

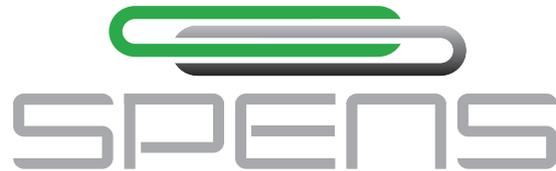


**EUROPEAN COMMISSION
DG RESEARCH**



**SIXTH FRAMEWORK PROGRAMME
Sustainable Surface Transport**

Sustainable Pavements for European New Member States



FINAL REPORT – EXECUTIVE SUMMARY

Deliverable no.	D20
Dissemination level	Public
Work Package	WP1 Task 1.1
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Co-authors	Adewole Adesiyun, László Gáspár, Marjan Tušar, Safwat Said, Manfred Haider
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1 Introduction

This report represents the final report of the STREP project named Sustainable Pavements for European New Member States. The objective of this research project was to develop appropriate tools and procedures for the rapid and cost-effective rehabilitation and maintenance of roads. The overall objective was to search for materials and technologies for road pavement construction and rehabilitation that would behave satisfactorily, have an acceptable environmental impact and be cost-effective.

The European Commission, participating partners and national organizations have funded this project, which is gratefully acknowledged.

2 Presentation of the SPENS project

2.1 Scope of the project

In 2006 the European Commission set up a research project named 'Sustainable Pavements for European New Member States' (SPENS). This three year project, which was funded within the EU Sixth Framework Programme, Sustainable Surface Transport priority, ended in August 2009.

The standard of the road infrastructure differs throughout the European Union member states, but the present volume of heavy road transport requires a sustainable road infrastructure immediately. There is a constant need for new resistant pavement materials, which should comply with the EU regulations.



Figure 1: Deterioration of roads

Due to the priority of motorway construction, the standard of maintenance of other roads has lowered, resulting in an increased need for effective road maintenance and improvement over the years to come. The materials and technologies now used in the New Member States differ from those adopted in common practice in the EU-15.

The objective of this Specific Targeted Research Project was to develop appropriate tools and procedures for the optimum and cost-effective rehabilitation and maintenance of roads in

the EU New Member States. The overall objective was to search for materials and technologies for road pavement construction and rehabilitation that would:

- behave satisfactorily in a typical climate,
- have an acceptable environmental impact,
- be easy to incorporate within existing technologies,
- be cost-effective and easy to maintain.

2.2 Co-ordinator contact details

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2.3 Contractors involved

The consortium mainly consisted of experts from the New Member States, in order to ensure that the research is focused on issues relevant to the latter. Within SPENS thirteen different languages were spoken.

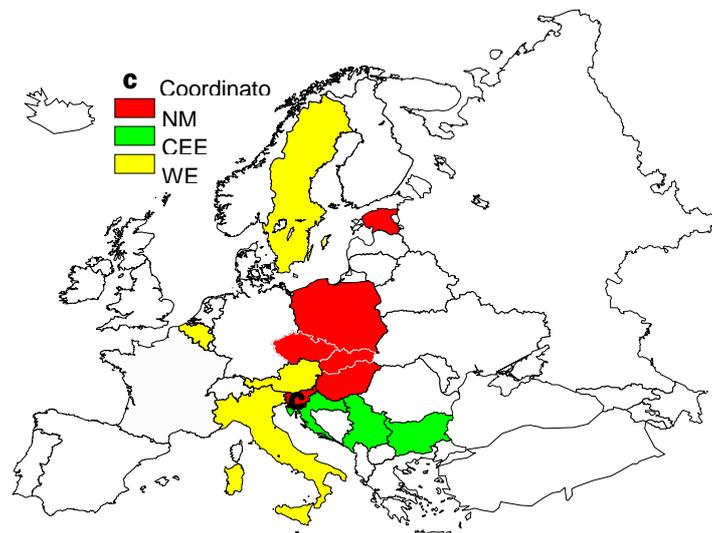


Figure 2: SPENS partners

The consortium of the following partners has conducted the SPENS project.

Partner	Partner acronym	Country
Slovenian National Building and Civil Engineering Institute	ZAG	Slovenia
Institute for Transport Sciences	KTI	Hungary
The Swedish National Road and Transport Research Institute	VTI	Sweden
Austrian Institute of Technology (arsenal research)	AIT	Austria
Transport Research Centre	CDV	Czech Rep.
Road and Bridge Research Institute	IBDiM	Poland
Zilina University	TUZA	Slovakia
Europe's National Road Research Centres with **	FEHRL	Belgium
DDC Consulting & Engineering Ltd.	DDC	Slovenia
Ferriere Nord SpA	FENO	Italy

** TECER- Transport and Road Research Institute (Estonia)
 IGH - Civil Engineering Institute of Croatia (Croatia)
 IP - The Highway Institute (Serbia)
 CRBL - Central Roads and Bridges Laboratory (Bulgaria)

In the period of September 2006 to August 2009 ten partners together with four institutes under the FEHRL umbrella cooperated in the performance of laboratory and field tests asphalt materials, as well as in the evaluation of the impact of roads on the environment. The project, with a total budget of 2,47 Mio EUR, was coordinated by the Slovenian National Building and Civil Engineering Institute (ZAG).

The research work focused on the development of procedures for producing and implementing materials for road construction, using only local materials and taking into account the existing traditions and construction techniques, as well as the specifics of already constructed roads. Laboratory and in-situ tests were performed in several European countries. Field trials and monitoring during the project were used to verify the research results.

2.4 Organization of work

The research work was organized into four technical work packages (WP), which dealt with

- The optimization of assessment techniques and procedures for roads - WP2, led by László Gáspár (KTI)
- The improvement of pavement structures - WP3, led by Safwat Said (VTI)
- Evaluation of materials for road upgrading - WP4, led by Marjan Tušar (ZAG)
- Impact assessment of roads on the environment - WP5, led by Manfred Haider (AIT).

Within WP6 Dissemination of results Steve Phillips (FEHRL), together with Adewole Adesiyun and Aleš Žnidarič, coordinator of the clustered CERTAIN coordination action, have organized several dissemination events before the end of the SPENS project.

Within WP1 Management, led by project coordinator Mojca Ravnikar Turk (ZAG) two Contractor's Committee meetings per year were held, whereas the Management group had meetings and contacts more often. We had the opportunity to work with several Project officers - Mr. Herbert Thanner, Mrs. Ms. Maria-Cristina Marolda and César Pérez-García. The current officer in charge of the project is Mr. William Bird of the Research Directorate-General, European Commission.

Overview of SPENS task leaders:

WP1 - Mojca Ravnikar Turk (ZAG)

WP2 - Slovenko Henigman (DDC), Roland Spielhofer (AIT), Darko Kokot (ZAG),

WP3 - Safwat Said (VTI), Ana Mladenovič (ZAG), Imre Pap (IP),

WP4 - Björn Kalman (VTI), Dariusz Sybilski and Wojciech Bańkowski (IBDiM), Leif G. Wi-man (VTI),

WP5 - Lennart Folkesson (VTI), Manfred Haider (AIT),

WP6 - Mojca Ravnikar Turk (ZAG), Steve Phillips (FEHRL), Adewole Adesiyun (FEHRL)



Figure 3: August 2009 – SPENS task and WP leaders

3 Work performed in the period September 2007 to August 2009

3.1 WP1 Project management

In the last three years there were six Contractor's Committee meetings and seven Management group meetings. All partners attended Contractor's Committee meetings and the Work Package leaders regularly attended the Management group meetings.

Meeting No.	Place	Date
CC-1	Ljubljana, Slovenia	16-17 October 2006
CC-2	Budapest, Hungary	4 September 2007
CC-3	Ljubljana, Slovenia	22 April 2008
CC-4	Stockholm, Sweden	8 September 2008
CC-5	Belgrade, Serbia	11 March 2009
CC-6	Ljubljana, Slovenia	27 August 2009

The minutes of the meetings are available on the SPENS web-site under the non-public segment. During the course of the project, the 'Project roadmap' was regularly updated and made available on the non-public segment of the SPENS web-site: These updates provided an up-to-date activity guide for all partners in the project consortium, as well as for the European Commission.



Figure 4: August 2009 – SPENS Contractor's representatives

3.1.1 Results achieved and expected end results

The research work was planned in such a way that the test fields were constructed in Year 1, the tests were performed in Year 2 and the results of the laboratory and field testing were analyzed in Year 3. All field test sections (in Slovenia and in Poland) were established as planned and the tests were completed in Year 2. Most of the obtained test results were within

the expected limits, however further long-term monitoring of the specific test sections would be necessary.

3.1.2 Intentions for use and impact

Within the CERTAIN Coordination Action (Central European Research in TrAnsport INfrastructure), ending in June 2010, special focus is given to the needs of the New Member States and other non-EU European countries. This will be achieved through close links with other projects and by integration into the current FEHRL Strategic Road Research Programme (SERRP) Cluster. The SPENS final report will be translated and published in Slovene, Polish and Czech languages.

3.1.3 Main elements of publishable dissemination plan

At the beginning of the project a brochure presenting the SPENS project was printed for dissemination at several events. Two posters were prepared and printed – one was on display at FEHRL headquarters in Brussels and the other one at ZAG, Slovenia. Three hundred copies of the SPENS final report were printed and sent to SPENS partners and disseminated at the Final seminar. In Figure 5 SPENS Coordinator Mrs. Mojca Ravnikar Turk is handing over the SPENS Final report to Project Officer Mr. William Bird with the SPENS poster in the background.



Figure 5: August 2009 - SPENS poster and SPENS Final report

Throughout the course of the project, close working relations were established and maintained with projects named ARCHES (Assessment and Rehabilitation of Central European Highway Structures) and CERTAIN. Dissemination activities were linked with ARCHES dissemination plans, and were mostly organized by the CERTAIN project.

All the research results were presented during the SPENS final seminar, held on the 27 and 28 August 2009 in Ljubljana, Slovenia.

3.2 WP2 Road assessment

The research was focused on gathering the proper input parameters and analyzing them in order to obtain results upon which long-term optimum decisions can be made. The research has concentrated on:

- analysis of effects caused by various axle loadings on pavements,
- measuring and visual condition evaluation techniques for pavement quality characterization,
- development of a systematic methodology for the selection of optimum intervention techniques for pavement management.

The goal of the task *Traffic load equivalency* was the analysis of the effect caused by various axle loadings on pavements. In order to get the necessary input, a Heavy Vehicle Simulator (HVS) response test on six test sections near Maribor (in co-operation with WP4) was carried out. Different loads between 30 and 80 kN were applied. Strains and deformations of the structure were recorded. Falling Weight Deflectometer measurements on each of the test sections were also performed. The outcomes are presented in **D.12 Recommendations for traffic equivalency factors**.

Within the work task *Non-destructive testing of pavement condition*, a test device harmonization test was carried out in Vienna in May 2008, after careful preparatory activities. Seven bearing capacity, six longitudinal evenness and nine skid resistance measuring devices took part in the test. The bearing capacity test was performed in accordance with the Protocol C5 of COST 336 Action, and the results obtained were analyzed by CDV. The longitudinal evenness test was carried out on 6 sections using three measuring speeds. International Roughness Index (IRI), longitudinal profile and Power Spectrum Density results were analyzed by VTI. The skid resistance test was performed on 6 sections of 100 m length each. Analysis of the results was carried out in accordance with prENV 13036-3 by Arsenal and KTI. Certificates were issued to the participants of the harmonization test and the **D11 Guidelines of a complex methodology for non-destructive pavement measuring techniques** was prepared on time.



Figure 6: May 2008 – harmonization test (skid resistance and longitudinal evenness)

In work task *Systematic decision making methodology on pavement rehabilitation and upgrading* the answers given to the questionnaire developed during the year 1 were utilized. The guidelines concentrate on low-volume roads with max. 300 ESAL/day heavy traffic. They deal with the following main topics: goals, compilation procedure for decision-making methodology, pavement condition evaluation methods, road rehabilitation and upgrading techniques, case studies, questionnaire, different national road rehabilitation methods. The methodology is presented in **D.13 Guidelines on a systematic decision-making methodology for the pavement rehabilitation of low volume roads**.

3.3 WP3 Improvement of pavement structures

This research of the three work tasks was focused on the following:

- Establishing the efficiency of different kinds of reinforcement for the rehabilitation of pavement.

Measurement data from several reinforced road sections (in Poland, Italy and Sweden) were collected and analyzed. Evaluations of the reinforced structures based on the analysis of the FWD measurements, response measurements and visual inspections. A design procedure for reinforced pavements was adapted. The adapted design model based on data from existing reinforced roads and deterioration development in the Heavy Vehicle Simulator tests (conducted by WP4) was analyzed. The outcomes are presented in **D9 Long-term performance of reinforced pavements**.

- Gaining experience about the use of recycled materials and by-products in road construction with regard to engineering and environmental performance, and using laboratory and field tests.

In Slovenia three test sections were constructed in Year 1 using construction and demolition (C&D) waste materials, as well as industrial by-products (steel slag). Two test sections with steel slag aggregate in wearing courses were constructed, one on a regional road (in Tolmin) and one on a highway. One instrumented road section was constructed in Muljava, using recycled crushed concrete in the unbound layer. Monitoring of the test sections was continued in Year 2 and Year 3. Gathered experience and analysis of the laboratory tests and monitoring are presented in **D18 A methodology for testing and implementing selected recycled materials and industrial by-products in road construction**.



Figure 7: Construction of test fields in Muljava (and in Tolmin (2008))

- Finding a practical model for the optimization of asphalt mixture design.

The work was performed in laboratories of several partners (IP, IGH, ZAG, TUZA, IBDiM, VTI). Manufacturing of bituminous mixes, compaction of test specimens preparation of asphalt slabs was the base for extensive testing of asphalt mixtures. Mix recipes were related to the target functional properties relevant for various climatic and traffic conditions in the field. The outcomes are presented in **D10 Practical mix design model for asphalt mixtures**.

3.4 WP4 Evaluation of materials for road upgrading

Within the scope of task *Investigation of the Performance of Conventional and Polymer Modified Bitumen* two types of aggregates and seven binders were used to produce the asphalt samples. One type of aggregate was siliceous and the other one limestone. Each aggregate was sieved and each fraction was characterized according to European standard practices. During Year 2 samples of AC (Asphalt concrete), SMA (Stone mastic asphalt) and PA (porous asphalt) were produced with siliceous aggregate. In the Year 3, the mix design of AC with limestone aggregate and samples of stated material were produced and tested. In Year 2 all binders were tested for penetration EN 1426, softening point EN 1427, density EN 15326, dynamic viscosity at 60°C EN 12596, kinematic viscosity at 135°C EN 12695, weight loss after RTFOT EN 12607-1, as well as penetration, softening and dynamic viscosity according to RTFOT. For the four polymer modified binders the deformation energy, load at elongation and elongation at break were determined at 10°C and 25° using the methods EN 13589 and EN 13703. The elastic recoveries for the modified bitumen were determined using the method EN 13398. The results of extensive testing and analyses of these results are presented in **D15 Recommendations for modified binder usage in pavements**.

Within the scope of task *Material Recommendations and Performance-based Requirements for High Modulus Asphalt Mixtures and Flexible Pavement Design* requirements for HMAC usage were prepared. The requirements of Polish recommendations for HMAC usage were verified in the laboratory and at field tests and these recommendations were adopted to the needs and conditions of Slovenia, Serbia, Sweden, Croatia, Estonia taking into account the climate, materials and test methods used in these countries.

Laboratory tests on materials were performed and several HMAC were designed. The research covered three binders: 20/30, DE30B (polymer modified), MG10/20 (multigrade) and five types of aggregates (basalt, granite, limestone, crushed gravel and steel slag). The results of the performance tests (fatigue, stiffness, rutting) indicated the suitability of different binders and aggregates of different type, quality and origin. In October 2007 a test sections, which were later on in 2008 subjected to accelerated loading test, was built at Pruszków, near Warsaw. The test section was constructed with two different mixes for the base course: asphalt concrete (AC) and HMAC of the same layer thickness. So the direct evaluation of the effect of HMAC on pavement durability was possible.



Figure 8: Construction of test field in Pruszków, near Warsaw, Poland

Pavements were instrumented with strain gauges at the bottom of the asphalt layers, and vertical strain gauges at the top of the subgrade. The accelerated loading test (ALT) was performed using Heavy Vehicle Simulator (HVS) at a constant air temperature of 10°C. The

HVS tests were accompanied by other field tests (Falling Weight Deflectometer, Ground Penetration Radar) and a number of laboratory tests. A few dozen slabs and cores were cut from the pavement after the ALT was completed. The laboratory test program consisted of the evaluation of composition (binder content, grading, air voids), resistance to rutting, stiffness and fatigue. The results of extensive testing as well as the recommendations are presented in the **D8 Laboratory and field implementation of high modulus asphalt concrete. Subtitle: Requirements for HMAC mix design and pavement design.**

Within the scope of task *Upgrading of asphalt macadam and light asphalt pavements to the bearing capacity level needed by EU-regulations* during the autumn of 2007 and spring 2008 six full scale test structures were built at Dragučova near Maribor in Slovenia. Each test field was 50m long, a short section of each test field was also heavily instrumented. The strain, deformations and pressure sensors were installed into unbound and asphalt layers to be used during the accelerated load tests (ALT). The main difference between the test fields, e.g. pavements structures was in the thickness of the asphalt layers. Additionally test section No. 6 was reinforced with steel mesh at the bottom of the asphalt layer. During the construction of the test fields, the quality of the unbound layers was checked. All asphalt mixes used in test fields were analyzed in ZAG's laboratory for asphalts and bitumens.

The HVS was transported from Sweden to Slovenia in April 2008 to perform the full-scale accelerated load testing. The load of the test wheel was 60 kN and was increased to 80 kN and to 100 kN at the test sections No. 5 and 6 having the thickest asphalt layer. The number of load repetitions on each structure exceeded 190.000 repetitions (230.000 on average), which corresponds to about 3 years of heavy traffic load. During the accelerated load tests, surface cross-profile measurements were performed to obtain the surface rut depth propagation data. Before and at the end of the accelerated load tests response measurements were carried out at different load levels to get data about stresses, strains and deformation data from the different structures.

After the HVS test the FWD (falling weight deflectometer) was used to determine the difference between the properties of pavements that were loaded with HVS and those that were not. Additionally seven asphalt cores were drilled at each test section and the voids, compaction rate and thickness of asphalt layers were determined. The description of tests and analyses of results are presented in **D16 Guidelines for selection the most convenient upgrading systems based on results of heavy vehicle simulator.**

In the scope of the Transport Research Arena (TRA 2008), which was held in Ljubljana, Slovenia, a technical visit was organized to the SPENS test field at Dragučova near Maribor.



Figure 9: Accelerated load testing, Dragučova, April 25, 2008 - the TRA08 technical visit

3.5 WP5 Impact assessment of roads on the environment

The main focus of work in WP5 was on the execution and analyses of results obtained from several measurement series to provide data and insight into the environmental effects of typical road pavements in European new Member States (NMS). Based on the questionnaire results it was decided to focus on asphalt concrete with 11 mm maximum chipping size, being the most common NMS road surface. The following investigations were performed:

- Particle emission tests in the VTI road simulator on samples from Slovenia and the Czech Republic
- In-situ measurements of particle emission (Czech Republic, Slovakia)
- Measurements of gaseous air pollutants
- Measurements of pass-by vehicle noise in Slovenia, Slovakia and the Czech Republic
- Measurements of rolling noise in Slovenia, Slovakia and the Czech Republic (performed by 'arsenal research')

All measurement series were completed and results evaluated as input for deliverable **D17 Guidelines for the environmental assessment of various pavement types including recommendations to road authorities in New Member States**, which was completed on time.

The work of SPENS WP 5 was presented by 'arsenal research' at the INQUEST workshop in Brno on November 15, 2007 and at the SPENS workshop in Bled on May 7, 2009.



Figure 10: CPX measurements by AIT in the Czech Republic



Figure 11: Bled, May 7, 2009 Presenters at the WP5 workshop

3.6 WP6 Dissemination

Some of the results of the research within SPENS were presented at several national and international events. The main dissemination events were

- Transport Research Arena - TRA 2008, Ljubljana, Slovenia, where several presentations were held. A technical visit was organized to the SPENS test field at Dragučova near Maribor.
- Outcomes were presented in workshops organized by the CERTAIN clustered project in Tallin (Estonia), Kiev (Ukraine), Brno (Czech Republic), Budapest (Hungary), Bled (Slovenia) and also in Moscow (Russia).
- The SPENS final seminar on August 27 and 28, 2009, which was held in Ljubljana, Slovenia together with the ARCHES final seminar



Figure 12: The Transport Research Arena TRA08 exhibition – the EU booth



Figure 13: August 27-28, 2009, Final seminar, Ljubljana, Slovenia

A brochure and two posters were prepared and put on display for the last three years. The concluding period of the project was accompanied by a newsletter, issued in July 2009.

The SPENS web site, which was continuously updated, consists of a non-public and a public part. The public part is designed used to attract stakeholders and to provide end-users with the downloadable SPENS deliverables.

All final reports, containing the outcomes of the research are public and thus available on the for downloading on the SPENS web-site.

Presentations given by SPENS members at the TRA08 are available at

http://videolectures.net/tra08_green/

Videolectures from SPENS final seminar are available at

http://videolectures.net/asfs09_ljubljana/

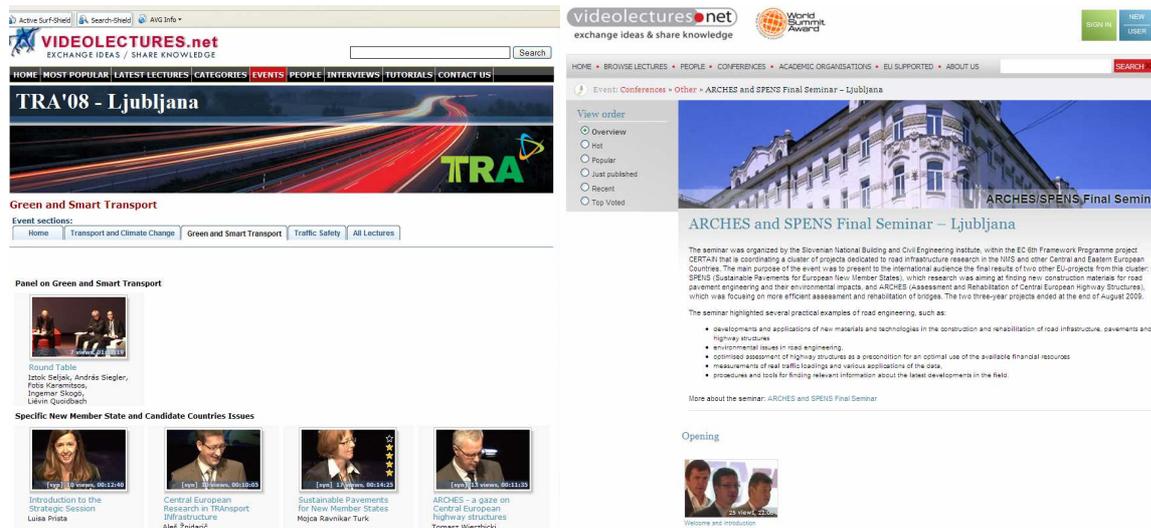


Figure 14: SPENS videolectures (TRA08 and Final seminar)

4 Main outcomes

Based on the results of the research within the technical work packages, practical guidelines and recommendations have been produced. The printed copy of the Final report is available at SPENS partner institutes and at the FEHRL office.

Table 1 Overview table of SPENS deliverables

Del. No.	Deliverable name	WP	Lead participant	Dissemination level
D1	SPENS project website	6	FEHRL	PU
D2	Initial Project Roadmap	6	FEHRL	PP
D3	Inception report	1	ZAG	PP
D4	Brochure presenting the project	6	FEHRL	PP
D5	Year one progress report	1	ZAG	PP
D6	Mid-Term Assessment report	1	ZAG	PP
D7	Year two progress report	1	ZAG	PP
D8	Laboratory and field implementation of high modulus asphalt concrete. Subtitle: Requirements for HMAC mix design and pavement design	4	IBDiM	PU
D9	Long-term performance of reinforced pavements	3	VTI	PU
D10	Practical mix design model for asphalt mixtures	3	FEHRL	PU
D11	Guidelines of a complex methodology for non-destructive pavement measuring techniques	2	arsenal	PU
D12	Recommendations for traffic equivalency factors	2	ZAG	PU
D13	Guidelines on a systematic decision-making methodology for the pavement rehabilitation of low volume roads	2	DDC	PU
D14	Final Plan for using and disseminating knowledge	1	ZAG	PU
D15	Recommendations for modified binder usage in pavements	4	VTI	PU
D16	Guidelines for selection the most convenient upgrading systems based on results of heavy vehicle simulator	4	VTI	PU
D17	Guidelines for the environmental assessment of various pavement types including recommendations to road authorities in New Member States	5	arsenal	PU
D18	A methodology for testing and implementing selected recycled materials and industrial by-products in road construction	3	ZAG	PU
D19	SPENS Final report	1	ZAG	PU
D20	SPENS Final report - executive summary	1	ZAG	PU
D21	SPENS Final reporting questionnaires	1	ZAG	PP
D22	SPENS Final Activity report	1	ZAG	PP
D23	SPENS Final Management report	1	ZAG	PP

Legend:

PU = Public, **PP** = Restricted to other programme participants (including the Commission Services),

All the public deliverables are available on the SPENS web-site.

<http://spens.fehrl.org>

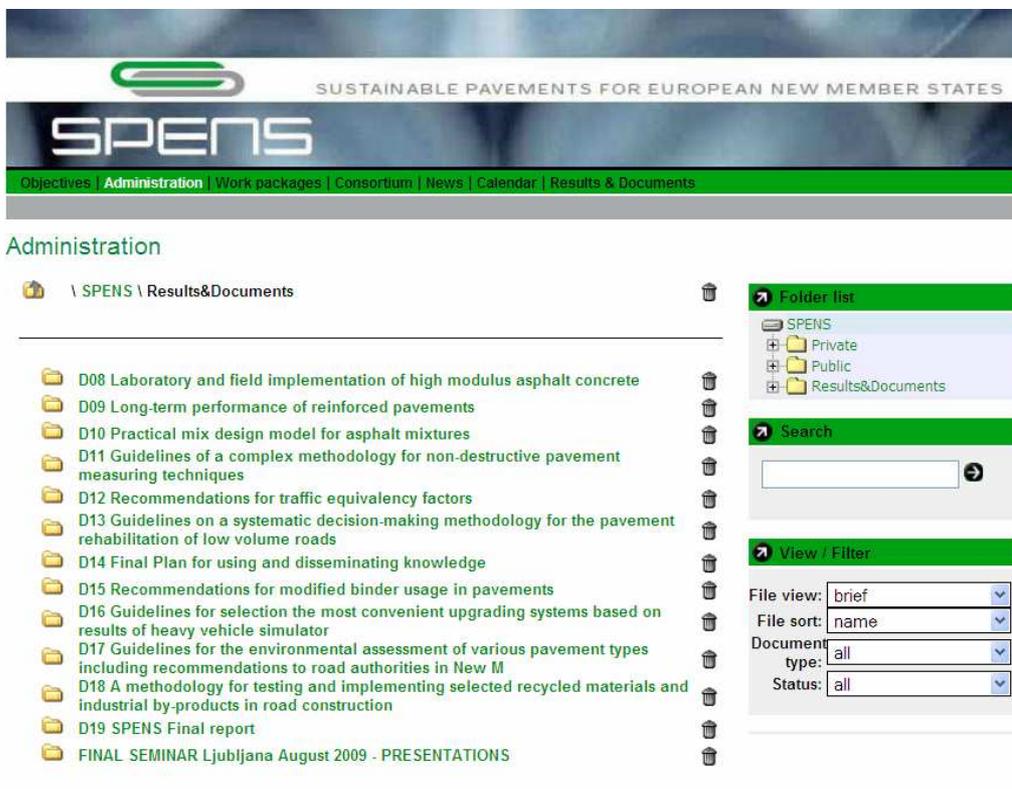


Figure 15: SPENS web-site – public final reports (September 2009)

The dissemination of results is provided for through national and international conferences (e.g. TRA08 and TRA10), as well as via the SPENS web site. A quick overview with references to deliverables is given in D19 SPENS Final report. 300 copies were printed and most of them were already distributed.

A more detailed brief overview of the results is available in the presentations held at the SPENS final seminar on the SPENS web-site under

FINAL SEMINAR Ljubljana August 2009 – PRESENTATIONS.