2 Pa s) and compaction (20 Pa s).**
Third, the software of course must have some capability of static and dynamic loads simulation modeling.
Fourth, asphalt paving mixture composition pre-determination will be followed by lab specimen preparation and testing.
Finally, results will be analyzed and commented.

The goal of the rational mix design is always the creation of an OPTIMUM asphalt composite material for the purpose intended. Structural soundness of the material is what counts, not the amount of testing or 'sophistication' of (dynamic) testing equipment. For those able not to misinterpret testing results there won't be any surprise. Such sound material has to be fairly easily constructed, compatible with interactive layers within pavement structure, on the long run unaffected by 'trigger' conditions (adverse traffic and environmental factors), cost efficient and, if possible, environmentally friendly.

3. 2. Software Simulation

Asphalt Expert System ® seems to be the right technology choice for this specific multi-level task: comparison of two aggregate grading methods, comprehensive simulation modeling, and according to 'COMPARABILITY principle fulfilled' the results evaluation. Among many stand alone applications, several programs were perfectly tailored for this job: The Modified Bailey Method ®, Grand Rational Mix Design ®, and Status Verification ®. Last two programs have the unique capacity for the skeletal aggregate structure optimization at the highest conceivable math level (Figure 2), and the cost-efficient functional constituents optimization according to valid criteria for Rational Asphalt Technology Mix Design Method ©. Output is always presented in both volumetrics and conventional mass units.

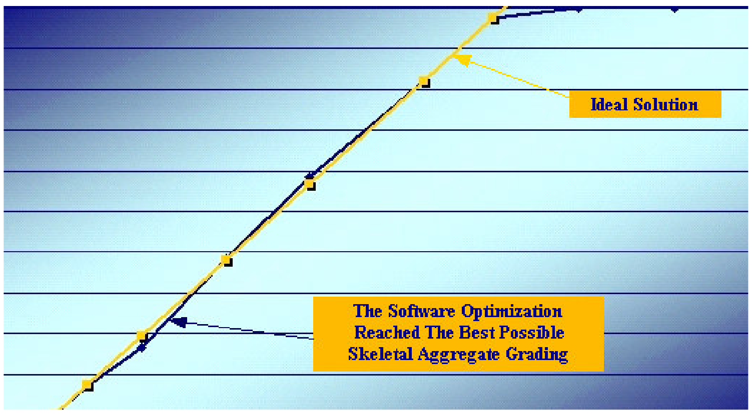

Figure 2 : A Screenshot of Typical Skeletal Aggregate Design Intelligent Solution Provided by the Non-linear Optimization Technologies

The programs also take into account the following: applied specs, traffic & environment loads, constructability factors, and pavement conditions (Figure 3).

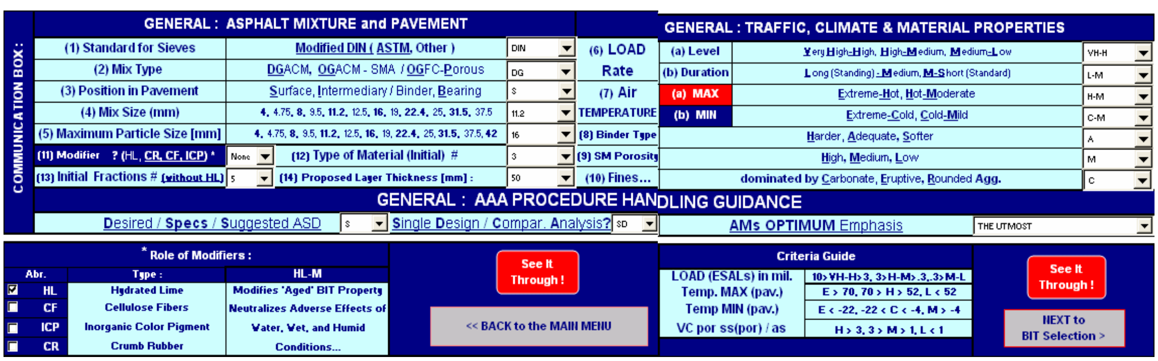

Figure 3 : A Screenshot of Asphalt Expert System ® General Selection Parameters Menu / Guide

In addition, there is capacity for simulation modeling that includes the field assessment of a mixture performance in regular and extreme conditions. Some applications can produce in advance, along the volumetrics, the 'mechanical' values such as Marshall Stability in function of water absorbed by the specimen, and the Indirect Tensile Stress (beta version). Asphalt Expert System ® not only effectively delivers intelligent solutions assuring resistance to permanent deformation and fatigue resistance but to some extent successfully tackles issues such as resistance to low temperature cracking and moisture induced damages.

3. 1. Indirect Tensile Strength

This test is one of the often used worldwide in attempt to characterize asphalt paving mixtures describing mixture cohesion. The indirect tensile strength at failure is used in the analysis of three pairs of samples prepared the standard way using gyratory compactor.

4. RESULTS

4.1. Analysis

The bitumen type selected by the software was PG 64-22 for ACs. Even though, the software allows selection of various modifiers such as Hydrated Lime (HL), Crumb Rubber (CR) etc., nothing of it was used for SMA 11, but PmB 45, the polymerized equivalent from DuPont Elvaloy ® product line, plus commercial Cellulose Fibers (CF) against draining down.

Both, Indirect Tensile Strength values and Marshall Stability values reached in the lab correlate highly to the software predicted values (0.92 and 0.94 respectively). What is particularly important is the finding that relatively small 'added value' in the mathematical curve 'smoothening' during final optimization in software skeletal aggregate design produces an incredible 'extras'/ increments in quality of structural 'packing', which is specifically seen in the core quality of AC 16s composite material. It is practically impossible to reach such quality of 'packing' by 'manual' adjustment of volumetric grading, even if sieves passing of fractions provide favorable conditions for skeletal design. It is clear that with the software assistance each design could be substantially improved in ALL important aspects irrespective of the method used. The highly relevant 'output' is shown in self-explainable Table 1 and Table 2.

By the Software Optimized & Simulated Skeletal Aggregate and Mix Design for AC 11								
Sieve Oppenings in (mm) & Passings in (% m/m)								
0.09	**0.25**	**0.71**	**2**	**4**	**8**	**11.2**	**16**	22.4
7.1	13.7	21.9	41.2	59.5	82.6	97.5	100	100
Fractions Participations in (% m/m)							Bitumen Content on Agg. M. in (% m/m)	
Add. Fil.	**0/2**	**2/4**	**4/8**	**8/11**	11/16	16/22		
3.2	41.8	5.1	24.1	25	0	0	5.44	
VC ss(por) / as max in (% v/v)		For VTM (voids total in mix) = 5%			Marshal Stability in (kN)		ID Tensile Strength in (N/mm^2)	
		VC ss/as (% v/v)	VC bm/as (% v/v)	Density as (t/m^3)	Simul.	Lab	Simul.	Lab
85.6		81.8	13.2	2.540	12.37	13.4	2.41	2.3

By the Software Optimized & Simulated Skeletal Aggregate and Mix Design for AC 16 s								
Sieve Oppenings in (mm) & Passings in (% m/m)								
0.09	**0.25**	**0.71**	**2**	**4**	**8**	**11.2**	**16**	**22.4**
5.7	11.3	18.2	34.4	50.1	69.6	82	97.6	100
Fractions Participations in (% m/m)							Bitumen Content on Agg. M. in (% m/m)	
Add. Fil.	**0/2**	**2/4**	**4/8**	**8/11**	**11/16**	16/22		
2.37	33.41	4.77	21.32	15.19	18.21	0	5.07	
VC ss(por) / as max in (% v/v)		For VTM (voids total in mix) = 5%			Marshal Stability in (kN)		ID Tensile Strength in (N/mm^2)	
		VC ss/as (% v/v)	VC bm/as (% v/v)	Density as (t/m^3)	Simul.	Lab	Simul.	Lab
86.5		82.6	12.4	2.553	20.53	19.4	2.72	2.65

By the Software Optimized & Simulated Skeletal Aggregate and Mix Design for SMA 11								
Sieve Oppenings in (mm) & Passings in (% m/m)								
0.09	**0.25**	**0.71**	**2**	**4**	**8**	**11.2**	**16**	22.4
10.4	13.5	16	23.1	33.3	55.9	93.1	100	100
Fractions Participations in (% m/m)							Bitumen Content on Agg. M. in (% m/m)	
Cel. Fiber	**Add. Filler**	**0/2**	**4/8**	**8/11**	11/16	16/22		
0.3	11	11	12	62.7	0	0	6.19	
VC ss(por) / as max in (% v/v)		For VTM (voids total in mix) = 5%			Marshal Stability in (kN)		ID Tensile Strength in (N/mm^2)	
		VC ss/as (% v/v)	VC bm/as (% v/v)	Density as (t/m^3)	Simul.	Lab	Simul.	Lab
74.8		73.2	21.8	2.557	13.41	11.4	-	2.2

Table 1 : Optimizations of Asphalt Mixtures According to Rational Asphalt Technology Design Method ©

By the Software Optimized & Simulated Bailey Skeletal Aggregate and Mix Design for AC 11								
Sieve Oppenings in (mm) & Passings in (% m/m)								
0.09	**0.25**	**0.71**	**2**	**4**	**8**	**11.2**	**16**	22.4
6.3	12.1	19.3	36.7	55.3	80.5	97.2	100	100
Fractions Participations in (% m/m)							**Bitumen Content on Agg. M. in (% m/m)**	
Add. Fil.	**0/2**	**2/4**	**4/8**	**8/11**	11/16	16/22		
3	35.9	6.1	27.2	27.8	0	0	5.69	
VC ss(por) / as max in (% v/v)		**For VTM (voids total in mix) = 5%**			**Marshal Stability in (kN)**		**ID Tensile Strength in (N/mm^2)**	
		VC ss/as (% v/v)	**VC bm/as (% v/v)**	**Density as (t/m^3)**	**Simul.**	**Lab**	**Simul.**	**Lab**
85		81.4	13.6	2.519	13.02	12.7	2.21	2.28

By the Software Optimized & Simulated Bailey Skeletal Aggregate and Mix Design for AC 16 s								
Sieve Oppenings in (mm) & Passings in (% m/m)								
0.09	**0.25**	**0.71**	**2**	**4**	**8**	**11.2**	**16**	**22.4**
5.4	9.9	15.4	29	46.3	66.2	82.3	97.7	100
Fractions Participations in (% m/m)							**Bitumen Content on Agg. M. in (% m/m)**	
Add. Fil.	**0/2**	**2/4**	**4/8**	**8/11**	**11/16**	16/22		
2.9	27.1	9	20.1	22.9	18.1	0	5.14	
VC ss(por) / as max in (% v/v)		**For VTM (voids total in mix) = 5%**			**Marshal Stability in (kN)**		**ID Tensile Strength in (N/mm^2)**	
		VC ss/as (% v/v)	**VC bm/as (% v/v)**	**Density as (t/m^3)**	**Simul.**	**Lab**	**Simul.**	**Lab**
86.3		82.5	12.5	2.544	19.42	18.7	2.65	2.56

By the Software Optimized & Simulated Bailey Skeletal Aggregate and Mix Design for SMA 11								
Sieve Oppenings in (mm) & Passings in (% m/m)								
0.09	**0.25**	**0.71**	**2**	**4**	**8**	**11.2**	**16**	22.4
11.4	14.8	17.5	24.9	35	56.7	93.5	100	100
Fractions Participations in (% m/m)							**Bitumen Content on Agg. M. in (% m/m)**	
Cel. Fiber	**Add. Filler**	**0/2**	**4/8**	**8/11**	11/16	16/22		
0.3	11	11	12	62.7	0	0	6.41	
VC ss(por) / as max in (% v/v)		**For VTM (voids total in mix) = 5%**			**Marshal Stability in (kN)**		**ID Tensile Strength in (N/mm^2)**	
		VC ss/as (% v/v)	**VC bm/as (% v/v)**	**Density as (t/m^3)**	**Simul.**	**Lab**	**Simul.**	**Lab**
75.8		72.9	22.1	2.531	13.75	12.5	-	2.3

Table 2 : Optimized Mix Design Initiated by the Bailey Method & Completed by Rational Asphalt Technology Mix Design Method ©

The energy given to the system is equivalent of 75 blows by Marshall Compactor. Voids Total in Mix (VTM) 'default' value is 5 %. Any other VTM could have been selected under condition that belongs to the same 'upper scale' of the compaction range. Role of the optimized accessible part of VTM in the field compacted asphalt mixtures is effective prevention against accelerated 'aging'. On another side, the inaccessible part of VTM should make the sufficient room for bitumen expansion at the high temperatures, especially in a case when highly porous aggregate fractions are used. Smart designer should always play down on the "significance of VTM". Rational design approach always looks FIRST how to optimize skeletal 'packing', which gives structural strength to the asphalt composite. Bituminous mortar optimization secures cohesion and indirectly the rutting resistance. The way to prevent rutting through mix design is to optimize asphalt mortar soft & firm phase and provide a volumetric concentration which is equal or slightly less then the space available after optimization of skeletal aggregate structure VC bm / as opt < = 100 - VC ss (por) / as max.

The obtained results clearly indicate that SMA paving mixtures should be replaced by substantially cheaper (35 - 50 %) Premium Asphalt Concretes (PAC). The software guided skeletal aggregate grading adjustments and optimum mix design would allow extra savings within 3 -7 % range depending on specific conditions and the type of asphalt.

5. CONCLUSION

The main purpose of this paper was to outline the basic critical principles and rational criteria for an optimum skeletal aggregate design and structural evaluation as the significant step ONE towards fully rational mix design. Such guidance is physically valid and applicable to ANY conceivable type of asphalt paving mixture. Nature of this study also includes an upgrade to the rational mix design level.

Unless re-processed and positively altered by powerful software optimization technologies The Bailey Method skeletal aggregate design would show itself as much less potent in comparison with Rational Asphalt Technology Skeletal Aggregate Design Method ©.

Author must point out that practically the optimum solutions stay beyond reach unless is used asphalt software with 'built in' the latest generation of non-linear optimization technologies and adequate expert knowledge base.

Asphalt industry, asphalt research and investors should be aware of the fact that continuing with conventional approach in design and evaluation of asphalt paving mixtures always bears potential for (massive & costly) abuse of resources and rational thinking. Eventual 'in depth' analyses on this subject would clearly go beyond the scope of this paper

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