TRACC – Road techniques adapted to climate change

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ABSTRACT

Conventional road techniques lead to use materials transported far from production sites, to incorporate them in very high temperature asphalt mixtures, and finally to transport them to road construction sites and to lay them down with specific equipment.
In context of climate change and with the need to minimize the use of natural resources, the TRACC project, focused on road techniques adapted to climate change, studied all products in regard with sustainable development and technical aims.
Technical evaluation of one hundred products was done with studying capacities of each to be laid down on various previously defined deteriorated pavement as the capacities to resolve those troubles.
All aspects of sustainable development were apprehended :
• economy integrating direct costs, durability, …,
• environmental balance with ecocalculator simulations (emission of greenhouse gases, energy consumptions, …)
• social approach taking into account workers, residents/users and operating of infrastructures.
Initiated in South West Europe (Spain, Portugal and South West of France) between infrastructures owners, contractors and public laboratories, this process is now used, in France, with professional national associations to build a shared database.
Utilization of these data leads to propose to users road techniques resolving their technical maintenance problems of users in promoting those that are the best relating to sustainable development.
The final aim of TRACC is to demonstrate that this is possible to have equivalent but alternative maintenance system in using road techniques more correct regarding environmental, economic and social aspects than conventional products.

Keywords: Climate change, Energy saving, Maintenance, Public Private Partnership, Sustainable urban and rural infrastructure

1 INTRODUCTION

Road maintenance uses natural materials brought in from production sites. Asphalt is produced at very high temperature, transported to the construction site and laid, sometimes with special machines causing a great amount of greenhouse gas emission.

The TRACC project [1, 2] was begun in the context of global climate change and the unavoidable need to save raw materials.
Initiated as part of the Interreg SUDOE (south-western Europe) cooperation programme, it first involved a full review of available road maintenance techniques in France, Spain and Portugal.
Comparisons were made according to technical, social, economic and environmental analyses to identify the best solutions and to publish recommendations for infrastructure owners and road professionals in order to have more extensive use of sustainable solutions.
This project was headed by CEREMA/Laboratory of Toulouse with the Haute Garonne local council and the Regional Professional Road Industry Association in the Midi Pyrénées area (SPRIR), Spanish partners (Junta de Castilla y León and the emulsion bitumen technical association, ATEB) and a Portuguese partner (Sines Tecnopolo)

2 THE BIRTH OF NEW REFERENCE SOFTWARE

At the start of the project, the needs were as follows:

- To decrease energy consumption and the environmental impact of road works,
- To provide decision support tools for infrastructure owners,
- To measure the social and economic impact of these environmentally-friendly techniques,
- To compile technical reviews,
- To carry out feasibility studies and make experimental tracks.

This three-year project, with a budget of €2 M, was based on:

- A first stage of inventory and evaluation of all existing techniques in the southwest European area (27 in Spain, 10 in Portugal and 52 in south west France) and especially, the most environmentally friendly of these.
- Experimental tracks to be developed and to be improved for some of them [3, 4, 5],
- Environmental analysis with eco-comparison software tools,
- Social and economic evaluation and market price analysis.

In late 2012, the process led to the creation of decision support software dedicated to all road professionals (infrastructure owners, consulting engineers, contractors) including an exceptional database. The final aim is to integrate sustainable development during the earliest stages of road construction projects.

2.1 A unique, exceptional database

2.1.1 Technical evaluation in situ and in the laboratory

For each technique used for construction, preventive or curative maintenance, an inventory of sites was made (the oldest is over 20 years old). Some of these were sampled (based on traffic, geographical situation, etc.), and investigated in detail (visual inspections, samples, laboratory tests, etc.).
The database was compiled to evaluate techniques according to their ability:

- to solve damage patterns (cracking, bleeding, transversal and longitudinal deformations, etc.),
- to be laid on specific supports and identified by damage patterns.

Evaluation was based on observations, results of laboratory tests and experts' experience.
Some techniques have to be banned on roads with some particular defects (for example, a thin layer of asphalt must not be laid on roads with potholes [figure1]).)

Figure 1 – Road with pothole

The area of use, conditions of laying down (climate, traffic, road geometry) and suitability for use in urban areas with specific imperatives (cable/pipe networks, etc.) were defined according to the experience of project members (infrastructure owners, laboratory experts, contractors) and a study of reference documents.

2.1.2 Environmental evaluation of road techniques

Some eco-comparison software like SEVE® [6] and ECORCE [7] were used to quantify the environmental impact of each technique.

For a given distance of transport, production site, etc., the techniques were characterized on the basis of:

- Saving of natural resources (aggregate, bitumen, water)
- Energy consumption on detailed phases (preparing raw materials, transport, mixing, laying [figure 2])
- Greenhouse gas emission on the same detailed phases.

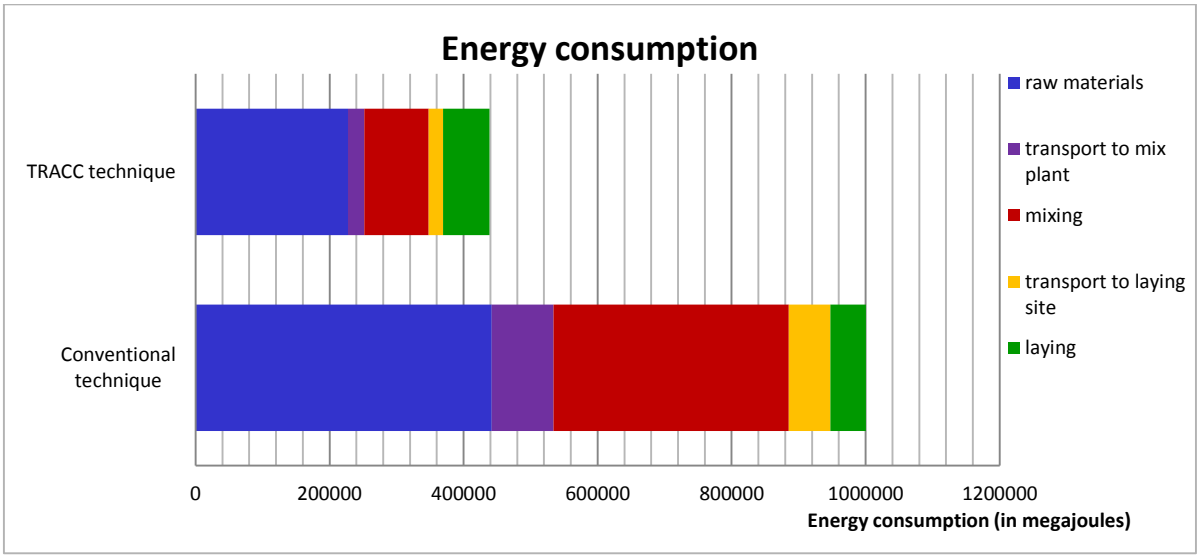

Figure 2 – Example of evaluation on energy consumption with an eco-comparison tool (TRACC technique and its conventional equivalent)

2.1.3 Social evaluation quantifiable with difficulty

Social consequences, on users or nearby residents and on production or construction workers are difficult to evaluate. Some studies carried out by contractors (for work conditions) or infrastructure owners (for user or resident inconvenience) provided information to evaluate all database techniques.

2.1.4 Economic evaluation based on a global approach

The economic aspect was not limited to direct cost, which is only presented as a guide.
A global approach was developed with these parameters:

- Material sustainability,

- Ability of the material to be recycled leading to long-term savings.
- Indirect costs, with the aim of limiting HGV traffic used for production and laying operations in order not to damage connected infrastructure,
- Operating cost, especially due to winter road maintenance.

The TRACC database contains 89 road techniques. Each was evaluated on 43 criteria dealing with the three fields of sustainable development and technical aspects.
Evaluation of technical, social and economic aspects is based on a 0-4 range (0 correspond to negative effect, 4 to the best effect).
Environmental impacts are quantified with eco-comparison for one centimeter thickness of mix asphalt.

The evaluations are reported on a summary sheet with technical reference documents and commentaries to justify the rating applied.
This database is of great interest. It provides a global approach integrating technical, environmental, social and economic aspects. Sustainable development will therefore be the major goal of infrastructure owners and other road professionals.

2.2 TRACC-EXPERT

This database is based on a specially developed interface named TRACC-Expert [figure 3] [8].
It ranks road techniques on the basis of objectives fixed by the user and weights each field.

Figure 3 –TRACC-Expert software home page

2.2.1 Special approach linked with user wishes

Different entries are available, corresponding to the user's profile:

- The entry "Infrastructure owner" allows a global road maintenance policy compatible with defined sustainable development objectives to be drawn up, taking into account the type of works planned and the user's objectives. The software ranks road techniques and suggests the best solutions. These proposals are the key to developing a sustainable road maintenance system.
- The entry "Contractors" deals with equipment policy to answer new sustainable development issues. With this entry, you can find an inventory of all production sites in south west France: aggregate (85), bitumen (40), warm or cold mixing (90). For each road technique, indications are given as to production and laying equipment.
- The last entry "Consulting engineers" is the one for which database use is optimal.

2.2.2 The user chooses his priorities

The software simulates real projects. It provides help in choosing road techniques to be use in projects. The analysis starts with a definition of objectives according to different available items: technique, environment, social acceptance, economy. The weighting of each criterion depends on the user's objectives and is absolutely free: One can assign up to 100% to a single criterion.

2.2.3 Solutions for real situations

The user then indicates some information according to the project he is working on.
Local context is defined by:

- Type of works,
- Local climate,
- Traffic on this section,

- Road localization (inside or outside an urban area)

He then defines the support on which works are planned, using following damage pattern:

- Cracking
- Fatigue cracking
- Delaminating
- Permeability
- Bleeding
- Transversal deformation
- Evenness
- Potholes
- Rutting

.

Finally, the software proposes a correction level for each type of damage.

The completed elements are used to query the database and bring out all the products that meet with the technical issues submitted (based on technical evaluation included in database).

All acceptable techniques are sorted by three categories:

- Surface courses able to solve the problems by themselves,
- Base layers able to solve problems but which need to be associated with a wearing course,
- Wearing courses to be associated with previous layers (they are checked depending upon selected traffic and criteria on superficial characteristics – skid resistance, driver comfort, noise, etc.)

All techniques are ranked according to the evaluation in the database and the weighting chosen by the user [figure 4].
Mark of each technique is calculated in some stages :

1. On each criteria, initial value is extracted from database (values from 0 to 4)
2. This value is normalized using formula Y = 100*(X-Min)/(Max-Min) – Min and Max values are defined according to individual value from all the products that meet with the technical issues submitted
3. For each item (technique, social, economy), average of individual normalized values is calculated and finally multiplied by weighting selected by the user

Calculation is different on environmental aspect :

1. For each criteria, database contains quantified value of environmental impacts (for one centimeter thickness)
2. This value is multiplied by thickness ordered by the traffic selected by user
3. This value is normalized using formula Y = 100-100*(X-Min)/(Max-Min) – Min and Max values are defined according to individual value from all the products that meet with the technical issues submitted
4. Average of individual normalized values is calculated and finally multiplied by weighting selected by the user

Thus, if a road technique is perfect on each criteria, it score 100%. For each item, the maximal possible note is equal to weighting value.

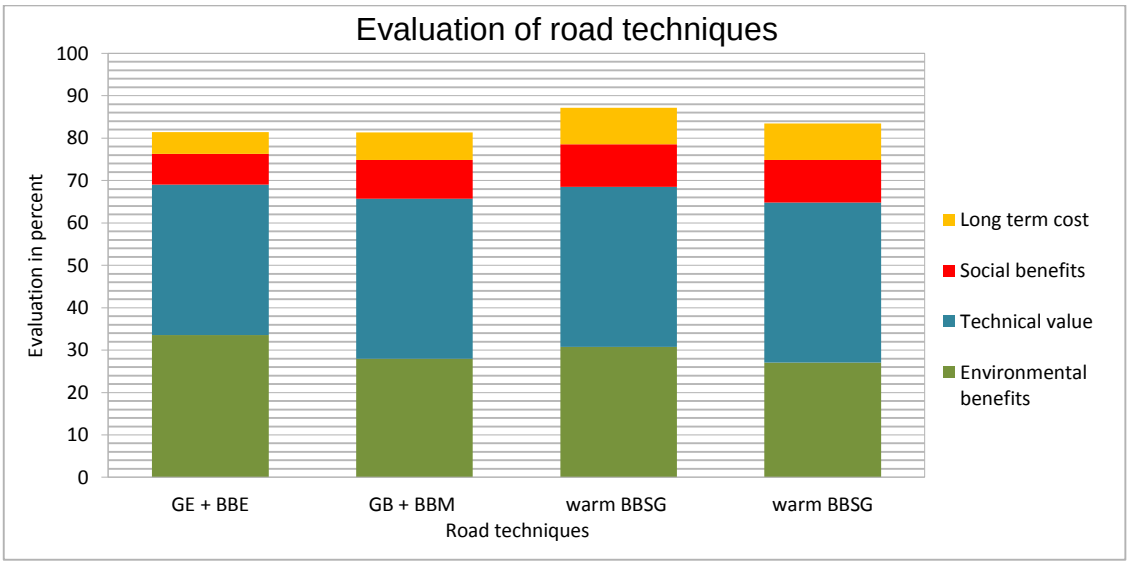

Figure 4 – example of TRACC-Expert results
(score out of 100% obtained by multiplication of evaluated values and weightings chosen by the user)

BBSG = hot mix asphalt, GE = gravel with emulsion, BBE = mix asphalt with emulsion, GB = asphalt gravel, BBM = thin hot mix asphalt)

3 LARGE-SCALE DEPLOYMENT IN FRANCE

3.1 Software validated by national institutions

In 2009, the TRACC project was registered in the national commitment between the French State, local public authorities and contractors targeting ecological solidarity.
The aim of the commitment is to introduce sustainable development in infrastructure construction and maintenance with a special focus on:

- The fight against global warming,
- Biodiversity protection,
- Waste recycling to achieve a circular economy,
- Saving in natural resources,
- Reduction of health and environmental risks,
- The fight against social discrimination,
- The development of an environmentally friendly economy.

The TRACC philosophy is clearly in line with this national global incentive.

In 2010, the Institute of Roads, Streets and Infrastructure for Mobility (IDRRIM) was set up to as a partnership institution in the fields of design, construction, maintenance and use of roads and transport infrastructure. The objective is to work towards coherence of a state-of the-art doctrine, and to promote innovation and the worldwide influence of French expertise. IDRRIM's mission is to unite those involved, private or public institutions working in transport infrastructures, so that they can work more closely together.
As a unifying project between these same stakeholders, TRACC corresponds to IDRRIM's mission. The Institute brings its support to this project and is aiming at a large-scale national deployment of the TRACC-Expert software.

3.2 Available freeware

Since October 2012, the software has been proposed for free to all transport infrastructure professionals [9, 10]. For the moment, there are more than 700 users among local authorities (35%), contractors (22%), private consulting engineers (28%), universities, etc.[figure 5]

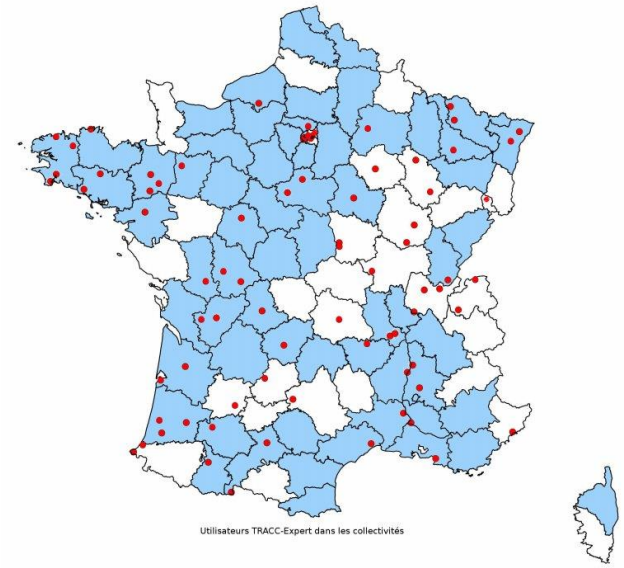

Figure 5 – TRACC-Expert users in local institutions (2015/02/25)

A new stage was reached in 2014. Within IDRRIM, a national working group was created to consolidate the database with national data and to reach a national agreement [11].

4 TOWARDS A CHANGE IN METHODS

TRACC is an approach to improve sustainable development in road maintenance without neglecting the technical aspects which are central to durability.
TRACC-Expert is a decision support tool proposing environmentally friendly techniques without giving up on conventional technical objectives. A broader distribution is the right way to achieve a lower direct costs by modifying the current balance between needs and offers.

4.1 Local efforts for a global outcome

Some local authorities have integrated TRACC-Expert in the decision-making process, such as the Gironde local council (the French department with the largest road network: 6500km), where all technicians and engineers dealing with construction or maintenance projects have been trained to use the software.
Each project is now analysed with TRACC-Expert to define or consolidate the choice of technique. In this way, technical specifications take into account technical needs and focus on sustainable development solutions. Contractors' proposals are analysed with eco-comparison software tools to exactly quantify the expected environmental benefits.
This process is in accordance with local Agenda 21, a territorial and participative variation of the worldwide Agenda 21 adopted in Rio in 1992 [12]. This agreement is a guideline for sustainable development in the 21st century. 178 nations have signed and must apply it at local, regional and national levels. The introduction to the document states: "Humanity is now at decisive stage in its history". "Action 21 (or Agenda 21) is concerned with present-day urgent problems and prepares the world for future tasks for the next century".

4.2 Open mindedness to other solutions

Other local authorities took into account sustainable development in road maintenance and initiated changes in their conventional processes. For example, in 2013, a user survey identified 35 projects on which TRACC-Expert had been used, and for 60% of these, the TRACC-Expert proposal was selected to be used in the project concerned.
All the experiences collected will be used to complete the current database. All users will then be able to find all the bibliographical and technical information indispensable for changing the way things are done.

For example, a road manager uses TRACC-Expert in a maintenance project for a secondary road with a moderately high but constantly increasing traffic (fewer than 100 lorries per day and per direction).

The road where maintenance works are planned is a flexible pavement with superficial cracking, bleeding and transversal deformation. The figure 7 shows software screens on which information of project are filled :

- Context (climate, situation, type of pavement, …)
- Characterization of pavement to renovate
- Expected level of treatment for each noticed deterioration

a : Context of project

b : Characterization of pavement to renovate and associated treatment

Figure 7 (a and b) : software screens to define project (English version in progress)

In application of the policy defined by the elected representatives, a weighting of 40% for environmental issues, 40% for technical aspects and 20% balanced between social and economic questions is chosen.

Then the software extracts from database the road techniques that meet with the technical issues submitted. A Road technique is selected if its technical capacities (evaluated in database, §2.1.1) correspond to hypothesis selected by the user.
Each solution is marked on the base of technical aspects, social and environmental benefits and long term costs. All those elements are weighting according to user's choice.

The input of this example gives the solutions presented below [figure 6].

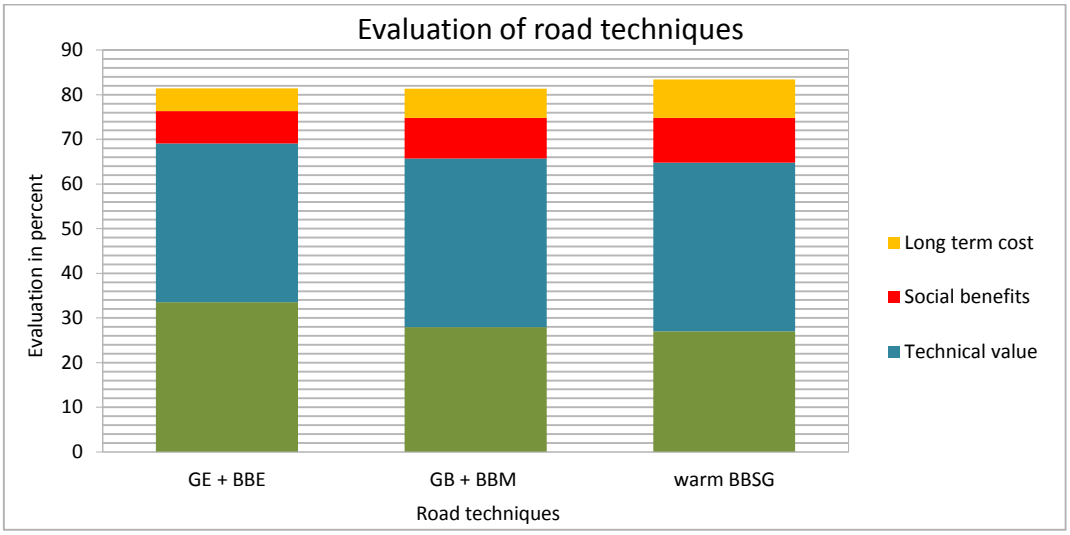

Figure 6 – TRACC-Expert results (ordinate in %)

The user will select the couple "gravel with emulsion + mix asphalt with emulsion" because it is an equivalent technical solution to hot mix asphalts but with a real environmental benefit (reduction in energy consumption and greenhouse gases emission). The use of the software will incite him to go further and demand 100% RAP gravel.
This solution is now 15-20% more expensive but he thinks that if he orders it more often, prices will decrease.
This choice is consolidated by a design study to verify that this solution is compatible with the expected traffic increase.
An eco-comparison analysis will evaluate the real environmental benefits.

5 CONCLUSION

Sustainable development in infrastructures is possible. The TRACC approach is a success. It unites all road professionals around one process that provides practical solutions to a major current issue.
TRACC-Expert is unique software, easy to use and focusing on a global approach. It's a wonderful tool for helping new solutions and new ways of doing things to emerge.

The path to sustainable road maintenance will be long and full of hazards. The current economic context and existing industrial fabric make a real revolution in this field complicated.
But it is everyone's duty to make the necessary efforts to achieve more eco-responsible road maintenance.
TRACC-Expert is a tool that will help all those involved in this ambitious objective.

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Acronyms

TRACC: Techniques Routières Adaptées au Changement Climatique – Road Techniques Adapted to Climate Change
CEREMA: Centre for studies and expertise on Risks, Environment, Mobility, and Urban and Country Planning
SEVE: Assessment System for Ecological Technical Alternatives
ECORCE: Eco-comparing Road construction Maintenance
BBSG: Hot mix asphalt
BBME: High modulus mix asphalt
GE: Gravel with emulsion
BBE: Mix asphalt with emulsion
BBM: Thin mix asphalt