

## IMPACT OF THE SABITA/CSIR ASPHALT RESEARCH PROGRAMME ON THE SOUTH AFRICAN ROADS INDUSTRY

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DRTT, CSIR**Abstract**

Technologies developed at the CSIR as part of the Sabita ARP research programme over the last five years have been implemented successfully in a number of instances. Significant benefits (tangible as well as intangible) have accrued to the asphalt industry from this programme. The broader roads industry, users and the community have also benefitted in terms of savings, an improved road network as well as improved functionality of roads resulting in reduced transport costs and improved road safety. A measure of the success of the programme was the extent of the participation of road authorities and especially the Department of Transport in particularly the Heavy Vehicle Simulator testing of trial sections containing some of the new technologies.

**1 INTRODUCTION**

The Southern African Bitumen and Tar Association (Sabita) and the CSIR initiated a research and development programme for the Asphalt industry in 1988. It was envisaged that such a programme would enhance asphalt technology in the industry, create an improved profile for the industry and enhance the industry's efficiency. The research programme addressed a number of issues ranging from the development and improvement of hard product technologies to decision support and strategic positioning projects. The main criterion by which the success of the programme was to be judged, was the tangible as well as the intangible returns to the industry. Since inception, the research programme was managed rigorously and has been very successful. This paper discusses the history of the Sabita Asphalt Research Programme (ARP), describes typical projects and evaluates their impact on the industry. The impact of the ARP is discussed in terms of tangible and intangible benefits to the asphalt industry as well as the broader road industry, users and the community. Based upon the findings in this paper, the investment by the industry in asphalt research has yielded significant returns.

## 2 HISTORY OF SABITA RESEARCH PROGRAMME

The ARP was initiated by the CSIR and Sabita through a formal research agreement in 1988. The objective of the programme was to enhance bitumen product technology in the industry, make the industry more competitive and provide improved services and products to the industry's clients. The basis of the ARP was a needs-driven research programme based on real needs of the industry and its clients. Prior to the commencement of the programme significant effort was put into the determination of research needs. A series of workshop-like meetings formed the Asphalt Research Strategic Taskforce planning process (AREST). The process was facilitated by the CSIR and involved participants from the road authorities, the road industry as well as from local authorities and communities. The highest priority projects emerging from the first AREST sessions focused on technology development including work such as the Heavy Duty Asphalt Pavements and Appropriate Standards for Bituminous Surfacing projects. The industry's acceptance and prioritisation of projects was based on benefit/cost assessment. The determining factor which facilitated implementation of the programme was its foundation on real research needs as identified by the stakeholders in the road industry.

The Sabita ARP Board was created to give direction to the projects, to monitor their progress and make recommendations on future research topics. The Board consisted of six members nominated from : Sabita, the asphalt industry, the CSIR and the road authorities. In addition to the role of the Board, a formal management system was established to ensure that the projects met their original briefs as well as the deadlines. The project plans were, nevertheless, kept flexible and in some cases projects were redirected in order to address changing needs.

In 1990, using a similar approach to that of 1988, the industry reviewed its needs and how the ARP projects should be realigned to address these changed needs. A major theme of the 1990 AREST meeting was to position the asphalt industry for the imminent socio-political changes in South Africa. A number of issues regarding the role of the asphalt industry and the future social development in South Africa were identified and action plans formulated.

Currently the focus is on developing technologies for the benefit of the future South Africa, as well as on training and implementation of research results. The implementation programme is currently yielding excellent results, particularly in the areas of large-aggregate mixes, porous asphalt, emulsion treated bases and in addressing social development needs. In order to maintain a continuous process of implementation in the long term, the needs of the industry and its clients should be determined on a regular basis and new research and development programmes defined.

### 3 TYPICAL PROJECTS

The projects conducted by the CSIR on behalf of Sabita are listed below in five categories :

#### Product/technology development

- Heavy Duty Asphalt Pavements (HDAPs)
- Emulsion treated bases (ETBs)
- Polymer-modified wearing courses (PMWC)
- Sabita Manual on the design and use of Large-Aggregate Mixes for Bases (LAMBS)
- Sabita Manual on the design and use of Granular Emulsion Mixes (GEMS)
- Sabita Manual on porous asphalt
- Guidelines on fatigue criteria for LAMBS
- HVS testing of ETB trial sections at Heilbron (joint funding between Sabita and Department of Transport, DOT)
- Labour-enhanced construction of bituminous surfacings

#### Performance evaluation for setting standards

- Appropriate standards for bituminous surfacings
- Evaluation of the N3 trial sections (joint funding between Sabita and DOT)
- Fatigue of modified binders under simulated crack movement
- Crack sealing and crack reflection

#### Decision support for road authorities - economic evaluation

- Guidelines for stage construction
- Development of SURF and upgrading to SURF<sup>+</sup>
- Warrants for upgrading gravel roads

#### Industry strategic issues

- The effect of fluctuating funding on the asphalt industry
- A feasibility study on a facility for accelerated testing of materials in the laboratory
- Social development issues, forum and needs determination

#### Training and dissemination of information

- Appropriate standards seminars
- Seminars on SURF
- Seminars on LAMBS, GEMS and SURF<sup>+</sup>
- Bituminous Materials Liaison Committee



An overview of the objectives of some of these projects in the categories above are given below.

### 3.1 Product/technology development

#### 3.1.1 Heavy duty asphalt pavements (HDAPS)

The project was initiated in 1989 and completed in 1992. The main objectives of the project were :

- to develop a new mix design method, based on relevant engineering properties, for asphalt mixes with large aggregates;
- to investigate the constructibility of these mixes, and
- to determine the ability of these mixes to carry very heavy traffic.

The South African Department of Transport (DOT) and the Natal Provincial Administration funded accelerated testing of trial sections with the Heavy Vehicle Simulator (HVS). This work showed that Large Aggregate Mixes for Bases (LAMBS) can carry in excess of 50 million equivalent axles before failure in rutting.

The result of this work has been implemented successfully in a number of projects including the Jan Smuts airport and the M2 freeway in Johannesburg. Further implementation actions included several research papers (Rust et al, 1 and Hugo et al, 2), a manual on the design and use of LAMBS (Sabita, 3), seminars introducing the new manual and several technology transfer projects with consultants and clients.

#### 3.1.2 Emulsion treated bases (ETBS)

ETBs have been used in South Africa for a number of years with residual binder contents varying from 0.7% to 5%. However, there was a lack of a performance related mix design method and criteria for this material. The main purpose of this project was :

- to develop a laboratory mix design method for ETBs
- to evaluate ETB materials using various raw materials in terms of relevant engineering properties
- to evaluate the field performance of ETBs under accelerated trafficking
- to evaluate the construction process and curing behaviour of ETBs
- to investigate the cost-effectiveness of using ETBs.

Once again, HVS testing funded by the DOT and the OFS Provincial Administration formed an integral part of the work conducted. Sabita manual 14 "GEMS - The design and use of granular emulsion mixes" (Sabita, 4) was compiled in conjunction with members of the roads industry and presented at a number of seminars.

#### 3.1.3 Polymer-modified asphalt wearing courses (PMWC)

The project originally started as "Polymer-modified asphalt". The flexible project plan approach allowed for the re-direction of the work to include the use of polymer-modified binders in thin surfacings and porous asphalt layers.

The main goals of this project were :

- to develop a laboratory mix design method for porous asphalt with voids in excess of 20%
- to evaluate the use of polymer-modified binders in a variety of asphalt surfacings including thin surfacings.

The new porous asphalt mix design method was implemented on the M2 in Johannesburg and on the M1 freeway. A draft manual on the design and use of porous asphalt is currently being compiled.

### 3.1.4 Labour-enhanced construction (LEC)

Arising from AREST 1990 the need was identified for easier access to the road building industry by small contractors. The unemployment prevailing in South Africa was considered as an ideal challenge in the development of labour-enhanced methods of constructing bituminous surfacings.

The main goals of this project were :

- to provide a manual (aimed at road authorities) on recommendations on bitumen surfacings suitable for LEC
- to guide and advise practitioners who may be getting involved in LEC

Sabita manuals on methods and procedures to undertake labour-enhanced construction (Sabita, 9) and on the principles of labour-enhanced construction were compiled (Sabita, 10).

## 3.2 Performance evaluation for setting standards

### 3.2.1 Appropriate standards for bituminous surfacings

This project was also re-directed as a result of re-evaluated needs defined during the 1990 AREST meeting. The project was refocussed to accommodate the conditions and constraints applying in the under-developed areas of South Africa.

The main goals of the project were :

- to prepare a state-of-the-art review on current sealing practice for low volume roads and surfacings used for deviations
- to compare construction costs for various surfacings with life-cycle costs of unpaved roads
- to make recommendations on the suitability and use of slurries
- to make recommendations on the suitability and use of appropriate surfacings for temporary deviations
- to make final recommendations for the suitability and use of various surfacings for low volume roads

As part of the implementation action following this work, Sabita manuals 9 and 10 (Sabita 5 & 6)) were compiled and presented at 9 seminars in Southern Africa.

### 3.2.2 Crack sealing and crack reflection

A number of investigations were conducted by the CSIR as well as BKS Inc for both the Department of Transport and Sabita into the use of modified binders to seal active cracks. As part of this work, the Crack-Activity Meter and the Crack Movement Simulator were developed. Laboratory testing was supplemented with several field trials.

The main goals of this project were :

- to develop a means of measuring crack movement on the road and to investigate factors that influence crack movement;
- to evaluate the ability of bituminous binders to address the crack reflection problem by testing them under simulated crack movement in the laboratory;
- to correlate laboratory findings with field performance, and
- to prepare a draft manual for use in the industry.

This work was reported at a number of national and international conferences including CAPSA '89, the TRB, the AAPT, the 7th ICAP and the ATC.

### 3.3 Decision support

#### 3.3.1 Warrants for upgrading gravel roads

The need to capture the South African experience in economic evaluation of road projects and the use of locally developed data on road user costs, traffic composition and time costs was met through the SURF1 and SURF2 computer programmes. These programmes which access economic warrants for upgrading gravel roads were matched by the introduction of the DOT's CB roads computer package. SURF+ is an accessible, user-friendly package yielding results comparable to that of the DOT package.

The main goals of this project were :

- to provide user-friendly guidelines for upgrading unsurfaced roads to a surfaced standard from a consolidation of existing information
- to provide a single package for economic analysis during the planning and design stages of a project

The SURF computer program and manual (Sabita, 7) on economic warrants for surfacing roads were introduced at several seminars in South African and neighbouring African States.

### 3.4 Industry strategic issues

#### 3.4.1 Social development issues

The 1990 AREST meeting identified this project as of the highest priority. The objectives of the project were to:

- determine social development issues involving roads that affect underprivileged and under-developed communities
- establish the perceived needs of these communities in terms of roads



- describe and estimate the extent of the road and street system in rural and urban developing areas
- assess its adequacy in addressing the identified needs.

### 3.5 Dissemination of information and training

Several seminars, mini-seminars and courses were held to ensure effective dissemination of information to the industry. These included the annual Road Infrastructure course presented by the CSIR and the recent workshops on LAMBS, GEMS, SURF+ and Appropriate Standards for bituminous surfacings. The Bituminous Materials Liaison Committee (BMLC) serves as a forum where the industry is kept up to date with technological developments on a bi-annual basis. The progress of specific research projects is critically reviewed at the BMLC's research forum. Papers and articles were published at technical conferences and in the technical press to promote discussion, evaluation and acceptance of research findings. A number of papers stemming from this programme was for example published in the proceedings of the 7th International Conference on Asphalt Pavements held in Nottingham in 1992.

## 4 VALUE OF THE SABITA ASPHALT RESEARCH PROGRAMME TO THE INDUSTRY

When considering the benefit of the Sabita asphalt research programme to the industry, the returns from these projects can be either direct or indirect and either tangible or intangible. For the purposes of this paper direct benefits to the asphalt industry are defined as :

- tangible benefits in terms of increases in readily measurable indicators i.e bitumen volumes sold;
- intangible benefits in terms of an improved service to its clients and enhancement of the image of the asphalt industry.

Indirect benefits accrue to the road building industry, users and the community through :

- more efficient investment of tax payer's money including the economically warranted provision of roads
- a road network of improved quality and reduced transport costs
- improved functionality of the road network in terms of factors such as decreased road user costs and road safety.

### 4.1 Direct benefits to the industry

Direct, tangible benefits have tended to result from the development of new technologies such as LAMBS, GEMS and porous asphalt. Table 1 gives a summary of the implementation of some of the new technologies developed in the programme and the direct benefits to the industry in terms of increased work created over the last two years and additional volumes of bitumen sold. Table 2 gives the future prospects for application of the new technologies in work planned over the next twelve months.

The total investment by the asphalt industry into the three projects above was R2,31 million over a five year period. In addition, the Department of Transport and other road authorities invested R775 000 into Heavy Vehicle Simulator testing of trial sections. Table 1 shows direct returns to the industry in terms of turnover to the value of R27 million. Prospects over the next year include work to the potential value of R50 million (see Table 2).

The value of the projects where these technologies have been used or are going to be used in the near future exceeded all expectations and these technologies are very likely to become an integral part of the roads industry. In some cases new products replaced other asphalt products, providing improved functionality and value to the community. A typical case is where the planned 25 mm bitumen-rubber surfacing on the M1 freeway was replaced with a 40 mm porous asphalt thus providing a much safer and quieter riding surface. In other cases the new asphalt products were selected above competing granular or cementitious materials. Typical cases are the M2 freeway in Johannesburg and portions of the N2 in Natal. These results are indicative of the willingness of the roads industry to implement the research findings obtained from these projects.

The research investment of R2,3 million by the asphalt industry on the three projects was well justified in view of the estimated value to the asphalt industry of R77 million in the first two years after completion of the research projects. This represents the use of approximately 28 000 tonnes of bitumen.

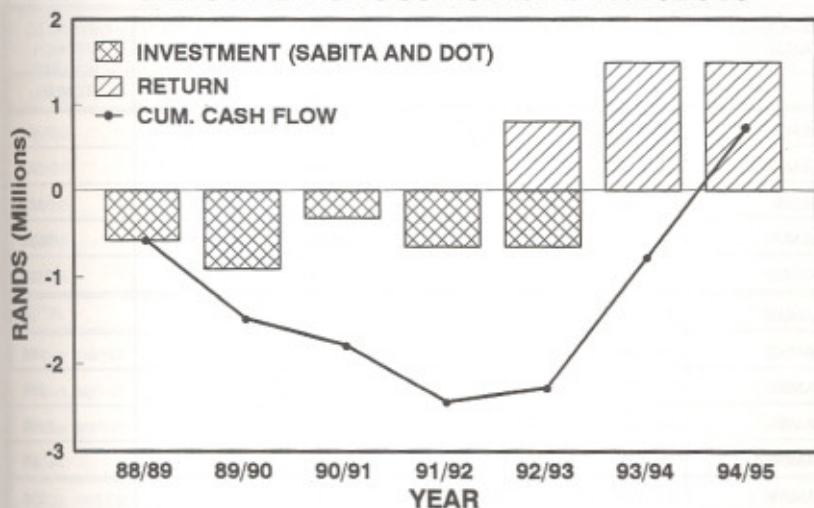
In order to assess the return on the investment in a simplistic way, it was assumed that only 50% of this amount accrued to the industry from additional asphalt work, and that normal industry profit margins were achieved. Figure 1 shows the resulting cash flow to the industry (taking into account investment by the industry as well as investment by the DOT into HVS testing). With these assumptions, the research investment was recovered within two and a half years after completion of the projects. If it is assumed that the third year will show a similar return to the second year, this indicates an initial rate of return of 7% on the investment (9% to the industry if the DOT expenditure is excluded). As the use of these products becomes entrenched in the market place and the product cycle matures, this rate of return on the original investment is expected to increase. If it is assumed that the returns will remain constant for the next 10 years, the internal rate of return will increase to 29 % (33 % to the industry if the DOT expenditure is excluded).

Intangible benefits to the industry resulted mainly from

- the improvement of asphalt technology in general,
- generating an awareness in the roads industry of the latest available technologies and their use,
- image of an industry providing products and technologies of quality and cost effective solutions
- an awareness in the industry regarding the future challenges in southern Africa and how they may be addressed.



**FIGURE 1 : BREAK-EVEN ANALYSIS FOR LAMBS, GEMS AND POROUS ASPHALT PROJECTS**



#### 4.2 Indirect benefits to the industry and community

The broader roads industry benefitted from the SABITA Research Programme, firstly, by virtue of the fact that road authorities now have additional products and technologies to select from in new road construction as well as in maintenance and rehabilitation projects. These products are backed by analytically-based design methods and performance-related test methods thus improving confidence in their use.

Some of these new technologies have effected significant savings to the road authorities. For example, the work conducted in the LAMBS project indicated that a saving of 40 per cent in binder content can be effected if 37,5 mm top size stone is used in place of 27,5 mm. As part of the GEMS trial section evaluation at Heilbron (OFS), an estimate was made of the savings due to the use of a GEMS with the locally available weathered dolerite as base material as an alternative to an imported G2 crushed aggregate base. The estimated saving on the materials was in the order of R30 000 per km.

The total benefit to the road user is difficult to quantify - especially if improved performance of the new materials and user cost savings due to better functionality (eg improved accident statistics due to the use of porous asphalt) is taken into account. However, the direct material cost savings to the taxpayer on LAMBS and GEMS were conservatively estimated as R4,1 million over the first two years of use of these two

**Table 1 : Value of implementation projects awarded to date where LAMBS, GEMS and Porous Asphalt will be used**

RESEARCH PROJECT	IMPLEMENTATION PROJECT	QUANTITY (TONNE)	VALUE TO INDUSTRY (RAND)	ESTIMATED BITUMEN VOLUME (TONNE)
GEMS	Kwamashu	2835	270000	57
GEMS	Emzulweni	19845	1900000	397
GEMS	Kokstad	7560	252000	151
GEMS	GP13-3, Britstown	126000	4160000	2520
TOTAL		156240	6582000	3125
LAMBS	MR7, Queensborough	1000	120000	40
LAMBS	N3, Athlone	4000	480000	160
LAMBS	Jan Smuts Airport	5100	640000	204
LAMBS	Mitchell's Pass	27000	2970000	1080
LAMBS	Heidelbergroad, Johannesburg	1000	110000	40
LAMBS	M2 West, Johannesburg	8904	979440	356
LAMBS	Outeniqua Pass	33000	3630000	1320
LAMBS (26,5mm)	Durban Corporation	15000	1800000	600
TOTAL		95004	10729440	3800
Porous asphalt	Sarnia	200	24000	11
Porous asphalt	Rifle Range RD, Johannesburg	298	35760	16
Porous asphalt	Oxford RD, Johannesburg	315	37800	17
Porous asphalt	M2 West, Johannesburg	4020	482400	221
Porous asphalt	Majuba Pass	500	60000	28
Porous asphalt	Hilton, Natal	600	72000	33
Porous asphalt	N17	29640	4110000	1630
Porous asphalt	M1, South	40800	4820000	2244
TOTAL		76373	9641960	4200
TOTAL AWARDED			26953400	11125

**Table 2 : Value of envisaged future projects where LAMBS, GEMS and Porous Asphalt will be used**

RESEARCH PROJECT	IMPLEMENTATION PROJECT	QUANTITY (TONNE)	VALUE TO INDUSTRY (RAND)	ESTIMATED BITUMEN VOLUME (TONNE)
LAMBS	N10, Olifantskop	35000	5390000	1400
LAMBS	Johannesburg City Council, 94/95	50000	5500000	2000
LAMBS	N2, Umtunzwini, project 1	57600	6336000	2304
LAMBS	N2, Umtunzwini, project 2	57600	6336000	2304
LAMBS	N2, Umtunzwini, project 3	57600	6336000	2304
LAMBS	N2, Umtunzwini, project 4	57600	6336000	2304
TOTAL		315400	36234000	12616
Porous asphalt	Eshowe	1200	144000	66
Porous asphalt	Johannesburg City Council, 94/95	20000	2400000	1100
Porous asphalt	M1 North	62400	11400000	3432
TOTAL		83600	13944000	4598
TOTAL PREDICTED			50178000	17214

technologies. Savings such as these can make funds available for investment into building road infrastructure in areas of need.

The introduction of an analytical mix design method for porous asphalt (> 20 % voids) has facilitated its use on a number of major projects (including the M2 and the M1 Freeway). Porous asphalt provides a sound-absorbing surface which reduces traffic noise significantly, and based upon investigations in Europe, the number of accidents on a specific route can be significantly reduced by surfacing a road with porous asphalt.

The research project which has had the most significant benefit to the community is the Social-Development Issues Project. This project has shown that an estimated length of 220 000 km of rural and 40 000 km of urban unproclaimed roads exist and are not included in the rural road authorities' records. These roads comprise local distributors, access collectors and access roads and tracks located in the developing areas in South Africa and should be taken cognisance of in the future planning of road authorities. The demand for bitumen for the surfacing of these roads will result in significant additional volumes of bitumen sold.



## 5 CONCLUSIONS

The SABITA research programme which was conducted at the CSIR over the last five years has been very successful, both in technological development as well as in implementation. The asphalt industry has benefitted significantly from this programme in terms of increased turnover generated by the introduction of new technologies backed up by analytical design methods and performance-related test methods. The roads industry in general has benefitted from the work conducted in view of the improved performance of the new materials, improved design and test methods and improved specifications. In addition, the community at large has benefitted in terms of savings and the improved functional performance of the road network.

The success of the Sabita Research Programme is attributed to, firstly, the fact that the projects were based on real needs defined by the industry, the users and the community. Secondly, the establishment of a structure through which the projects were evaluated regularly and directed (sometimes re-directed), combined with the rigorous management of adherence to briefs and deadlines resulted in a focused, well defined research effort yielding results which were readily implemented. The implementation of research results was facilitated by the quality of the tripartite partnership between industry, road authorities and researchers.

## 6 ACKNOWLEDGEMENT

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