COMPETITIVE AND SUSTAINABLE GROWTH (GROWTH) PROGRAMME

Contract for:

Shared-cost RTD
and
Demonstration project

Annex 1 "Description of Work"

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Project acronym:	SAMARIS
Project title:	Sustainable and Advanced MAterials for Road InfraStructures
Duration:	36 Months

Project
Co-ordinator: Danish Road Institute

Contractors:

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2. Laboratoire Central des Ponts et Chaussèes (LCPC)	F
3. Slovenian National Building and Civil Engineering Inst. (ZAG)	SI
4. Transport Research Laboratory (TRL)	UK
5. National University of Ireland (UCD)	IRL
6.Centro de Estudios y Experimentacion de Obras Publicas (CEDEX)	E
7. Swiss Federal Institute of Technology, Lausanne (EPFL)	CH
8. Vienna University of Technology	A
9. Shell Global Solutions (S.A.)	F
10. Trinity College Dublin (TCD)	IRL
11. Universitat Politécnica de Catalunya	E
12. Instituto Superior Tècnico (IST)	P
13. Swedish National Road and Transport Research Institute	S
14. SIKA Ireland Ltd. (SIKA)	IRL
15. DHI Water and Environment (DHI)	DK
16. Netherlands Energy Research Foundation (ECN)	NL
17. Formequip.Ecole Nationale des Travaux Publics de L'Etat (ENTP	F
19. University of New Hampshire (UNH)	US
20. Ruhr University Bochum (RUB)	D
21. Raastof og Genanvendelse Selskabet af 1990 A/S (RSG90)	DK
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23. Road and Bridge Research Institute (IBDIM)	PL
24. Eurovia Management (EUROVIA)	F

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1. CONFIDENTIAL SUMMARY

This project addresses Task 2.2.1/18 'Road infrastructure materials' of Key Action 'Sustainable Mobility and Intermodality[1]. It merges two proposals which were accepted by the Commission for contract negotiation: project MAP, about materials used in highway pavements, and project STRIM, about innovative materials used for maintenance of highway structures.

The societal needs that are specifically targeted in the project are to support the EU policy on sustainable development, waste management and energy efficiency, and, as a specific issue under task 2.2.1/18, the challenge of finding optimal repair strategies for a large number of critical concrete structures on the main road networks in CE countries as well as in some EEA countries.

Pavements

The primary means by which the project will contribute are by encouraging a greater use of recycled components in pavement materials and by the explicit consideration of environmental performance in the design. Attention will also be paid to the situation within Central European countries for which the RETRA-EST programme has identified environmental considerations in recycling and use of alternative materials as a first priority for co-operative actions.

The second key objective is to prepare for the harmonisation of European approaches of material specification within the next generation of CEN standards. This will involve moving from a recipe approach, which puts much emphasis on the intrinsic characteristics of the constituents, to a performance-based approach of the in-place products, which allows consideration to be made irrespective of the type of material.

This part of the project has the following technical and scientific objectives:

1. to produce a general methodology for the assessment of functional, safety and environmental aspects for the use and re-use of any kind of material taking into consideration the actual context of use. The originality is the consideration of the material interactivity with its environment in the assessment process;
2. to draft an environmental annex to CEN products standards and to define testing protocols for investigation of hazardous components when considering the re-use of pavement materials;
3. to develop mechanical models and test methods in order to derive performance-based specifications related to functional properties;
4. to produce technical guides and recommendations for a proper use of recycling techniques in road construction.

The scientific and technical work plan is structured in four work packages which are closely inter-related to produce the expected results of call 2.2.1/18. The topics, subdivided into practical tasks, are:

5. Assessment of materials to produce a methodology to assess the eco-compatibility of materials in road pavement design.

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[1] Reference: Work Programme for RTD action in support of 'Competitive and sustainable growth', 1998 - 2000. Edition June 2000.

6. Safety and environmental aspects in material specifications to incorporate these aspects in product standards and to develop the associated testing protocols.
7. Performance-based specifications to address functional properties in the view of a new generation of specifications for pavement materials.
8. Techniques for recycling to draw recommendations from the many different approaches to recycling that have been tried, with various degrees of success, within Europe, with particular attention paid to the situation in CE countries.

Innovations introduced by this project require combining expertise from a variety of disciplines: pavement, material and environmental engineering. From a scientific point of view, the different tasks require competence in physico-chemical analysis, mechanical testing, development of constitutive models and of numerical models of pavement behaviour, pollution transfer, etc. The very practical objectives of a better use of primary materials and by-products also necessitate that the technological aspects be correctly addressed with expertise in material processing and techniques of recycling. Participating in the four work packages are R&D institutes, engineering consultants, university laboratories, product manufacturers and road contractors, representing 17 partners from 11 European countries including 2 CE countries. This group is complemented by one research organisation from the U.S.A.

Outputs from this part of the project will permit a more efficient use of local aggregate and of by-products which is a direct contribution to EU policy of a sustainable development. Recommendations on recycling techniques will give benefit to road authorities and to the construction profession as fewer cases of failure due to inappropriate processing or construction methods and more cost effective road works. They will help CE countries for a more efficient use of recycling for upgrading the existing networks. Moreover work on specification will represent a direct input to CEN for the next generation of European pavement product standards.

Structures

The maintenance of concrete structures, be it pre-emptive or for repair or strengthening, is a heavy burden for society not only in financial terms but also as a major potential disturbance of civil systems. The structures part of the project is specifically targeted to support the EU policy to improve the highway structure maintenance with respect to greater efficiency and durability of the applied procedures, resulting in reduced number of necessary road closures. This will lead to considerable reduction of associated costs and increase users' safety. Special attention will be given to the Central European (CE) countries where condition of the highway structures may differ from the EU situation.

This part of the project has the following technical and scientific objectives:

9. To draw together the requirements for a sustainable maintenance strategy which satisfies the functional, safety, economic and environmental requirements for highway structures.
10. To investigate the applicability of two innovative techniques, the corrosion inhibitors and the high performance fibre reinforced cementitious composites, which can be used for maintenance of bridges, tunnels, embankment, culverts and retaining walls, at different levels of corrosion attack of the reinforcement.
11. To update and analyse the inventory of highway structures in the selected EEA and CE countries.
12. To propose methods and procedures for improved maintenance of highway structures.

The scientific and technical work plan is structured to give clear answers about the applicability of innovative materials and to clarify the state of the highway structures in EEA and CE countries. To produce the results expected by the task description, the project work plan is structured in four technical work packages.

The innovative materials investigated here require expertise from a variety of disciplines: structures, materials and environmental engineering, as well as interdisciplinary fields such as maintenance engineering. The different tasks require a high level of competence in fundamental as well as applied sciences and engineering, both experimentally and numerically, for materials and for structures. These needs are met by a group of participants from R&D institutes, engineering consulting firms, university laboratories, product manufacturers and road administrations from thirteen European countries. Five principal contractors, each having overall responsibility for one or two of the work packages, will form the core management of this part of the project. They will be assisted by five assistant contractors, including two from the industry, and ten sub-contractors. One principal and one assistant contractor are from the CE countries.

The expected results will have economic impacts far beyond costs of construction and maintenance. They will contribute to a safer and more efficient road network by reducing the need and duration of repair work on highway structures and thus curbing the unsafe and congestive effects of this activity on road traffic. Thus, societal value of the project is seen as being orders of magnitude greater than project costs. The 'highway structures' engineering profession will benefit directly from the project by being given a basis for the practical use of new materials and techniques for maintaining and constructing structures which aim at reducing dramatically future durability problems. Highway infrastructure managers will benefit from the verified assessment tools and guidelines for the new maintenance strategies.

The results of the project will contribute substantially to European technological progress. The dissemination plan will promote wide distribution of the results, both at the European and national level.

Management, Exploitation and Implementation

The decision-making structure of the project will consist of the Contractors' Committee, with a representative for each principal or assistant contractor, the Management Group, consisting of all work-package leaders, and the Work Package Teams. The Contractors' Committee has the ultimate responsibility for the project and makes all decisions which influence the overall project plan, total project economy or the internal distribution of costs. It approves deliverables and makes milestone decisions. Chaired by the project co-ordinator it meets as necessary, normally 2 times per year. The Management Group monitors the progress of the project and makes all decisions necessary to stay within the project plan and budget. Chaired by the project co-ordinator and co-chaired by the two scientific co-ordinators, one for the pavement part and one for the structures part, it meets four times per year.

A Reference Group of end-users involving partner country road authorities and European professional associations will be formed to provide guidance at important project milestones and to be kept informed about the results so at to be able to prepare for their implementation. The Reference Group of end-users will provide feedback, support dissemination and secure commitment to implement project results.

In addition, in order to obtain a reliable and comprehensive survey of highway structures in selected EEA and CE countries, a subcommittee will be set up comprising technical experts and end-users from these countries.

2. SCIENTIFIC/TECHNICAL OBJECTIVES AND INNOVATION

2.1. Overall objective

This project has two distinct, but functionally related aims:

One is to make better use and reuse of materials (primary aggregate, road or industrial by-products) in road pavements within a sustainable and eco-compatibility perspective. The objective is to preserve natural resources and to ensure that reuse of local aggregate and by-products will be made while still satisfying functional, safety and environmental requirements for road infrastructures. It aims at preparing a new generation of European performance-based product standards in place of present empirical and recipe-based approach.

The other is to provide for repairs of corrosion suffering reinforced concrete highway structures that are durable, cost-effective in a broader sense (including life-cycle costs) and causing minimum traffic delays. This requires a detailed specification of what is required for satisfactory interventions, the materials used in the interventions and of the method of their application. Here the objectives are firstly, to develop guidelines and specifications for use of intervention techniques, and secondly to provide an updated inventory of highway structures in selected EEA and CE countries and tools for their optimised assessment.

2.2. International state of the art

Pavements

In a 1977 report, OECD was already calling attention on the fact that increasing needs of materials for construction have induced in many places a shortage of local resources traditionally used for construction (annual aggregate consumption per inhabitant is between 6 and 8 tons). In this context, recycling (considered here irrespective of whether the material is reused for the same or a different application) of road construction and industrial by-products in road pavements has evident benefits for sustainable development, provided that their use does not alter the performance of the road infrastructure (functional, safety and environmental requirements).

Since then, several European countries have started to implement different policies in line with the 1993 European Council resolution in favour of the concept of management and treatment of products over their life cycle. However, the stages of implementation and the approaches are fairly different. Research programs such as ALTMAT, COURAGE and POLMIT or COST 337 have permitted progress to be made in the identification of the hazards associated with the use in road construction of the main by-products found in the European Union. They also have highlighted the shortcomings of traditional approaches for specification of road material characteristics.

Groups of experts in CEN technical committees (in particular here TC 227, 19 and 154) have been working over the past 10 years to produce by 2003 a set of harmonised standards as a response to the Mandate 124 on road construction products. However, due to the large differences in approaches and experiences existing between the different European countries, this first generation of product standards will be largely based on a recipe type of approach and empirical tests instead of being performance-related.

From this situation and in order to achieve the best use of the different kinds of materials for pavement construction, different actions need to be pursued:

1. A general methodology has to be defined for the assessment of functional, safety and environmental aspects, in particular long-term performance taking into consideration the actual context of use of the materials.
2. Safety and environmental aspects have to be considered in the definition of pavement products. This idea has been put forward by CEN with an environmental annex to the products standards but it has not been implemented yet. In addition, practical test methods have to be developed in order to allow a proper assessment of the hazards and possibilities of reuse of by-products and recycled materials.
3. Real harmonisation, which is important to assist the development of European road industry, requires changes to be introduced in the functional specification system. It requires moving from a recipe approach, that puts much emphasis on the intrinsic characteristics of the constituents, to a performance-based approach of the in-place products which allows consideration to be made irrespective of the type of material.
4. Conclusions should be drawn from the varied applications of recycling made throughout Europe, paying particular attention to the techniques of recycling. Technical recommendations should be very useful to prevent reproduction of failures and to make road authorities more confident in the use of appropriate recycling solutions. As pointed out in the transport research programme RETRA-EST, launched in 1998 by the Commission, recycling, life cycle and environmental considerations in use and reuse of materials in road construction are ranked among the first priorities for Central and Eastern European countries which are now facing the challenge of upgrading their road network to face the large increase in heavy traffic.

Structures

Considerable research has been undertaken on the repair of damaged highway structures. The most common cause of deterioration is corrosion of the reinforcement in concrete structures and much research has been done on the detection of reinforcement corrosion and intervention methods for its remedy. However, most of the available methods have shortcomings: they are expensive to apply, disrupt traffic using the structure and, in some cases, their effectiveness is short lived. Furthermore, there is increasing interest in the development of intervention methods that meet social and environmental as well as technical and economic needs, but research on such methods is still in its infancy. Generally speaking, the intervention must always be restricted to the minimum necessary actions to stop the deterioration process at its source, restore serviceability and load-carrying capacity. With this aim, methods for various degrees of intervention on the structural component should be made available for various levels of severity of the corrosion process. Corrosion inhibitors and advanced repair or strengthening materials such as HPFRCC (High Performance Fibre Reinforced Cementitious Composites) provide a wide palette that covers possible intervention needs from pre-emptive to full replacement of concrete cover and reinforcement in the case of advanced damage.

When corrosion damage is imminent or at an early stage, corrosion inhibitors can be used. They are chemical compounds, which can reduce or prevent corrosion of metals if they are present in sufficient concentrations. Their use in contexts has proved to be effective. Successful extension of this technology to prevent corrosion of reinforcement in concrete is under development. A group of organic compounds was proposed a few years ago to serve this purpose. Few studies of these inhibitors have been finalised but already there are conflicting opinions about their effectiveness. The main conclusions to date are that, while the mechanism of passivation is not completely clear, the effectiveness is related to inhibitor concentration to chloride concentration. However, there is no

general agreement about the efficiency of the inhibitors neither in concrete nor about their influence on mechanical properties and long-term behaviour. Such agreement is needed to establish clear guidelines on their application. New or modified versions of the inhibitors were recently created and need to be investigated.

When corrosion damage is critical, it can be necessary to replace the concrete cover and the reinforcement. The qualitative requirements for the replacement materials for bonding, compatibility with the substrate and water tightness are nowadays well known. Unfortunately, in the long term most building materials cannot fulfil these very demanding requirements in the very aggressive environment of road infrastructure components (bridges, galleries, tunnels, etc.) due to, for example, de-icing salts. One possible solution to overcome this problem is to use advanced cementitious materials with very high performances related to durability (i.e. with an ultra dense skin impervious to water and aggressive substances and highly resistant to cracking). This approach makes the concept of "zero maintenance structures" realistic.

A major advantage of these materials is that they avoid several major causes of durability concerns: poor compaction, because they are self-compacting; incorrect placement of reinforcement, because the reinforcement is provided solely by the fibres; and deficient waterproofing membranes, because such membranes are no longer needed due to the ultra-low permeability of HPFRCC's. Until now, no effort has been made to optimise these advanced cementitious materials for the maintenance of concrete structures, although they show an obvious potential in this field. Preliminary tests performed on hybrid elements simulating the repair of a concrete beam with a HPFRCC have led to very promising results in terms of structural and cracking behaviour.

There have been several activities in Europe and wider to provide information on highway structures and their condition. The two recent European activities in this area are the research project BRIME from the EC 4th Framework Programme and the running COST action 345. BRIME aimed to develop tools and procedures for efficient bridge management and in doing so collected information on the condition of bridges in a number of European countries. COST 345 prepared a comprehensive questionnaire on highway structures, but is mainly focused on their number and funds spent on their maintenance. It will however not provide information on condition, loading or structural safety needed for improving management of highway structures. Just recently the PIARC TC C11 started an initiative for collecting data on highway structures from countries around the world. The aim of this questionnaire is closer to the work of COST 345 and will not provide technical information for analysis of highway structures. Most of the results will also directly comply with the objectives of the multi-annual RETRA-EST R&D transport programme between the EU and CEE countries. This programme lists a number of activities related to development of intelligent use of a Pan-European transport system and to strengthening of the research capabilities of CEE countries.

2.3. Scientific and technological approach

The project will address several material topics from the areas of pavements and highway structures. On one hand it will deal with four main topics closely inter-related and directed at a better use of the various sources of pavement materials: i.e. assessment of materials, improved consideration of safety and environment concerns in material specifications, performance-based specifications, recommendations about techniques for recycling. In the structures related work package it will address the following two main topics: the implementation of two advanced techniques for the maintenance of highway structures and an update and analysis of the inventory of highway structures in selected EEA and CE countries. A multi-disciplinary team of experts will

ensure that the various components of the project are drawn together in a single integrated approach. In addition to the technical Work Packages, two further Work Packages have been set up to cover management of the project (WP 1) and exploitation of the results (WP 16).

Work Package 3, "**Assessment of materials**", introduces now a comprehensive approach covering the different aspects (technical, environmental and economical implications) to be developed. Former projects like ALT-MAT made first suggestions for a methodology to assess environmental impact (leaching potential and long-term stability) in order to judge the suitability of alternative materials for use in road pavement. However, further development is required in order to make the approach generally applicable by use of the concept of scenarios and by the refinement of models of interaction between the material and given environmental conditions. The project will concentrate on the main by-products as identified from the survey made both within ALT-MAT and the OECD's 1997 report "Strategies of recycling in road works" and the complementary survey carried out within Work Package "Techniques for recycling".

Work Package 4, "**Safety and environmental aspects in material specifications**", will address the important issue of incorporating environmental aspects in products standards, in particular in order to assess the environmental impacts during all phases of the product life, from production to end of life. Some guidelines have been issued by CEN on how to perform the analysis from which the result could be documented in an environmental annex in product standards. However, at present this approach is voluntary and has not been applied to pavement materials. It is proposed to make pilot studies on this topic by considering various types of pavement materials in order to derive proposals and recommendations for further applications. This part will be developed from the analysis made within the WP "Assessment of materials". It will also serve to orientate the production of tests methods for making a proper identification of the constituents that are to be recycled for detection of potentially hazardous products. These are products which could be detrimental to the final pavement or hazardous for the environment or for the health and safety of operatives working with pavement materials.

Work Package 5, "**Performance-based specifications**", aims at preparing the production of a new set of performance-based specifications for pavement materials. With regard to mechanical properties, important work has been done within RILEM in the Technical Committee for testing on bituminous materials. Recommendations have been produced for the determination of materials moduli and research is presently being carried out on the interpretation of fatigue cracking tests; these aspects should not be duplicated. Therefore, the project will concentrate on the topic of permanent deformation:

- Deformation of the unbound granular layers, which is of concern with flexible pavements that represent by far the largest share of European roads. Research done within the previous projects of the 4th FP, COURAGE for unbound materials and ALT-MAT for alternative materials, has demonstrated the short-comings of some tests developed for traditional aggregate when applied to non-standard materials that, in several instances, have shown good in-place performance. Emphasis will be placed on the confirmation of the pertinence of some mechanical lab tests in order to be able to encompass both traditional and alternative materials.
- Rutting of the bituminous surface layers, a topic of major importance (from both a safety and an economical point of view) considering the increase of traffic and the effect of wide single tyres as demonstrated by COST 334. Permanent deformation is presently dealt with in the various countries by the use of different empirical tests, the results of which cannot be directly related to one another. A rational unified method would assist in the development of a true performance-related specification.

Laboratory tests and interpretation of field results of pavement performance from selected test-tracks experiments and road test trials will complement theoretical modelling.

Work package 6, "**Techniques for recycling**", will concentrate on road works. In former studies, such as ALTMAT and the 1997 OECD report on *Strategies of recycling in road works*, investigations were made to determine what were the main types of by-products and their potential for use in road construction. More attention was paid to the suitability of the materials than to the assessment of the techniques of recycling. In order to promote a wider and more efficient use of recycling, it is time to draw conclusions from the many different approaches that have been tried with various degrees of success within the different European countries. From a review of available recycling techniques and from the experience gained in different countries, recommendations will be drawn for a proper selection of the ways of recycling. They will include recommendations for a correct protection of the environment depending on the toxicity of the by-products and their context of use.

Work package 12, **'Strategies for repair of highway structures',** will draw together the requirements for sustainable maintenance strategy which satisfies the functional, safety, economic and environmental requirements for highway structures. This will take account of previous and on going work and put particular emphasis on the techniques being studied under WP 13 'Corrosion inhibitors' and WP 14 'HPFRCC materials'. The initial work will be used to help direct the work being undertaken in these WPs. However, as the project progresses the concepts will be amended as required based on the findings from these work packages. They will also take account of the findings from WP 15 'Survey', the inventory and assessment of highway structures in EEA and CE countries to ensure that it meets the needs of those countries.

Work Package 13, **'Corrosion Inhibitors',** will evaluate the effectiveness of the new generation of these materials through laboratory and site trials. The mechanism of passivation will be studied in simulated pore water by several electrochemical techniques (potentiodynamical polarization, electrochemical impedance, electrochemical noise) and physical methods (optical microscopy combined with the computer visualization technique). The effectiveness of corrosion inhibitors in concrete will be examined at different concentrations of inhibitor over a range of chloride concentrations and concrete permeability values. The influence of the inhibitors on the mechanical properties of concrete will also be studied, especially freeze-thawing resistance of concrete. Field trials will include both corrosion monitoring of structures rehabilitated by inhibitor application and use of a marine exposure facility for controlled experiments on laboratory specimens. Specifications on use of corrosion inhibitors will be prepared.

Work Package 14, '**HPFRCC** (**High Performance Fiber Reinforced Cementitious Composites) materials**', will deal with the following aspects:

- Characterisation of the time dependent behaviour (auto stresses, viscous deformations, onset and development of micro-cracking and cracking) of hybrid structural elements at young age and long term (thermal and hygral effects, couplings).
- Evaluation of the serviceability of these elements throughout their lifetime.
- Evaluation of the risks of delamination.
- Characterisation of the transport properties (permeability to water and aggressive substances) at different load levels.
- Characterisation of the statistical distribution of the properties in view of probabilistic design methods.

- Tests will be performed in the laboratory on specimens and on hybrid structural components and will be complemented by on site field trials. Both, experimental facilities and numerical simulation tools will be used in close interaction for the identification of the significant phenomena, the exploitation of the experimental data and parametric studies to complement the specifications on their use.

Work Package 15, **'Survey',** will collect and evaluate some basic data on highway structures in selected countries (number and age of structures, maintenance resources, procedures used for assessment) as well as the technical data needed to optimise the decisions making process (information on condition, loading and structural safety). The 'Condition' survey will focus on procedures used for determination of the condition of the structures (visual, with condition ratings). The 'Loading' survey will examine the applied dead and live load models for existing structures, the usually over-conservative parameter in determination of true structural safety. To optimise the analysis, special emphasis will be put on realistic traffic load modelling and on assessment of dynamic loading of bridges. The task on 'Structural safety' will examine procedures used in the surveyed countries for structural safety assessment (deterministic, probabilistic, combined). The data will be collected using a considerably extended COST 345 questionnaire and evaluated according to the recommendations of BRIME and COST 345. Possible differences between EC, EEA and CE countries will be identified. Assessment procedures will be proposed to reduce maintenance costs and to shorten the traffic delays, thus reducing users' costs and impacts to the environment. The objectives of this WP also comply closely to the 'Improved structures' theme of the RETRA-EST programme and its two high priority topics, the *Structures monitoring and detection of structural deficiencies* and *Assessment of the residual bearing capacity of engineering structures*.

2.4. Originality of the work and main innovations

Pavements

In the traditional approach to the definition of material specifications, one is usually looking for intrinsic properties of the constituents or of the mixture largely irrespective of the use. This approach, as reflected in the present sets of national and European standards, creates barriers for the use of non-conventional materials. The originality of this project is that it takes into due consideration a new dimension, which is the interactivity of the material with its environment (i.e. by considering the actual context of use), drawing from the conclusions of ALT-MAT, POLMIT and COURAGE programmes and drawing from the work made in the domain of solid wastes. Necessary specifications reflecting both environmental and durability concerns will be identified from this analysis. This global and multi-disciplinary approach is made possible by the contribution of experts from different backgrounds environment, hydraulics, material, pavement specialists, etc.

Considering mechanical specifications, the project develops a performance-based approach to the very general problem of permanent deformation in order to supplement present empirical and recipe-type of specifications. The novel work is the development of practical approaches combining laboratory tests and numerical models for the prediction of permanent deformation.

The methodological guide to be produced on recycling techniques will fill a critical gap in the present technical literature and will pay particular attention to the needs of Central European countries which are now facing the considerable challenge of upgrading their road network to meet the increase in heavy traffic.

Structures

The project will contribute to the basic knowledge concerning the degradation processes in concrete and provide some information about the methods that can be used to study/monitor these processes. The results of the project will help to optimise procedures/materials for the construction and rehabilitation of concrete structures. The maintenance of road infrastructure components at sustainable costs is a challenge that requires creativity and the optimal use of available resources and techniques.

Corrosion inhibitors, if effective, will provide an improved repair technique for highway structures by overcoming the costly and time-consuming process of breaking-out and restoring the cover concrete over corroding reinforcement. This has the potential to reduce repair times, cost and traffic disruption. The service life of structures may also become extended beyond their initial expectations.

The application of advanced cementitious materials to the repair and reinforcement of structural components is a major innovation in the field of maintenance of concrete structures. The very high performance of these new materials requires a completely new approach to technological problems by design, testing and quality control. The implementation of such materials in a practical maintenance application shall lead to new concepts for more efficient structures in order to minimise maintenance burdens for the society.

For the first time a balanced analysis of the available data on highway structures from CE countries is planned. In addition, some assessment procedures, developed in BRIME and COST 345, will be tested on a wider range of data.

2.5. Scientific and technological research objectives

Pavements

The main objectives of the pavement parts of the project are:

- to produce a general methodology for the assessment of functional, safety and environmental aspects of the use and reuse of any kind of material in pavements, in particular long-term performance taking into consideration the actual context of use ;
- to draft an environmental annex to CEN products standards and to define testing protocols to be used when considering the possibility to reuse materials ;
- to develop mechanical models and test methods for the evaluation of the risk of permanent deformation of pavement materials in order to derive performance-based specifications related to functional properties ;
- to produce a technical guide and recommendations for proper use of recycling techniques in road construction.

Structures

The main objectives of the structures part of the project are:

- to promote sustainable solutions for the maintenance of highway structures, based on advanced techniques and advanced materials and on methods for specifying their use,
- to establish methods which give reliable data about the action of the corrosion inhibitors for steel in concrete, to assess their efficiency in concrete, to establish the eventual negative side-

effects caused by their presence, to propose the procedures by which they can effectively prevent corrosion of steel in concrete structures and to identify limitations of the technique,

- to develop concepts and recommendations for the use of HPFRCC materials in the maintenance of concrete road infrastructure components,
- to collect information on number, condition, loading, maintenance costs and structural safety of highway structures in selected EEA and CE countries and to apply the most advanced technologies, developed in BRIME and COST 345, for analysis of these data.

2.6. Technical risks

The project will combine different types of activities: gathering and reviewing state of the art information and data, laboratory tests, theoretical and numerical modelling, analytical deskwork. The following risks have been considered:

- Lack of information for the WP 2: data for development and validation of mechanical models are known to exist already from previous research projects. Information about current practice in recycling can be obtained from the different research institutes, professional associations and governmental agencies associated with the project and access to this information will be facilitated by the reference end-users group.
- There is no technical risk to WP 12. However, the detailed guidelines to be developed under this WP will inevitably be a compromise that balances the conflicting economic, environmental and social requirements of a particular structure. This will almost certainly contain an element of subjective judgement.
- Besides cathodic protection, the application of inhibitors is the most promising technique for the corrosion protection of concrete highway structures. The results of the proposed investigations might, however, indicate that these inhibitors do not effectively protect steel in concrete against corrosion in all circumstances. In that case some inappropriate procedures for anti-corrosion protection of steel in concrete can be eliminated and the basis for eventual further research of corrosion inhibitors for concrete will be formed. In the case of positive results, the application of corrosion inhibitors will surely be the most cost-beneficial technique for the rehabilitation of concrete structures with minimal traffic delay and diversion costs.
- The main technical risk associated with HPFRCC is their long-term behaviour given the limited time scale of the proposed research and development. However, the numerical simulation tools should help capture the long-term behaviour of these materials and hybrid structures in a realistic way.
- In the survey on highway infrastructures not all EEA and CE countries can be involved into the project. However, efforts will be made to ensure that the selected partners will provide relevant data for a comprehensive survey on highway structures in these countries.
- Lack of expertise: the experts enlisted for the project are key researchers in Europe in their field. Most of them have taken part in the past in various European projects and are active in the field of standardisation. They can be assisted or replaced by other experts working in their organisation if needed. Execution of the project is not dependent on the availability of any piece of equipment or on long-lasting experiments.

3. PROJECT WORKPLAN

3.1. Description of the work plan

In order to address the first objective of key action 2.2.1/18, the project is organised in two streams of technical work packages: one stream comprising WPs 2 through 6, dealing with material issues relating to pavements, and another stream comprising WPs 12 through 15, dealing with material and assessment issues relating to maintenance of structures.

The WPs dealing with pavements handle four main aspects of achieving a better use of materials in road pavements: the extended assessment of materials, incorporation of safety and environmental aspects within product specifications, specification of functional properties on a performance-based approach and adequate use of recycling techniques.

The WPs on materials and methods for the maintenance of concrete structures will test two very promising advanced materials and develop guidelines for their use. They will also analyse an updated inventory of highway structures in some EEA and CE countries and the associated maintenance needs.

Each of the streams of work packages is initiated by dedicated work packages (WPs 2 and 12) which define precisely the technical approach, relationships between work packages and QA procedures. Work Package 16 "Exploitation and dissemination" will ensure effective communication both within the project, with the professional community and the with the end users as represented in the reference group, with which the project will have close contacts through this work package.

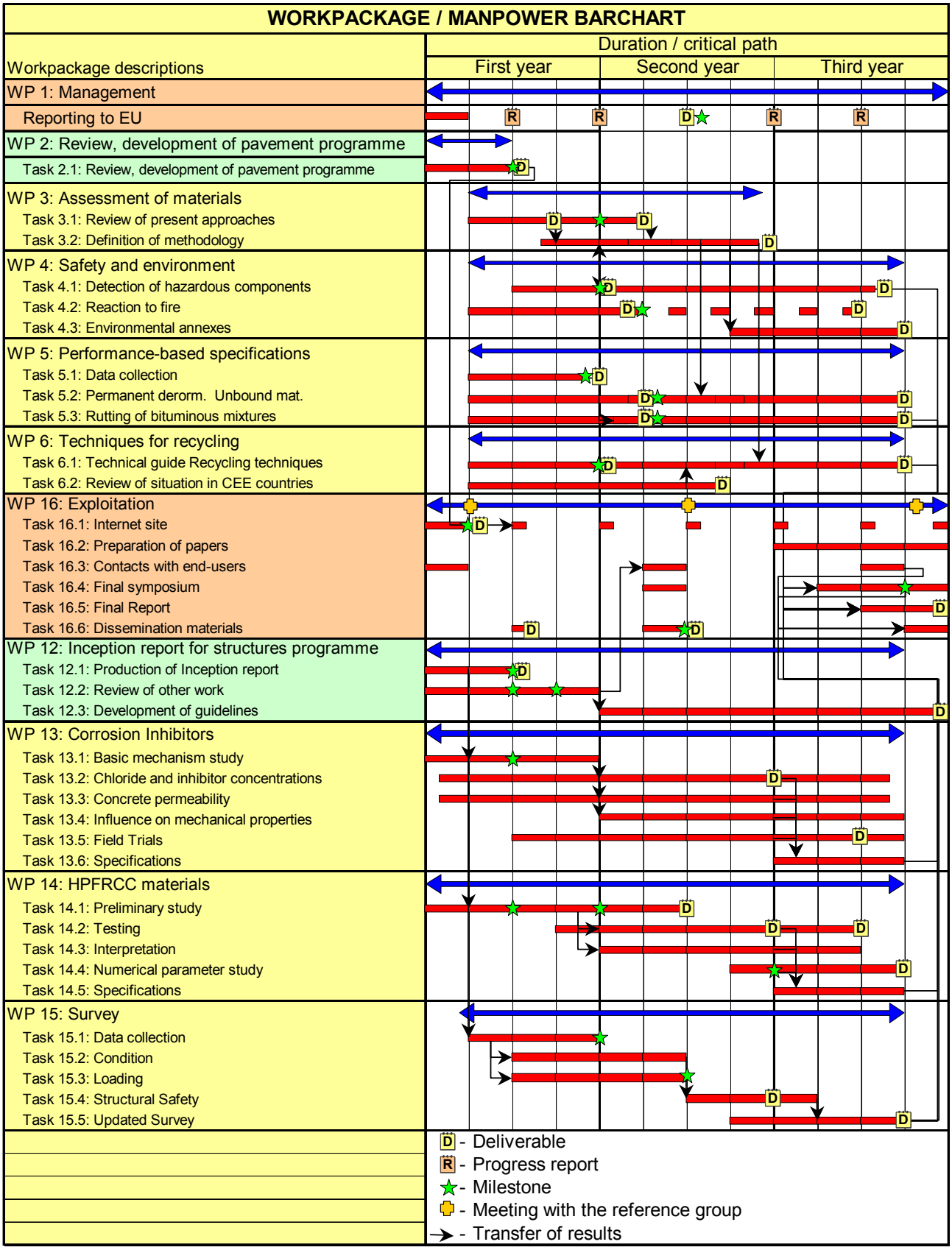
Table 1 lists the title of the work packages the content of which is given in section B5.6.

The interrelationships between the WPs are presented in the bar-chart of the project of Table 2. This diagram also indicates the position of the milestones defined later in the text, the deliverables and the other main events.

Table 1: List of the Work Packages

Work Package number	Work Package Title
1	Management
2	Development of programme
3	Assessment of materials
4	Safety and environmental aspects in material specifications
5	Performance-based specifications
6	Techniques for recycling
12	Strategies for repair of highway structures
13	Corrosion inhibitors
14	High performance fibre reinforced cementitious concrete (HPFRCC) materials
15	Survey of highway structures
16	Dissemination and Exploitation

Table 2: Bar chart of the project



Consortium composition

Innovations introduced by this project and achievement of the objectives require combining expertise from a variety of disciplines: pavement, highway structures, material and environmental engineering. From a scientific point of view the different tasks require in particular competence in physico-chemical analysis, in structural behaviour, of mechanical and mechanical testing of road materials, of development of constitutive models for materials and of numerical models of pavement behaviour, water seepage and pollution transfer in porous media. Survey of highway structures requires experts in structural assessment as well as in traffic and safety engineering. However, the very practical objectives of a better use of primary, recycled materials and by-products in pavement structures necessitate also that the technological aspects of the problem be correctly addressed with expertise in material processing and techniques of recycling.

To be capable of dealing with all these aspects a consortium needs to be diverse and fairly large, considering also the need to involve stakeholders such as road owners and the relevant industry. In order to also be efficient, the Consortium must be manageable and well structured. The core of the Consortium will provide the required expertise whilst avoiding duplication between partners.

This has led to a consortium composed of experienced R&D institutes, university laboratories, product manufacturers and road contractors, all selected for their complementary expertise. The project also comprises the formation of a group of stakeholders playing the role of a reference end-users group to provide input and guidance to the elaboration of the detailed work programme and anticipate the results of the project and secure their exploitation. This reference group will gather together road authorities and European professional associations. Table 3 gives an overview of the consortium.

For efficient management of the project, three levels of involvement are defined according to the Commission's guidelines:

- Seven Principal Contractors will contribute almost 70 % of the work, measured in man-months, and will be active throughout the whole duration of the project. Each will lead at least one of the Work Packages and will contribute to several others. Their experts from different backgrounds will provide the wide-ranging expertise required to deal with the technical elements of the project.
- Sixteen of the remaining partners will be Assistant Contractors. They will play an important, but focussed role in the project, generally related to one of the technical Work Packages.
- The eleven remaining participants will be Sub-Contractors. In WP15 in particular they are foreseen as the essential providers of reliable data on existing highway structures from the selected EEA and CE countries and on procedures used for their assessments. The volume of the work of the Sub-Contractors is small and hence, their financial involvement is about 3 %. To keep the project administration manageable they will each be directly responsible to one of the Principal Contractors. A Consortium agreement will ensure that they will have full access to the project's results.

The project Contract will therefore have 23 Contractors on the project side, plus the European Commission.

REC 01 is the Administrative Project Co-ordinator, responsible for the project management and the communication with the Commission. It is also in charge of technical WP5 and will manage WP16, Exploitation.

In the pavement stream REC02 is the Scientific Co-ordinator and will also manage technical WP3, while partners REC 04 and REC 06 also acting as Principal Contractors are leading WP4 and WP6 respectively in addition to providing input to some of the other WPs. A leading research group in the field of environmental and waste engineering, HES 19 from USA is participating in WP3 in order to introduce US advances in this field. HES 22 and REC 23 bring specific input from the situation in Central Europe together with the technological support of IND 24, a road contractor company with subsidiaries in CE countries.

In the structures stream REC03 is the Scientific Co-ordinator, also in charge for the WP15. Three further Principal Contractors, REC 04, HES 05 and HES 07, will co-ordinate work of WP12, WP13 and WP14 respectively**.** As assistant contractors, REC23 and HES11 will provide valuable experience in assessment of highway structures, while HES10 contributes expertise on optimised traffic load modelling. An industry partner IND14 along with REC02 will provide technical input into Work Packages WP13 and WP14. REC03 and REC23 will serve as links to the CE countries. Subcontractors HES26, IND27, REC28 and HES29 will provide special technical knowledge and support, while the remaining subcontractors as highway infrastructure data owners from selected EEA and CE countries will provide reliable input to WP15 and some limited contributions to WPs 12 and 16.

Table 3: Overview of Consortium

Type of contractor	Activity code	No.	Business activity	RTD role in project
PC	**REC**	**01**	Research	**WP1 project coordinator** WP3: environmental engineering **WP5: bituminous material testing** **WP16: dissemination and exploitation**
PC	**REC**	**02**	Research	**WP3: material engineering** WP4: chemical testing WP5: numerical modelling WP14: HPFRCC, technical input
PC	**REC**	**03**	Research	WP12: Strategies for repair of structures WP13: Corrosion inhibitors **WP15: Survey of highway structures**
PC	**REC**	**04**	Research	**WP4: bituminous material testing** WP5: mech. testing on pavement mixes **WP12: Strategies for repair of structures** WP13: Corrosion inhibitors
PC	**UCD**	**05**	Education/Research	WP12: Strategies for repair of structures **WP13: Corrosion inhibitors**
PC	**REC**	**06**	Research	**WP6: recycling methodology**
PC	**HES**	**07**	Education/Research	WP12: Strategies for repair of structures **WP14: HPFRCC materials** WP15: Survey of highway structures
AC	HES	08	Education/research	WP5 : theoretical modelling of bituminous pavements

Type of contractor	Activity code	No.	Business activity	RTD role in project
AC	IND	09	Product manufacturer research centre	WP4: environmental testing WP5: advanced mechanical testing of bituminous materials
AC	HES	10	Education/Research	WP15: load modelling, structural safety
AC	HES	11	Education/Research	WP15: condition and safety assessment
AC	HES	12	Education/research	WP5 : mechanical testing of unbound materials
AC	REC	13	Research	WP3 : pavement engineering
AC	IND	14	Product manufacturer	WP13: corrosion inhibitors, industry input
AC	REC	15	Research	WP3 : impact on quality of water
AC	REC	16	Research	WP3 : environmental engineering
AC	HES	17	Education/Research	WP3 : environmental engineering
AC	HES	19	Education/research	WP3 : environmental engineering Input from the U.S.A.
AC	HES	20	Education/research	WP4 : pavement material engineering
AC	IND	21	Road contractor	WP6: recycled road materials and recycling plants
AC	HES	22	Education/research	WP6 : investigation of situation in CE countries
AC	REC	23	Research/consultant	WP6 : investigation of situation in CE countries
AC	IND	24	Road contractor	WP6 : recycling techniques
SC	REC	25	Research	WP4: fire testing
SC	HES	26	Education/research	WP13: corrosion inhibitors, testing
SC	IND	27	Industrial-FEM Codes	WP14: HPFRCC, software support, technology
SC	REC	28	Research	WP14: HPFRCC, testing
SC	REC	29	Research	WP14: HPFRCC, testing
SC	OTH	30	Road authority	WP15: data provider
SC	OTH	31	Road authority	WP15: data provider
SC	REC	32	Research	WP15: data provider
SC	OTH	33	Road authority	WP15: data provider
SC	OTH	34	Road authority	WP15: data provider
SC	OTH	35	Road authority	WP15: data provider

PC: Principal contractors; AC: Assistant Contractors; SC: Sub Contractors; WP Leaders printed in bold

3.2. Manpower requirements

This information is given in Table 4 for the different work packages.

Table 4: Manpower requirements

Code	Work packages											Total	Total %
	1	2	3	4	5	6	12	13	14	15	16		
REC 01	12	2	7		9						8	38	7,0%
REC 02	6	3	10	6	13				6		6	50	9,2%
REC 03	6						4	17		22	6	55	10,2%
REC 04	0	2		8	3		11	14	6	2	4	50	9,2%
HES 05	0						4	42		42	2	90	16,6%
REC 06	0	2				12					2	16	3,0%
HES 07	0						4		76	2	2	84	15,5%
HES 08	0				12						0	12	2,2%
IND 09	0			4	4						0	8	1,5%
HES 10	0									10	0	10	1,8%
HES 11	0									5	0	5	0,9%
HES 12	0				6						0	6	1,1%
REC 13	0		5								0	5	0,9%
IND 14	0							4			0	4	0,7%
REC 15	0		5								0	5	0,9%
REC 16	0		8								0	8	1,5%
HES 17	0		7								0	7	1,3%
IND 18	0								0		0	0	0%
HES 19	0		8								0	8	1,5%
HES 20	0			16							0	16	3,0%
IND 21	0					6					0	6	1,1%
HES 22	0					12					0	12	2,2%
REC 23	0					8				17	0	25	4,6%
IND 24	0					5					0	5	0,9%
REC 25	0										0	0	0,0%
HES 26	0										0	0	0,0%
IND 27	0								4		0	4	0,7%
REC 28	0								3		0	3	0,6%
HES 29	0								3		0	3	0,6%
OTH 30	0									1	0	1	0,2%
OTH 31	0									1	0	1	0,2%
REC 32	0									1	0	1	0,2%
OTH 33	0									1	0	1	0,2%
OTH 34	0									1	0	1	0,2%
OTH 35	0									1	0	1	0,2%
Totals	24	9	50	34	47	43	23	77	98	106	30	541	100,0%

3.3. Deliverables

For each WP, deliverables have been defined: at intermediate steps to facilitate the management of the project and the assessment by the European Commission, and at the final stage to contribute to the implementation of results. Table 5 lists the deliverables.

Table 5: Overview of the deliverables

Delivera-ble No.	Delivery date (month)	Output from WP No.	Nature of deliverable and brief description
D1	3	16	Project web-site
D2	6	2 and 12	Developed work programme/Inception report
D3	7	16	Brochure presenting the project
D4	9	3	State of the art report "Assessment of eco-compatibility of materials in the field of waste disposal"
D5	12	6	Literature survey of recycling of by-products in road construction in Europe
D6	12	5	Data base and report on reference full-scale tests results on pavements
D7	12	4	State of the art report on test methods for the detection of hazardous components in road materials to be recycled
D8	14	4	Review of road authorities' positions on reaction to fire of pavement materials
D9	15	3	Review of present national regulations in the EU for recycling by-products in road construction
D10	15	5	Report on models for prediction of permanent deformation of unbound materials in flexible pavements
D11	15	5	Report on models for prediction of rutting of bituminous surface layers
D12	18	6	Recommendations for mixing plants for recycling works
D13	18	14	Report on preliminary studies for the use of HPFRCC for maintenance of road infrastructure components
D14	18	1	Mid-term assessment report
D15	20	6	Situation in the CE countries as regard recycling
D16	24	3	Report on methodology for assessing the possibility to re-use materials for road construction
D17	24	13	Report on test of effectiveness of corrosion inhibitors in laboratory trials
D18	24	14	Report on tests of HPFRCC in the laboratory
D19	24	15	Report on state-of-the-art of the assessment of structures in selected EEA and CE countries
D20	30	4	Report on test procedure for reaction to fire of pavement materials
D21	30	13	Report on test of effectiveness of corrosion inhibitors in field trials
D22	30	14	Report on tests of HPFRCC in the field
D23	32	4	Report on test methods for the detection of hazardous components in road by-products

Delivera-ble No.	Delivery date (month)	Output from WP No.	Nature of deliverable and brief description
D24	33	4	Environmental annexes to road products standards
D25	33	13	Specifications for the use of corrosion inhibitors for maintenance of highway structures
D26	33	14	Modelling of HPFRCC in hybrid structures
D27	33	5	Calibration and validation report for modelling of permanent deformation of unbound materials in flexible pavements and recommendations for the definition of performance-based specifications
D28	33	5	Calibration and validation report for modelling rutting of bituminous layers and recommendations for the definition of performance-based specifications
D29	33	6	Technical guide for recycling techniques in road construction
D30	33	15	Guidelines for optimised assessment of highway structures
D31	36	12	Guidelines on selection and use of innovative materials for the repair of highway structures
D32	36	16	Final executive summary report
D33	36	16	Briefing material

3.4. Milestones

A number of milestones have been identified for the four technical Work Packages. They indicate points in the progress of the scientific work on which decisions with respect to the course of the research have to be taken. In addition to the Work Package specific milestones, a mid-term assessment milestone has been identified to allow for evaluation of the project direction and a go/no go decision for the second part of the project. Table 6 gives an overview of the milestones

Table 6: Overview of the Milestones

Mile-stone No.	Delivery date (mon.)	Output from WP No.	Brief description of Milestone objectives	Criteria for assessment
M1	3	16	Project web-site	Fully operational home page with basic project information
M2	6	12	Complete review of repair methods for structures	Inception report for structure WPs available
M3	6	13	Decisions on properties of concretes to be used in laboratory and field test trials of CI.	Selection of materials
M4	6	14	Identification of most important phenomena for defining HPFRCC main test programme	Results of numerical simulations and preliminary tests available
M5	6	2	Approval of scientific methodology and work programme for pavement WPs	Consistency with objectives of project

Mile-stone No.	Delivery date (mon.)	Output from WP No.	Brief description of Milestone objectives	Criteria for assessment
M6	9	12	Complete critical review of relevant R&D work	Internal draft report available
M7	12	3	Determine the influent parameters and their range of variation before developing the methodology for assessing the possibility to use by-products	Suitability of the information collected
M8	12	4	Evaluation of existing test methods for detection of hazardous components and decision for the development of new tests	Applicability of existing methods to the context of recycling
M9	12	5	Evaluation of full-scale pavement tests results data base and need for additional specific data to be collected	Quality and completeness of data sets
M10	12	6	Approval of the draft of the structure and table of content of the technical guide on recycling techniques	Comparison with information collected from literature survey and enquiry.
M11	12	15	Collection of structural data completed	All questionnaires completed and returned
´M12	12	14	Selection of materials for main test series of HPFRCC	Preliminary test results and conclusions concerning materials for main tests available
M13	15	4	Determine the necessity to develop test methods for assessing the reaction to fire of pavement materials.	From road authorities answers.
M14	16	5	Evaluation of the need for additional tests for validation of models for permanent deformation of unbound materials in flexible pavements	Comparison of existing data with model requirements
M15	16	5	Evaluation of the need for additional laboratory tests for validation of models for rutting of bituminous layers	Comparison of existing data with model requirements
M16	18	15	Collection of traffic data completed	Database on traffic data base and WIM measurements available
M17	19	1	Mid-term assessment passed	Consistency with work-programme and objectives of the project
M18	24	14	Choice of on-site applications for pilot tests of HPFRCC	Results and interpretations of main test series available
M19	33	16	Final symposium organised	Preparations completed

3.5. Work Packages description

WP1 "Management"

The objective of WP1 "Management" is to manage the project and to deliver its results in accordance with the project planning and budget. The Project Co-ordinator will carry out the administrative and support management, with the support of a Scientific Co-ordinator who will be responsible for the scientific Quality Assurance throughout the project. An internal, password protected part of the project's web-site will enable the exchange information between all project partners. Table 7 gives a concise Work Package description.

Table 7: Description of WP1 "Management"

Work package Title: *Management*		**WP No.** 1
Starting date: Month No. 0 **Duration:** 36 months		**Total Effort:** 24
Partners involved	**R&D Task / Activity of partner**	**Effort:**
REC 01	Project Administrative and financial Co-ordinator	12
REC 02	Scientific co-ordinator of pavement stream and leader of WP2 and WP3	6
REC 03	Scientific co-ordinator of structures stream and leader of WP12 and WP15	6
Objectives Management of the project and monitoring of its scientific content.		
Description of Work/tasks Communication with European Commission, checking progress, corrective action including re-allocation of work, project secretariat, project file, financial control, Quality Assurance		
Deliverables Deliverable D14: Mid-term Assessment report. Date due: Month 18 Six-monthly Progress Reports.		
Milestones and criteria Milestone M17: Mid-term assessment. Date due: Month 19 The milestone criteria are the progress of the project towards delivering its specified results and the financial and man months expenditures relative to those planned.		
Interrelation with other work packages WP1 has ties with all Work Packages, since it is to monitor their progress and take remedial action where required.		

WP2 "Review, Development of programme"

Within WP2 "Review, Development of programme" a detailed work programme will be developed from the work plan of the proposal. This will allow that the different aspects covered by the work packages are considered within an integrated approach. Moreover, the definition of the surveys needed for the different WPs will be co-ordinated for efficiency and to minimise disturbance. A meeting with the end-users reference group will ensure that the needs are correctly considered. Table 8 describes the content of WP2.

Table 8: Description of WP2 'Review, Integration and Elaboration'

Work package Title: *Review, Development of programme for pavement stream*		**WP No.** 2
Starting date: Month No. 0 **Duration:** 6 months		**Total Effort:** 9
Partners involved	**R&D Task / Activity of partner**	**Effort:**
REC 02	Scientific co-ordinator and leader of WP3	3
REC 04	Leader of WP4	2
REC 06	Leader of WP6	2
REC 01	Leader of WP5	2
Objectives Development of the detailed work-programme for pavement stream Co-ordination of the surveys for the different WPs in the pavement stream		
Description of Work/tasks Task 1: To refine the definition of the work-programme of the pavement stream where necessary in particular for the interrelation between the WPs. To take advice from the end-users reference group and from there to produce the detailed project planning. To co-ordinate the definition and organisation of the different surveys necessary for the different pavement WPs.		
Deliverables Deliverable D2: Developed work-programme for the pavement stream.		Date due: Month 6
Milestones and criteria Milestone M5: approval of the proposed methodology and detailed planning Criteria: consistency with objectives of the project.		Date due: Month 6
Interrelation with other work packages WP2 will set the detailed work programme for all other WPs.		

WP3 "Assessment of materials"

The objective of this work package is to define a general methodology to assess the suitability of use and reuse of materials (including road construction and industrial by-products) in road pavements in conditions that would guarantee the durability of the road structure and the eco-compatibility of the materials. This work will also serve to identify the functional and environmental tests, which are necessary in relation with the proposed context of use of the materials, from the construction phase to the end of life of the road structure.

Task 1 – Review of present approaches

The work-package will start from a detailed review and analysis of the proposals made in the field of waste disposal as regard to the way of assessing the eco-compatibility of the materials. Attention will be paid to the material interactivity with its environment, drawing also on the conclusions of ALTMAT, POLMIT and COURAGE projects. This first phase will also serve to identify the present regulations and limits enforced in different EU countries for the re-use of by-products in road construction.

Task 2 – Definition of a methodology applicable to road pavements

Road structures durability and eco-compatibility depend, not only on the material characteristics, but also on the sensitivity of these characteristics to a set of factors defined by the local context. This nature and intensity and also the combination of these influent factors need to be defined through scenarios from the construction stage to the end of life of the road structure. Such an approach has already been identified for the case of waste disposal and a few standards such as XP

EN 12920 provide guidelines for the assessment of long-term performance. A methodology applicable to road pavements will be defined taking into consideration the most important by-products found in the EU. Properties and tests methods appropriate for assessing the suitability of materials for a given use will be identified; recommendations will be given for the selection of test methods. The work of this task will also serve as an input to the study to be carried out in WP4 on the environmental annex to pavement materials product standards.

Table 9 gives a brief description of WP3.

WP4 "Safety and environmental concerns in material specifications"

The objective of this Work Package is to address safety and environmental aspects in products standards. The WP, briefly described in Table 10, will be organised in three tasks:

- to identify practical means of identifying hazardous components in existing pavements prior to them being recycled;
- to investigate the necessity for an appropriate way to assess the reaction to fire of materials used in pavements;
- to prepare informative annexes on environmental aspects for CEN products standards in this area.

Task 1 – Detection of hazardous components in materials to be recycled

When recycling by-products in road structures, there should be nothing either detrimental to the performance of the finished pavement and the environment or hazardous to those constructing or using the pavement. Therefore, practical tests need to be readily available for identification of components with environmental implications, such as tar in early asphalt products (because it is carcinogenic) and polymers and other binder modifiers in asphalt (because of their possible effect on the properties of the binder in the recycled mixture, particularly if other polymers are to be included in the mixture).

Produce an overall procedure devised for the identification of component materials together with a set of test procedures duly formatted so as to be suitable for future standardisation.

Task 2 – Reaction to fire of pavement materials

The reaction of pavement materials to fire is an issue raised in the EU Mandate 124 for Road Construction Products. However there is much debate about this topic and opposite attitudes in national regulations. The objective is to clarify the situation, to identify the situations and the aspects of fire-damage, which could be of concern.

A first step will be a survey carried out among road authorities and regulatory institutions to assess the pertinence of the question raised in the Mandate. If there is a positive confirmation of the need for an assessment of the reaction of pavement materials to fire, from a literature search on existing tests (in particular with building and roofing materials) their relevance to pavement materials will be investigated. The last step will be to revise the test procedures as required making them specific to pavement materials and validating the test procedures.

Table 9: Description of WP3 "Assessment of materials"

Work package Title: *Assessment of materials*	**WP No.** 3

Starting date: Month No. 3 **Duration:** 21 months		**Total Effort:** 50
Partners involved	**R&D Task / Activity of partner**	**Effort:**
REC 02	WP leader responsible for task 1 and 2	10
REC 01	Aggregate and by-products material characterisation	7
REC 13	Pavement engineering aspects	5
REC 15	Water pollution and protection aspects	5
REC 16	Water movements and pollution migration aspects	8
HES 17	Environmental engineering	7
HES 19	Environmental engineering (U.S. experience and input)	8

Objectives

To define a general methodology to assess the suitability of use and reuse of materials in road pavements in conditions that would guarantee the durability of the road structure and the eco-compatibility of the materials.

Description of Work/tasks

Task 1: Review of the present state of the art of material assessment in the field of waste disposal. Review of present national regulations for reuse of by-products in road construction.

Task 2: Identification of scenarios for the assessment of the suitability of re-use of by-products. Definition of a general methodology and recommendations for the selection of test methods.

Deliverables

Deliverable D4:	Report "State of the art on assessment of eco-compatibility of materials in the field of waste disposal".	Date due: Month 9
Deliverable D9:	Report "Review of present national regulations and limits enforced in European countries for re-use of by-products in road construction".	Date due: Month 15
Deliverable D16:	Report "Methodology for assessing the possibility of re-use materials and by-products in road construction".	Date due: Month 24

Milestones and criteria

Milestone M7:	Review of influent parameters and of their range of variation. Criteria: Suitability of information collected.	Date due: Month 12

Interrelation with other work packages

Analysis carried out in task 2 will serve for the pilot study for drafting environmental annexes to product standards in WP4.

Recommendations will feed into WP5 for the assessment of the mechanical stability of unbound by-products.

Results of task 2 will also provide input for WP6 for the definition of protection measures when recycling by-products in road construction.

Task 3 – Environmental annexes to product standards

The objective is to make pilot studies by considering various types of pavement materials for drafting an environmental annex to CEN product standards. Such analysis has to assess the environmental impacts during all phases of the product life, from production to end of life. This part will be developed from the methodology produced within WP3 "Assessment of materials".

WP5 "Performance-based specifications"

The objective of this Work Package, described in Table 11, is to prepare and facilitate the production of a new set of performance-based specifications for pavement materials irrespective of their kind. It will concentrate on the important topic of permanent deformation of standard and non-standard materials: deformation of the unbound granular layers and rutting of the bituminous layers.

The central part of the work package is the assessment and development of predictive models for permanent deformation. This will be supported by data collected from field pavement trials and accelerated test tracks experiments, which will provide actual cases for the latter validation of the models. The theoretical work will also complemented by laboratory tests for the calibration of

constitutive models of pavement materials. The work on bituminous mixes and on unbound granular materials will be managed in separate tasks.

Table 10: Description of WP4

Work package Title: *Safety and environmental concerns in material specifications*		**WP No.** 4
Starting date: Month No. 3 **Duration:** 30 months		**Total Effort:** 34
Partners involved	**R&D Task / Activity of partner**	**Effort:**
REC 04	WP leader and task 2 leader	8
REC 02	Physico-chemical analysis on bituminous binders Assessment of environmental impact in relation with WP3	6
IND 09	Tests regarding toxicity of components in recycling road materials	4
HES 20	Task 3 leader	16

Objectives

To address safety and environmental aspects in products standards and for decisions of recycling materials in road pavements.

Description of Work/tasks

Task 1: To produce an overall procedure for the identification of hazardous component in road materials to be recycled together with a set of test procedures, duly formatted so as to be suitable for future standardisation.

Task 2: Clarification of the need for investigation reaction to fire of pavement materials. Definition of testing procedures.

Task 3: Draft an environmental annex to CEN product standards for different types of road materials.

Deliverables

Deliverable D7:	Report on existing test methods for detection of hazardous components.	Date due: Month 12
Deliverable D8:	Report on the survey on road authorities positions with regards to reaction of pavement materials to fire.	Date due: Month 14
Deliverable D20:	Report on testing procedure for reaction to fire of pavement materials.	Date due: Month 30
Deliverable D23:	Report on the test methods for the detection of hazardous components.	Date due: Month 32
Deliverable D24:	Report on the environmental annex to road product standards.	Date due: Month 33

Milestones and criteria

Milestone M8:	Literature review on test methods for detection of hazardous components. Criteria: Collected information will determine the topics for which tests protocols need to be developed, refined or adjusted to the context of pavement works.	Date due: Month 12
Milestone M13:	Survey of road authorities' positions as regard reaction of pavement materials to fire. Criteria: The answers will determine if and under which situations reaction of pavement materials need to be assessed. In case of positive answers, testing methods will be developed; otherwise task 2 is stopped.	Date due: Month 15

Interrelation with other work packages

WP3 will serve as an input to tasks 1 and 3 of this WP for detection of hazardous components and for the environmental annex.

Task 1 – Data collection

From the experiments already performed by the partners of the project, a common database of well-documented cases will be organised. It will contain the information on the pavement structures, loading and climatic data, laboratory tests results describing the composition and performance of the pavement materials, etc., which is necessary for validation of predictive models of permanent

deformation. This work will also serve COST 347 on the use of accelerated pavement testing facilities, which has been recently approved.

Task 2 – Permanent deformation of unbound granular materials

The project will draw on the main conclusions of COST 337 and COURAGE projects where significant advances were made concerning resilient behaviour of unbound materials but not on permanent deformation which however determine the main design criteria for flexible pavements. Modelling and testing approaches will be produced from laboratory repeated loading tri-axial and suction tests and finite element model taking into account non-linearity of unbound aggregate. As it was identified in COURAGE, attention will be paid to the study of the influence of the hydric state of the materials. Validation of the proposed procedure will be made by comparison with pavement performance results gathered as part of task 1. The results will serve to define specifications on unbound materials (primary aggregate or by-products) from mechanical lab tests in relation with the expected pavement performance.

Task 3 – Rutting of bituminous mixtures

Significant progress has been made recently in the capability to model the thermo visco-elastic behaviour of bituminous mixtures and to compute stresses and strains in pavement structures under moving loads. A correct modelling of the stress distribution in the immediate vicinity of the tyre is however also essential. These elements will be combined with the aim to predict the development of permanent deformation in bituminous surface layers under given loading and climatic conditions. Theoretical analysis will be supplemented by laboratory tests including triaxial cyclic tests. Validation of the models will be made by use of a special large wheel-tracking apparatus and by comparison with pavement performance results gathered as part of task 1. Recommendations will be given for the definition of performance-based specifications that shall replace the various empirical tests and criteria used today.

WP6 "Techniques for recycling"

In the past decades, much effort has been put in European countries on the management of wastes and by-products that the industry no longer needs. One of the main locations for these materials has been the road. As a result of this, many non-co-ordinated experiments have been carried out and techniques for conversion of these materials into road have been developed throughout Europe. This WP has as objective to provide up-dated information and recommendations about the techniques and applications of recycling. The purpose is to assist road authorities in using or increasing their understanding of the possible applications of by-products highlighting the issues that need to be evaluated when considering their use as identified from the analysis made in WP1.

The work will focus on the main productions of by-products in Europe.

The work, described in Table 12, is organised in two tasks, one being specifically dedicated to the situation in Central European countries in line with the priorities of action of the RETRA-EST programme.

Table 11: Description of WP 5

Work package Title: *Performance-based specifications*		**WP No.** 5
Starting date: Month No. 3 **Duration:** 30 months		**Total Effort:** 47
Partners involved	**R&D Task / Activity of partner**	**Effort:**

Work package Title: *Performance-based specifications*		**WP No.** 5
Starting date: Month No. 3 **Duration:** 30 months		**Total Effort:** 47
Partners involved	**R&D Task / Activity of partner**	**Effort:**
REC 01	Manage WP and task 1, Organise the data base, Contribute to data base of test-track experiments, Perform large wheel-tracking tests	9
REC 02	Contribute to data base with test-track experiments, Manage task 2, Perform lab tests and develop numerical models for unbound granular materials, Develop numerical models for pavement behaviour	13
HES 08	Manage task 3, Develop numerical models of permanent deformation of bituminous mixtures	12
IND 09	Perform advanced laboratory mechanical tests on bituminous mixtures	4
REC 04	Contribute to data base, Perform mechanical tests for bituminous mixtures characterisation	3
HES 12	Perform cyclic tri-axial tests on unbound materials	6

Objectives

To produce models and laboratory protocols to assess permanent deformation of pavement materials in view of the definition of performance-based specifications.

Description of Work/tasks

Task 1: Data collection of well-documented field experiment trials and accelerated loading tests on test-tracks for calibration and validation of models.

Task 2: Modelling and validation of permanent deformation of unbound granular materials.

Task 2: Modelling and validation of rutting of bituminous mixtures.

Deliverables

Deliverable D6:	Database and report on reference full-scale tests.	Date due: Month 12
Deliverable D10:	Report on models for prediction of permanent deformation of unbound materials in flexible pavements.	Date due: Month 15
Deliverable D11:	Report on models for prediction of rutting of bituminous surface layers.	Date due: Month 15
Deliverable D27:	Calibration and validation report for modelling of permanent deformation of unbound materials in flexible pavements and recommendations for the definition of performance-based specifications.	Date due: Month 33
Deliverable D28:	Calibration and validation report for modelling rutting of bituminous layers and recommendations for the definition of performance-based specifications.	Date due: Month 33

Milestones and criteria

Milestone M9:	Assessment of full-scale pavement results and need for additional specific data to be collected.	Date due: Month 12
Milestone M14:	Assessment of the need for additional laboratory tests for validation of models for permanent deformation of unbound materials in flexible pavements	Date due: Month 16
Milestone M15:	Assessment of the need for additional laboratory tests for validation of models for rutting of bituminous layers. Criteria: Quality and completeness of data sets.	Date due: Month 16

Interrelation with other work packages

WP3 will provide recommendations for the assessment of the mechanical stability of unbound by-products.

Table 12: Work package description of WP 6

Work package Title: *Techniques for recycling*		**WP No.** 6
Starting date: Month No. 3 **Duration:** 30 months		**Total Effort:** 43
Partners involved	**R&D Task / Activity of partner**	**Effort:**

Work package Title: *Techniques for recycling*		**WP No.** 6
Starting date: Month No. 3 **Duration:** 30 months		**Total Effort:** 43
Partners involved	**R&D Task / Activity of partner**	**Effort:**
REC 06	WP leader. Leader task 1	12
IND 21	Material processing and plants technology	6
HES 22	Leader task 2. Review situation in CE countries	12
REC 23	Review situation in CE countries	8
IND 24	Techniques of recycling and input to the analysis of the situation in CE countries	5

Objectives

Produce a technical guide on recycling techniques. Evaluate the situation in CE countries.

Description of Work/tasks

Task 1: Production of the technical guide on techniques of recycling, including recommendations for the plants.

Task 2: Review of the situation in CE countries about recycling.

Deliverables

Deliverable D5:	Report on literature review on recycling of by-products in road construction in Europe.	Date due: Month 12
Deliverable D12:	Report on recommendations for mixing plants for recycling works.	Date due: Month 18
Deliverable D15:	Report on the situation on recycling in Central European countries.	Date due: Month 20
Deliverable D29:	Technical guide on techniques of recycling (will include D11 as an appendix).	Date due: Month 33

Milestones and criteria

Milestone M10:	Approval of the draft of the structure and table of content of the technical guide on recycling techniques. Criteria: Comparison with information collected from literature survey and enquiry.	Date due: Month 12

Interrelation with other work packages

WP3 will provide input about recommendations for protection of the environment.

Task 1 – Elaboration of a technical guide on recycling techniques

This guide will mention, for each type of material, the relevant parameters to be considered, environmental implications and handling hazards. Specific operations needed for an adequate reuse of some materials: storage and processing, construction, mitigating measures (protection from the environment or leachage prevention) during service life and post service life will be considered and described. The main applications for the different materials will be pointed out and the main technical characteristics of these applications described.

A special appendix will provide information and recommendations about the plants for the production of road materials from recycled constituents.

Task 2 – Review of the situation in Central European countries

A comprehensive review will be made of the present situation for CE countries regarding recycling techniques and the re-use of by-products. This information will be an input to recommendations in particular on the potential of recycling techniques with regard to upgrading present road networks. Information will be collected from road authorities, civil engineering research institutes and professional associations.

WP12 'Strategies for repair of highway structures'

The objective of WP 12 'Strategies for repair of highway structures' is to draw together the requirements for a sustainable maintenance strategy which satisfies the functional, safety, economic and environmental requirements for highway structures. The inception report will be used to help direct the work being undertaken in WP 13 and WP 14. However, as the project progresses the concept will be amended as required based on the findings from these WP. It will also take account of the findings from WP 15, the inventory and assessment of highway structures in selected EEA and CE countries to ensure that it meets the needs of those countries.

Simply repairing structures as they deteriorate is not necessarily the best strategy. Comprehensive diagnostics of the causes of deterioration and appropriate interventions to remedy these causes are the keys to optimum maintenance. Therefore the WP will focus on methods to determine the most suitable intervention method and its optimum scheduling. This will be the strategy that minimises the costs of maintenance over the life of the structure, taking into account indirect costs such as delays and inconvenience to uses of the structure, as well as the direct costs associated with the repair. The WP will also consider the principles of sustainable construction and take environmental and social impacts into account as well as the economic costs. For example, local issues such as the impact of partial or total closure of the structure on the local community or local industry will be taken into consideration. Table 13 gives a concise Work Package description.

The study will also consider the implications for the network as well as for individual structures, as the most appropriate strategy for a particular structure may not be the most appropriate for the network as a whole.

WP13 'Corrosion inhibitors'

The objective of WP 13 'Corrosion Inhibitors' is to determine the effectiveness of surface applied corrosion inhibitors for reinforced concrete and the circumstances in which they can be applied. The study is oriented towards the investigation of passivation/initiation corrosion processes induced by the inhibitors, and the assessment of the long-term behaviour of inhibitors in concrete. The effectiveness of corrosion inhibitors for concrete and possible undesirable side-effects need to be investigated before their extensive use is recommended.

Task 'Basic Mechanism Study' will examine the influence of the corrosion inhibitor to chloride level ratio in reducing corrosion through a laboratory study using simulated pore water. Various electrochemical techniques and physical methods will be used to monitor the experiment including potentiodynamical polarisation, electrochemical impedance, electrochemical noise, and optical microscopy combined with the computer visualisation technique.

Task 'Chloride and Inhibitor Concentrations' will examine the influence of the corrosion inhibitor to chloride level ratio in reducing corrosion through a laboratory study using concrete specimens. Three types of specimen will be cast: one with chlorides in the mix; another without chlorides but which will be exposed to periodic ponding with chloride solution; and a third set subjected to accelerated carbonation. Once corrosion commences, corrosion inhibitor will be surface applied and their influence on corrosion activity will be monitored. Corrosion activity will be assessed using a combination of techniques including electrode potential, corrosion current and linear polarisation resistance measurement. Chloride levels will be monitored by chemical analysis of drilled samples.

Table 13: Work package description of WP12 'Guidelines for repair'

Work package Title: *Strategies for repair of highway structures*	**WP No.** 12

Starting date: Month No. 1 **Duration:** 36 months		**Total Effort:** 23
Partners involved	**R&D Task / Activity of partner**	**Effort:**
REC 04	WP leader/Collate information & draft guidelines	11
REC 03	Provide information & specify requirements	4
HES 05	Provide information & specify requirements	4
HES 07	Provide information & specify requirements	4

Objectives

Develop guidelines for use of innovative materials and techniques for the repair of highway structures.

Description of Work/tasks

Task 12.1: **Production of the Inception report.** Review methods available for repair of highway structures, and define how the methods chosen for more detailed study fit into the overall strategy for management of the highway network. Define scientific QA procedures.

Task 12.2: **Review of other work.** Undertake critical review of all relevant work undertaken to date. Identify factors that have most influence on selecting the most suitable repair strategy.

Task 12.3: **Development of guidelines.** Draw together the requirements for a repair strategy and develop guidelines for use of innovative materials and techniques for the repair of highway structures.

Deliverables

Deliverable D2:	Inception Report	Date due: Month 6
Deliverable D31:	Guidelines on selection and use of innovative materials for the re-pair of highway structures	Date due: Month 36

Milestones and criteria

Milestone M3:	Complete review of repair methods. Deliverable D2 available.	Date due: Month 6
Milestone M5:	Complete critical review of relevant R&D work. Internal draft report available.	Date due: Month 9

Interrelation with other work packages

WP 13, WP 14, WP 15, WP 16.

Task '*Concrete Permeability*' will examine the effectiveness of the inhibitor with respect to a range of concrete permeability. This will enable quantification of the permeability characteristics of concrete surfaces on which the inhibitor is most effective. Similar laboratory procedures will be employed to those outlined for Task 3.2.

Task '*Influence on Mechanical Properties*' will examine whether or not the inhibitor has any deleterious influence on the mechanical properties of mature concrete. In particular the influence of the inhibitor on freeze-thawing resistance of concrete will be studied. Mature specimens, with and without corrosion inhibitor will be exposed to 56 cycles of freezing and thawing in sodium chloride solution and their resistance will be assessed through scaling tests.

Task '*Field Trials*' will involve two aspects. Firstly, monitoring of bridges which were rehabilitated by patch-repairs and the application of inhibitors. Secondly, in parallel with those for Task 3.2 and Task 3.3, additional concrete specimens will be produced and stored in a marine exposure site subject to both tidal zone and splash zone exposure. These twin aspects will allow validation of the laboratory study findings.

Task '*Specifications*' will produce specifications which will provide characterisation of the CI, their range of usage and methods of applications.

Table 14 gives a concise Work Package description.

Table 14: Work package description of WP 13 'Corrosion inhibitors'

Work package Title: Corrosion inhibitors		**WP No.** 13
Starting date: Month No. 1 **Duration:** 36 months		**Total Effort:** 77
Partners involved	**R&D Task / Activity of partner**	**Effort:**
HES 05	WP leader, testing	42
REC 03	Testing	17
IND 14	Industry input	4
REC 04	Testing	14
HES 26	Testing	0

Objectives

Determine the effectiveness of surface applied corrosion inhibitors for concrete and the circumstances in which they can be applied

Description of Work/tasks

Task 13.1:	**Basic mechanism study.** Laboratory study of corrosion inhibitor in simulated pore water using electrochemical techniques and physical methods.
Task 13.2:	**Chloride and inhibitor concentrations.** Laboratory study of effectiveness of corrosion inhibitor at various chloride concentrations using varying inhibitor concentrations.
Task 13.3:	**Concrete permeability.** Laboratory study of effectiveness of corrosion inhibitor at various concrete permeability levels.
Task 13.4:	**Influence on mechanical properties.** Laboratory study of the effect of corrosion inhibitor on the mechanical properties of concrete with particular reference to freeze/thaw resistance.
Task 13.5: of	**Field Trials.** Corrosion monitoring of two bridges rehabilitated with patch repairs and application corrosion inhibitors. Corrosion monitoring of samples stored in a marine exposure facility.
Task 13.6:	**Specifications.** Preparation of specifications for the use of CI for maintenance.

Deliverables

Deliverable D17:	Test report on effectiveness of corrosion inhibitor in laboratory trials	Date due: Month 24
Deliverable D21:	Test report on effectiveness of corrosion inhibitor in field trials	Date due: Month 30
Deliverable D25:	Specification for the use of CI for maintenance of highway structures	Date due: Month 33

Milestones and criteria

Milestone M3:	Decision on the properties of the concretes to be used in the laboratory trials and field exposure trial. Selection of the materials.	Date due: Month 6

Interrelation with other work packages

WP 12, WP 16

WP14 'HPFRCC materials'

The objectives of WP 14 'HPFRCC materials' (High Performance Fibre Reinforced Cementitious Composites) are threefold: 1. Demonstrate the applicability and advantages of HPFRCC materials for the maintenance of concrete road infrastructure components (including aspects of global Life-Cycle-Cost in relation with WP 2). 2. Make a first step towards the optimisation of these materials for maintenance. 3. Provide guidelines for the use of these materials and their further optimisation (numerical simulation tools, test methods, limit states for design, etc.). Table 15 gives a concise Work Package description.

Task 'Preliminary Study' will begin with a study of the state-of-the-art and will provide a sound basis for the main scientific work. The aims of this task are to identify the phenomena that require further study and to select the materials that will be used in the main test series.

Task 'Testing' will include testing in the laboratory and in pilot field trials. Both specimens and structural components will be tested in order to investigate the mechanical and physical properties

of the materials selected in the preliminary study. The early age behaviour will be studied in detail since this is especially important with respect to the creation of residual stresses in the material that is added to existing structural components. Furthermore, the subsequent long-term behaviour will be studied with respect to durability and strength.

Task 'Interpretation' will run concurrently with the testing. The aim will be to provide feedback for the testing with respect to the study of different materials and to make the first steps towards their optimisation for maintenance. The interpretation will also include the determination of the significant properties, models and phenomena that will be studied using numerical simulation.

Task 'Numerical Parameter Study' will involve the numerical simulation of typical structural components and their maintenance, repair and strengthening using HPFRCC materials. Simulations will be based on the interpretation of the laboratory and field testing with a view to extending and completing the study.

Task 'Specifications' will produce specifications for the use and further optimisation of HPFRCC for maintenance of highway structures. They will cover the use of numerical simulation tools and test methods as well as the definition of appropriate limit states for the design of maintenance using HPFRCC materials.

WP15 'Survey of highway structures'

The aim of WP 15 'Survey of highway structures' is to provide an updated inventory and assessment of highway structures in selected EEA and CE countries. The WP will start with a detailed review of the state of the art.

Task 'Data collection' will collect data provided by subcontractors from seven EEA and CE countries. An appropriate database with associated software will be developed to evaluate the data.

Task 'Condition' will focus on procedures used for determination of the condition of the structures (visual, using condition rating methods). Different methodologies will be compared and assessed according to the BRIME recommendations. An overview of the condition of highway structures in the selected countries will be provided.

Task 'Loading' will examine loading conditions on existing structures and propose procedures for optimised load modelling. The following aspects of loading will be looked at:

1. Dead loads: Procedures used to evaluate dead loads in structural assessment will be examined (based on codes, bridge inspections and testing).
2. Traffic loading: Procedures used for determination of traffic load models will be examined to identify differences between traffic patterns in EU, EEA and CE countries. Analysis will be based on available weigh-in-motion (WIM) data and on measurements performed for this purpose.
3. Live load modelling: While new bridges should be designed on the basis of generalised conservative loading schemes to withstand the whole life time of the structure, assessment of existing bridges should be optimised if specific assessment loading schemes or site-specific load models are applied. Such load models are rarely used around Europe which often leads to unnecessarily frequent interventions on bridges. Optimised assessment live load models for bridges will be derived so as to relate logically to the derivation procedure used for the Eurocode, EC1, Part 3 and will be applicable to any traffic conditions.

Table 15: Work package description of WP14 'HPFRCC materials'

Work package Title: HPFRCC materials'		**WP No.** 14
Starting date: Month No. 1 **Duration:** 36 months		**Total Effort:** 98
Partners involved	**R&D Task / Activity of partner**	**Effort:**
HES 07	WP leader, testing, numerical simulations.	76
REC 04	State of the art review, advice on applications.	6
REC02	Technology input – testing, provide materials.	6
IND 27	Industry input – development of FEM.	4
REC 28	Research – advanced testing methods.	3
HES 29	Research – fabrication and advanced testing methods on materials.	3

Objectives

Investigate the applicability of HPFRCC's for the maintenance of road infrastructure components. Optimise them for this application. Provide guidelines for their use.

Description of Work/tasks

Task 14.1: **Preliminary study.** Identification of the significant phenomena. Selection of materials for main test series.

Task 14.2: **Testing.** Laboratory testing on specimens and structural components. Pilot field trials. Mechanical and physical properties, early age and long term.

Task 14.3: **Interpretation.** Exploitation of the experimental results. Comparison of different materials. Determination of significant properties and models for numerical simulations.

Task 14.4: **Numerical parameter study.** Case Study for practical geometries and boundary conditions.

Task 14.5: **Specifications.** Preparation of specifications for the use of HPFRCC for maintenance.

Deliverables

Deliverable D13:	Report on preliminary studies for the use of HPFRCC for maintenance of road infrastructure components.	Date due: Month 18
Deliverable D18:	Test report on laboratory testing of HPFRCC	Date due: Month 24
Deliverable D22:	Test report on pilot field trials of HPFRCC	Date due: Month 30
Deliverable D26:	Modelling of HPFRCC in hybrid structures	Date due: Month 33

Milestones and criteria

Milestone M4:	Identification of most important phenomena for defining main test programme. Results of numerical simulations and preliminary tests available.	Date due: Month 6
Milestone M12:	Selection of materials for main test series of HPRFCC. Preliminary test results and conclusion concerning materials for the main tests available.	Date due: Month 12
Milestone M18:	Choice of on site applications for pilot tests og HPFRCC. Results and interpretation of main test series available.	Date due: Month 24

Interrelation with other work packages

WP 12, WP 16

4. Dynamic loading: The Eurocode for bridge traffic loading incorporates dynamic impact factors based on experiments carried out using single truck crossing events. Such an approach is excessively conservative as dynamic effects of heavier, multiple vehicle loading events are generally considerably lower. To optimise the dynamic loading in the assessment of bridges, a dynamic computer model will be compared to field tests, using trucks of known weights and bridge weigh-in-motion measurements.

Task *'Structural Safety'* will examine quality and extension of structural safety assessment procedures used in the selected countries. To reduce maintenance and users' costs, impacts to the environment and traffic delays, improved safety assessment procedures, based on the

recommendations of BRIME and COST 345, will be proposed. They will include optimised traffic load models and target safety levels as well as account for the possible differences between EC, EEA and CE countries due to different structural and traffic conditions.

Task '*Updated survey*' will prepare State-of-the-art report on assessment of structures in selected EEA and CE countries and Guidelines for optimised assessment of highway structures.

Table 16 gives a concise Work Package description.

Table 16: Work package description of WP15 'Survey of highway structures'

Work package Title: 'Survey of highway structures'		**WP No.** 15
Starting date: Month No. 1 **Duration:** 36 months		**Total Effort:** 106
Partners involved	**R&D Task / Activity of partner**	**Effort:**
REC 03	WP leader, condition & safety assessment, CE country	22
REC 23	Condition & safety assessment, CE country	17
HES 10	Load modelling	10
HES 11	Condition & safety assessment	5
HES 05	Condition assessment & Load modelling	42
REC 04	Bridge management	2
HES 07	Input from EEA country	2
OTH 30	End user, input from CE (EU) country	1
OTH 31	End user, input from CE country	1
REC 32	End user, input from CE country	1
OTH 33	End user, input from EEA country	1
OTH 34	End user, input from CE country	1
OTH 35	End user, input from CE country	1

Objectives

To provide an updated inventory and assessment of highway structures in EEA and CE countries. To propose procedures for optimised assessment of highway structures taking into account site-specific parameters.

Description of Work/tasks

Task 15.1: **Data collection.** Collect data on highway structures from selected EEA and CE countries.

Task 15.2: **Condition.** Evaluation of condition assessment procedures from selected EEA and CE countries.

Task 15.3: **Loading.** Examine existing assessment load models. Propose optimised load models based on experimental data and performed WIM measurements.

Task 15.4: **Structural Safety.** Evaluate structural safety assessment procedures in selected countries. Propose optimised and easy-to-use safety assessment procedures.

Task 15.5: **Updated Survey.** Prepare report on analysis of the highway structures in selected EEA and CE countries and Guidelines for optimised assessment of highway structures.

Deliverables

Deliverable D19:	State-of-the-art report on assessment of structures in selected EEA and CE countries.	Date due: Month 24
Deliverable D30:	Guidelines for optimised assessment of highway structures.	Date due: Month 33

Milestones and criteria

Milestone M11:	Collection of structural data. All questionnaires completed and returned.	Date due: Month 12
Milestone M16:	Collection of traffic data. Database on traffic data and WIM measurements available.	Date due: Month 18

Interrelation with other work packages

All other Work Packages in the structures stream

WP16 'Dissemination and Exploitation'

The objective of WP16 is to disseminate, implement and exploit the results of the project, with special regards for the needs of the project network, to expose the project process to the scientific peer review and to prepare end-users for the implementation and exploitation potential of project results. A day-to-day homepage will be set-up and maintained to provide up-to-date information about the life of the project and to facilitate work of the partners. To present outputs of the project, a Final project symposium will be organised close to the end of the project. During the project, follow-up materials will be prepared to facilitate dissemination of results through international and national conferences. WP 16 will be also in charge of forming and managing the Reference Group that will be composed of end-users from road administrations and industrial associations. The exploitation plan will be refined during the course of the project, taking into account the indications of the reference end-users group (three meetings are considered: 1st during preparation of the detailed work-plan, 2nd at mid-term, 3rd near the end in conjunction with the preparation of the final symposium..

Refined versions of the exploitation plan will be presented at the mid-term assessment and project end. Table 17 gives a brief description of the Work Package.

Table 17: Work package description of WP16 'Dissemination and Exploitation'

Work package Title: 'Dissemination and Exploitation'		**WP No.** 16
Starting date: Month No. 1 **Duration:** 36 months		**Total Effort:** 18
Partners involved	**R&D Task / Activity of partner**	**Effort:**
REC 01	Project coordinator, WP leader, papers, follow-up materials	8
REC 02	Scientific manager, papers, follow-up materials, Internet site	6
REC03	Scientific manager, papers, follow-up materials, Internet site	6
REC04	Papers, follow-up materials	4
HES 05	Papers, follow-up materials	2
REC 06	Papers, follow-up materials	2
HES 07	Papers, follow-up materials	2

Objectives

To disseminate, implement and exploit the results of the project. To develop Guidelines on use of advanced materials in maintenance of structures and on optimised structural assessment procedures'.

Description of Work/tasks

Task 16.1:	**Internet site.** Creation and maintenance of the project WWW site.
Task 16.2:	**Preparation of papers.** Preparation of papers for international conferences, articles for national journals, newsletters for end users and network.
Task 16.3:	**Contacts with end-users.** Preparation and implementation of meetings with reference end-users, feeding guidance from these meetings into the project.
Task 16.4:	**Final symposium.** Organisation of the final symposium for presentation of the results of the project.
Task 16.5:	**Final report.** Final executive summary report on the project for release and publication by EU
Task 16.6:	**Dissemination materials.** Development of materials for use in national follow-up presentations of project progress and results.

Deliverables

Deliverable D1:	Project internal Internet home page	Date due: Month 3
Deliverable D3:	Brochure presenting the project	Date due: Month 6

Work package Title: 'Dissemination and Exploitation'		**WP No.** 16
Starting date: Month No. 1	**Duration:** 36 months	**Total Effort:** 18
Partners involved	**R&D Task / Activity of partner**	**Effort:**
Deliverable D32:	Executive summary report of the project	Date due: Month 36
Deliverable D33:	Follow-up materials to support project progress and results	Date due: Month 36
Milestones and criteria		
Milestone M17:	Mid-term follow-up. Consistency demonstrated with work programme and objectives.	Date due: Month 19
Milestone M19:	Final symposium. Preparations for the final symposium completed.	Date due: Month 33
Interrelation with other work packages		
WP 16 will work towards dissemination, implementation and exploitation of the outputs of WP 2, WP 3, WP 4,WP 5, WP 12, WP 13, WP 14 and WP 15. It will also integrate the technical outputs of these WPs into the Executive summary report.		

4. Contribution to objectives of programme / call

This project addresses Task 2.2.1/18 'Road infrastructure materials' included into the Research Objective 2.2 'Infrastructures and their interfaces with transport systems and means' of Key Action 'Sustainable Mobility and Intermodality' of the Specific Programme 'Promoting Competitive and Sustainable Growth'[2]. The project has been defined in direct relation to the objectives of the call. It will have outputs that correspond closely to the expected results of innovative specification of materials. It will facilitate the use of recycled materials in road pavements. It will develop guidelines and specifications for use of advanced materials and intervention techniques in the maintenance of highway structures and deliver an updated inventory of highway structures in CE and EEA countries.

Pavements

Results from the pavement part of the project will serve to preserve natural resources and to insure that reuse of local aggregate and by-products will be made while still satisfying functional, safety and environmental requirements for road infrastructures. They will support the development of performance-related specifications so that all materials can be assessed on a common basis, including materials from other sources than traditional primary ones. They will help in promoting the adequate use of recycling techniques of road and industrial by-products. Particular attention will be paid to the situation in Central European countries, which have met important problems in rehabilitating their road networks while preserving and protecting the environment.

Structures

In addition to the updated inventory and assessment of highway structures in selected EEA and Central European countries, detailed specifications for two innovative materials will be prepared, defining their suitability for highway structures maintenance. Particular attention will be paid to the situation in Central European countries. Results are expected to lead to considerable savings for the road owners and road users, through more efficient and durable maintenance procedures resulting in reduction of delays and accidents due to road works and therefore to a reduction in the cost of these activities for the community in general.

4.1. Expected project results

Pavements

The project aims at producing the main following outputs concerning materials for pavements:

- A general methodology to assess the environmental impact of using alternative component materials in road pavements. As such, it should help to provide the second expected result of techniques and procedures for selecting materials that can be recycled in road pavements.
- Environmental annexes for pavement products standards in line with the CEN guidelines.
- Tests methods for the assessment of hazardous components in materials to be recycled.

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[2] Reference: Work Programme for RTD action in support of 'Competitive and sustainable growth', 1998 - 2000. Edition June 2000.

- Mechanical models and associated test methods for the evaluation of functional properties with regard to permanent deformation of pavements.
- A technical guide, drawn from present European experience, on recycling techniques including considerations paid to processing techniques and measures for protecting the environment.
- Analysis of the present situation in CE countries with respect to the problem of recycling of by-products in road structures and practical recommendations on promising techniques.

Structures

On the issue of materials for structures the project aims at achieving the following exploitable outputs:

- Development of the requirements for a sustainable maintenance strategy, which satisfy the functional, safety, economic and environmental requirements for highway structures.
- Verification of effectiveness of surface applied corrosion inhibitors for concrete and the circumstances in which they can be applied in maintenance of highway structures.
- Validation and implementation of the use of advanced fibre reinforced cementitious materials (HPFRCC) for the repair or strengthening of highway structures.
- Updated inventory and assessment of highway structures in selected EEA and CE countries, taking into account results from the material related work packages.
- Guidelines on selection and use of innovative materials for the repair of highway structures and for optimised assessment of highway structures.

4.2. Exploitation timing

The project outputs are specifically developed so that they can be applied directly when the project is completed.

With respect to questions related to the production of a new generation of European performance-based pavement specifications, the timing for exploitation will depend on the plans of the relevant CEN Committees. However with the direct participation in the project of many experts having responsibilities in CEN TC's, it is expected that the results will be considered as early as possible.

Specifications and guidelines on selection and use of innovative materials for the repair of highway structures will provide a characterisation of these materials, define their range of usage and give methods of applications. Guidelines for optimised assessment of highway structures will provide tools for managers of highway structures to improve their maintenance procedures, also by accounting for the possible specific conditions in the selected EEA and CE countries.

5. Community added value and contribution to EU policies

5.1. Benefit of a European approach

Pavements

As it has been recognised long ago by the Council Directive 89/106/EEC of 21 December 1988, otherwise known as the Construction Products Directive, that harmonisation of specifications of environment- and consumer-friendly products is essential to remove trade barriers and to promote the European industrial system. The proposed project related to the preparation of a new generation of specification for pavement material could not be considered at national scale when standardisation and conformity assessment procedures are already organised at the European scale.

There are also technical reasons for the work to be done at the European level. In order to identify general methodologies for the assessment of materials of all kinds, which would be acceptable in the different European countries, the work should take into account the various climatic regions, types of materials and engineering traditions within Europe.

Problems faced by Central European countries with the urgent needs to improve existing road infrastructures taking into consideration environmental considerations in use and reuse of materials require enhanced co-operation with EU research organisations as it is stressed by the multi-annual R&D Transport Programme RETRA-EST.

Finally, when looking for a global approach, such as the one considered in this project for assessing environmental impacts in order to judge the suitability of materials for use and re-use in road pavement, this requires the contribution of a number of experts from different fields and different backgrounds, which can hardly be gathered together at a national level.

The trans-national composition of the Consortium, shown in table 19, with the support of a reference end-users group that gathers road authorities from different countries and European professional organisations, demonstrates how different origins and skills are combined to provide European added value to the proposed project.

Structures

New advanced materials are typically more established in some countries than in others. Their continued development and verification therefore call for the problem to be addressed at the European level so as to effectively encourage exploitation and use. Also, a quality updated inventory and assessment of highway structures in different European countries is a time-consuming process that requires contributions from a wide range of experts and from local road authorities. The wide European base of the Consortium, with its strong links to the national road authorities in thirteen European countries including Central European countries, is designed to promote the acceptance across Europe of the innovative maintenance strategies, techniques and procedures delivered by the project.

The second benefit for the project to be carried out at the European level is a technical one. Deterioration processes and the technologies required for maintaining highway structures are different for different climates and types of structures used throughout Europe. Also, the expected structural condition and maintenance procedures in Central Europe tend to be different to those in Western Europe. Hence, in order for the results from this project to have Europe-wide applicability, input from many countries is required.

The third reason is the size of the project in terms of the number of experts and the financial resources needed. It is too large for a small number of organisations to conduct effectively, both in terms of human and financial resources. For example, research facilities for testing the corrosion inhibitors are spread among different European institutes, which alone makes a European based project fully justified. In addition, the composition of the Consortium in relation to the Reference Group of end users demonstrates how different backgrounds and skills of partners are combined to ascertain a European added value to the proposed project.

5.2. Contribution to European policies

The following paragraphs highlight the contribution of the proposed project to several European Union policies.

Environment

It is now recognised that the European model of development cannot be based on the depletion of natural resources and the deterioration of our environment. The Treaty of Amsterdam enshrines the principle of sustainable development as one of the European Community's aims. Encouraging a proper recycling and re-use of by-products, as it should result from the proposed project actually correspond to one of the three complementary strategies of the Community policy on waste management. More details about the project contributions are given in chapter 6.2.

The following other aspects of the project will also contribute directly to the environment policy:

- The optimisation of the maintenance procedures will reduce the overall ecological cost of maintenance operations (dust, by products, contaminated waters, etc).
- Longer lifetime of structures due to improved assessment and maintenance procedures will reduce the quantities of waste products for recycling or deposits,
- HPFRCC materials with a large potential volume of future use make optimal use of a fair amount (around 12 %) of high-tech industrial by-products from the ferro-silicium industry.
- HPFRCC materials use lower amount of aggregates than usual concrete (30 % in volume instead of 70 %) and their very high performances lead to much lower quantities of materials being needed to obtain a given strength. This is of essence in view of coming shortages of natural aggregates for concrete construction.
- Shorter delays due to maintenance of structures will reduce the amount of harmful emissions from queuing vehicles, and optimised bridge posting will reduce the fuel consumption, which is now spent for unnecessary detours.

Transport

The development of the common transport policy is associated with the Trans-European Networks. For road transport, there are still missing links in the CE countries in particular and, in many places, improvement and/or rehabilitation of existing parts of the networks are needed. More recycling should play here a significant part to increase the acceptance of these works by taking account of environmental concerns.

Also the expected reductions in traffic congestions by reduced maintenance of structures will meet transport policy objectives by improving efficiency and safety of the road network. Optimised and more reliable structural assessment and maintenance procedures using improved analytical methods on one side and advanced materials on the other will extend the lifetime of structures and reduce

and shorten the duration of road closures. The improved knowledge about the highway structures and the advanced structural analyses will also eliminate the need for many bridge postings or reduce their severity. Consequently, traffic will flow more freely, there will be fewer detours for heavy freight vehicles, and journey times will shorten, with fewer accidents and less stress suffered by these road users.

Energy

As part of a general rational use of natural resources, energy efficiency is considered a cornerstone of Community action, which led to a multi-annual programme for the promotion of energy efficiency (SAVE). Processing of road materials from primary aggregate is particularly energy consuming. Hence the development of recycling and the re-use of road and industrial by-products in road construction will directly contribute to a reduction of energy consumption and of import of crude oil for bitumen production.

This project will also indirectly contribute to the European energy policy by reducing traffic congestion and vehicle delays due to optimised highway structure maintenance procedures and by shortening the detours due to optimised assessment and bridge postings. This will reduce considerably the amount of fuel consumed.

Enlargement of the European Union (Regional policies)

The multi-annual transport research work programme RETRA-EST launched in 1998 by the Commission identifies several priorities, which are in direct relation with some of the proposed project and outputs. For road construction and maintenance, attention is called for life cycle and environmental considerations in use and reuse of materials; in improving pavement maintenance, it is stressed that in many CE countries equipment available for recycling is of such quality that new types of machines are needed.

Alternative geotechnical works and materials are also considered a first priority since in many CE countries large quantities of local materials for construction exist, the use of which could be developed (quarry waste, industrial by-products, construction wastes…). Among the first co-operative actions, it is suggested to study the properties of these materials and the preparation of specifications for their use. Furthermore, concerted RTD is proposed to encourage an increase in recycling research and demonstration projects (for pavements and structures), and in sharing recycling technology among the countries.

These different aspects are directly addressed by the project with the active contribution of CE countries. The project which aims at promoting recycling techniques in road construction appears to be particularly timely when one considers the European Commission Agenda 2000. For supporting the pre-accession process to the Union of the CE applicant countries, the Agenda 2000 has established a financial framework, which contains an important structural aid to help applicant countries comply with Community infrastructure standards in the transport and environmental sectors.

The other group of results from this project will help to guide regional policies on the maintenance of highway structures. A considerable part of this project directly addresses highway structures in selected EEA and CE countries, which again seem timely for the pre-accession process of the Central European applicant countries to the European Union. The highway infrastructure survey will identify differences between condition of highway structures in different European countries and give recommendations on implementation of new maintenance techniques in these countries from the structural, traffic, environmental and financial points of view. These expected results of the project fit exactly into one of the four proposed themes of the RETRA-EST transport research

programme, the 'Improved structures', and its two topics with the highest priority: the Structures monitoring and detection of structural deficiencies and Assessment of the residual bearing capacity of engineering structures.

5.3. European standardisation, regulation and conformity assessment

The pavement part of this project is directly addressing different aspects of European standardisation, regulation and conformity assessment procedures:

- the introduction of an environmental annex to CEN road product standards;
- the development of test protocols to identify the existence of hazardous components in materials to be recycled;
- the development of mechanistic approaches that would permit the definition of performance-based specification with regard to the functional property of permanent deformation of pavements;
- the assessment of the need for regulation on fire reaction of pavement materials.

A key objective pursued by this project is to establish a basis for a new generation of standards (material specifications and test methods) for pavement materials. It shall replace the current draft specifications (with a planned implementation date of December 2003), which are based on the harmonisation of existing national recipe specifications.

The part of the project dealing with highway structures is not addressing directly European standardisation procedures. However, the techniques and procedures for using advanced materials for maintenance of highway structures and the optimised assessment procedures will provide important knowledge at the European level, which will be much easier to standardise than national developments. Documents on assessment of highway structures in the selected countries may also serve as the background documents for future standardisation and regulation documents in the area of structural assessment.

5.4. Community added value by networking

This project provides substantial additional Community Added Value from strong interactions between this project and other ongoing and proposed research activities at European, national and international level. Many of the partners are actively associated with other European RTD projects and individual experts are involved personally or by colleagues at their institutions. The project will take maximum advantage of the results produced by past projects such as:

- the on-going actions COST 345 'Procedures Required for Assessing Highway Structures', COST 347 'Pavement research with accelerated loading testing facilities' and COST 521 'Corrosion of steel in reinforced concrete structures',
- the Transport RTD projects ALT-MAT, AMADEUS, COURAGE, POLMIT, BRIME 'Bridge Management in Europe', WAVE 'Weighing-in-Motion of Axles and Vehicles for Europe', and
- the SMT project SPECOMPACT,

which will all provide significant inputs to this project which will work towards their implementation. In addition, links are shown with:

- the PIARC committee C11 'Bridges and other structures', which has as an aim to collect information from around the world and to prepare guidelines on different aspects of structural assessment and as such is complementary to the COST 345 action;

- *fib* (International Concrete Federation) Commission 5, dealing with service life aspects of concrete structures;
- IABMAS (International Association for Bridge Management and Safety), which aims to promote international co-operation in the fields of bridge maintenance, safety, and management for the purpose of enhancing the welfare of society, and
- WP 11 'Corrosion in Concrete' of the European Federation for Corrosion.

Most of the research institutes in this consortium are associated with FEHRL (Forum of European National Highway Research Laboratories). Many partners have taken part in other transport related COST actions (COST 323, COST 334, COST 337) and past and present Framework Programme RTD projects and most relevant inputs are expected from the members of COST 323 'Weigh-in-Motion of Road Vehicles'. This COST action provided guidelines on using weigh-in-motion measurements for improved bridge assessment. The consortium is extremely keen to co-operate with other projects by providing information and taking on board any relevant developments in other projects. In addition to those projects listed above, co-operation will be sought from future 5th Framework Programme projects, where applicable.

A link is also created with research going on in the United States and supported by the Federal Highways Administration (FHWA) through the participation in the project of the leading Recycled Materials Resource Centre of the University of New Hampshire.

The proposal also complies with the objective of the RETRA-EST programme to encourage participation of the researchers from the CEE countries in the projects covered by the European Community RTD Transport Framework Programme.

6. Contribution to community social objectives

6.1. Employment, education and training

The results of the project are not expected to have an overall impact on employment in terms of increasing overall employment numbers, but it will help to facilitate a change of employment.

With the move towards using more recycled materials, there will be less need for natural aggregate to be exploited, but more need for the selection and preparation of the replacement materials. There will be a change in the job skill requirements with the change from quarrying to preparation. These changes will be in terms of actual skills required rather than the skill level. It is thus anticipated that the change will require re-training of some operatives, but that it will be an on-going process as the change to more recycling is implemented.

Correspondingly, in the maintenance of highway structures there will be some growth in the number of jobs in the high technology repair sector to replace to some extent those lost in the demolition sector. These new jobs will however require higher skills and be more rewarding

Any move towards performance-based specifications, particularly when all aspects of the performance of a material are considered (i.e. safety and environmental as well as functional), will enhance the understanding of engineers as to precisely what they are doing. This direct linkage of criteria to the reason for applying them is not only advantageous in ensuring that the implications of non-compliance are fully understood; it also spurs development when more explicit means of ensuring the performance are needed.

The easier understanding of the logic behind the design of materials will not only make training of engineers easier, but should allow a broader population to understand the need for appropriate design.

The technical guide on recycling techniques and the briefing documents produced by the project will represent very useful tools for education of road engineers.

Also, in order to deploy the specific knowledge required by the advanced assessment and maintenance of highway structures, modified education programmes would be needed to fill the gap between design of a new structure and optimal assessment of an existing one. This will increase the need for specialised structural assessment engineers.

Reports produced by this project could serve as background documents for training courses for structural assessment engineers and for people involved in new maintenance technologies. They could also influence the teaching programmes of universities and technical schools. Practitioners and students will have to learn to understand differences between design of new structures and assessment of the existing ones, and, thus, be able to implement more advanced and optimised procedures for maintenance of highway structures.

6.2. Environment

As mentioned before, in connection with European policies, the environment is specifically targeted in the proposed project. There are two primary means by which the pavement part of the project will contribute to the environment: by the greater use of recycled materials and by the explicit consideration of environmental performance in the design of pavement materials.

The greater use of recycled materials in road pavements will itself have three environmental benefits. These benefits, generated by treating waste materials that can perform satisfactorily on a more equitable footing with traditional materials, are:

- The concomitant reduction in the consumption of natural aggregate will reduce the demand for quarries that can scar the countryside and, unless sculptured, leave heaps of the remnant fine material.
- The reduction in the waste that is going into the pavement materials that would otherwise be stored in deposits.
- Assuming that generally the waste will be available closer to where the pavement is required than the quarry, there may also be a saving in transporting the bulk material with all the associated reduction in heavy vehicle movements and generation of noise and pollution.

The explicit consideration of environmental performance in the design of pavement materials is also addressed by the proposed project. In this way it is proposed to link more directly the infrastructure to be built, its environment and the selection of materials.

The concept of defining environmental and health performance requirements as well as performance requirements should facilitate a consistent encouragement for maximising the enhancement of, or at least minimising the damage to, the environment by the construction or rehabilitation of a pavement. This concept should be clearly set out in the draft Environmental annexes to product standards that are to be prepared as part of the proposed project.

Although it is difficult to have numbers at the EU scale, information from some countries can help in understanding the issues. In France, recycling of by-products represents 11 million tons /year, and wastes of bituminous materials amount for 5 million tons which represent over 12 % of the total yearly production of bituminous mixes. In the Netherlands, which is among the most advanced countries in this field, because of their limited primary aggregate resources and landfill capacity, the goal is to re-use 90% of construction and demolition material by 2000, while in the U.-K. the goal is to double the use of recycled materials within 15 years. The annual production of hot mix asphalt in Europe is of the order of 300 million tons. While most of the material reclaimed during demolishing works is suitable for recycling, the percentage routinely recycled is still low. The same is true for cement concrete materials. Hence any progress in the increase of recycling and in the optimisation of the reuse of the materials has a significant economical and environmental impact because of the volumes at play.

Also, advanced assessment procedures will reduce the overall ecological cost of maintenance operations (dust, by products, contaminated waters, etc) and number and severity of interventions, including bridge postings. This will diminish or shorten the required road closures and long detours for heavy vehicles. Consequently, number of traffic delays will significantly decrease, which will reduce fuel consumption and emissions.

The extension of the service life of existing structures through the use of corrosion inhibitors will obviate the need for full or partial demolition of structures and will therefore reduce the volume of replacement concrete required in the short, medium and long term. Similarly, HPFRCC uses less than half the amount of aggregate required for the traditional concrete and the high performance of the material enables use of much lower quantities of materials for a much better level of performances (reduction of thickness, etc.). These arguments are essential when considering the coming shortages of available natural aggregates for concrete production, thus extending the life of existing quarries and postponing the need to extract from new sources.

HPFRCC materials also use a fair amount of industrial by-products (silica fume from the ferro-silicium industry). With a large potential volume of HPFRCC needed for maintenance of highway structures in the future these high-tech by-products can be extensively exploited.

In general, optimised structural assessments and improved maintenance techniques will reduce the needs for replacement of highway structures or their components, which will reduce the quantities of waste products that need to be stored in deposits or reprocessed. It will also result in energy saving and greenhouse gas emission reduction because of the reduced demand for cement and reinforcement steel production.

6.3. Quality of life, health and safety of the citizens, including working conditions

The expected results of the project will in many ways be of benefit to the citizens' and road workers' quality of life, health and safety.

The proposed development of test methods to identify hazardous components in the materials to be recycled will have direct impact on the safety and health of workers in the road industry.

Explicit aspect of the reaction to fire will be clarified and specific performance requirements, if appropriate, developed to mitigate future problems.

Quality of life for many citizens will also be enhanced by the environmental benefits of less quarrying and of the reduction of landfill disposals.

Strong growth in traffic congestion all around Europe, but particularly in highly populated areas of Western Europe, is causing constant increase in travel time. Any road closures due to road works or detours to lower class roads as a result of obsolete highway structures brings further reduction in mobility.

Fewer and shorter road closures and avoidance of unnecessary bridge postings will therefore lead to faster and safer travel, cause less annoyance for the travelling public and improve the efficiency of transportation of goods.

Thousands of people are employed in Europe to work on maintenance of highway structures, often in poor weather conditions and at anti-social hours. And although less exposed to the danger of passing traffic than the pavement and road maintenance workers, the risks are still considerable when interventions are done under running traffic. Therefore, any decrease or avoidance of such works will improve safety of workers and of people involved in highway consultancy.

The innovative repair materials included in this proposal will extend the life of existing structures, thus reducing the requirement for demolitions with their attendant safety risks. The associated new high-skills jobs in the highway structure maintenance and repair industry will employ cleaner technology by well-trained personnel thus improving both health and safety at work

7. Economic development and S&T projects

7.1. Exploitation and dissemination of results, Intellectual Property Rights

The main project outputs and benefits in relation to the Community as discussed in the previous sections are summarised in Table 1. It presents range of applications, their expected impacts, exploitation schedule and project partners, responsible for exploitation For this table partners in the project have been grouped in the following categories: road owners, road industry and research institutes. One has also to mention here the important role that the CEN standardisation Technical Committees will have in the exploitation of the outputs of the present project.

The main project outputs and benefits to the community, described in the previous chapters, are summarised in Table 18.

Exploitation and dissemination of results

The project has been structured so as to produce results, which can be applicable and implemented soon in the practice. The number, the nature and the content of the technical documents to be produced by the project (Cf. Table 5 of the deliverables in section B5) reflect this, which include e.g.:

- technical guides for assessing the possibility to re-use materials in road construction,
- guides on techniques of recycling,
- analysis and recommendations for CE countries as regard recycling,
- models and test methods to support performance-based specification with regard to permanent deformation of pavements, tests protocols, etc.,
- state-of-the-art report on assessment of structures in selected EEA and CE countries,
- specifications for the use of CI and HPFRCC in maintenance of highway structures,
- guidelines for materials for the repair of highway structures,
- guidelines for optimised assessment of highway structures.

The implementation of the results is considered a significant aspect of the proposed project. Special attention will be given to implementation of the results in Central and Eastern European countries

As such, there is a separate Work Package, lead by the exploitation manager, for this task. For details of this Work Package, see the description of Work Package 16 in chapter 3.5. The dissemination and exploitation plan that will be drafted in WP16 will refine the present ideas and get the feedback from the reference end-users group. The Technology Implementation Plan will be submitted to the Commission as part of the mid-term assessment and at project end.

A seminar will be organised at the end of the project to explain the findings to a large audience. Current plans would let the seminar have two special sessions:

- one dedicated to the situation in CE countries and
- one devoted to the members of CEN TC 227 (Road materials) and open to members of TC 154 (Aggregate) and ex TC 19/SG1 (Bituminous binders) who are responsible for drafting the European specifications for pavement materials.

Given the three-year duration of the project, the seminar would come soon after the current harmonised specifications for road materials have been implemented in July 2004. Hence, the timing will be suitable for thinking of how to improve in the near future these standards. The

precise timing and location of the seminar will be selected later, possibly in conjunction with some European Transport Research conference, in order to maximise its impact.

Although the primary route to implementation is through the European standards, it is intended that the members of the Consortium will keep their national standardisation body informed of the developments so that they can also be implemented in any national standards for associated aspects not covered by the European Standards.

In addition to the directly exploitable outputs, the project will result in more efficient and durable maintenance of highway structures, increased traffic comfort due to less delays and detours caused by maintenance works and increased networking between researchers and practitioners.

A very important feature in the planned organisation of the project is the Reference Group of end-users, which will be established in order to strengthen and support the end-users' commitment to put the project's findings and recommendations to practical use. The Reference Group will be composed of senior representatives of national road administrations and representatives from the relevant industry associations. It will meet three times in the course of the project: when the final work plan has been made by Work Package 2 and Work Package 12, at the mid-term assessment and at the final symposium.

Table 18: Expected results and exploitation

Project output / Result	Range of Applications	Expected Impact	Timing	Partner(s) responsible for exploitation
Community Added Value:				
Networking	Framework Programme / COST, FP, COST, CEN, RETRA-EST	Co-ordination of actions, Implementation, no duplication of effort, association of CEE countries	>2001	Research institutes Road owners
Social / Environmental Impact:				
Assessment of the eco-compatibility of materials to be re-used in road works	All types of road networks	Less problems of pollution. Better use of by-products and preservation of natural resources.	>2004	Road owners
Increased safety at road works	All types of road networks	Less health problems with undetected hazardous components when recycling	>2004	Road owners, road industry
More efficient road network	Entire road network	Less delays, less annoyance	>2004	Infrastructure owners
Optimised road closures	Entire road network	Less people killed/injured, less fuel consumed	>2004	Infrastructure owners, road industry
Optimised maintenance	Entire road network	Less natural aggregate needed, exploitation of by-products	>2004	Infrastructure owners, road industry
Technical / Economical Impact:				
Assessment of suitability of materials for re-use in road pavements	All types of road networks	Integrated assessment of the different aspects within a given context More efficient use of local aggregate and of by-products	>2004	Road owners, road industry
Performance-based	Flexible	Possibility to assess in a common	> 2004	CEN Technical

Project output / Result	Range of Applications	Expected Impact	Timing	Partner(s) responsible for exploitation
specification for functional properties of pavement materials	pavements, Bituminous surface layers	way different types of materials including secondary materials and by-products. Reduction in cost of pavement works by the use of a larger range of materials		committees Road owners, road industry
Technical guide on recycling techniques	All types of road materials	Development of recycling. Less cases of failure due to inappropriate processing or construction methods.	> 2004	Road owners, road industry
Recommendations for CEE countries for recycling	All types of road materials and networks	More efficient use of recycling for upgrading the existing networks	> 2004	Road owners, road industry
Optimised assessment and maintenance procedures	Entire road network	Less and more efficient maintenance application, less traffic detours, better use of financial resources	>2004	Infrastructure owners, road industry
Innovative maintenance	Entire road network	Faster, less frequent maintenance	>2004	Infrastructure owners, road industry
Specifications on new materials	Entire road network	Better quality maintenance	>2004	Infrastructure owners, road industry
Follow-up materials	All levels of network	Dissemination of knowledge on improved maintenance procedures	>2002	Researchers, infrastructure owners, consultants
Technical reports	All levels of network	Optimised maintenance of structures	>2003	Infrastructure owners, consultants, researchers, road industry

Intellectual Property Rights

The objectives of task 2.2.1.18 clearly calls for the results and outputs at large to be in the public domain in order to permit the development of new specification and standards and to enhance the development of recycling techniques. As an answer to these needs the project is not concerned with the development of a particular product or a particular technique, but it focuses on the production of new knowledge and of applicable methodology. Therefore, it is generally not considered desirable for anyone to secure the Intellectual Property Rights (IPR) for themselves. No money has been allocated in the budget for protection of knowledge.

There is, however, in the structures research part of the project one important exception to this general condition. It is tied to LCPC, who as an important contributor to WP14, requires the participants' acceptance of certain restrictions on the dissemination of information from the project to the extent necessary to protect the confidential data and know-how relating to HPFRCC products developed and made available for the project by LCPC. A written agreement to safeguard this and to cover the industrial property rights over any patentable applications based on these products will have to be signed in parallel to this contract as part of a Consortium agreement

7.2. Economic growth and competitiveness

Economic growth without unnecessary depletion of resources needed also by future generations is a key element of the present European model of sustainable development. Considering the situation

in the road construction industry, the situation is far from being ideal. There are conflicting economical interests, such as sale of primary aggregate from hard rocks versus use of local aggregate and re-use of road and industrial by-products. These require methodological tools and sets of specifications to be made available to road owners, so that they can consider in a more effective way the recovery and recycling of materials in pavement works. The outputs of the proposed project directly contribute to these aims.

The direct economic gains which should benefit both the general public and the local authorities who own the road networks, are several:

- Reduced costs of waste disposal and reduced needs for landfill disposal,
- Reduced costs of pavement works by making use of local available materials,
- More cost-efficient designs with performance-based specifications for pavement materials instead of present recipe-type approaches, which do not permit to assess correctly non-traditional aggregate.

Even if one considers recycling of road materials alone, as indicated earlier, the potential of savings of virgin aggregate represents in each country millions of tons yearly. Optimum re-use of asphalt mixes should also spare a few percent of bitumen. Hence even small progress made here will have a significant impact on resources and on the general economy of the road industry. At the EU scale the implication of these large volumes represents billions of Euros.

Recycling and use of local aggregate will bring savings in the transport of pavement materials from quarries to work-sites; this reduction in traffic of these aggressive lorries has also an important indirect economic impact for the involved municipalities with less damage of local roads.

The main exploitable results from the project will optimise planning and execution of maintenance of highway structures. Improved assessment and application of advanced materials will lead to reduction in the number, size and duration of road closures for maintenance of structures. This will result in fewer user delays and, consequently, contribute to improving the efficiency of the European road network. The project's results will contribute to economic growth by allowing faster and more reliable transportation of people and goods to their destination or to other transport modes.

The partners in the project may be divided into three categories, the road owners, and the research organisations and material industry.

The road owners do not operate in a competitive market, but are public bodies that provide transportation facilities to the public. The road owners of the national networks are loosely organised at the European level in the WERD (West European Road Directors), thus making a channel for technology transfer, also to the CEE countries.

Many of the research organisations involved in the project are members of FEHRL (Forum of European National Highway Research Laboratories), which allows for a continuous technology transfer. Their legal status ranges from public to private organisations; most of the private organisations originated from government owned national highway research institutes. Several of the research organisations are currently in such a transition from public to private. The private organisations and those in transition often work in a competitive environment, whereas the public organisations mostly work for their national Ministry of Transport. In addition to carrying out research, the project partners are also often active as consultants and service providers, in various degrees of competitiveness.

The industrial partners in the project are major players in the material manufacturing and maintenance industry, operating in a competitive market.

The economic impact of the project output goes far beyond the project partners. The EU countries alone spend some 80 billion € annually on transport infrastructure, the greater part of which is on road infrastructure. The direct benefits of this project will be considerable savings on the costs of maintaining the infrastructure, as well as the consideration of social and environmental aspects. Optimised planning and execution of maintenance of highway structures will enhance efficiency of the European road network. The transportation industry and the travelling public will benefit through less time lost at road works and detours. Indirectly, the whole economic activity in Europe will gain from faster and safer transportation of people and goods. The economic benefits achieved through this are many orders of magnitude greater than the overall costs of the proposed project.

7.3. Scientific and technological prospects, dissemination and technology transfer

Scientific and technological prospects

This project introduces an original approach in the field of construction, the definition of a methodology for assessing the eco-compatibility of materials with consideration of their context of use. Such an approach, developed here for road pavements, will open prospects in other construction fields. The pilot studies for the establishment of an environmental annex to products standards will also permit to extend the work to other building materials.

The definition of mechanical models and testing for the prediction of permanent deformation of pavement will be a major step forward both for the definition of general performance-based specifications for materials and for the design of pavement structures. This will have impact on laboratory test methods used throughout Europe. This approach will enable Europe to eventually challenge pavement design approaches under development in the U.S.A. this topic being an important issue world-wide.

The proposed advanced, integrated, multi-disciplinary approach to several aspects of assessment and maintenance of structures will lead to increased technology transfer and to improved scientific evaluation procedures. The application of scientific techniques to industrial processes will contribute to the technological development of the road industry. Education will also benefit from the proposed approach. As a result, future structural engineers will be familiar in their engineering approach with new advanced techniques and methods for solving problems related to maintenance of highway structures.

Policy and plans for dissemination of results

Since the main objectives of task 2.2.1.18 are to achieve significant improvement in routine processes of maintenance, the proposed policy is to achieve as wide dissemination as possible.

For the dissemination of the project's outputs and results, the following targeted users have been identified: - managers of highway infrastructures, - road owners, - contractors, - consultants and - road user organisations.

The policy clearly calls for the results and outputs to be in the public domain. Dissemination of the results under the responsibility of WP16 includes:

- A project web site for information of the project content, progress and outputs, which will be active from the start of the project and will be regularly updated;
- Articles in technical journals to reach the road industry (contractors, material producers, engineering consultants, road authorities…);

- Papers at international conferences and in scientific journals to disseminate the results among academia;
- A final symposium to promote and discuss outcomes of the project;
- A final symposium to promote and discussion outcomes of the project with two special sessions, one for CEE countries and one for CEN experts;
- Ready-to-use guides and reports as defined in the list of deliverable; briefing materials prepared for easy dissemination of results at different national and international events;

With the help of the American partner, results will also be presented at major North American conferences in order to promote this European work and its outputs.

The Reference Group of end-users, which was mentioned in chapter 5.1, plays a major role in the effort to disseminate project findings effectively to the national beneficiaries who are also co-funding the project. Also, professional associations will be invited to join the group. That will widen the scope of the Group and provide some guarantee that resources spent on this project will also, subsequently, result in the practical availability of the kind of innovative materials and techniques which have been recommended by the project.

8. The consortium

8.1. Overview of the consortium

Production of the deliverables corresponding to the expected results of task 2.2.1.18 requires scientific expertise in many different fields together with technological expertise related to road works, recycling techniques and assessment and maintenance of structures. Moreover consideration of the situation in Central European countries necessitates also participation of experts from this area for a correct access to information and a good understanding of the present situation.

For these different reasons the Consortium is large and includes a diversity of members (academia, research institutes, engineering consultants, product manufacturers, road contractors) that will carry out t major part of the research. Many of these organisations are national road research laboratories, with close ties to the national road authorities. They are selected for the expertise and ability to work in such a group, that, most of them have demonstrated with success in past European projects (COST actions and RTD projects). The four industrial partners on the Consortium ensure that results of the research become exploitable

The consortium will be supported by a reference end-users group, gathering together public road authorities from the EU and from CE countries together with European professional associations. This reference group will provide guidance to the project and will ensure that the outputs are correctly disseminated.

For efficient management of the project, seven experienced public institutes with complementary expertise will form the core group of Principal Contractors. Each of them has responsibility for a technical work package and is involved in other WPs. Sixteen assistant contractors each have a focused role in one work package and provide specific expertise as required by the project. From a scientific point of view it is important to note that technical tasks are always carried out by two or more teams in order to ensure that all parts of work are critically assessed and do not reflect single, and perhaps biased, views.

The Consortium is completed by a group of ten Sub-Contractors. Their role in the project is of limited extent, but is nevertheless important, as they will provide input on the definition of the problem and on exploitation of the results. Given their pre-defined role in the project, HES 26 and IND 27 will act as Sub-Contractors to REC 04, REC 28 and HES 29 will act as Sub-Contractors to HES 07 and the remaining Sub-Contractors will act as Sub-Contractors to REC 03. Table 20 lists all Sub-Contractors.

One task only is considered to be sub-contracted (test on reaction to fire) because of its very specific character.

Table 19 gives an overview of the consortium; complementarity is briefly explained below.

WP3 Assessment of materials requires expertise in material engineering - aggregate and by-products characterisation - (DRI and LCPC), pavement engineering and road design (VTI), environmental engineering (ENTPE/LES), water pollution and protection aspects (DHI), water movements and pollution migration aspects (ECN). The participation of the University of New Hampshire will provide a direct link with research carried out in this field in U.S.A.

WP4 on safety and environmental concerns requires expertise in physico-chemical testing (LCPC and SHELL), specification and standards (RUB and TRL).

WP5 on functional specifications requires expertise in theoretical modelling of material behaviour and pavement performance (ISTU and LCPC), mechanical testing of bituminous mixes (SHELL, DRI), and mechanical testing of unbound pavement materials (LCPC, IST).

WP6 on recycling techniques requires general expertise in pavement maintenance (CEDEX), and technical expertise provided by road contractors on plants and processing of by-products for recycling (RGS90) and on recycling works (EJL/EUROVIA). The review of the situation in CE countries will be made with participation of the Technical University of Brno (Czech Republic) of the Polish research institute IBDiM and of the EJL/EUROVIA group.

WP12 on strategies for repair of highway structures need general expertise on the issue (TRL) supported by the leaders (UCD, EPFL and ZAG) of the other work packages in the structures stream.

WP13 on corrosion inhibitors requires experts in physics and chemical analysis (UCD , ZAG, TRL), mechanical testing (UCD, ZAG) and industry-level experience with the compounds (Sika)

WP14 on high performance fibre reinforced cementitious concrete (HPFRCC) materials similarly requires experts in mechanical testing (EPFL, TRL) and numerical modelling of mechanical and structural behaviour (EPFL) in addition to product-level know-how about the materials (LCPC)

WP15 on survey of highway structures requires experience in condition assessment of structures (ZAG, TRL, UPC, IBDiM) in addition to experience in live and static bridge loading (ZAG, TCD, UCD), dynamic loading (TCD) and structural safety (ZAG, UPC, UCD). Specific input from Central Europe is required by this work package to ensure that the results of the project are also relevant to structural maintenance problems in that region.

Many of the partners in the proposal have close links from working together on previous European projects. Several of them are members of the Forum of European National Highway Research Laboratories (FEHRL) and have jointly carried out COST Action 323 ‘Weigh-in-Motion of Road Vehicles’ and the 4th Framework Programme projects ‘WAVE – Weighing of Axles and Vehicles for Europe’ and ‘BRIME – Bridge Management in Europe’. Members of the group are also active in the COST actions 345 ‘Procedures required for Assessing Highway Structures’ and 521 ‘Corrosion of steel in reinforced concrete structures’. Through this previous and current co-operation, the core groups of the Consortium form a team in which many have worked successfully together for over seven years.

Table 19: Overview of the Consortium (Principal Contractors and Assistant Contractors)

Participant		Organisation name and Country		No. of em-ployees	Business Activity: Main Mission / Area of Activity	RTD Role in project
Activity Code	No.					
REC	**01**	**DRI**	DK	S6	Research and development	Co-ordination, monitoring, WP5 leader, Testing on bituminous mixes
REC	**02**	**LCPC**	FR	S4	Research and development	WP3 leader, Exploitation, Material characterisation and modelling, HPFRCC product input
REC	**03**	**ZAG**	SI	S6	Research and development	Scientific co-ordination, QA, WP15 leader, CI
REC	**04**	**TRL**	GB	S5	Research and development	WP4 and WP12 leader, Pavement material testing, CI
HES	**05**	**UCD**	IE	S7	Education and research	WP14 leader, Survey, Load modelling
REC	**06**	**CEDEX**	SP	S6	Research and development	WP6 leader, Recycling techniques
HES	**07**	**EPFL**	CH	S7	Education and research	WP14 leader, Survey
HES	08	ISTU	AT	S3	Education, Research	Theoretical modelling
IND	09	SHELL Global solutions	FR	S4	R&D/Product manufacturer	Physico-chemical analysis Mechanical testing
HES	10	TCD	IE	S6	Education and research	Load modelling, Structural safety
HES	11	UPC	SP	S7	Education and research	Condition assessment, Structural safety
HES	12	IST	PT	S3	Education, Research	Testing on unbound materials
REC	13	VTI	SE	S4	R&D	Pavement design
IND	14	Sika	IE	S2	Material manufacturer	CI, Industrial input
REC	15	DHI	DK	S5	R&D/water	Water pollution and protection aspects
REC	16	ECN	NL	S6	R&D/Environmental engineering	Water movements and pollution transfer
HES	17	ENTPE/LES	FR	S5	Education, Research	Environmental engineering
HES	19	UNH	USA	S4	Education, Research	Environmental engineering
HES	20	RUB	DE	S5	Education, Research	Products standards
IND	21	RGS90	DK	S6	Road contractor and material producer	Recycling plants
HES	22	TU Brno	CZ	S5	Education, Research	Situation in CE countries
REC	23	IBDiM	PL	S4	Research and development	Situation in CE countries Survey, Structural safety
IND	24	EJL/EUROVIA	FR	S7	Road contractor	Recycling techniques

1: Coding as in Form A3: S2 1-9, S3 10-49, S4 50-249, S5 250-499, S6 500-1999, S7 2000 and more employees

Table 20: Overview of the Sub-Contractors

Participant		Organisation name and country		No. of em-ployees[1]	Business Activity / Main Mission / Area of Activity	RTD Role in project
Activity Code	No.					
HES	26	ULIS	GB	S4	Education/research	CI, testing
IND	27	Roelfstra Co.	NL	S2	Industrial-FEM Codes	HPFRCC, software support, technology
REC	28	PSI	CH	S3	Research and development	HPFRCC, testing
HES	29	EPFL-LMC	CH	S3	Research and development	HPFRCC, testing
OTH	30	BMVIT	AT	S4	Road authority	Data provider, exploitation
OTH	31	RSD CR	CZ	S5	Road authority	Data provider, exploitation
REC	32	KTI	HU	S4	Research and development	Data provider
OTH	33	NPRA	NO	S4	Road authority	Data provider, exploitation
OTH	34	GDDP	PL	S4	Road authority	Data provider, exploitation
OTH	35	DRSC	SI	S4	Road authority	Data provider, exploitation

1: Coding as in Form A3: S2 1-9, S3 10-49, S4 50-249, S5 250-499, S6 500-1999, S7 2000 and more employees

8.2. Description of the participants

REC01 – Danish Road Institute (DRI)

DRI is the public materials research laboratory of the Danish road sector and a branch of the Road Directorate. It undertakes R&D, laboratory testing of materials, road condition measurements and consultancy on road infrastructure management. DRI is also active in specifying Danish road materials in national standards and in the development of European standards

Through participation in several EC funded projects and co-ordination of the PAV-ECO project, DRI has gained experience in the management of large European projects and the exploitation of their results. The Director of DRI, Mr. Jørgen Christensen, will act as the administrative and financial co-ordinator of the proposed project and be responsible for the dissemination and exploitation as leader of work package 16.

DRI has specialist teams working on the technology of road materials: natural aggregates, bitumens and bituminous materials, recycled materials and by-products. It has a fully equipped, accredited asphalt and soil mechanics/concrete laboratory for routine and research testing programmes. Specialist teams in road and non-road by-products, which were partners in the recently completed ALT-MAT and POLMIT projects, will also assist in WP3.

The Danish asphalt rut tester, a stationary, full-scale, heavy wheeltracking ALT facility, which has been designed by the DRI and installed at the Institute in 1997, will assist in WP5 to establish the risk of permanent deformation in bituminous pavements materials. WP5 will be led by Dr Carsten Bredahl Nielsen, a DRI specialist in the functional properties of bituminous pavement materials, rut testing and materials technology.

REC02– Laboratoire Central des Ponts et Chaussées (LCPC)

LCPC is a public research institute which depends on the French Ministries of Research and Transportation. With a staff of over 500 persons, it undertakes R&D on a large spectrum of problems in the field of civil engineering. LCPC has acquired a renowned expertise in particular in material characterisation, design of construction material, numerical modelling and design of pavement structures. LCPC contributed to most of the past European projects which are to some extend connected to the present proposal: ALTMAT, COURAGE, POLMIT, SPECOMPACT, COST 337…

Mr. J.-M.Piau, LCPC's Pavement Technical Director, will act as the scientific co-ordinator of the pavement part of the project. WP3 on Assessment of materials will be led by Dr. Denis François, a specialist of environmental engineering in the field of road infrastructures. Dr. François was an active participant to ALTMAT. In WP5 the task on deformation of unbound material will be managed by P. Hornych, a senior researcher who participated in several European projects Science SC0130-C, COURAGE, COST 337 for his contributions in this field. In WP14 the head of LCPC's department on concrete and cementitious composites will provide HPFRCC materials and product information, including testing data, relating to these specific materials.

REC 03 - ZAG

ZAG is the Slovenian National Building and Civil Engineering Institute. It is working as governmental research and testing institute. It is an independent, impartial and non-profit organisation, which fulfils all requirements of the EEC Council Directive No. 89/106 regarding approval bodies which carry out the testing and attestation of conformity of construction products. This includes all the products and works that are needed for the new motorway construction and all the products and works that are needed in maintenance and management of other national roads.

ZAG has developed the comprehensive bridge inspection system in Slovenia, including procedures for condition rating, safety assessment and site specific live load modelling of bridges based on true traffic condition. Corrosion inhibitors have been extensively tested as a part of studies on corrosion processes of steel and in concrete.

ZAG will act as the scientific co-ordinator of the structure part of the project and as WP15 leader. Key experts involved are Mr. Aleš Žnidarič, also the vice-chairman of the COST action 345 and national delegate in the PIARC committee C11, working for 12 years on assessment of existing bridges, and Dr. Andraž Legat, leading researcher in the area of corrosion inhibitors, member of the COST action 521 and NACE, the International organisation of corrosion engineers.

Six subcontractors, the national Road Administrations or other data providers from Austria, Czech republic, Hungary, Poland, Norway and Slovenia, will be involved in the activities of ZAG to ensure delivery of reliable information on highway structures from these countries.

REC04 – Transport Research Laboratory (TRL)

The Transport Research Laboratory is a comprehensive centre for the study of transport that is located in the United Kingdom. Research on highway materials is carried out at TRL in the Pavements Department, which has specialist teams working on the material properties, structural properties, surface characteristics and maintenance procedures of asphalt, concrete and unbound materials for highways. TRL also has both Safety and Environment Departments to assist in Work Package 4, Safety and environment concerns in material specifications, which TRL will lead. TRL is developing a co-ordinated approach to many aspects of sustainable development for transport. TRL developed the

small wheel-tracking equipment now incorporated in the draft CEN standard, with which they will assist on Work Package 5.

Research carried out in TRL's Infrastructure Department includes inspection, assessment, maintenance and repair of highway structures. This involves assessment of the techniques available for repairing concrete structures, development of procedures for ensuring durable repairs and determining the most appropriate durability option considering both technical and economic issues.

Dr Cliff Nicholls, a specialist in asphalt surfacing and road marking materials, will lead TRL's contributions to the pavement part of SAMARIS as WP4 leader and a participant in WP5. Dr Nicholls has participated in previous European contracts, SPECOMPACT, as well as managed many projects for the UK Highways Agency.

The Fire Research Station (FRS), part of the UK Building Research Establishment, will be acting as a sub-contractor to TRL for the task on the reaction to fire of the pavement materials.

Dr. Richard Woodward will lead TRL's contribution to the structure part of SAMARIS as WP12 leader and participant in WP13, WP14 and WP15. He was the co-ordinator of the recently finished BRIME project from the 4t^{h} FW programme.

Two subcontractors will be used in TRL's contributions to the project's structure part: University of Leeds will provide testing facilities for WP13 while Roelfstra Co. will be responsible for modifying existing numerical tools as required for considering the specific properties of HPFRCCs.

HES 05 – UCD

University College Dublin (UCD) was founded in 1854 and is now a ten-faculty institution with a student population of 18,000. It is the largest third level institution in the Republic of Ireland. In 1908 UCD was granted its own Charter and became a Constituent College of the National University of Ireland. The University became independent (NUID/UCD) under the Universities Act of 1998. The University has an excellent contractual record in successive EU Framework Programmes, for example participation in 141 contracts both as co-ordinators and partners in the Fourth Framework Programme.

The Department of Civil Engineering is one of 7 within the Faculty of Engineering and Architecture. It is the largest such department in Ireland. The Department houses the Irish Bridge Engineering Research Group that brings together a group of Ireland's most active researchers in the field of Bridge Engineering. There are six full-time academic staff members conducting research within the group supported by about twice that number of postgraduate students, visiting professors and post-doctoral researchers.

Key experts from UCD for the project are Professor Eugene O'Brien and Dr. Mark Richardson. Eugene O'Brien, Professor of Civil Engineering and national delegate to COST 345, was chairperson of the Scientific Committee of the 4th Framework WAVE project and vice-chairperson of COST 323. Dr. Mark Richardson, Senior Lecturer, is chairman of the National Standards Authority of Ireland Concrete Consultative Committee and of the Irish Concrete Society Durability Committee. He has received several awards in respect of his teaching and concrete technology research. Two full-time postgraduate researchers will join the project together with a post-doctoral fellow.

REC06 – Centro de Estudios de Carreteras (CEDEX)

The Centro de Estudios y Experimentación de Obras Públicas (CEDEX) is an autonomous institute attached to the Ministerio de Fomento (Ministry of Public Works) of Spain. CEDEX provides multidisciplinary support for the civil engineering and construction technologies. The specialised

technical units, centres and laboratories of CEDEX provide high level technical assistance, applied research and technological development in their own areas of the civil engineering sector: public works, environment, transport and building.

The Road Research Center of CEDEX has a broad experience in the research on roads in general and in the recycled materials in particular. In this last field, CEDEX has participated in the analysis, development or implementation of most of the techniques in use in Spain for recycled materials: slags, coal wastes, fly ashes, recycled pavements, plastics, used oils, used tires, etc. CEDEX has also participated in a number of European research projects.

WP6 on recycling techniques will be led by Mr. Aurelio Ruiz, Director of the Laboratory of Road Infrastructures from CEDEX.

HES 07 – EPFL-MCS

The socio-economic value of the civil engineering infrastructure is greater today than ever before and the management of existing structures is therefore now a task of the highest importance. For this reason the SFIT (Swiss Federal Institute of Technology), Lausanne, created the laboratory for Maintenance, Construction and Safety of Structures (MCS), in the framework of the civil engineering department, Institute for Statics and Structures, in April 1995.

The mission of MCS is to teach, conduct research and co-operate with practising engineers in order to: promote safety evaluation of structures; improve durability and service life of structures; develop tools for managing structures; and ensure adequate reliability of structures.

MCS is actively involved in consulting, testing and work on commissions. MCS also carries out testing for industrial partners in the accredited ISS laboratories. MCS actively participates in committees for the development of codes and for the exchange of knowledge and the advance of structural engineering and concepts for sustainable maintenance. Close co-operation with other laboratories in the framework of SFIT enable the application of advanced techniques for the identification of significant phenomena and validation of numerical models.

Key experts from MCS for the project are Dr. Emmanuel Denarié, specialist of fibre reinforced cementitious materials, concrete technology and durability of concrete structures and Dr. Simon Bailey, specialist of traffic load modelling and maintenance of highway structures. It is foreseen to have a doctoral student and a post-doctoral student to carry out the works at MCS.

Two subcontractors will be involved in the MCS contribution to the project. PSI-Würenlingen (Swiss Nuclear Research Center) will provide facilities and the interpretation of the results of Neutron Radiographic measurements of moisture profiles and micro cracking patterns in HPFRCC specimens. LMC-EPFL (Laboratory for Building Materials) shall provide the facilities for the fabrication of the HPFRCC specimens and HPFRCC-Concrete model hybrid beams, as well as several specific test methods.

HES08 - Institute of Road Construction and Maintenance (ISTU)

The Institute of Road Construction and Maintenance ISTU is affiliated to the Faculty of Civil Engineering of the Vienna University of Technology. The main research activities of the institute in relation with this project are in the fields of road materials with emphasis on bituminous materials, pavement engineering including pavement design and rehabilitation techniques. ISTU has been involved in several research projects funded by the Austrian Federal Road Administration, was an active partner in the Management Committee of COST 323, 324, 333, 334 and partner in the RTD-projects PARIS and AMADEUS. ISTU co-operates for more than 15 years in a close partnership

with the bituminous road material testing laboratory from the Road Research Centre Arsenal in Vienna, which is member of FEHRL.

The principal investigator for this project will be Assistant professor Dr. Ronald Blab, who will manage the task on theoretical modeling of permanent deformation of flexible pavement in WP5. He received awards by the Austrian Academy of Science with the Max Kade Fellowship for his work on analytical design of flexible pavements and performance related testing of bituminous road materials. He worked for more than one year as research assistant at the Pavement Research Center at the University of California at Berkeley.

IND09 – Shell Global solutions (SHELL)

For many years, Shell has played the role of bitumen technology leader, particularly in the area of bitumen Health and Environment and in the development of performance-related tests on bitumen mixes and binders.

Today, Shell's bitumen R&D concentrates on the formulation of premium road binders. Along with this, focus is on emulsion systems enabling lower operating temperatures for asphalt production and application, and on the health and environment aspects of bitumen systems. These activities are supported by continuing developments in the field of mix design. Most of the bitumen technology activities of Shell are now carried out in the European laboratories and in Singapore.

The network of expertise is now part of Shell's global technology company, Shell Global Solutions. In 1998, the decision was made to concentrate the major bitumen development activities of Shell Global Solutions in a new laboratory in France. In this laboratory today, 32 researchers are working on bitumen as part of a network of 5 bitumen laboratories. They use the latest equipment, particularly for bitumen H&E analysis and binder and mix evaluation, which are the topics with which Shell Global Solutions will contribute to the project in WP4 and WP5. SGS' researchers have also access to technological support from Shell Global Solutions, which represent a total of 1500 persons together with professional consultants and technologists.

HES 10 – TCD

Civil Engineering has been taught at Trinity College since 1842 within one of the oldest and most respected Engineering Schools in the world.

Throughout the years, the Department of Civil, Structural and Environmental Engineering has maintained an international standard of teaching and research. It has close contacts with universities, scientific organisations and professional institutions world wide, notably in the study of heavy steel and concrete structures, geotechnical, highway, transportation and environmental engineering, in third world technology and the use of probabilistic methods in structural engineering. The Department of Civil Engineering has remained at the forefront of international research in recent years with the construction of the largest structural testing facilities in the Republic of Ireland. Many international research contracts have been awarded on the strength of this facility including testing of tunnelling panels for the extension to the London underground. Investment has also ensured that state-of-the-art computer modelling facilities and access for large-scale simulations are available.

Key expert from TCD for the project is Mr. Alan O'Connor who is a full time lecturer in the Department of Civil, Structural & Environmental Engineering. He specialises in Probabilistic live load modelling for design and assessment of bridge structures, extreme value theory and applications in civil/structural engineering, dynamics of highway bridge structures and dynamic interaction modelling. He was responsible for the re-calibration of the Normal Load Model of

Eurocode 1, Part 3, Traffic Loads on Bridges' and for the calibration of the Eurocode 1, Part 3 to suit Irish national loading conditions.

HES 11 – UPC

UPC, Universitat Politècnica de Catalunya, is a technical University only teaching engineering curricula with a student population of 30,000 students and a teaching staff of 2,245 professors. It is one of the leading technical Universities in Spain with excellence in teaching, research and technology transfer with Industry and Public Authorities. The University has an excellent contractual record in successive EU Framework Programmes, as well as in National Programmes within Spain.

The Department of Construction develops important research projects in its two laboratories (materials and structural technology). The Department is one of the leading research departments in Civil Engineering in Spain and Europe regarding the number of publications in the top international journals of civil engineering. There are 20 full-time academic staff, 40 part-time professors and 30 postgraduate students.

Key expert from UPC for the project is Professor Joan R. Casas, professor of bridge engineering and expert on bridge evaluation and assessment using reliability techniques. He has recently been responsible of the evaluation of the safety of bridges in the Spanish Highway network. He is founder and member of the Executive Board of IABMAS (International Association for Bridge Management and Safety). He is also member of Technical Committees of IABSE, ASCE, TRB and ACI related with structural safety and evaluation of existing structures. He is author of numerous scientific articles and professional communications and is a recognised consultant in the fields of bridge design, construction and assessment. He was awarded with the Bill Curtin Medal from the Institution of Civil Engineers of the UK in 1998.

HES12 – Instituto Superior Tecnico (IST)

The Instituto Superior Técnico (IST) is part of the Technical University of Lisbon. The research and development activities at IST are mainly carried out within Institutes, Centers and Research Groups that integrate teaching and research staff allocated to the various departments of IST.

The main research activities of IST at the Geotechnical Centre, in relation with this project, are in the field of unbound granular materials: laboratory testing, in situ testing and modelling. IST has developed important research work for the Portuguese Road Administration and at a European level has IST been an active participant in COURAGE and COST 337.

IST will contribute to WP5 with cyclic tri-axial tests on unbound granular materials for which they have special equipment and a large expertise. Work will be performed by A. Gomes Correia, an assistant professor at IST, who managed and participated in several European projects in this field: Science project SC0130-C "An approach to a European Pavement Design", COURAGE, COST 337. Professor Correia is also a member of the task group on standardisation of unbound materials (CEN TC 227/WG4/TG2).

REC13 – Swedish National Road and Transport Research Institute (VTI)

The Swedish National Road and Transport Research Institute, VTI, is a national research institute under the Ministry for Industry, Employment and Communications. VTI conducts applied research, commissioned by the transport sector, in the fields of infrastructure, traffic and transport. VTI has an annual turnover of about 23 million Euros, of which 80% is acquired through commissioned research. The Institute employs 200 researchers and other experts, of whom 32 hold a doctor's

degree. Four senior researchers are associate professors at Swedish universities or institutes of technology. The wide range of skills reflects the inter-disciplinary composition of the research staff.

VTI holds the Quality System Certificate ISO 9001.

VTI has a long experience in research on the use of by-products in road construction. It started in the 1950's when the possibilities of using wood waste as insulation material in roads were investigated. In the 1970's research concentrated on blast furnace slag and steel slag. In the beginning of the 1980's it focussed on fly ash, coal bottom ash and desulphurisation products. After the Rio Conference and the beginning of the Agenda 21-work, VTI has been working to identify the engineering factors which are critical for alternative materials, and to identify the greatest potential for recycling considering engineering, economic and environmental factors.

VTI's expertise will be very beneficial to WP3 on Assessment of materials. Dr. H. Johansson who is a senior research scientist and was an active contributor to the ALT-MAT project will lead VTI's contribution.

IND 14 – Sika Ireland

Sika Ireland is a wholly owned subsidiary of Sika Finanz AG of Zurich Switzerland. Sika is a world wide organisation with operations in 54 countries. Sika is a research and development, manufacturing and sales organisation specialising in construction chemicals, particularly waterproofing, sealing, protecting and extending the life of concrete and steel structures.

Sika has pioneered the use of many innovative technologies, including complex silicate waterproofing solutions, high performance epoxy resin adhesives, polymer concrete admixture, composite structural strengthening solutions and blended corrosion inhibiting materials. Sika's research and development activities are conducted on a "think global, act local" principle. A central Research and Development facility in Switzerland is supported by five global centres enabling close contact with local construction practice and enables uniform transfer of technology and know-how.

Key expert from Sika Ireland for the project will be Dr. Urs Maeder.

REC15 – Danish Hydraulic Institute (DHI)

DHI Water & Environment is an independent research and consulting organisation affiliated to the Danish Academy of Technical Sciences. The institute employs a staff of approximately 460 persons.

The services of DHI are based on the development and application of know-how and advanced technologies within ecology and environmental chemistry, water resources, hydraulic structures and hydrodynamics, and other areas related to the water environment. DHI is actively involved in several activities supporting Danish and EU legislation on treatment and utilisation and of contaminated soil and waste products. The Institute was established on 1 January 2000 as a merger between Danish Hydraulic Institute and VKI - Institute for the Water Environment, established in 1964 and 1972, respectively.

DHI will act in WP3. Ole Hjelmar is Chief Engineer at DHI in charge of solid waste research and director of Centre for Waste Rearch, a 4-year co-operation between industry, universities and applied R&S institutions aimed at improving treatment and utilisation of waste and soil. He heads the Danish delegation to the European Standardisation Committee, CEN/TC 292 "Characterisation of Waste" and he is Chairman of the corresponding Danish national standardisation committee. He is also one of the co-ordinators of the European Network of Harmonisation of Leaching/Extraction procedure. Ole Hjelmar and the Department of Groundwater, Soil and Waste at DHI have

participated in the ALT-MAT and POLMIT projects and have produced the background material upon which the new Danish regulations of soil and waste utilisation is are based.

RES 16 – Netherlands Energy Research Foundation (ECN)

The Netherlands Energy Research Foundation is a government supported independent research institute, which performs R&D on energy technology and its environmental implications. The institute employs a staff of more than 850 employees. The research encompasses coal conversion, gas cleaning/separation, renewable energy, fuel cell research, climatic change research, acid rain research and research into waste characterization and treatment. ECN is actively involved in national activities to regulate the utilization of waste materials in construction within the framework of the Dutch Soil Protection Act

Dr H.A. van der Sloot, a senior scientist in the Soil & Waste Research group will contribute to WP3. His group is engaged in studying leaching mechanisms of potentially hazardous constituents from waste materials, contaminated soil, sediments and construction materials It is seeking development and harmonization of leaching tests, environmental aspects of utilization of materials, waste/soil interactions of leached components and studies to improve the quality of waste materials and products containing waste materials. Dr H.A van der Sloot is convenor for WG 6 (long term behaviour) in CEN TC 292 on "Characterisation of Waste". Since 1998 he is associate editor of Waste Management for Europe.

HES 17 - Laboratoire des Sciences de l'Environnement (ENTPE/LSE)

The National School of Public Work depends on the Ministry of Public Works. It employs over 200 persons in its different laboratories. The Environmental Sciences Laboratory (L.S.E.) is carrying out interdisciplinary research dealing with the analysis and modelling of human activities impact on the natural environment. The objectives are to create methodological tools and knowledge to assess the impact of urban development on fluvial systems or soil ecosystems. L.S.E. is in particular working on :

- transfer of heavy metals in porous media (soils, solid wastes) in different environmental conditions ;
- the ecotoxic effect of single or mixed pollutants on aquatic and terrestrial organisms, in laboratory and field conditions (metabolism perturbations, growth inhibition, DNA damage or death at individual or population level) ;

as a contribution to various national programs on risk assessment in different situations: use of waste in agriculture, discharge of road stormwater in rivers, ecotoxic characterization of PAH, deposit of dredge sediments in the environment.

L.S.E. will contribute to WP3 under the direction of Dr Y. Perrodin, a senior scientist engaged in studying waste material as a source of pollutants.

HES 19 – Recycled Materials Resource Center (RMRC)

The Recycled Materials Resource Center at the University of New Hampshire (UNH) is a University-Federal Highway Administration (FHWA) partnership to promote the wise use of recycled materials in the highway environment. The Center is funded via the Transportation Efficiency Act for the 21st Century; its main focus is long term performance of recycled materials in the highway environment.

Dr Taylor Eighmy, director of the RMRC and of the Environmental Research Group at UNH will contribute to WP3. His research interests include materials characterization, geochemical modeling

of leaching, and leaching of highway products containing recycled materials. He is a co-principal investigator on an RMRC-funded project "Development of Application-Specific Source Term/Fate/Transport Models and Approaches for Recycled Materials Use in the Highway Environment" having strong links with the SAMARIS project. Formerly he was a member of the FHWA's Expert Advisory Panel for the "User Guideline for Waste and By-product Materials in Pavement Construction" project. He is a member of The International Society for the Environmental and Technical Implications of Construction with Alternative Materials (ISCOWA).

HES20 – Institut für Straßenwesen und Eisenbahnbau -Ruhr Universität Bochum (RUB)

The Institute for Roads and Railways is part of the Faculty of Civil Engineering of the Ruhr-University Bochum, a leading German University in the field of Civil Engineering. The Institute, directed by Prof. Dr.-Ing. Klaus Krass, is carrying out research on the use of industrial by-products in construction and on recycling.

RUB will contribute to WP4 and more specifically to the pilot study for drafting environmental annexes to products standards, which will be led by Professor Klaus Krass, who is the Chairman of CEN technical Committee 227 on Road materials. During the last 12 years, he was responsible for the proposals of German specifications for recycling materials and industrial by-products as road materials for both technical and environmental aspects.

IND21 – RGS 90 A/S

RGS 90 A/S is Denmark's largest recycling company. It receives annually about 1.0 million tons of waste, 90 % of which, after processing, could be used for recycling, primarily in the building and construction sectors. This includes treatment of building and construction waste, mineralisation and sanitation of sewage sludge, biological treatment and disposal of polluted soil, sorting and separation of combustible industrial waste, excavation of old waste deposits… The above activities have given RGS 90 A/S a great deal of know-how, which is why the company takes part in a number of development projects and acts as a consultant in conjunction with evaluation and implementation of recycling techniques abroad.

RGS 90 A/S will specifically contribute to WP6 on recycling techniques in drafting recommendations about recycling plants and processing operations. Mr. Karsten Ludvigsen who is the Director for Environmental Affairs at RGS 90 A/S will carry out this work.

HES22 – Technical University of Brno (TU Brno)

The Technical University of Brno is a leading educational and research centre in civil engineering in the Czech Republic. In recent years the Civil Engineering Department carried out several projects funded by the Ministry of Transport and Communication on secondary materials and pavement design; it participates in the preparation of the technical recommendations for the Ministry in this field.

Professor Jan Kudrna, who is also the Czech representative at CEN TC 227, will act as task leader in WP 06 in order to assess the situation in Central and Eastern European countries as regards recycling in the pavement area.

HES23 – Road and Bridge Research Institute (IBDiM)

The Road and Bridge Research Institute (IBDiM) is a subsidiary of the Ministry of Transport and Maritime Economy. It is a leading research institution in Poland, in the field of road and bridge construction, i.e. construction and maintenance of roads and road bridges, railway subgrade, railway bridges, underground structures. The Institute's research covers materials, methods,

equipment, organisation and economic problems, issues of environment protection, the management strategies and others. Laboratory research is performed in several laboratories with modern laboratory equipment for material, road pavement or structure testing. The activity of IBDiM includes also development of Polish standards, instructions, specifications and recommendations, as well as technical approvals and quality certificates for new materials and methods for road and bridge construction. The Institute is also the editor of journals and other publications, and the organiser of conferences and courses.

IBDiM co-operates with many Central European and EU scientific and technical organisations and its representatives are active members of international organisations or associations such as: PIARC, OECD, FEHRL, RILEM.

IBDiM contributes to WP6 and WP15. Key experts for the project are Dr. Dariusz Sybilski, deputy Director of IBDiM and head of the pavement sector, Dr. Marek Lagoda, the chief of Steel Bridges Department, with 30 years of experience in consulting of existing bridges assessment and testing, and Tomasz Wierzbicki with 10 years of experience in bridge assessment and testing. Mr. Lagoda and Wierzbicki contribute to the work of COST 345.

IND24 – Entreprise Jean Lefebvre (EJL/EUROVIA)

The EJL group is one the largest European road contractors. Besides France, it has subsidiaries in different EU and CE countries (Spain, U.K., Czech Republic, Estonia…). The group has a comprehensive expertise in the various road techniques (cold and hot bituminous mixtures, aggregate treated with hydraulic binders, soil stabilisation). The development of innovative construction techniques and road products is a key element of EJL strategy. Particular attention has been paid for several years to the development of environmentally friendly construction technologies such as: application of foamed bitumen for the treatment of recycled asphalt pavement and of municipal solid waste incinerator ash, special hydraulic binders compatible with stabilisation of MSWIA, special emulsions and cold recycling, etc. This technical expertise is steered by a highly skilled Technical Management Team and the support of EJL research centre. EJL has the experience of active participation in European R&D projects such as OPTEL.

DR. S. Soliman of the EJL Management team will lead EJL contribution to WP6 on recycling techniques. EJL will contribute both to the production of the technical guide on recycling techniques and to the analysis of the situation in CE countries with the help of its subsidiaries. The group will bring to the project its expertise on the questions of technology transfer in road construction in CE countries.

9. Project management and administration

9.1. Project management

Overall Management

The overall co-ordination of the project is by the Danish Road Institute (DRI), the project co-ordinator being the Director of DRI, Jorgen Christensen. Mr. Christensen has a large professional experience in managing international projects, ranging from projects under NATO's Defence Research Group to the Nordic Road Safety Council in the 1970s and 1980s to OECD Road Transport Research Committee projects in the 1980s and the 1990s. He was recently the chairman of the executive committee for the OECD/EU project DIVINE and is now chairing OECDs International Transport Research Database (ITRD). DRI will carry out the project management and will provide the corresponding administrative resources.

Mr. Jean-François Corté from the Laboratoire Central des Ponts et Chaussées (LCPC) will act as the Scientific Co-ordinator of the pavement part of the project. As such he will be responsible for managing the scientific Quality Assurance part of the pavement part of the project. Mr J.-F. Corté was the Scientific Co-ordinator of past Science and Stimulation projects. He is LCPC's Technical Manager for the Road sector. He is also France Head of Delegation to CEN TC 227.

Mr. Aleš Žnidarič from the Slovenian National Building and Civil Engineering Institute (ZAG) will act as the Scientific Co-ordinator of the structural part of the project and will be responsible for managing its scientific Quality Assurance part. Mr. Žnidarič is the vice-chairman of the COST 345 action and national representative on PIARC committee C11 on 'Bridges and other structures'.

A management group will be formed. It will gather:

- The project co-ordinator who will chair the management group,
- The project scientific co-ordinators,
- The technical work-package leaders and the exploitation manager.

This group will manage also the relations with the Reference Group of End-users, which comprises representatives of public road authorities from the EU and Central European countries and from European professional associations. Three meetings are planned with the Reference Group of End-users: during the first semester before completion of the detailed work-plan, at mid-term of the project and near the end for preparation of the symposium and dissemination of the outputs.

The management group will direct the project, approve milestone decisions and the deliverable according to the Quality Assurance Plan as indicated below. The group will meet on a quarterly basis and for special meetings with the Reference Group of End-users.

An extended management group, called the 'Contractors' Committee', consisting of one representative for every principal or assistant contractor and chaired by the project co-ordinator, assembles for the scheduled meetings with the Reference Group of End Users, for the mid-term assessment and if major redirections of research or reallocations of the budget are deemed necessary.

The Work Package Teams, each under the responsibility of a WP leader who is an experienced researcher of the Principal Contractors, will carry out research. The work within the WPs will be defined in the detailed work-plan prepared within WP2 and submitted to approval of the management group.

Quality Assurance Plan

During the first term of the project, a Quality Assurance Plan (QAP) will be established. The QAP will document decision-making, methods for progress control and filing system. Auditing of the QAP will be made every six months.

For control of the progress made by each participant, quarterly reports will be required with indications on: the progress relative to the project planning, man-months and other expenditures, remedial actions to compensate for eventual deviations from the project plan. The Project Co-ordinator will collate this information and report to the quarterly meetings of the Management Group.

The QAP will also define the system for scientific quality assurance. This part will be under the responsibility of the Scientific Co-ordinators. Senior scientists of the principal contractors who are not working on the project tasks in question will perform the audit and report to the management group on their findings. This process will insure adequate review of all the proposed deliverables before their approval for dissemination.

Communication within the Consortium

A web site will provide means for easy communications within the Consortium. It will be partly public to inform the visitors on the progress of the project and partly accessible only to the project members. The protected part of the site will contain all project documents (minutes of meetings, decisions, draft reports…), thereby allowing for swift communication between the partners and for an easily accessible central project file. This website will be controlled and maintained by the project Scientific Co-ordinators.

Networking

Pavements

The project will be related to COST 347 on accelerated pavement testing, which is about to be launched. Test results from accelerated pavement-testing facilities, which will be organized in a database for the calibration and assessment of mechanical models, will be supplied to COST 347.

Since several Consortium partners are members of the Forum of European Highway Research Laboratories (FEHRL) direct contact will be kept with ongoing projects or the preparation of new, related projects.

The main European international professional associations (European Asphalt Pavement Association, Eurobitume, Cembureau, Union of European Aggregate Producers) have expressed interest in the project and for becoming members of the Reference Group of End-users.

Several participants in the project are active members of CEN Technical Committees, including Prof. K. Krass, Chairman of TC 227 on Pavement Materials. This insures direct links with national and European standardisation organisations.

Structures

The part of the project, which is about highway structures, is closely related to the COST actions 345 and 521 (see also chapter on ‘Community added value by networking’). Results from these actions will be inputs to this project and early outputs from this project will be exchanged with the members of these COST actions.

Networking and exchange of information will also be pursued with members of other relevant COST actions and RTD projects, of which many from the transport area were initiated by FEHRL.

The project co-ordinator is a member of the FEHRL Board of directors and thereby has direct access to these past activities. Furthermore, many personal links exist between the participants in the project and these COST actions and RTD projects.

Close links will be established between European and international bodies involved in advanced materials and structural assessment. Information will be exchanged with PIARC committee C11 on 'Bridges and other structures', ***fib*** (International Federation for Concrete) Commission 5 on structural service life aspects, WP 11 'Corrosion in Concrete' of the European Federation for Corrosion, RETRA-EST programme etc.

Partners in the project have many contacts with researchers outside Europe and those links will be also used to exchange information and improve results of the project.

Mid-term assessment milestone clause

The Project Co-ordinator will organise a Mid-Term Assessment meeting of the Contractors' Committee and the Commission's representative at the end of the 19th month. During this meeting the progress of the work will be reviewed in relation to the detailed work-plan and decisions will be taken concerning eventual adjustments to the remaining work-plan. Procedures and processes to encourage and support the practical exploitation of results will be discussed and assessed. At the mid-term assessment meeting the satisfactory completion of the following deliverables and milestones will be assessed:

Table 21: List of the milestones for the first part of the project

Mile-stone No.	Delivery date (month)	Output from WP No.	Brief description of Milestone objectives	Criteria for assessment
M1	3	16	Project web-site	Fully operational home page with basic project information
M2	6	12	Complete review of repair methods for structures	Inception report for structure WPs available
M3	6	13	Decisions on properties of concretes to be used in laboratory and field test trials of CI.	Selection of materials
M4	6	14	Identification of most important phenomena for defining HPFRCC main test programme	Results of numerical simulations and preliminary tests available
M5	6	2	Approval of scientific methodology and work programme for pavement WPs	Consistency with objectives of project
M6	9	12	Complete critical review of relevant R&D work	Internal draft report available
M7	12	3	Determine the influent parameters and their range of variation before developing the methodology for assessing the possibility to use by-products	Suitability of the information collected
M8	12	4	Evaluation of existing test methods for detection of hazardous components and decision for the development of new tests	Applicability of existing methods to the context of recycling
M9	12	5	Evaluation of full-scale pavement tests results data base and need for additional specific data to be collected	Quality and completeness of data sets
M10	12	6	Approval of the draft of the structure and table of content of the technical guide on recycling techniques	Comparison with information collected from literature survey and enquiry.

Mile-stone No.	Delivery date (month)	Output from WP No.	Brief description of Milestone objectives	Criteria for assessment
M11	12	15	Collection of structural data completed	All questionnaires completed and returned
´M12	12	14	Selection of materials for main test series of HPFRCC	Preliminary test results and conclusions concerning materials for main tests available
M13	15	4	Determine the necessity to develop test methods for assessing the reaction to fire of pavement materials.	From road authorities answers.
M14	16	5	Evaluation of the need for additional tests for validation of models for permanent deformation of unbound materials in flexible pavements	Comparison of existing data with model requirements
M15	16	5	Evaluation of the need for additional laboratory tests for validation of models for rutting of bituminous layers	Comparison of existing data with model requirements
M16	18	15	Collection of traffic data completed	Database on traffic data base and WIM measurements available

Table 22: List of the deliverables for the first part of the project

Delive-rable No.	Delivery date (month)	Output from WP No.	Nature of deliverable and brief description
D1	3	16	Project web-site
D2	6	2 and 12	Developed work programme/Inception report
D3	7	16	Brochure presenting the project
D4	9	3	State of the art report “Assessment of eco-compatibility of materials in the field of waste disposal”
D5	12	6	Literature survey of recycling of by-products in road construction in Europe
D6	12	5	Data base and report on reference full-scale tests results on pavements
D7	12	4	State of the art report on test methods for the detection of hazardous components in road materials to be recycled
D8	14	4	Review of road authorities’ positions on reaction to fire of pavement materials
D9	15	3	Review of present national regulations in the EU for recycling by-products in road construction
D10	15	5	Report on models for prediction of permanent deformation of unbound materials in flexible pavements
D11	15	5	Report on models for prediction of rutting of bituminous surface layers
D12	18	6	Recommendations for mixing plants for recycling works
D13	18	14	Report on preliminary studies for the use of HPFRCC for maintenance of road infrastructure components

10. Other information

10.1. List of references

ALT-MAT:	Alternative materials for road construction
COURAGE:	Construction with unbound road aggregates in Europe
POLMIT:	Pollution mitigation
COST 324:	Long-term performance of road pavements
COST 333:	Development of new bituminous pavement design method
COST 334:	Effects of wide single tyres and dual tyres
COST 337:	Unbound materials for road pavements
COST 347:	Pavement research with accelerated loading testing facilities
RETRA-EST:	Multi-annual R&D transport programme European Union – Central and Eastern Europe countries
WAVE:	Weigh-in-motion of axles and vehicles for Europe

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10.2. Related projects

The following table lists the related projects.

Project	Input to	Input from	Personal links
ALT-MAT	/	+	++
AMADEUS	/	+	+
BRIME	/	++	++
COURAGE	/	+	+
POLMIT	/	+	++
WAVE	/	+	++
COST 323	/	+	++
COST 324	/	+	+
COST 333	/	+	+
COST 334	/	+	+
COST 337	/	+	++
COST 345	++	++	++
COST 347	+	+	+
COST 521	+	++	++
PIARC C11	+	+	++
Fib Committee 5	+	+	++
EFC WP 11	+	++	++
IABMAS	++	+	++
RETRA-EST	+	+	-
FEHRL	+	+	++

Legend: / Activities completed
- No input/links
+ Some input/links
++ Important input/links