A Performance Catalogue of Wearing Courses for Road Pavements

Agostinacchio M.
Full Professor in the Department of Architecture, Planning and Transportation Infrastructures (University of Basilicata)

Boscaino G.
Full Professor in the Department of Road Infrastructures Engineering (University of Palermo)

Dondi G.
Full Professor in the Department of Structures, Transportation, Water and Territory Survey Engineering (University of Bologna)

SYNOPSIS
Nowadays road construction has to satisfy essential requirements like safety and eco-compatibility of traffic, especially from the standpoint of paving surface properties.
For the time being, the satisfaction of these needs is based more and more on performance parameters (friction, evenness, bearing capacity, vibrations, noise, etc.) and relative benchmarks.
To facilitate this quality system to work properly, it is necessary to specify and characterize the functional relationship between composition, production and performance indicators. These problems are the basis of the proposed research program, whose target can be identified as the conception and development of a systematic catalogue of wearing courses in which the relationship between mix-composition and production, pavement construction techniques and performances are fixed and specified with adequate reliability.
In order to allow the drawing up of such a catalogue, a test program on a selected set of bituminous admixtures for road surfaces was carried out.
At the end of the project (December 2003), the results were reported and the Authors proposed an integration of the catalogue itself with further inter-laboratories collaboration.

A Performance Catalogue of Wearing Courses for Road Pavements

INTRODUCTION

As for the issues connected with safety, environment friendliness and, more in general, superficial characteristics, the road pavement is of great importance.
Furthermore, the general requirements tend to ask for higher standards from the point of view of performances (roughness, evenness, bearing capacity, noise reduction, etc.), the binding force of the "Execution Specifications" being sometimes relegated to minor applications.
Because of the above mentioned issues, which are basically agreed by both law and scientific world, fundamental is the role of the so-called "Performance Specifications": by means of these rules it is possible to manage, in a continuously developing market, the relations between clients (most of the times Local Authorities) and Building Contractors, on the basis of "performance codes" founded on a series of functional indicators.
As they can influence all the phenomena connected with the tire-surface contact, these codes are fundamental, the overall user safety, as well as comfort, environmental friendliness of road transportation from the view point of both pollution (noise and vibration) and energy consumption (petrol and tires) being, as a matter of fact, fundamental.
In order to validate the "performance" system relations between client and contractor, after the former requests, the latter should refer to certain indications on the instruments (materials, techniques, etc.) which are to be referred to for the success of the overall process.
In such a complex scenario ruled by the increase of performances request and by both costs and maintenance conveyance towards Local Institutions, the need for clear and reliable rules combining performances and executions is significant.
Referring to such requirements, in 2001 a relevant national project named "Set up of a performance catalogue of wearing courses for road pavements" was co-funded; the aim of the project, which is now finished, was the establishment of a reference for a realisation process which would combine execution and resulting performances.

THE RESEARCH PROJECT AND THE PERFORMANCE CATALOGUE

The optimisation process for the wearing courses performances can be implemented only if the connections between such requirements and the overall composition variables of execution are known.
This project intended to define a systematic reference point for both execution and maintenance; it was co-funded by MIUR (the former MURST) in 2001 and, in two years, involved three research units, the coordinator being Prof. Gabriele Boscaino:
- University of Basilicata: Research Manager Prof. Michele Agostinacchio (Department of Architecture, Planning and Transportation Infrastructures);
- University of Palermo: Research Manager Prof. Gabriele Boscaino (Department of Road Infrastructures Engineering);
- University of Bologna: Research Manager Prof. Giulio Dondi (Department of Structures, Transportation, Water and Territory Survey Engineering).

Every research group was composed by other lecturers and research fellows, as indicated in Table 1.
The project development was based on two main activities:
a) Finding of the mixes which were to be included in the Catalogue;
b) Implementation of a procedures manual.

After a survey on the national most commonly used techniques for building and maintaining road pavements[1], conducted with the Institutions in charge for such interventions, the researches decided to start working on five main wearing courses typologies (see Table 2):
M01. Traditional wearing course with calcareous aggregates;
M02. Traditional wearing course with both calcareous and basaltic aggregates;
M03. Wearing course with calcareous and basaltic aggregates, plus expanded clay;
M04. Draining wearing course;

[1] The survey considered the land differences (environmental conditions, aggregates availability, etc), as well as the required performances with respect to both traffic and the function of the route.

M05. SMA wearing course;
All the composition characteristics of each of them was clearly defined[2].

Table 1: Research group composition

PRIN01 SET UP OF A PERFORMANCE CATALOGUE OF WEARING COURSES FOR ROAD PAVEMENTS		
National coordinator: Prof. Gabriele Boscaino		
Research unit n.1	Research unit n.2	Research unit n.3
University of Basilicata	University of PAlermo	University of Bologna
Research Manager: Prof. M. Agostinacchio	Research Manager: Prof. G. Boscaino	Research Manager: Prof. G. Dondi
Research Group: Prof.M. Diomedi Ing. S. Olita Ing. D. Campa Geom. V. Tedesco Experimental laboratory: Department of Architecture, Planning and Transportation Infrastructures	Research Group: Prof. A. Lo Bianco Prof. G. Di Mino Prof. F. Praticò Prof. L. Bruno Ing. R. Vaiana Ing. J. Nigrelli Geom. A. Lorello Experimental laboratory: Department of Road Infrastructures Engineering	Research Group: Prof. A. Simone Ing. C. Sangiorgi Experimental laboratory: Department of Structures, Transportation, Water and Territory Survey Engineering

For this purpose, the needed quantities of components (aggregates, bitumen, additives) were collected, the corresponding physical and mechanical properties being therefore determined.
Every research unit joined the project sharing laboratory facilities and staff, according to a portioning out plan depending upon the available facilities themselves.
For the sake of the reproducibility of the tests, all the experimental sessions were based on the use of procedures coded in a manual implemented by the research units themselves.
The mixes were severely tested in order to get to the clearest possible characterisation from the standpoint of both composition and performances, the results being inserted in a report called "A PERFORMANCE CATALOGUE OF WEARING COURSES FOR ROAD PAVEMENTS" , Ed. n° 1/04, available upon request.

Table 2 Schema di composizione delle miscele

	AGGREGATES				BITUMEN		
COMPONENTS ➩	**I01**	**I02**	**I03**	**A01**	**L01**	**L02**	**MIX TYPOLOGY** ⇦
M01	☒				☒		**Traditional wearing course**
M02	☒	☒			☒		**Traditional wearing course**
M03	☒	☒	☒			☒	**Wearing course with expanded clay**
M04	☒	☒				☒	**Draining wearing course**
M05	☒	☒		☒		☒	**SMA wearing course**
	Limestone	**Basalt**	**Expanded Clay**	**Lime**	**Traditional Bitumen**	**Modified Bitumen**	

[2] Referring to the adopted symbology for the code system of components and mixes, I0X stands for the aggregate (0X=1÷3), L0X for the binder (0X=1÷2) and M0X the mix (0X=1÷5).

PROCEDURES MANUAL

All the experimental activity, no matter the research unit operating, followed a unique and particular system of procedures which was checked out with a specific control programme and collected into a dedicated section inside the Catalogue itself.
Just as an example, the procedures for Roller Compactor plates compactions and rutting tests are reported (Table 3 and Table 4).

Table 3: Roller Compactor plates compactions procedures

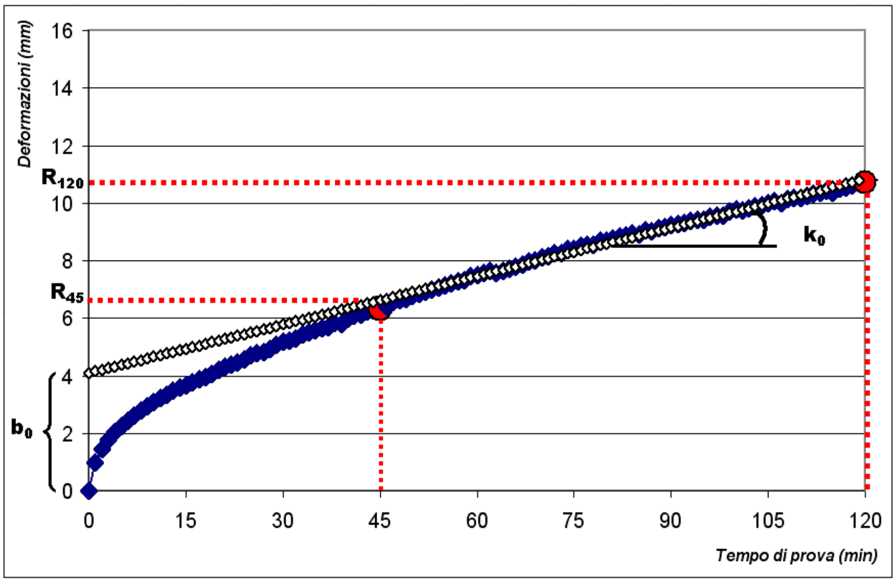
 	
Referring Standards	**prEN 12697-33** Bituminous mixes – Test methods for hot mix asphalt – Part 33: Specimen preparation slab compactor; **CME 54.18 – Belgian Standards** Essai au simulatour de trafic (Essai d'ornierage sur revetements hydrocarbones a partir de melanges fabriques en laboratoire); **C.N.R. - B.U. n° 30/73** Determinazione della stabilità e dello scorrimento di miscele di bitume e inerti lapidei a mezzo dell'apparecchio Marshall.
Purpose and applications	This procedure indicates a methodology for the realisation of dowel-plates of bituminous mixes with known characteristics from the viewpoint of both density and volume.
Tests apparatus	- Vibrating plate for a pre-thickening of the bituminous mix; - Compaction simulator (Roller compactor). It is made of an electric-pneumatic system reproducing, by means of a swinging mechanism of a metallic cylinder, the compaction effect of the roller usually adopted for roads construction; - (Metallic parallelepiped formwork with internal dimensions of 30,5 x 30,5 x H cm. - The height H varies according to the final thickness s of the dowel-plate ($s \leq 2/3\, H$).
Bituminous mixes preparation	See the P23 Procedure.

Design thickening study of the dowel-plates	The thickening management of the dowel plates inside the Compaction Simulation takes place through the setting of the following parameters: - Final thickness of the compacted specimen; - n°4 levels of pressure, the sector roller number of passages for each of them being programmable . The design thickening degree, in terms of apparent absolute gravity (MVA) is chosen from the density and volume data of the specimens, generally cylindrical, coming, for example, from: - compaction by means of the Marshall Hammer; - compaction with the Turning Press; - core samples taken from road sites. The design MVA is found referring to the following equation: $MVA_{design} = \Sigma\ (M_{i\ specimens} / V_{i\ specimens})$ per i =1,2,3…N where N = number of specimens used for the MVA_{design} calculation, never smaller than n°4; $M_{i\ specimens}$ = bulk of the “i” specimen; $V_{i\ specimens}$ = volume of the “i” specimen, geometrically calculated as follows: $V_{i\ specimens} = A_i \times h_{mi}$ where A_i = base surface of the cylindrical “i” specimen, h_{mi} = mean height of the “i” specimen calculated from n°4 measurements taken with a precision calliper. Once the final thickness *s* of the dowel plate is chosen, and imposing that $MVA_{plate} \equiv MVA_{desin}$, the overall process practically involves the calculation of the exact mass of the asphalt which is to be introduced into the formwork and is to be subsequently compacted: $M_{asphalt} = V_{plate} \times MVA_{design}$ where V_{plate} = dowel-plate volume after compaction 30,5 x 30,5 x s cm; MVA_{design} = Design apparent absolute gravity.
Compaction execution	The $M_{asphalt}$ bulk asphalt coming from the mix (temperature T_{mix} is function of the rheological characteristics of the binder adopted) with a temperature T_{comp} not lower than (T_{mix}-10°C) is inserted into the pre-heated formwork for about 12 hours at ≈150°C and it is subjected to a pre-thickening by means of the vibrating plate (n° 4 impulses of 15 secs each, the interval between each of them being around 10 secs). Placed into the Roller compactor, the asphalt is subjected to the so described 4 different pressure levels LP, imposed by the roller sector: 1° LP = 1,5 bar for n°5 passages (simulation of the finishing machine); 2° LP = 2,5 bar for n°30 passages; 3° LP = 4,5 bar for n°40 passages; 4° LP = 2,5 bar for n°20 passages. Actually, after the 3°LP, the asphalt goes up to the design density, which basically means that the dowel-plate takes the value of the design density. As a consequence, in this circumstance, putting the Roller compactor on a fixed height, further passages after the3° LP do not have any additional thickening effect but a sort of re-mixing of the cortical grains, the superficial texture of the dowel-plate being positively influenced. During the thickening phase, in order to avoid the asphalt sticking on the roller, the roller surface should be lubricated with soaped water or, alternatively, with a common 30,5x30,5 cm. paper sheet should be interposed between the bituminous mix and the roller surface itself.
Thickening degree of the dowel-plate check	The compacted dowel-plate is taken out from the formwork after 24h rest at room temperature and then the thickening degree is measured: $MVA_{plate} = M_{plate}/V_{plate} \geq 98\% MVA_{design}$ where M_{plate} = Plate bulk; $V_{plate} = 30,5 \times 30,5 \times s_{mean}$ cm; $s_{mean} = (\Sigma s_i)/N$, i =1, 2, 3… N=12; N = 4 *(n° of plate sides)* x 3 *(n° of measurements of the thickness s_i of each side of the plate)* = 12. (s_i is determined by means of a 1/100mm precision calliper) .
Shrewdness	It is advisable to univocally determine along the edge of the plate the rolling direction of the roller: an indelible felt-tip would work for the purpose. This reference will allow the user to perfectly position the dowel during the following performance tests.

For each of the experimental procedures, the referring Standards have been named, as well as the apparatus needed for the purpose and the methodology for both the specimens preparation and the results elaboration.

Table 4 Procedure for the rutting tests

	
Referring Standards	**British Standard – BS n° 598-110: 1998** Sampling and examination of bituminous mixtures for roads and other paved areas. Part 110: Methods of test for the determination of wheel-tracking rate and depth; **DRAFT prEN 12697-22** Bituminous mixes. Test methods for hot mix asphalt. Part 22: Wheel tracking; **CME 54.18 – Belgian Standards** Essai au simulatour de trafic (Essai d'ornierage sur revetements hydrocarbones a partir de melanges fabriques en laboratoire).
Tests apparatus	The test apparatus is made of a "traffic simulator" also called "rutting machine"; it is perfectly compatible with the prescriptions of the paragraph n°4 of the British Standard n° 598-110: 1998 and is mainly made of a loaded wheel put on a 30,5x30,5xh cm dowel-plate confined into its own formwork, the latter being fixed onto a moving plane whose motorised movement, driven by two small sliding tracks, is cyclic (back and forth) along a fixed moving length. The whole test area lies inside a thermal conditioning chamber. The prominent characteristics of the traffic simulator are described below: - Slick surface loading wheel solid rubber coated (Hardness 80±5 IRHD); external diameter of 200mm; 50 mm wide rectangular tread. - Overall load on the wheel: 520N (steady load + padding); - Moving plane stroke length: 230mm; - Swinging frequency of the moving plane: 42 passages per min; - Thermal conditioning chamber with adjustable temperature within the range 30°C÷60°C; - 25mm LVDT transducer for the continuous assessment of the rutting depth for 1 min intervals near the centre of the plate; - PC and software interface for the management of the main test parameters and the acquisition of the strain-time data.

Preparing of the mixes and casting of the specimens which were to be tested	The P23 procedure was followed for the specimens manufacture. The specimen (dimensions 30,5x30,5xh cm) to be tested under the traffic simulator must be inserted into a formwork (internal dimensions 30,5x30,5xH cm) for which H=h. In any case, one could refer to formworks with H>h, as long as a H-h thickness casting of gypsum mortar and/or a quick hardening cement grout is poured. In this case the rutting test must start only after a complete seasoning of the hydraulic mortar.
Test execution	The test can be performed at T= 45°C or T=60°C. The specimen which is to be tested must be saved at the test temperature for at least 12h before the start of the test session, which lasts for 120 min and is based on 5000 passages of the measuring wheel. Once the loading wheel and the padding are placed on the dowel-plate, the test execution is basically ruled by the interface managing software and is automatically performed. The tendency of the strain as function of the trial time is displayed in real time on the PC monitor together with the storage of the same data in text format file, for the sake of the following elaboration and results representation.
Results representation	Starting from the strain-time data, every dowel-plate tested under rutting tests is connected with the following characteristic parameters: - R_{45} = strain value in mm, recorded after 45 minutes of test; - R_{120} = strain value in mm, recorded after 120 minutes of test; - b_0 = intersection between the Y axis and the straight line obtained after the linear interpolation of the strain-time curve in correspondence of the interval [45min, 120min]; - k_0 = angular coefficient of the straight line obtained after the linear interpolation of the strain-time curve in correspondence of the interval [45min, 120min];  For the fixed test temperature, every bituminous admixture is represented by the arithmetic mean of the characteristic parameters of the strain-time curve of at least two dowel-plates, as below indicated with the apexes i and j: - $R_{45m} = (R^{i}_{45} + R^{j}_{45})/2$; - $R_{60m} = (R^{i}_{60} + R^{j}_{60})/2$; - $b_{0m} = (b_0^{i} + b_0^{j})/2$; - $k_{0m} = (k_0^{i} + k_0^{j})/2$.

MIXES COMPONENTS

The design mixes needed the supply of the components indicated in Table 2, each of them being identified by means of a file gathering the results of the characterisation and performance trials.
Table 5 includes a summary of the properties and the characteristics of the aggregates and the bitumen used for the purpose.

Table 5: Properties of the mixes components

Aggregates	Solid limestone	Basalt	Bitumen	Standard	Modified
	I01	**I02**		**L01**	**L02**
Shape coefficient	**2,10**	**2,64**	Ductility (cm)	**>100**	**>100**
Flattening coefficient	**1,54**	**1,65**	Density 25° (g/cmc)	**1,031**	**1,055**
Lengthening coefficient	**1,39**	**1,57**	Penetration PEN (dmm)	**64**	**55**
Shape index	**1,25**	**4,40**	Softening point PA	**47°**	**72°**
L.A. Weigh loss	**20,7**	**13,2**	Penetration index IP	**-1,41**	**3,5**
Humid Micro Deval	**7,0**	**9,0**	Fraass breaking point	**-8°**	**-15°**
Crushing coefficient	**113**	**85**	Dynamic viscosity γ' = 100 s^(-1)		
CLA coefficient	**0,39**	**0,48**	60° (Pa•s)	**19,45**	**27,13**
Apparent absolute gravity (g/cmc)	**2,84**	**2,99**	135° (Pa•s)	**0,08**	**0,25**
Real absolute gravity (g/cmc)	**2,86**	**3,00**	160° (Pa•s)	**0,035**	**0,11**
Voids ratio	**0,88**	**0,88**	60° (Pa•s) post RTFOT	**35,08**	**39,06**
Porosity	**0,72**	**0,42**	PEN post RTFOT (dmm)	**38**	**30**
Imbibition coefficient	**0,6**	**0**	Δ PA post RTFOT	**4°**	**7°**
Sand equivalent	**89**		BBR		
Rigden Voids	**31,29**		S(t)60 (MPa)	**136**	**260**
Stiffening Power	**10°**		T=	**(-12°)**	**(-18°)**
			m60	**0,44**	**0,35**
			Temperature LST	**-17°**	**-20**
			Temperature LmT	**-25°**	**-22**
			DSR		
			G*/sinδ (on plain bitumen) kPa	**1,87**	**1,46**
			T=	**(58°)**	**(58°)**
			G*/sinδ (post RTFOT) kPa	**5,72**	**3,23**
			T=	**(58°)**	**(52°)**
			G*•sinδ (post RTFOT+PAV) kPa	**3405**	**1238**
			T=	**(22°)**	**(16°)**
			Performance Grade	**PG 58-22**	**PG 52-28**

Origin

AGGREGATES
Limestone: Nord-West Sicily, place Giardinello (Termini Imerese - Palermo)

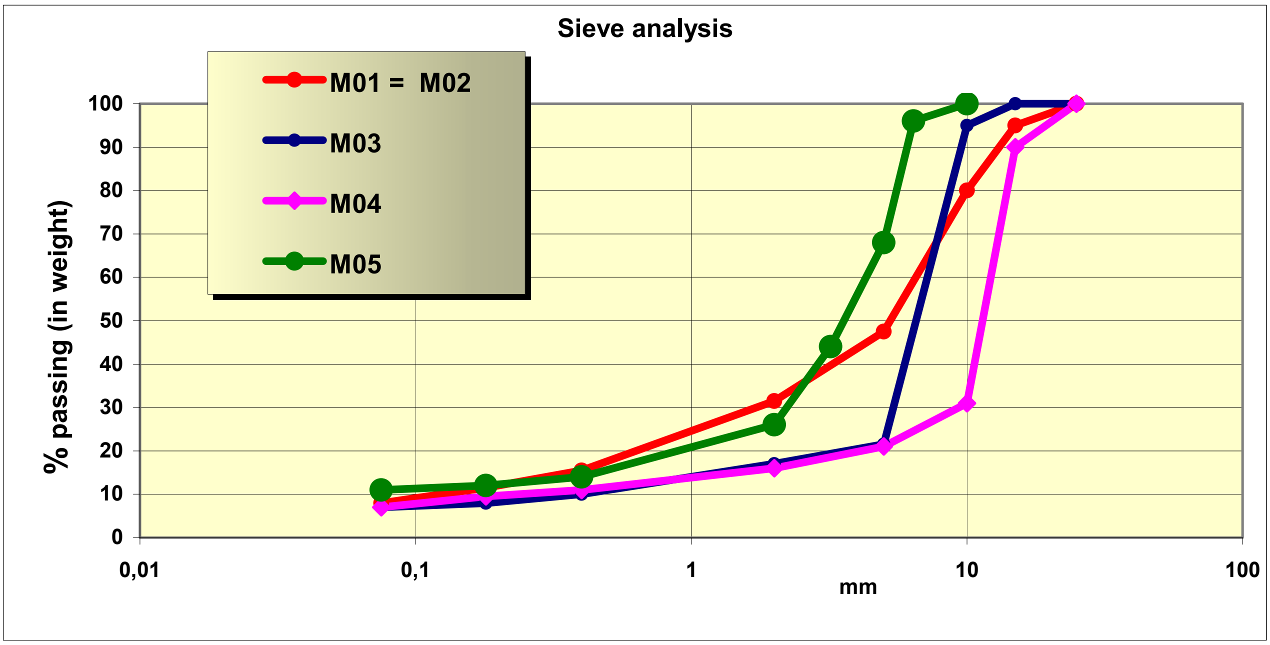
Basalt: West Veneto, place Lauri (Verona)

MIXES

As already stated, five mixes M01, .. M05 were prepared with the components I, L and A, according to the Table 2 scheme; Table 6 includes the particle size of the composition.
The M01 and M02 mixes can be considered as “traditional closed” mixes, as they are represented by the typical grading curve of the wearing courses prescriptions (with special reference to the Technical Contract Standards of the Società Autostrade, 1996) and the bitumen percentage has been chosen after the Marshall method optimisation.
The difference lay in the presence of basalt in M02, as most of the times requested for the sake of durability of performances in use.

The M03 admixture had a half-discontinuous grading curve with the presence of expanded clay; this technological solution is sometimes adopted in order to exalt the noise reducing characteristics of the layer as well as the potential superficial features which could be developed with time.
M04 was the classical draining compound; in this case also, the optimisation of the admixtures was ruled by the Marshall method.
A Stone Mastic Asphalt (SMA) solution was proposed with the mix M05, which is basically the material required when high performances from the viewpoint of both bearing capacity and superficial texture with reduced decay with time are needed.
The admixtures were obtained by mixing together discontinuous particle size, high quantities of filler and grit, modified binders and stabilizer agents (cellulose).

Table 6: Composition of the admixtures



Every mixes was completely tested to facilitate a clear assessment of the performance characteristics, the results being incorporated in Table 7.
As for the first solution M01, its features agreed with the specifications; it has been widely used for road pavements of West Sicily, because of the local abundance of the materials employed.
Actually, these calcareous materials are not always adequate for the sake of the superficial characteristics of the track under severe load conditions with time.
As a matter of fact, the change of such materials (10 mm retained) with similar size basaltic aggregates should avert the risk, especially after the very first use period, because of the loss of the superficial bitumen patina.
In the particular mix adopted, the not complete polyhedral shape of the aggregates caused a slight reduction in the mechanical performances, the values being in any case inside the specifications.
The use of expanded clay for the admixture M03 involved, as expected, a lighter conglomerate with a higher porosity, as well as a draining surface with reduced mechanical properties (see the strain under load conditions, rutting and static Creep): as for grip, the expected wear and tear of time should cause an improvement of the measured values.
The M04 mix represented a typical draining surface, a compromise solution between drainage, noise reduction and mechanical resistance.
Finally, the last mix was typical of a SMA material, closed, with high strength and significant superficial characteristics.
The complete results for all the five admixtures are included in the Catalogue: for example, in the following tables, some files are integrated, all of them referring to the M01 admixture.
A complete analysis of the properties of all the mixes, in any case, will be available only after the collection of the data belonging to the normal loading conditions experienced after some time of regular use of the materials.

Table 7 Performance features of the mixes M01, M02, M03, M04 e M05

M01 = closed wearing course with calcareous aggregates
M02 = closed wearing course with calcareous and basaltic aggregates
M03 = wearing course with calcareous, basaltic aggregates and expanded clay
M04 = draining wearing course with calcareous and basaltic aggregates
M05 = SMA (with 0,3% cellulose as stabiliser agent)

			Legante	**5,0% L01**	**5,2% L01**	**5,3% L02**	**4,9% L02**	**7,5% L02**
			Inerte	**I01**	**I01 I02**	**I01 I02 I03**	**I01 I02**	**I01 I02 A01**
Physical, mechanical and technological characteristics ⇨				**M01**	**M02**	**M03**	**M04**	**M05**
Physical and volumetric characteristics	MVA	Aparent absolute gravity	g/cmc	**2,54**	**2,55**	**2,10**	**2,19**	**2,44**
	v	Voids percentage	%	**3,00**	**3,97**	**12,60**	**18,60**	**3,80**
Marshall method	S	Marshall stability	Kg	**1.382**	**1.270**	**562**	**678**	**1513**
	R	Marshall stiffness	Kg/mm	**410**	**385**	**281**	**200**	**456**
	ΔS	Marshall stability loss	%	**11,00**	**8,30**	**11,00**	**25,30**	**2,50**
	Rt	Indirect tension (25°)	N/mmq	**2,20**	**1,32**	**0,70**	**1,30**	**1,80**
Turning compaction	Rt	Indirect tension (100giri)	N/mmq	**1,06**	**0,81**	**0,50**	**0,61**	**1,03**
	VA	Voids percentage (100giri)	%	**1,80**	**2,60**	**11,68**	**4,90**	**1,28**
Wear	c	Cantabro	%	**5,24**	**5,83**	**11,30**	**8,85**	**8,99**
Strain	i	Imprint	mm	**0,45**	**0,33**	**0,44**	**0,49**	**0,34**
Static Creep	J1	F(strain, t=1s) •10^6	cmq/ (daN•s)	**342**	**146**	**1560**	**1400**	**682**
	Jp	F(strain, t=500s) •10^6	cmq/ (daN•s)	**0,58**	**0,58**	**10,10**	**4,21**	**1,06**
	α	10•log(J10/J1)		**2,40**	**3,70**	**2,42**	**2,18**	**1,59**
Rutting	r45	Strain 45° 45 min	mm	**1,33**	**0,76**	**1,07**	**0,69**	**0,22**
	r120	Strain 45° 120 min	mm	**1,73**	**1,01**	**1,39**	**0,71**	**0,34**
	r45	Strain 60 ° 45 min	mm	**2,63**	**1,11**	**4,81**	**1,77**	**0,71**
	r120	Strain 60° 120 min	mm	**3,98**	**1,40**	**7,72**	**3,20**	**0,87**
Superficial features	BPN	Friction	BPN	**58**	**59**	**51**	**51**	**56**
	dren	Draining	sec	**401**	**425**	**9**	**12**	**730**
	HS	Sand height	mm	**0,86**	**0,88**	**3,79**	**3,63**	**0,58**[*]
	MPD	Mean profile depth (ISO)	mm	**1,03**	**1,02**	**2,55**	**2,74**	**0,68**
	AAD	Average Asperity Density	1/mm	**10,07**	**10,46**	**8,16**	**8,46**	**10,11**
	AAH	Average Asperity Height	mm	**0,15**	**0,14**	**0,22**	**0,27**	**0,11**

CONCLUSIONS

The catalogue herein synthetically represented is a scientific contribution to the technology of bituminous wearing courses for road pavements, which basically aims at reaching the purposes mentioned in the introduction.

The 1/04 version on the catalogue itself is to be intended as an open document for the addition of further mixes for superficial wearing courses, as:

- some laying will be prepared in order to assess the behaviour in use;
- every contribution from other research centres to the development of the catalogue, from the standpoint of wearing course typologies, would be much appreciated for a further edition, as long as the procedures and the uniformity adopted are respected;
- every Authority eager to check any particular situation, upon request, would find the help of the research units above mentioned.

For example, two wearing courses made of some mixes included in the catalogue are already being designed, in order to extend the results to the behaviour of real traffic conditions. This implementation is due to the contribution of the ANAS compartment of Palermo, Regional Administrative Department Highways and Motorways for Sicily.

[*] Value gathered after compaction by means of Roller Compactor compaction on specimens with an absolute gravity equal to the Marshall one. This value is susceptible of increase up to a value of 1 mm, in conditions of traditional compaction.

Eventually, to implement both the quality and the quantity of the first edition of the catalogue, the research units of Palermo, Basilicata and Bologna asked the MIUR for a co-funding for a dedicated PRIN04.

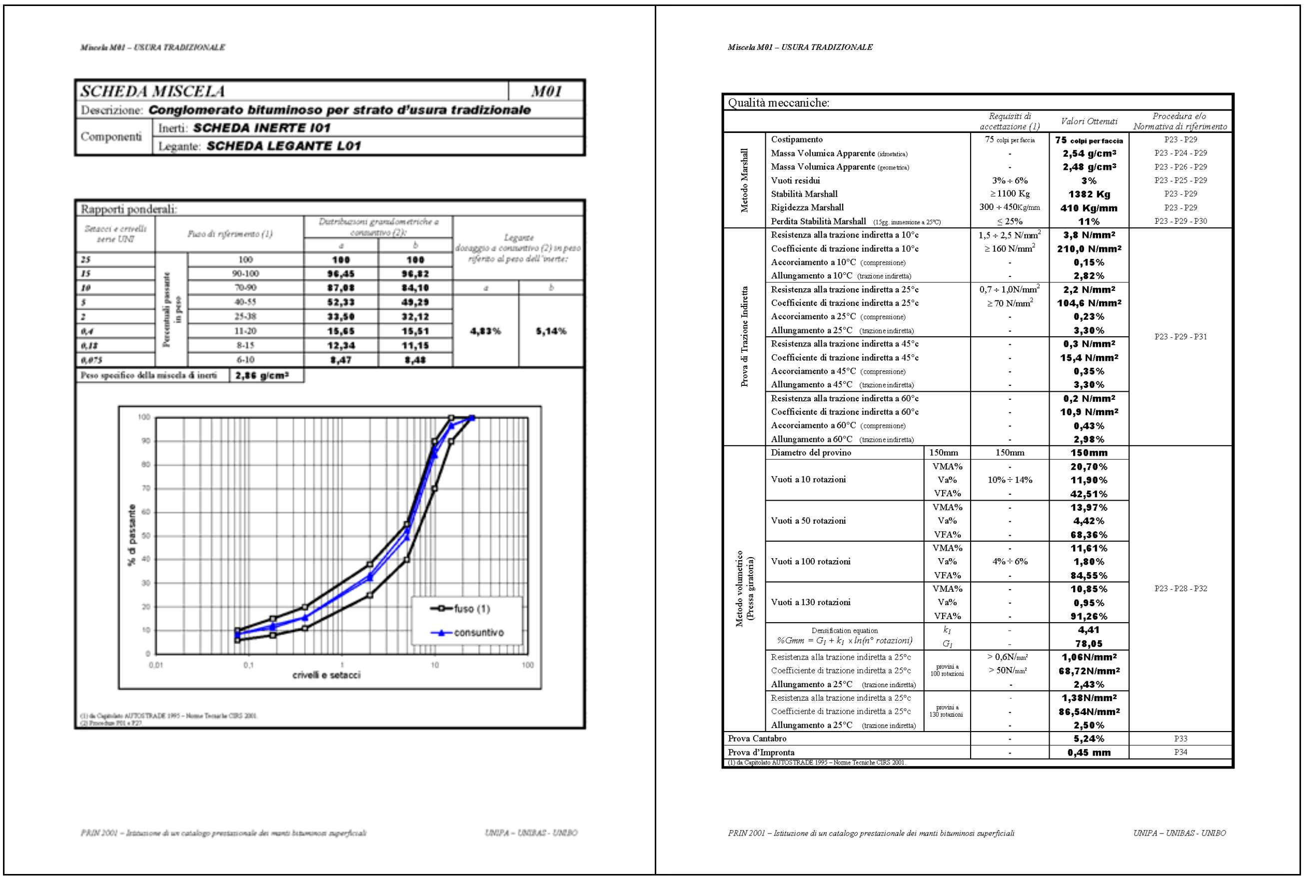


Table 8: Example of catalogue file (Mix M01)

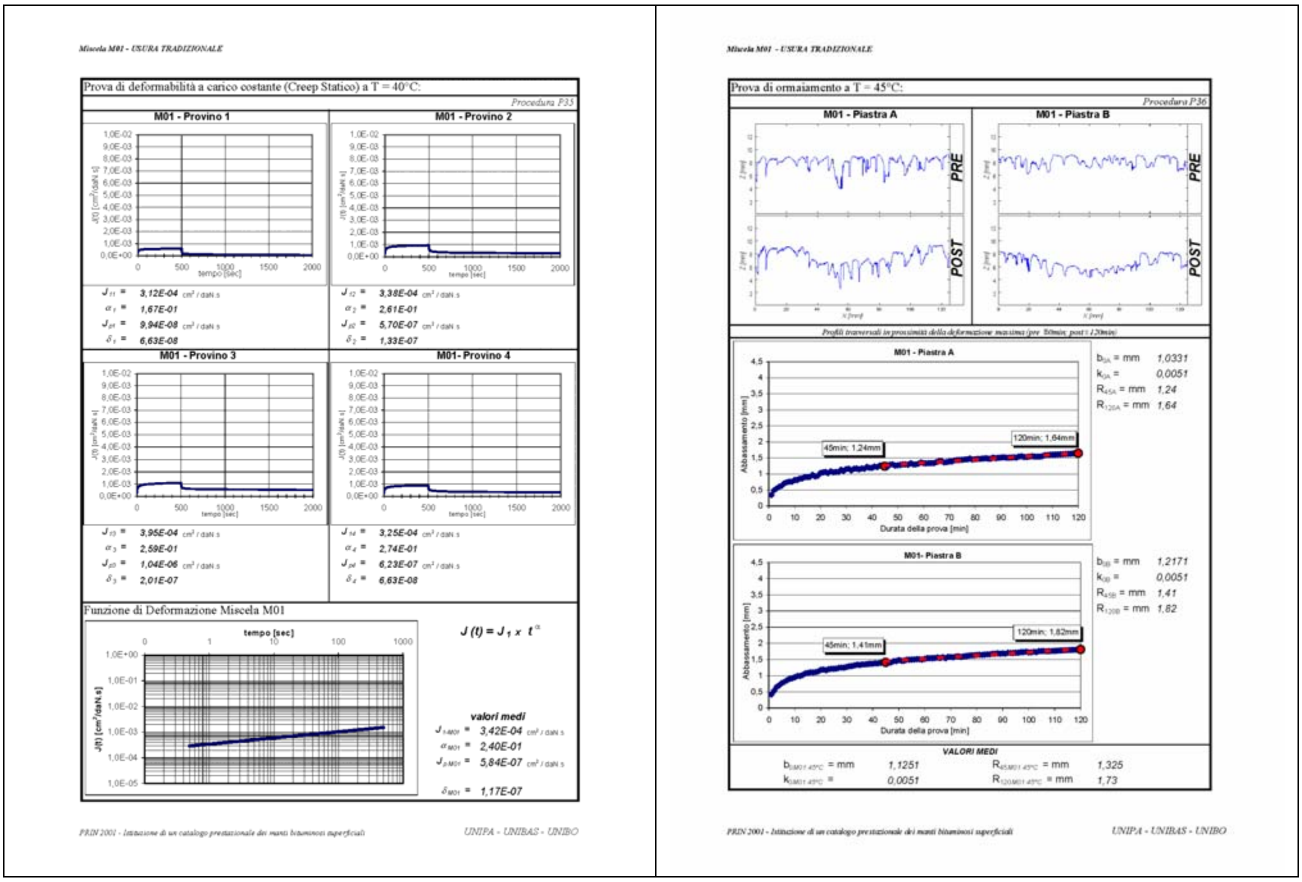


Table 9: Example of catalogue file (Mix M01)

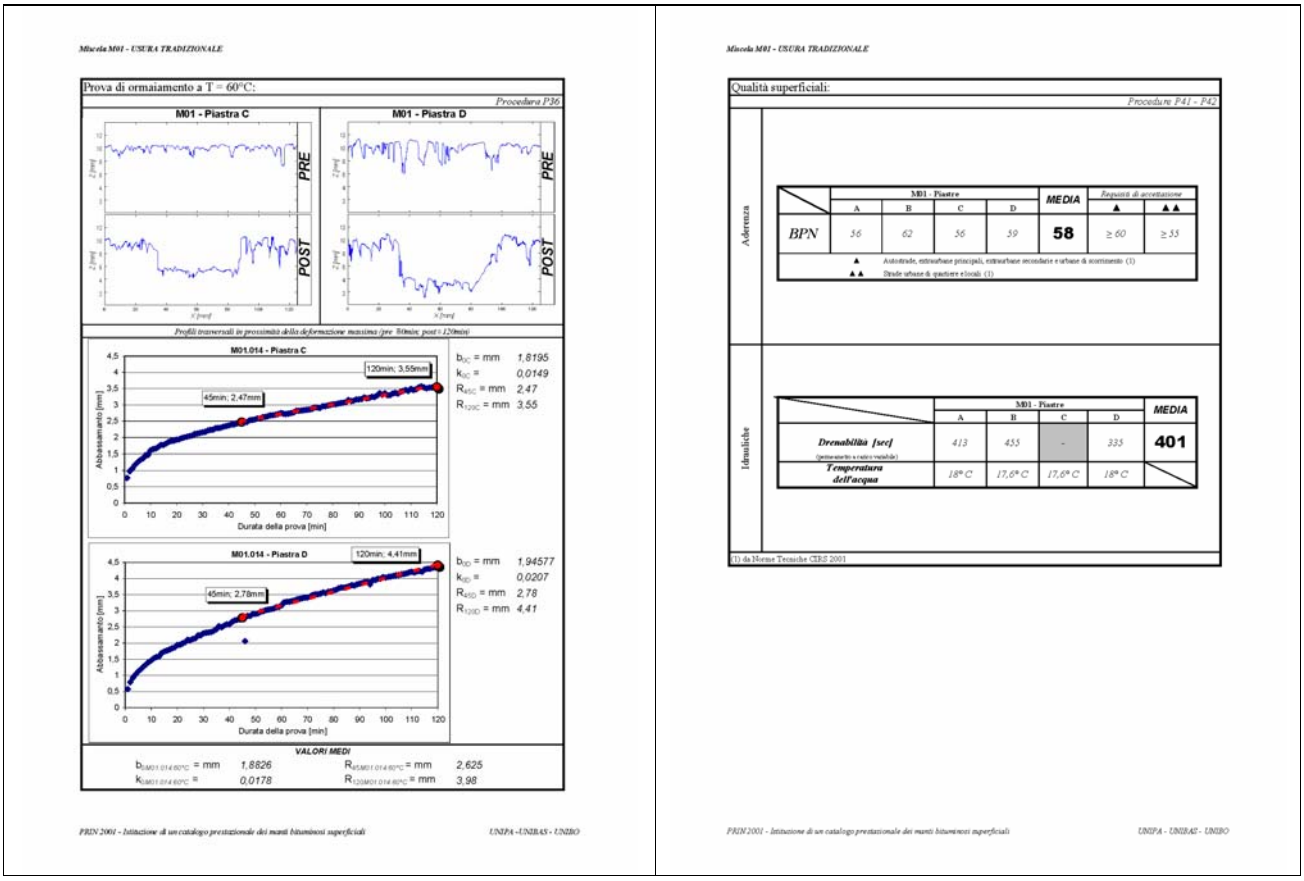


Table 10: Example of catalogue file (Mix M01)

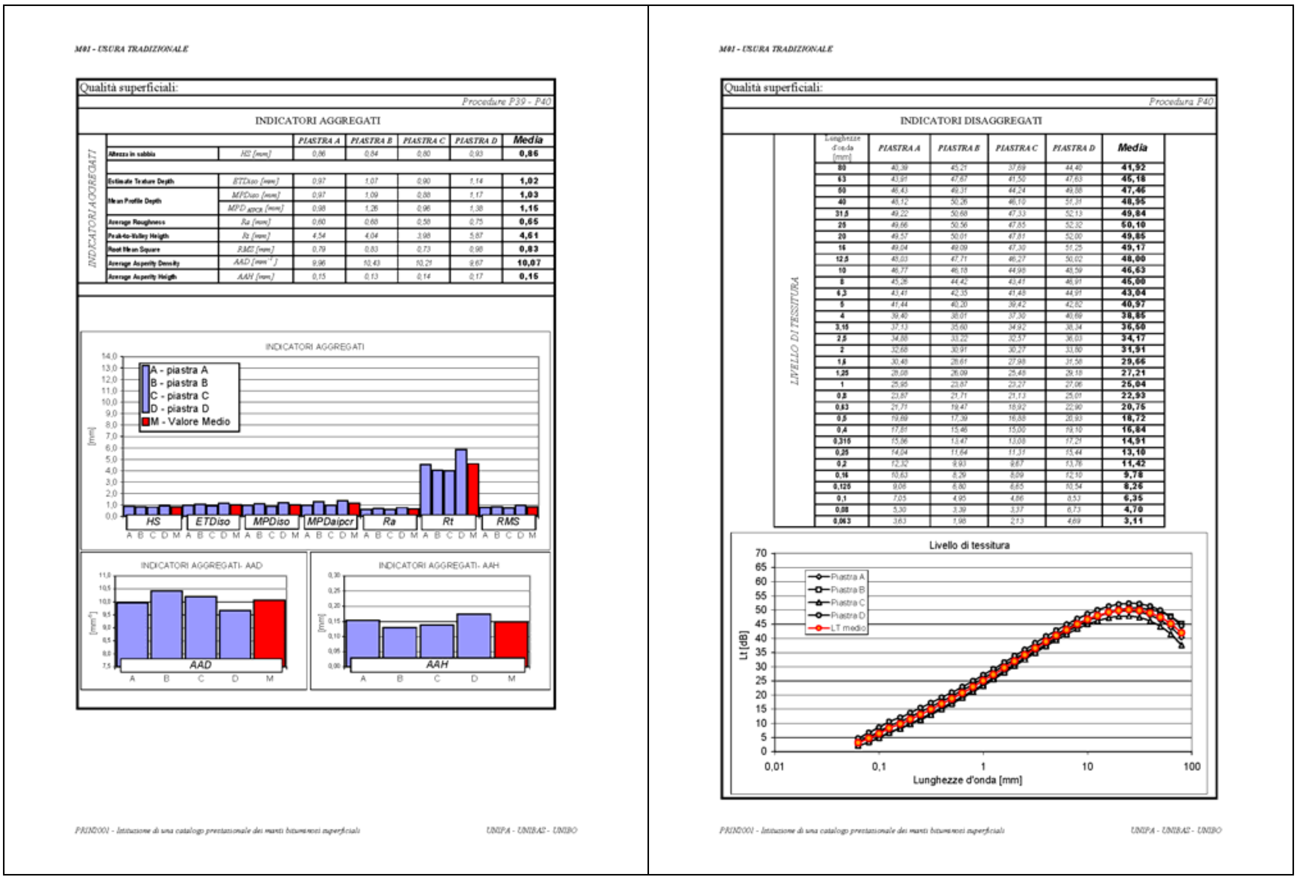


Table 11: Example of catalogue file (Mix M01)

REFERENCES

Agostinacchio M., Bernetti R., Diomedi M. (1996); *Experimental investigation on the behaviour of asphalt for loading three orthogonal directions*; Euroasphalt and Eurobitume Congress; Strasburg (France);

Agostinacchio M., Olita S. ; (2002) ;*Analisi reologica alle basse temperature di un legante bituminoso additivato con fibre* ; XXIV Convegno Nazionale Stradale AIPCR; St. Vincent (AO), Italy;

Agostinacchio M., Campa D., Diomedi M., Olita S. ; (2002) ; *Ottimizzazione del protocollo di prova M.P.T. e proposta di domini conservativi semplificati per il calcolo razionale delle pavimentazioni stradali*, XII Convegno Internazionale SIIV, Parma (Italy);

Autostrade s.p.a. (1995) ; *Norme tecniche per la manutenzione delle pavimentazioni* ; Italy;

Bocci M. ; (1994); *Indagine sperimentale sullo splittmastix asphalt* ; XXII Convegno Nazionale Stradale AIPCR, Perugia , Italy;

Boscaino G., Praticò F.G. ; (2001) ; *Classification et inventaire des indicateurs de la texture superficielle des revêtements des chaussées ; B.L.P.C. n° 234*, France;

Boscaino G., Praticò F.G., Vaiana R. (2002); *Descrittori della tessitura superficiale di miscele bituminose "smooth" e "rough"; XII Convegno Internazionale SIIV* ; Parma (Italy);

Boscaino G., Praticò F.G., Vaiana R. (2003); *Spectral texture indicators significance in relation to flexible pavements surface performance; XXII PIARC World Road Congress;* Durban (South Africa);

G. Boscaino, R. Vaiana; (2003); Deformazioni permanenti di manti superficiali valutate tramite simulatore "WheelTracker"; *XIII Convegno Nazionale SIIV*, Padova ; Italy.

Bucchi A., Dondi G., Bonini A., Simone A.; (1998); *Microtappeti drenanti: controlli in fase di messa in opera con pressa giratoria; Convegno Nazionale S.I.I.V.* , Milano , Italy;

CIRS (2001); *Norme tecniche di tipo prestazionale per capitolati speciali d'appalto;* Italy;

Diomedi M. (2000); *Ottimizzazione delle miscele di splittmastixasphalt con riferimento alle diverse normative internazionali* ; *X Convegno Nazionale S.I.I.V.* , Acireale (CT), Italy;

Dondi G., Simone A., Bonini A. (2000); *Metodologie di impiego della pressa giratoria (1° parte) ; Rassegna del bitume n° 34* , Italy;

Dondi G., Simone A., Bonini A. (2000); *Metodologie di impiego della pressa giratoria (2° parte);– Rassegna del bitume n° 35*; Italy;

Vaiana R. (2002); *La tecnologia laser nella caratterizzazione della micro e macro tessitura dei rivestimenti stradali* ; *Strade & Autostrade n°5;* Italy;