Pavement Evaluation 2014
September 15 -18, 2014 Blacksburg, VIRGINIA

EVALUATING THE PERFORMANCE OF NEW AND IN-SERVICE PAVEMENTS IN ITALY USING HIGH-SPEED NON-DESTRUCTIVE TESTING

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ANAS Company Profile

Key facts & figures

Established in 1928

Joint-stock company (100% property of Ministry of Treasury)

Quality certified (e.g. UNI ISO 9001/2000 and 17020/2005)

Share Capital: 2,269,892,000 Euro

Turnover: 2,900,000,000 Euro (in the last 5 years)

Employees: 6,700 (6,500 in Italy)

Managed Road/Motorway network : **25,000 km**

ANAS Company Profile

Managing Italian national road network

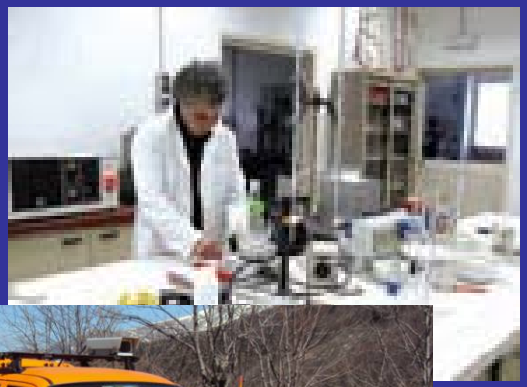
Construction of new highway and motorways

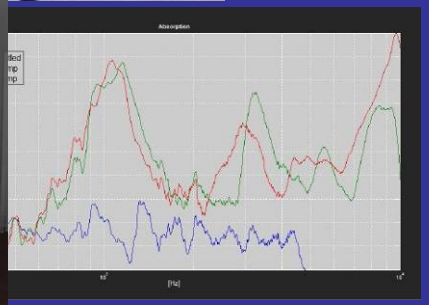
Maintenance of the national road and motorway network

Works Supervision on all road works

Study and research on safety and road maintenance

Mission

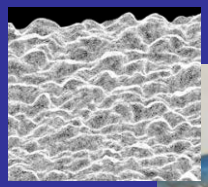


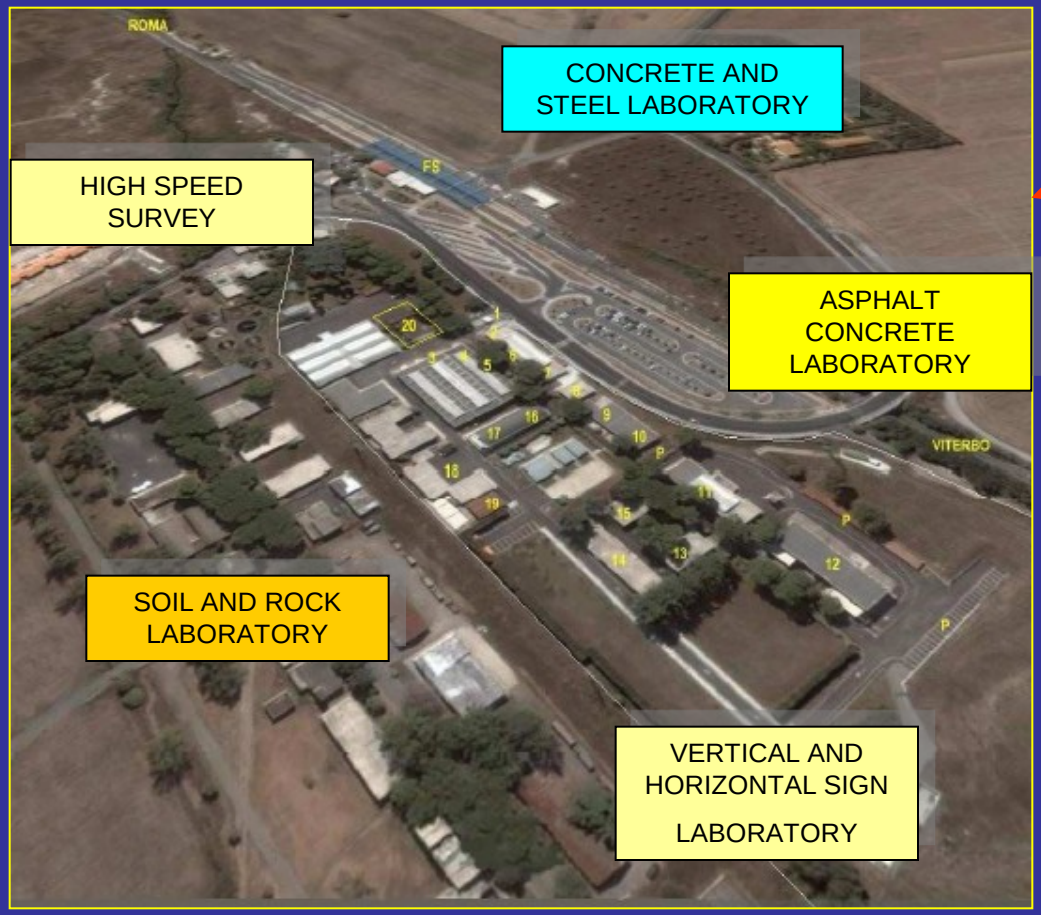


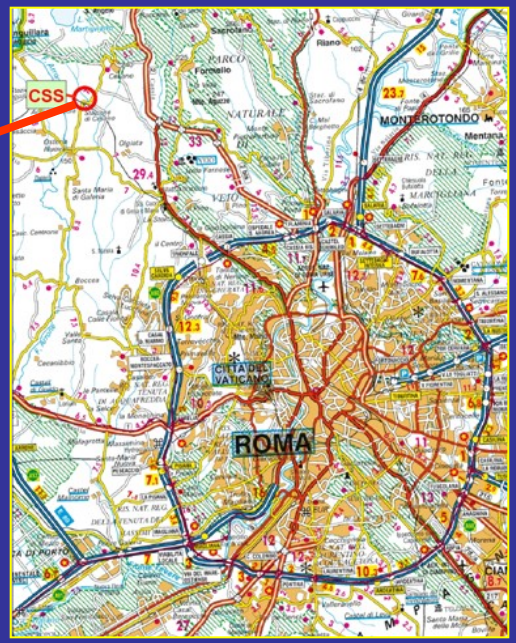
Research and Innovation

ANAS invests significant resources in research and innovation in all road related activities (materials; road safety; road management, etc.)..

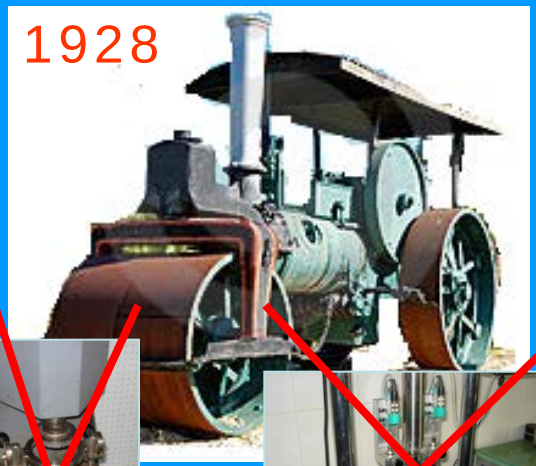
The **Cesano National Research Centre** is the scientific, and technical heart of ANAS setting standards, quality criteria and best practices for the entire road infrastructure




ROMA
CONCRETE AND STEEL LABORATORY
HIGH SPEED SURVEY
ASPHALT CONCRETE LABORATORY
SOIL AND ROCK LABORATORY
VERTICAL AND HORIZONTAL SIGN LABORATORY
FS
VITERBO


CSS
MONTEROTONDO
ROMA
CITTA DEL VATICANO

ROAD PAVEMENTS have been deeply changed due to the SCIENTIFIC EVOLUTION in this field



STARTING FROM EMPIRICAL SOLUTIONs BASED ON EXPERIENCE
PAVEMENTS EARNED THE DIGNITY OF SCIENCE

PAVEMENTS ARE NOW TREATED SUCH AS A PROPER STRUCTURE TO BE DESIGNED
not only in terms of materials, thickness, etc
BUT MAINLY IN TERMS OF PERFORMANCES TO BE GAINED IN THE FIELD

PERFORMANCEs PROVIDED BY CONTRACTORS MUST BE VERIFIABLE IN EACH PART OF THE WORK

THIS IS ANAS
PERFORMANCES BASED METHODOLOGY 2013

Evaluation of Actual Network Condition

Pavement Design

ANAS network
about 25.000 Km

All step integrated in the ANAS management system based on performance evaluation

Testing and Approval of Works

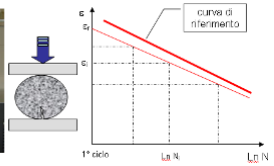
Maintenance of existing road
New road construction

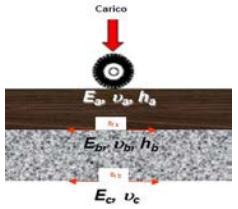
Pavement Construction

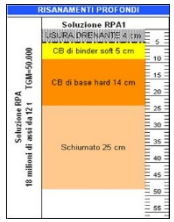
1- STEP OF EVALUATION OF THE ACTUAL NETWORK CONDITION TROUGH THE HIGH EFFICENCY SURVEY

WHIT THE SAME EQUIPMENTS

2 - STEP OF PAVEMENT DESIGN FOR NEW CONSTRUCTION OR FOR MAINTENANCE OF EXISTING PAVEMENT







3 - STEP OF PAVEMENT CONSTRUCTION

4 - STEP OF QUALITY CONTROL TROUGH THE HIGH EFFICENCY SURVEY FOR FINAL APPROUVAL OF WORK

The ANAS Management System is based on Performance Indicator (PI)connected to Technical Parameter (TP)

The **PI** is a non-dimensional measurement unit, which varies from 0 to 100, and measures the **DIFFUSION** of the **TP** that is under evaluation.

Its distribution, in the different **levels** of **QUALITY** of the **TP**, defines the state of the pavement

An illustrative **example** for the **TP** "***skid resistance***" clarifies the concept

TECHNICAL PARAMETER
In this example SKID NUMBER CAT

QUALITY LEVELS

A Excellent
B Good
C Medium
D Sufficient
E Bad

A% --------> Percentage of pavement at level A
B% --------> Percentage of pavement at level B
C% --------> Percentage of pavement at level C
D% --------> Percentage of pavement at level D etc.

The averaged diffusion of the different levels represent the Performance Indicator of skid resistance

ANAS formula to averaged this diffusion could be

$$I_{CAT} = f\,(A+3/4B+1/2C+1/4D)$$

I_{CAT} = *Performance Indicator of skid resistance*

In this way the index varies from 0 to 100

Following the suggested formula:

$$I_{CAT} = f(A+3/4B+1/2C+1/4D)$$

IF A = 100% ⟶ $I_{CAT} = 100$

IF A,B,C,D = 0% ⟶ $I_{CAT} = 0$

The ANAS Management System is based on performance indicator (PI)

The ANAS Management System is based on measurement of the overall Quality of the road starting from the Technical Parameters.

ANAS proposes the today best technology to fast measure each parameters taking into account environmental and traffic constraints.

For each evaluation more than one parameter is needed, for example the pavement

- Skid Resistance
- Roughness
- Bearing Capacity
- Distresses
- Traffic Noise

NEW

Technical Parameters are measured trough the **HIGH SPEED EQUIPMENT** that measure the road on site, continuously, with high accuracy, high speed, and extremely low impact on traffic.


ERMES
ROUTINE EVALUATION OF MACROTEXTURE, EVENNES AND SKID RESISTANCE


FWD - "FALLING WEIGHT DEFLECTOMETER"


TSD - TRAFFIC SPEED DEFLECTOMETER

TP PAV


FSD Dynamic Road Phonometer


HORIZONTAL SIGN


ROAD EYE

BEARING CAPACITY COLLECTED AT HIGH SPEED

NON-DESTRUCTIVE TESTING

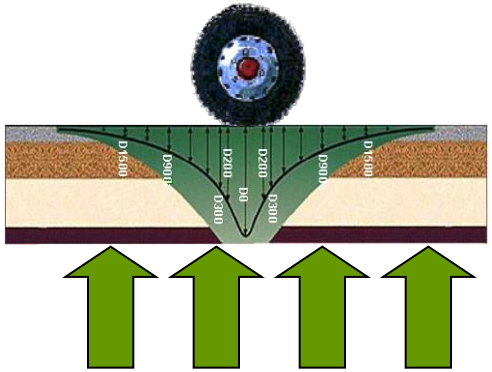
TRAFFIC SPEED DEFLECTOMETER

IN CONNECTION WITH “SLOW” FWD TEST

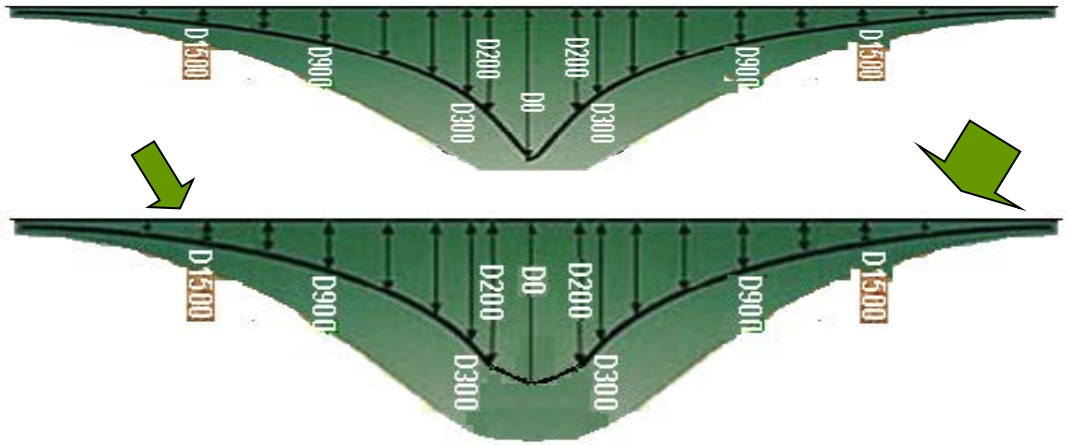
FIRST INTERNATIONAL TSD TRIAL IN DENMARK 2013

ANAS HAS DEVELOPED
Since 2009 THE USE OF
TSD
FOR FINAL APPROVAL OF WORK

BEATRING CAPACITY MEASUREMENT



THE SHAPE OF DEFLECTIONS BASIN



DEPENDS ON CONTRIBUTION BY ALL DIFFERENT LAYERS

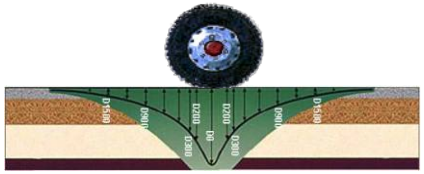
… DEFLECTIONS FARREST FROM THE LOAD (D_{1500})

PROVIDES INDICATIONS ON THE BC OF *SUBGRADE*

BEARING CAPACITY IS THE RESULT OF EACH COMPONENT

such as MATERIAL, LAYERS, THEIR INTERACTION

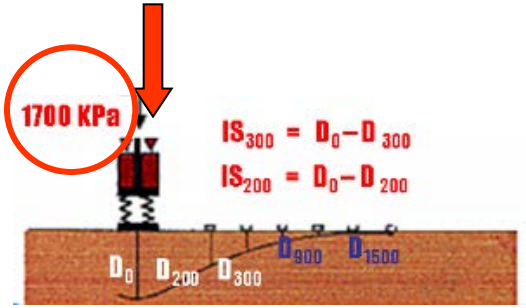
INCLUDED ANY CRACK INSIDE THEM



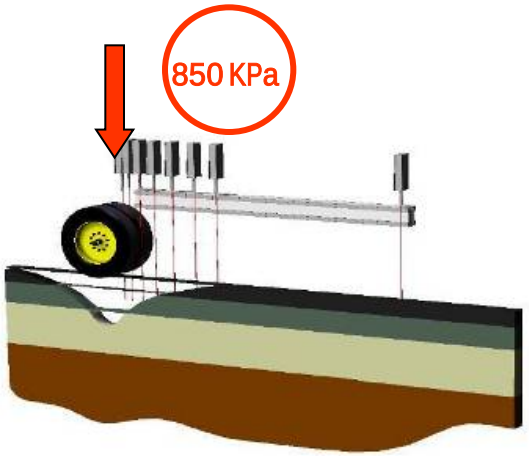
DEFLECTION BASINS CAN BE MEASURED WITH TWO ALTERNATIVES EQUIPEMENTS

FWD and TSD measure same parameter by different systems and different speed.

F.W.D.
FALLING WHEIGHT DEFLECTOMETER



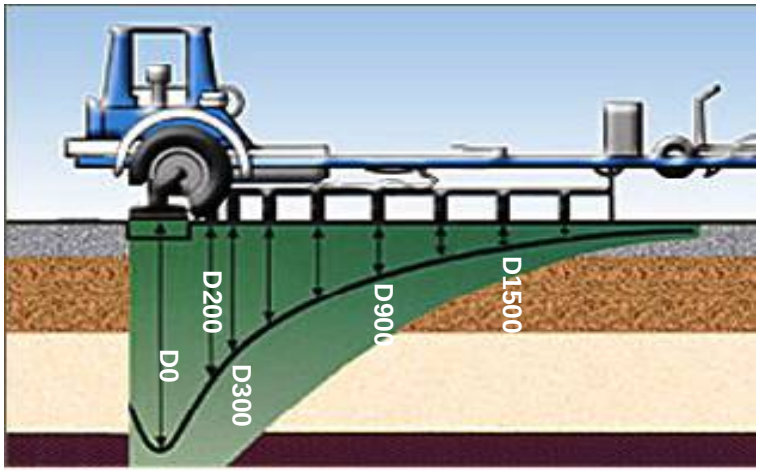
T.S.D.
TRAFFIC SPEED DEFLECTOMETER



Measuring Pavement Bearing Capacity with Traditional System

Applied stress load (1700 kPa) to simulate traffic conditions

Recorded air temperature at each measurement



RP control
Deep repair
IS300 = D0 - D300

RS control
Surface repair
IS200 = D0 - D200

adjusted to consider the deformability of the substrate

IS indexes are corrected and reported to standard conditions (14 ° C)

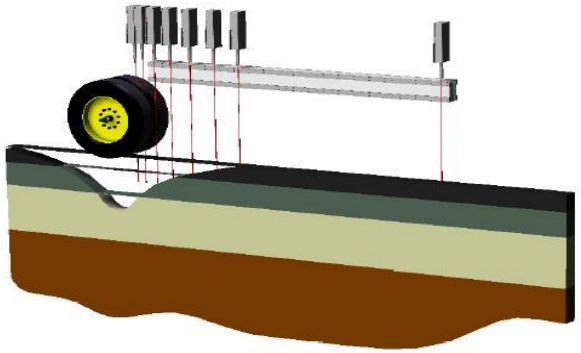
$$\frac{IS_{14°C}}{IS_{T_{testing}}} = e^{C\times(14-T_{testing})}$$

$T_{testing}$ = Tair (easy to evaluate).

Measuring Pavement Bearing Capacity with ANAS TSD

Stress load is applied continuously by a 12 tons loaded wheel rolling at 80 km/h

Multiple temperature recordings



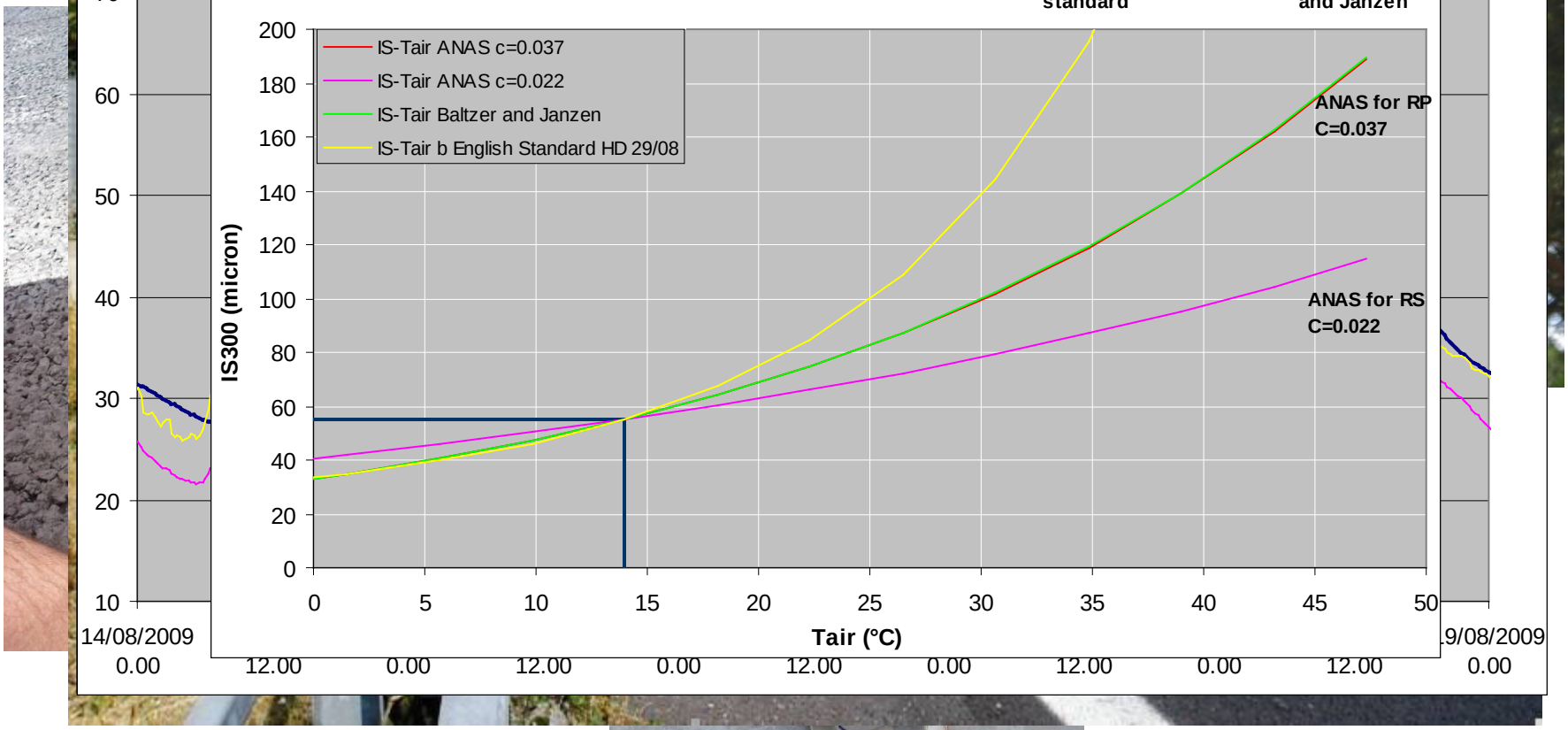
CALCULATED VALUES ARE THE SAME

RP control
Deep repair
IS300 = D0 - D300

MEASUREMENTS ARE CONTINUOUSLY RECORDED (1 m) AND AVERAGED EVERY 10 m

RS control
Surface repair
IS200 = D0 - D200

INFLUENCE OF TEMPERATURE

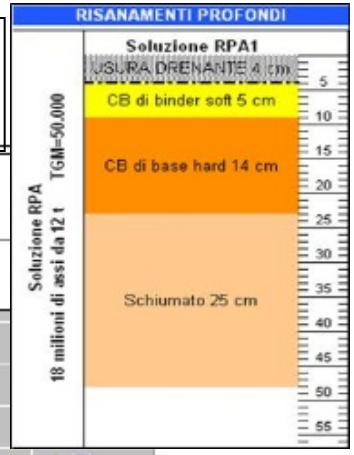


BEARING CAPACITY ASSESSMENT'S CRITERIA

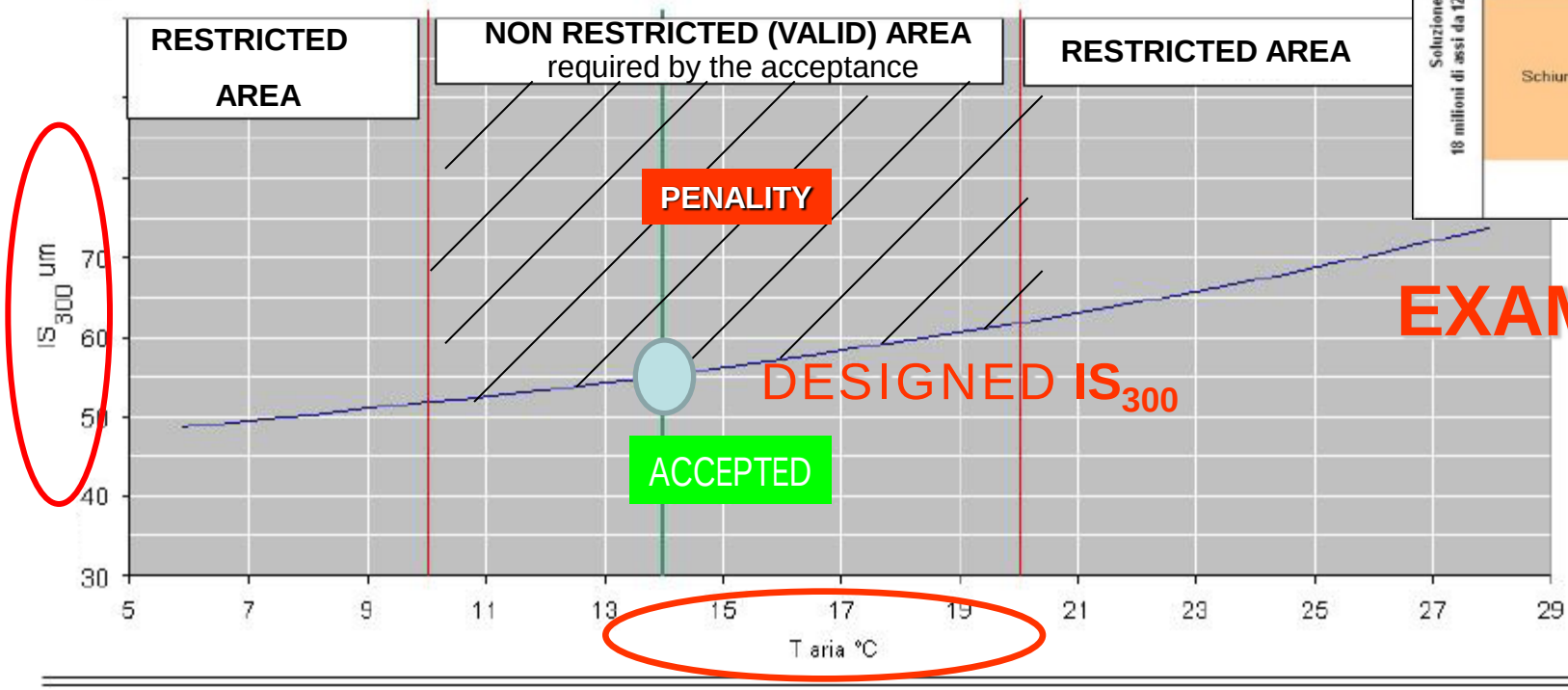
- DESIGNED IS_{300} VALUE IS CALCULATED FOR THE PAVEMENT STRUCTURE

- SINCE IS_{300} IS AFFECTED BY TEMPERATURE

  SOME TEMPERATURE CONSTRAINTS MUST BE CONSIDERED



ACCEPTANCE CURVE



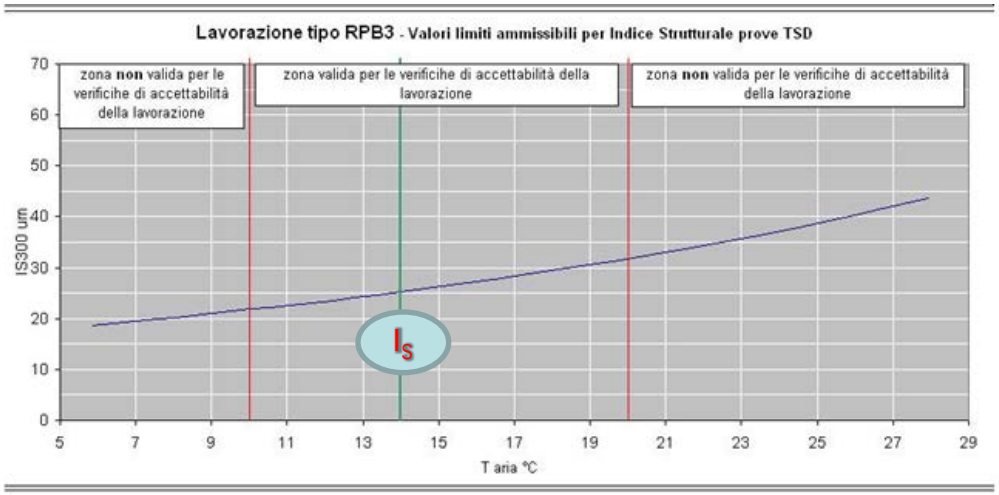
EXAMPLE

AVERAGE VALUES IS FALLING WITHIN " VALID AREA" - IF HIGHER THAN FIXED ONES WILL BE UNDER PENALTY - IF LOWER THEY WILL BE ACCEPTED

NEW CURVES IN PROGRESS FOR I_S COMPLIANCE VERIFICATION

Present acceptance curves I_S showed troubles in case of excessive use of recycled materials (RAP)

Very strong pavements showed very low values of I_S with negative influence on long term perfomance and reduction of residual life



Due to this I_S acceptance curve have been adjusted to be sure that designed fatigue life of mixes will be obtained

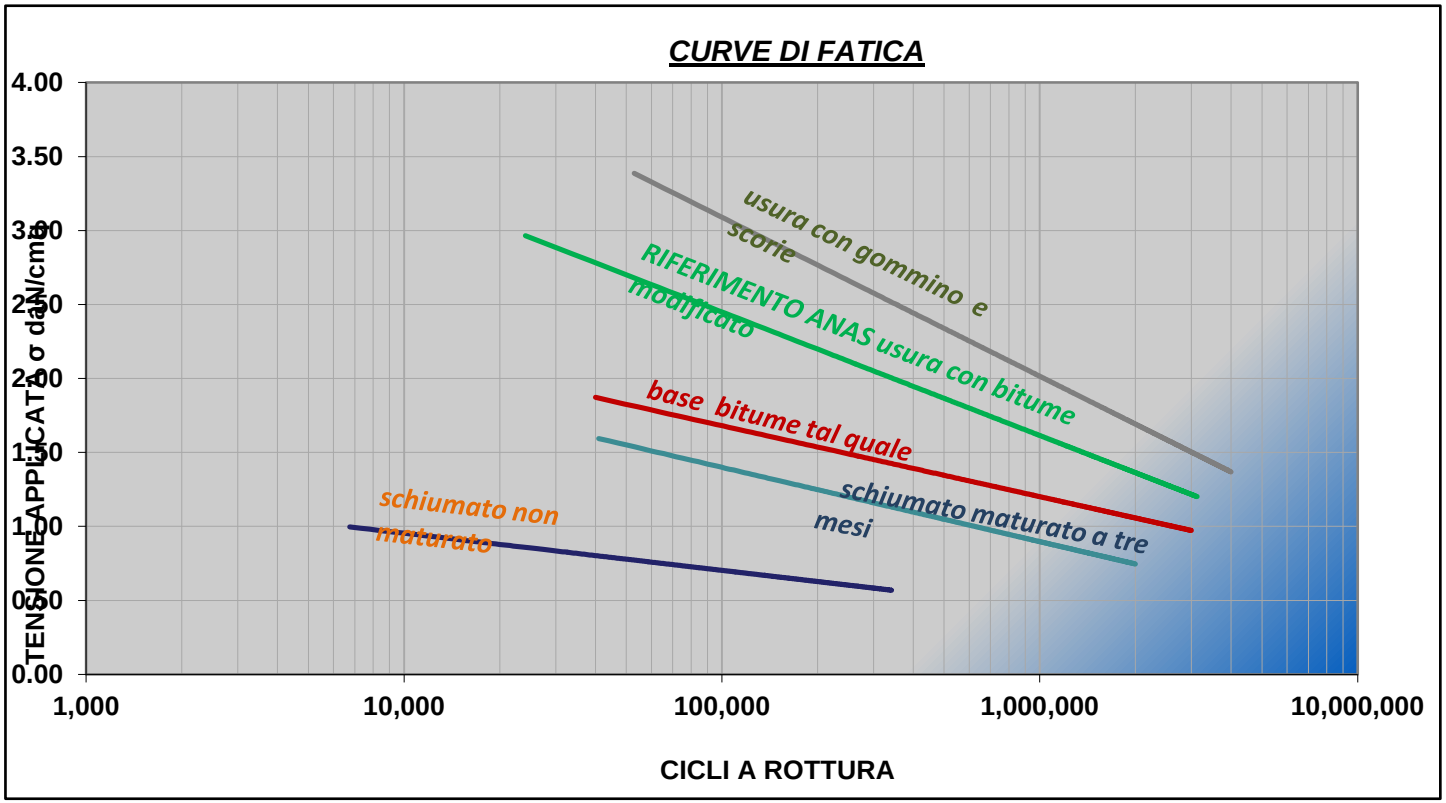
BEARING CAPACITY and FATIGUE LIFE ARE CHECKED

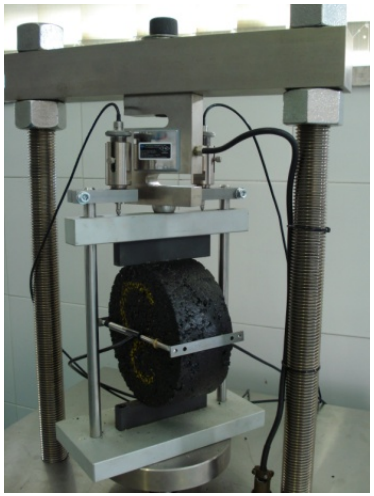
WITH ONE SINGLE HIGH PERFORMANCE TEST

FATIGUE OF MIXES IS TESTED BY ITS TESTS BASED ON

SINUSOIDAL LOAD AT 10Hz AND 20 °C Air Temperature

FAST ANAS MEASUREMENT OF FATIGUE LIFE

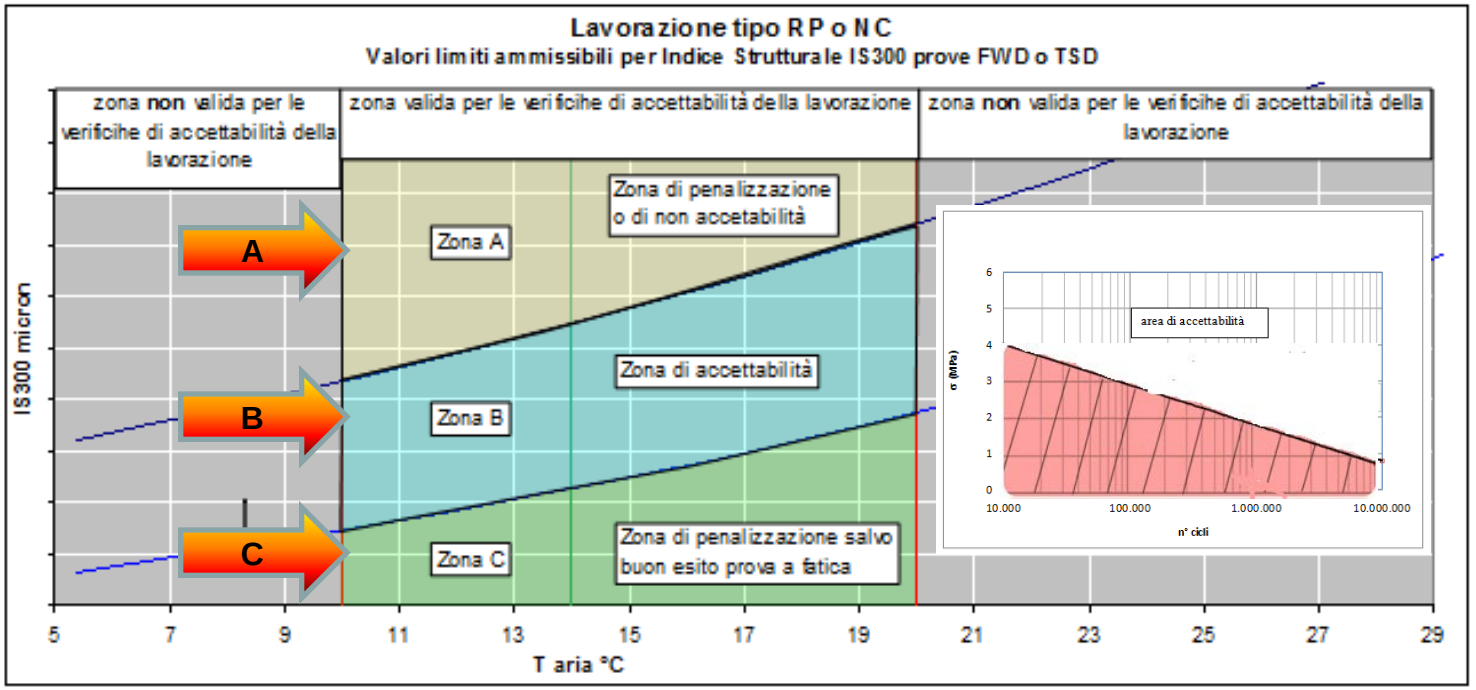




FATIGUE RESISTANCE IS CHECKED COMPARING VARIOUS MIXES WITH A REFERENCE ONE – *THE GREEN ONE*

NEW CURVES IN PROGRESS FOR I_S COMPLIANCE VERIFICATION

TO PREVENT CONTRATORS FROM USING TOO RIGID MIXES WITH LESS DEFORMABILTY BUT LESS RESIDUAL LIFE, A LOWER ACCEPTANCE CURVE WAS ADDED TO THE UPPER ONE.



I_S VALUES INCLUDED IN AREA "A" ARE *NOT ACCEPTABLE*

I_S VALUES INCLUDED IN AREA "B" ARE *ACCEPTABLE*

I_S VALUES INCLUDED IN AREA "C" ARE *UNDER PENALTY OR FATIGUE TEST ON CORES MUST BE REPEATED* (by comparison)

LET'S GO BACK TO THE MANAGEMENT OF PARAMETERS DETECTED

1. EVALUATION OF HOMOGENEOUS SECTION BY SPECIFIC SOFTWARE

2. DISTRIBUTION OF QUALITY LEVELS ON THE ROAD

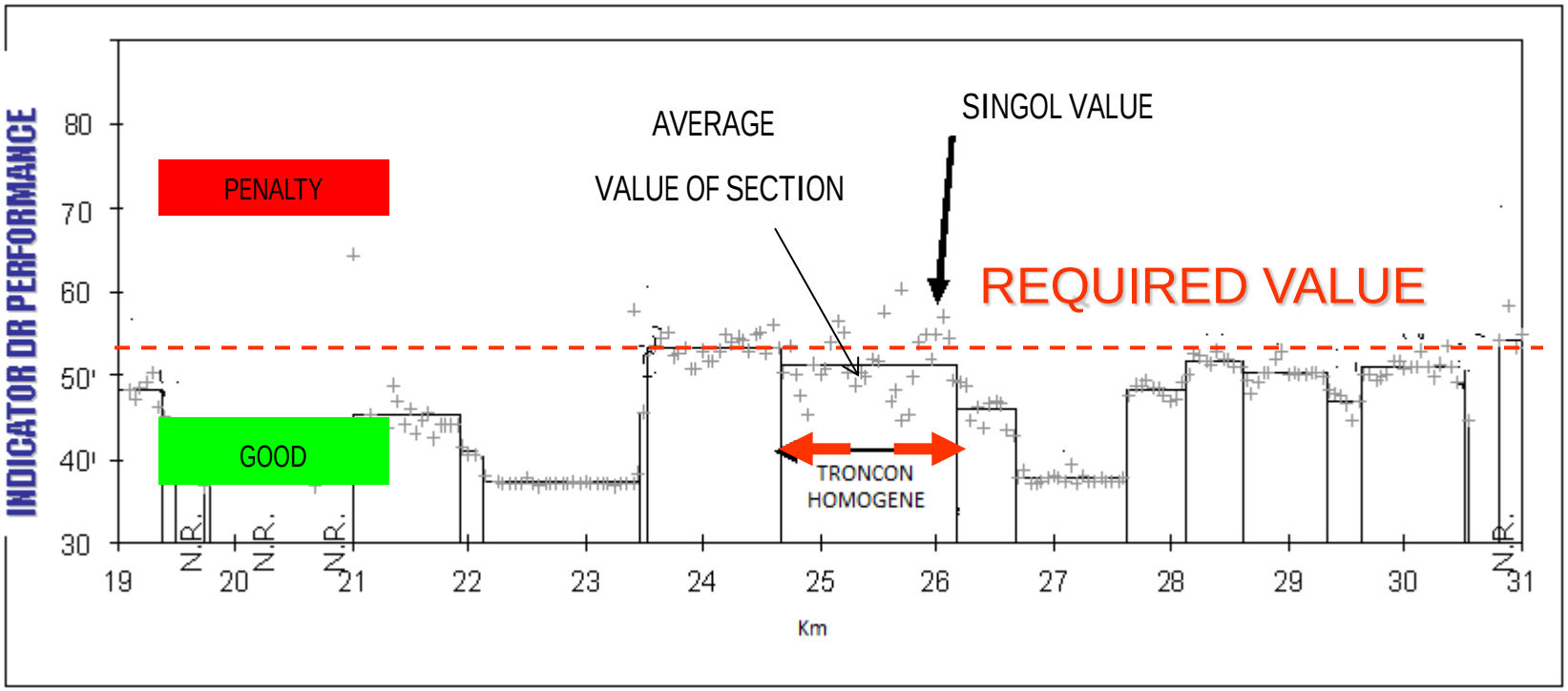
3. DESIGN OF MAINTENANCE

4. WORKS

5. PUNCTUAL CONTROL OF RESULTS OBTAINED WITH THE WORKS

1 - RESULTS PROCESSED TO FIND HOMOGENEOUS SECTIONS NAMELY SECTIONS SHOWING "STABLE" VALUES

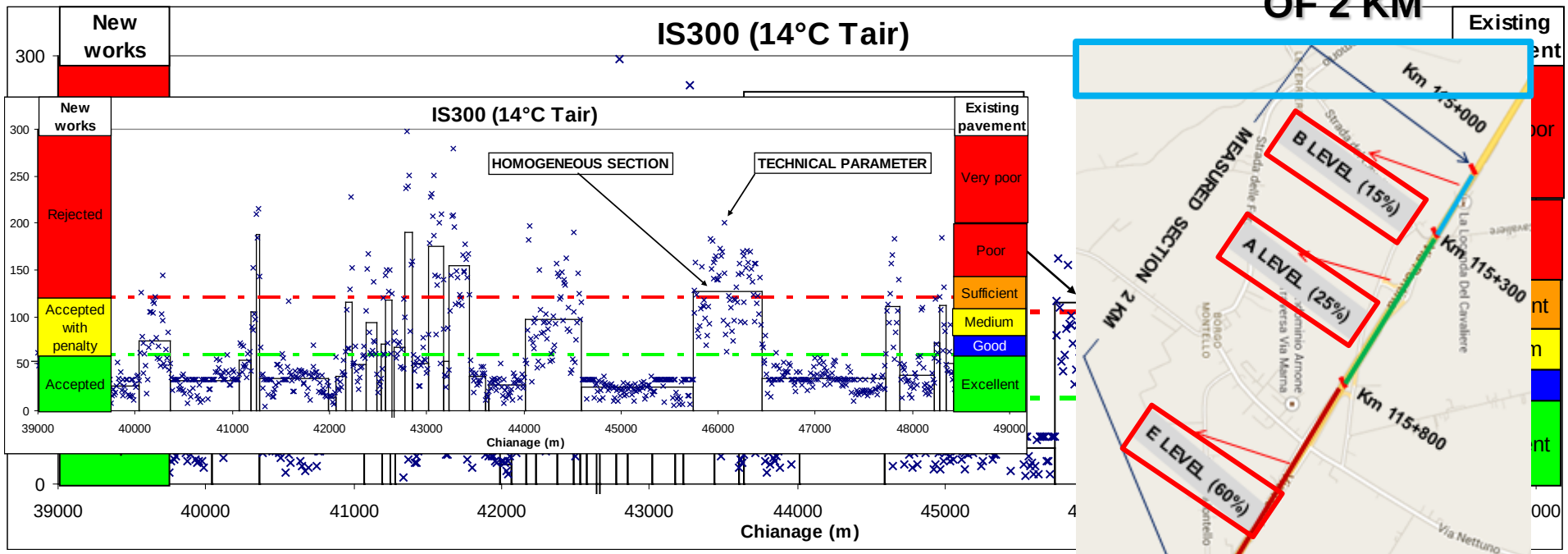
SINGOL VALUES IS NOT SIGNIFICANT



THE AVERAGE VALUE (OF EACH SECTION) INSTEAD MUST COMPLY WITH REQUIRED ONES

2. DISTRIBUTION OF QUALITY LEVELS ON THE ROAD

EXISTING PAVEMENT OF 2 KM



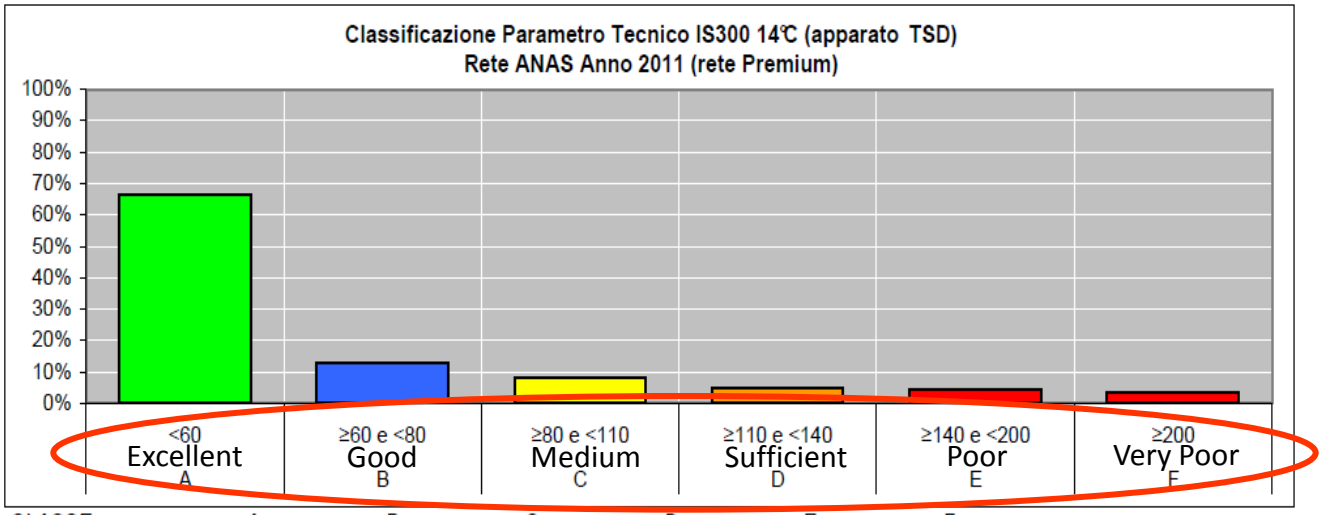
MANAGING INDICATOR is I_{bc} = 25 + ¾ 15 = 36,25

I_{bc} = 36,25

BEARING CAPACITY OF THE NETWORK IS REGULARLY INVESTIGATED

PERFORMANCE INDICATOR I_{BC} IS CALCULATED

«Premium network» I_{BC} 80,1 *(100)*



CLASSE	A	B	C	D	E	F		
intervallo IS300	<60	≥60 e <80	≥80 e <110	≥110 e <140	≥140 e <200	≥200	VALIDI	NON VALIDI
lunghezza in km	2060.530	392.410	251.280	145.870	140.400	104.640	3095.130	120.650
lunghezza in %	66.6%	12.7%	8.1%	4.7%	4.5%	3.4%	100.0%	3.8%
							I_{CP1} ($IS_{300\_14℃}$)	80.1

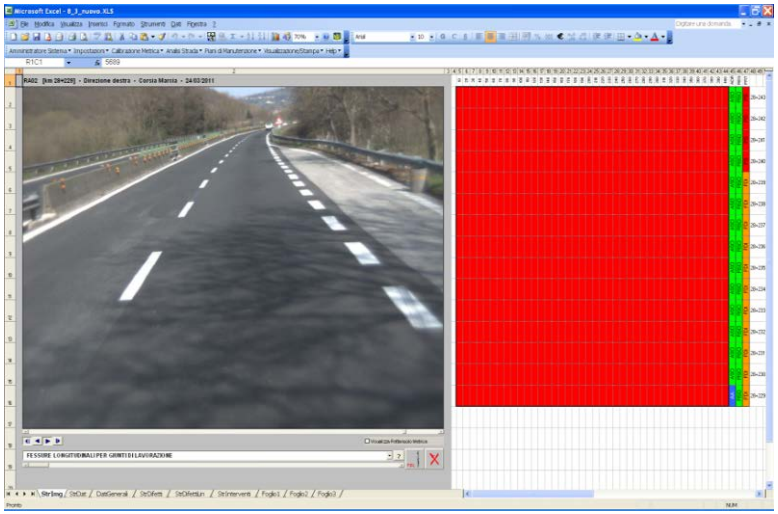
LEVELS of $I_{S30014°C}$

3. DESIGN OF MAINTENANCE

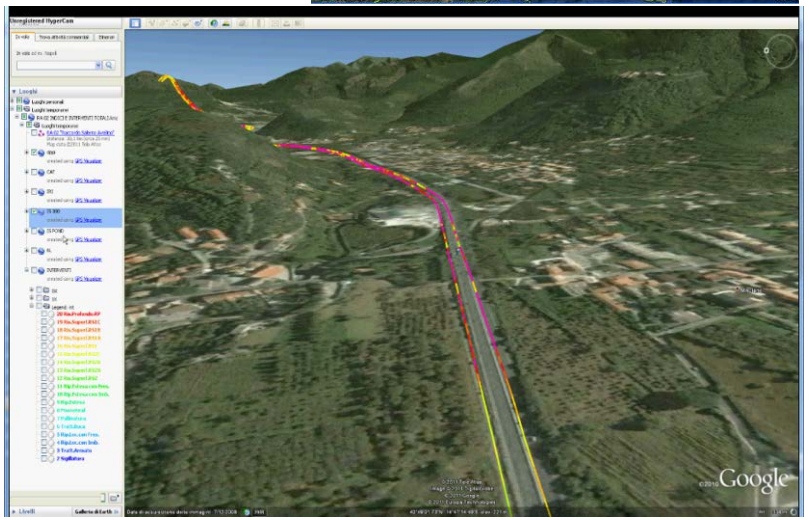
DISTRIBUTION OF PERFORMANCE INDICATOR USING GEOGRAFICAL REPRESENTATION

LOCATION AND IDENTIFICATION OF OPTIMAL MAINTENANCE SUPPORTED BY THE SOFTWARE ROAD EYE

ROAD EYE Software



Google MAPS



3. DESIGN OF MAINTENANCE

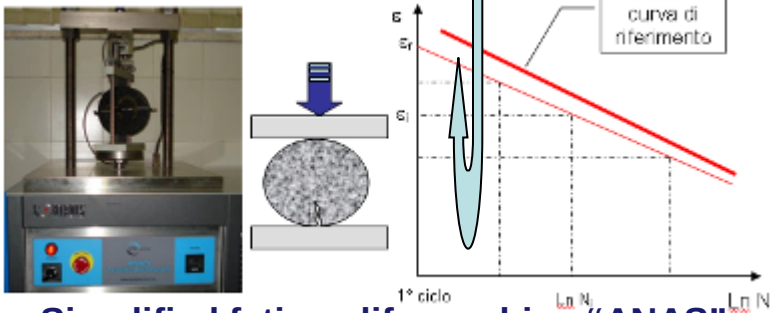
Materials

"ANY MATERIAL"

- Virgin materials
- Marginal materials
- Recycling
- Etc. etc

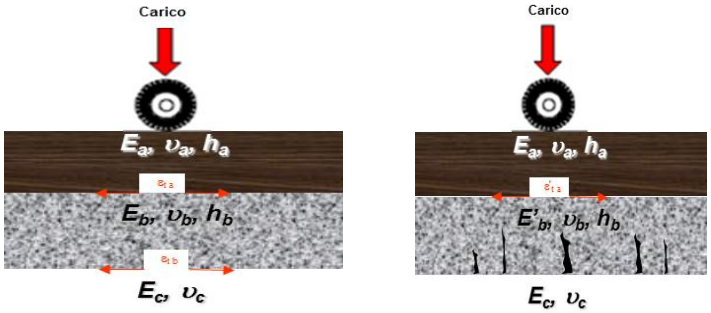
Fatigue life and Moduli

"Measure of fatigue life of material"

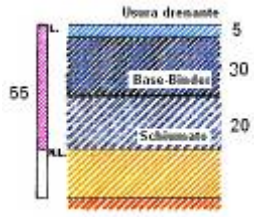


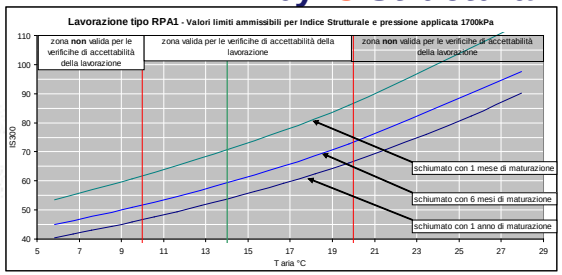
Simplified fatigue life machine "ANAS"

Design of thichnesses and evaluation residual life



Reference curves for final acceptance

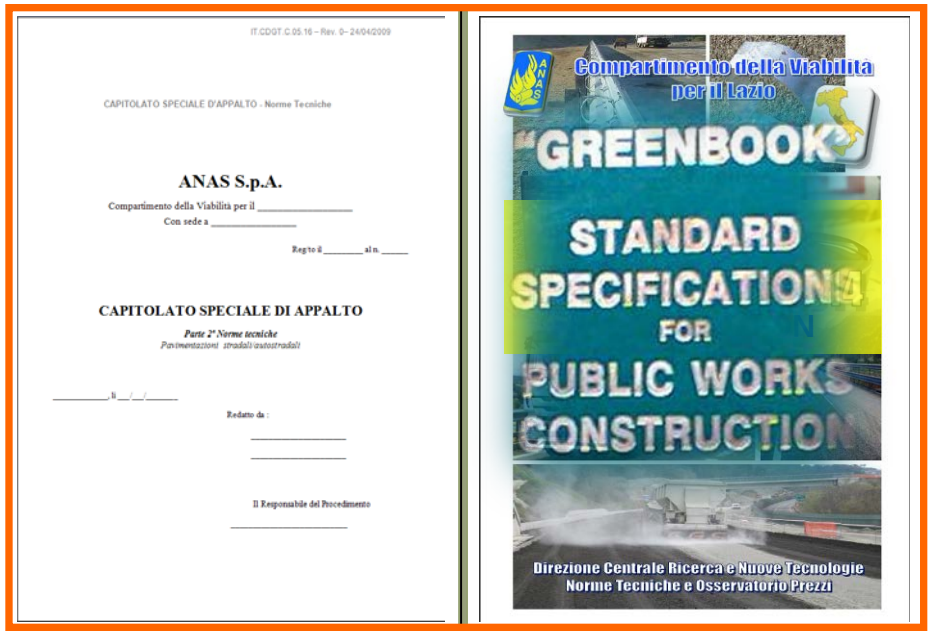




EXAMPLE - definition of Performance Bearing Capacity by Is Structural Index

4. WORKS

ANAS in 2009 adopted a CONTRACT SPECIFICATIONS where the approval and the final payment is related to the test performed at the end of work with measurements made with high-speed non-destructive testing



5. PUNCTUAL CONTROL OF RESULTS OBTAINED WITH THE WORKS

….to PAY ONLY WORKS WELL DONE!

THIS APPROACH enhances the self-control of the executing company during the execution of the work
ONLY JOB WELL DONE WILL BE PAYED

TSD

GREENWOOD ENGINEERING A/S

ANAS MANAGEMENT WITH THE PERFORMANCE INDICATORS