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

Mission

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
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.
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.
ANAS network about 25,000 Km

Evaluation of Actual Network Condition

Pavement Design

Testing and Approval of Works
  Maintenance of existing road
  New road construction

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

Pavement Construction
1 - STEP OF EVALUATION OF THE ACTUAL NETWORK CONDITION THROUGH THE HIGH EFFICIENCY SURVEY

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

3 - STEP OF PAVEMENT CONSTRUCTION

4 - STEP OF QUALITY CONTROL THROUGH THE HIGH EFFICIENCY SURVEY FOR FINAL APPROVAL OF WORK

WHIT THE SAME EQUIPMENTS
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

<table>
<thead>
<tr>
<th>Letter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Excellent</td>
</tr>
<tr>
<td>B</td>
<td>Good</td>
</tr>
<tr>
<td>C</td>
<td>Medium</td>
</tr>
<tr>
<td>D</td>
<td>Sufficient</td>
</tr>
<tr>
<td>E</td>
<td>Bad</td>
</tr>
</tbody>
</table>

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

ANAS formula to averaged this diffusion could be

\[ I_{\text{CAT}} = f (A + \frac{3}{4}B + \frac{1}{2}C + \frac{1}{4}D) \]
**ICAT** = *Performance Indicator of skid resistance*

In this way the index varies from 0 to 100

Following the suggested formula:

\[ ICAT = f(A + \frac{3}{4}B + \frac{1}{2}C + \frac{1}{4}D) \]

- IF \( A = 100\% \) \( \rightarrow \) \( ICAT = 100 \)
- IF \( A,B,C,D = 0\% \) \( \rightarrow \) \( ICAT = 0 \)
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

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

ERMES
ROUTINE EVALUATION OF MACROTEXTURE, EVENNES AND SKID RESISTANCE

FWD - "FALLING WEIGHT DEFLECTOMETER"

TSD - TRAFFIC SPEED DEFLECTOMETER

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

FIRST INTERNATIONAL TSD TRIAL IN DENMARK 2013
BEATING 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 EQUIPMENTS

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  
\[ IS_{300} = D_0 - D_{300} \]

RS control  
Surface repair  
\[ IS_{200} = D_0 - D_{200} \]

adjusted to consider the deformability of the substrate

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

\[
\frac{IS_{14^\circ C}}{IS_{testing}} = e^{C \times (14 - T_{testing})} 
\]

\[ T_{testing} = T_{air} \text{ (easy to evaluate).} \]
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

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

RP control
Deep repair
IS300 = D0 - D300

RS control
Surface repair
IS200 = D0 - D200
INFLUENCE OF TEMPERATURE

IS300 versus Tair

- IS-Tair ANAS c=0.037
- IS-Tair ANAS c=0.022
- IS-Tair Baltzer and Janzen
- IS-Tair b English Standard HD 29/08

English standard

from Baltzer and Janzen

ANAS for RP
C=0.037

ANAS for RS
C=0.022
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

<table>
<thead>
<tr>
<th>RESTRICTED AREA</th>
<th>NON RESTRICTED (VALID) AREA</th>
<th>RESTRICTED AREA</th>
</tr>
</thead>
<tbody>
<tr>
<td>REQUIRED BY THE ACCEPTANCE</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

PENALTY

DESIGNED $IS_{300}$

ACCEPTED

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 performance 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

**CURVE DI FATICA**

- TENSIONE APPLICATA $\sigma$ daN/cm²
- CICLI A ROTTURA

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 CONTRACTORS FROM USING TOO RIGID MIXES WITH LESS DEFORMABILITY 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 $I_{bc} = 25 + \frac{3}{4} 15 = 36.25$

$I_{bc} = 36.25$
BEARING CAPACITY OF THE NETWORK IS REGULARLY INVESTIGATED

PERFORMANCE INDICATOR $I_{BC}$ IS CALCULATED

"Premium network" $I_{BC} = 80.1$ (100)

LEVELS of $I_{S30014°C}$

25.000 Km
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

“ANY MATERIAL”

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

Design of thicknesses and evaluation residual life

“Measure of fatigue life of material”

Simplified fatigue life machine “ANAS”

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.
ANAS MANAGEMENT WITH THE PERFORMANCE INDICATORS