Attachment No. 6 to Annex 1 ‘Description of Work’

EUROPEAN CONSTRUCTION IN SERVICE OF SOCIETY

ECO-SERVE NETWORK

WORK PLAN
for
CLUSTER 4

Pavements

Specific Programme “Promoting Competitive and Sustainable Growth”
KA1: INNOVATIVE PRODUCTS, PROCESSES AND ORGANISATIONS

addressing priority 1.9 TRA INFRASTRUCTURE

Pre-amble

The present work plan describes the work of Cluster 4, which is an integrated part of the ECO-SERVE NETWORK.
Cluster 4 comprises the following members:

Partner No.	Name	Short name
1	Dansk Beton Teknik A/S	DBT
2	Intron B.V.	Intron
24	Hellenic Cement Research Center Ltd.	EKET
41	Dura Vermeer Group	Dura Vermeer
42	Laboratoire Central des Ponts et Chaussées	LCPC
43	COWI Consulting Engineers and Planners.	COWI
44	Technical University of Denmark	DTU
45	Road Directorate, Danish Road Institute	DRI
46	Instytut Badawczy Drog i Mostow	IBDiM
47	Transportation Research Laboratory Ltd	TRL

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1. Summary

Background and societal needs

The length of paved roads in the EU-15 totals 3.5 million kilometres representing a pavement value in excess of 500 x 10^9 EURO.

The traffic volume on these roads increased by more than 100% during the last 25 years.

During the same period European legislation has provided for an increase in axle loads from a maximum allowable load of 7 tons to the present load of 11.5 tons.

Both effects result direct (volume) and indirect (repair works) in traffic jams. Therefore, there is a need for more durable roads, which should be placed with increased speed.

There is still no sign of slowdown in the pace of growth. It is estimated that more than 50% of the European infrastructure needs improvement. A large part of this rehabilitation will be performed by application of existing, well-known technologies. It can, however, not be neglected that a complete reconstruction might be the most cost effective method for a great part of these roads, if complete life-cycle costing is taken into account.
It is estimated that the potential need for construction or re-construction of roads during the next ten years amounts to at least 150 x 10^9 EURO.

An overview prepared by the regional authorities in the so-called Oresund Region (South-west Sweden/Copenhagen area, population approx. 3 mill.) predicts as an example a need for investments in infrastructure in the region during this period of 10 billion EURO.

This figure more than confirms the above conservative estimate for EU-15.

If the need for infrastructure in the applicant countries of Eastern Europe and with a population of 170 mill. people are added to the EU-15 needs, a realistic demand for new or re-constructed infrastructure pavements can be estimated at a value of more than 250 billion EURO for the coming 10 years.

With the present technology this means a resource consumption of aggregate for unbound, hydraulically bound or bituminous pavements of close to 2.5 x 10^9 tons per year, an amount that is equal to the total present production of aggregate.

The consumption of material resources is significant. However, the imminent environmental impact is created by transportation of this huge amount of goods; in some areas of Europe materials of high quality are available in abundance, whereas in other areas the local materials do not meet the stringent European standard requirements to quality.

As a result high quality materials are being transported over long distances to the disadvantage of the existing infrastructure, the traffic, the energy consumption, the CO_2-emission etc.

It is, thus, the objective of the present cluster to address the issue of possible new types of unbound or cementitious pavements, materials and the correlated design models, which will allow for the introduction of

- Local materials, possibly of marginal quality compared with standard materials
- Pozzolanic binders with low CO_2-emission during production
- Design of pavements based on present needs (load) with future strengthening options built-in (stepwise design and construct principle)
- Reduction of the bituminous pavement layers.

In this way the work in cluster 4 will support the EU policies; particularly its environmental goals through the contribution to a sustainable construction industry but also through its contribution to cost effective construction methods.

The innovative developments, which are expected as a result of the work in cluster 4, are based on the following observations:

- Unbound and hydraulically bound base course layers are, at present, not introduced in the design with realistic values for elasticity, bearing capacity and service life potential (number of hole loads during service life).
- Conventional Cement Treated Base course layers (CTB) develop discrete transverse contraction cracking at spacings between 3 m and 7 m. These layers also require a high and well-defined quality of aggregate.
- Reports on CTB-pavements produced in China during the recent programme for extension of the infrastructure indicate that layers have been successfully placed without the occurrence of discrete contraction cracks and by introduction of locally available (marginal) aggregate materials
  Similar observations were made during the construction of the New Athens Int. Airport (2.2 mill.m^2, 1999)
- CTB-pavements, which are free of transverse cracks, do not need substantial asphaltic binder or wearing courses to prevent reflective cracking.
- Design rules for pavements with reduced strength and controlled cracking will result in resource saving pavements. Such rules are not available at present.

It is, consequently, one of the ideas for work in cluster 4 to review existing design methodologies and assess to which extent these methodologies may be applicable for pavements with ‘pseudo flexible’ behaviour.

2. Objectives and Achievements

During the evaluation of the ECO-SERVE proposal, the research in WP 'Pavements' was not retained for funding because the basic concepts were considered not to be new and the proposed research lacking innovative aspects.
The outcome of the evaluation did, however, support the fundamental objectives of the research.

These objectives, considered of vital importance to the European pavement construction industry in its endeavour to achieve sustainable products and processes were:

- Reducing the environmental impact of the industry
- Contribute to growth and wealth by increasing productivity, competitiveness and quality

These objectives are, consequently, maintained in the present work plan for cluster 4 of the ECO-SERVE Network.
Though dramatically reduced in the scope of research it is still the aim of the cluster to contribute to these overall objectives by assessing existing design methodologies, evaluate deterioration mechanisms of 'uncracked' stabilised sand or gravel base courses and address the possibilities of implementing an innovative approach to exploitation of primary raw materials, i.e. sand, gravel, aggregate and natural pozzolana for application in pavements.

It is the objective based on assessment of available research and design methods to select the most suitable approach for design of low strength, cementitious base course layers (as part of an integrated pavement design).

Such base course layers may be produced using materials (sand, gravel), which are available at the location of construction instead of applying standardised high quality components with proven performance.

If proven successful, this design methodology may result in the following achievements:

- Transportation of materials for pavements will be reduced by 20%
- CO_2-emission related to construction of pavements will be reduced by 20%
- Consumption of bitumen, which is an energy exchangeable resource (cracking process) may be reduced by more than 50%
- Overall costs of pavement construction may be reduced by 30% average.

3. Community Added Value and contribution of EU policies

3.1 General

This new approach focuses on regional or local conditions. The concept will be based on specification of performance characteristics of pavements, which will be met by use of locally available materials to the widest possible extent.

It could sound like a paradox that regional or local opportunities could not proficiently be addressed at local level. The situation is, however, that available materials vary in quality and character from one region to another. A local concept may be developed and, successfully, applied in one area, whereas the same concept may fail in neighbouring regions.

To establish a sizeable impact these concepts must be developed on a European level and be implemented through European norms.

The validity of the concepts on regional level must, of course, also be proven. The need to develop a concept on European level and prove the validity on regional level is clearly needed and provides the justification for addressing the research at EU level.

This dual view (European/regional) also indicates why it has been necessary to join European-wide expertise and resources in the network.

3.2 Contribution to European policies

The work clearly contributes to *European Union policies* e.g.:

- By reducing the CO_2-emission the project contributes to the commitments made by EU in the Kyoto Protocol and to the general commitment of EU to respond to the potential impacts of projected climate changes.
- By reducing the total need for transportation of aggregates, the proposal contributes to EU policies regarding improved capacity of the internal infrastructure

- By providing concepts for design of pavements with marginal quality materials the work contribute to higher quality of roads in periphic areas and, thereby, contributes to the regional policies and cohesion.

3.3 European standardisation and regulation

Already the introduction to the cluster activities indicates the need for performance-based specifications for construction of pavements.

This is seen as a way towards better quality in general and reduced life cycle costs.

Deliverables of the network are provisional guidelines for design and material production based on performance criteria and forms as such a direct proposal for revision of norms and standards in the field.
A so-called ‘expression of interest’ regarding new test methods is scheduled and it is believed that this will result in a ‘dedicated call’.

3.4 Networking activities

The present cluster 4 forms part of the overall ECO-SERVE Network. The cluster members will actively participate in this network as well as in the network activities of the strategic network named ‘E-core’. It should also be mentioned that several partners already are co-operating within the framework of FEHRL.

3.5 European element in the consortium

The work in this cluster represents a contribution to the overall objectives of the ECO-SERVE project. The partnership of this project is truly pan-European and the complementarity is established by involving representatives of the complete value chain of pavement construction. It should be commented that the very strong participation of National Road Institutes/Authorities should be assessed as a necessity to attract sufficient attention and pave the road towards implementation.

4. Contribution to Community Social Objectives

The work in cluster 4 addresses specifically the following societal needs:

Improved sustainability in infrastructure through

- Reduction of CO_2-emission
- Economising with limited natural resources
- Feasible extension of infrastructure in developing regions
- Reducing waste generation in aggregate production
- Contribution to growth and wealth by increased productivity, competitiveness and quality

4.1 Employment, education and training

It is stated that improvement of the infrastructure in a given area will create social stability and economical growth. This strategy is to a great extent applied in the European donor funded activities in developing countries (as and example it may be mentioned that donor countries invest in average 1 billion US$ in infrastructure per year in the East African Region).

In such a perspective it could be claimed that cluster 4 contributes to growth in wealth and employment as more infrastructure can be built for less money.

The development of a competitive pavement concept may, however, also in other respects influence the employment situation.

Through increased use of materials, which are locally available the need for transportation is being reduced. But at the same time production of aggregate is being transferred from large, centralised aggregate industries, which is optimally mechanised to less sophisticated, often mobile production facilities, which are in their nature more labour intensive.

As the general consumption of aggregate in Europe is increasing, according to recent prognosis, the result will be that the large plants still produce their highly specialised, high quality products and the mobile plants in the regional area will operate on job-specific production and provide increased employment opportunities.

This labour force will, typically, be provided from local populations without special education in production of pavement construction materials. This shift in employment will require an education of the labour force from unskilled to semiskilled.

Another aspect is the improved competitiveness and the possible export potential.

Infrastructure is being built all over the world and the competitive advantage of applying the ECO-SERVE design concept should yield an increase in European construction on a global level.
The potential for employment of an educated labour force and most other categories of human resources appears to be high.

4.2 Environment

ECO-SERVE is first of all addressing the environmental aspects related to the construction industry and specifically the materials production area.

The network and the work in cluster 4 aims at substantial reduction of transportation needs and preservation of high quality natural resources.

4.3 Quality of life, health and safety of the citizen

The work may yield an impact to the citizens and the society in the following fields:

- Cost of pavements may be reduced by 30% resulting in an overall reduction in cost of infrastructure by min. 15%
- ECO-SERVE offers a potential for design of pavements with extended service life. This means that e.g. motorways, primary roads etc. can be designed for a long rehabilitation free period
- The ECO-SERVE concept requires less transportation during construction.

These advantages do contribute to the improvement of quality of life. Most visible is probably the potential for extended and practically maintenance free service.

This means that potentially hazardous traffical scenarios in frequency can be reduced to a level well below the present and the risk of accidents will be reduced. The safety on our roads will be improved. Stress factors related to congestion on roads and slow traffic can be substantially reduced to the benefit of health and also to improved mobility.

Less visible is the improved working environment. Nevertheless, road repair works are amongst the most dangerous and unpleasant construction sites and the extension of service life will, indeed, reduce the amount of this exposure to poor conditions for health and life.

Eventually, the economic aspects attract attention as well. Added value/reduced costs should also in public expenditure contribute to a more prosperous society

5 . WORK PLAN

5.1 International state-of-the-art

Conventional pavements

Pavements with an asphaltic or bituminous surface represent 90% of all pavements in Europe –15. Other main categories are pavements with unbound surfaces (5%) and concrete pavements (5%).

Of the bituminous pavements on primary roads in Europe only 10% consist of asphaltic layers on a base course of cementitiously treated/stabilised material (semi-rigid pavements) the balance being made up by truly flexible pavements of asphaltic materials placed on sub-base and/or base course layers of unbound materials. If also the secondary roads were included in the assessment, the percentage of semi-rigid pavements would be negligible.

Terminology used in this description and different categories of pavements are presented in annex CL3.3 together with an overview of their relative production costs. From this information it appears that semi-rigid pavements are between 10% and 30% cheaper than flexible pavements in direct construction costs. These figures are well confirmed in literature.

The reason for the prevailing selection of flexible pavements, instead of the less expensive semi-rigid pavements, is related to the additional life cycle costs primarily caused by reflective cracking of the asphalt layers.

In Western Europe the (EU-15) conventional CTB materials are specified with ultimate strength levels in the range of 7-15 MPa (compressive). When these materials are applied in pavements discrete cracks develop in the base course layers with a spacing of 3 to 7 m due to material shrinkage and thermal contraction. When such cracks open to a crack width of more than 0.1 mm it has been demonstrated that the load transfer capacity over the crack is beginning to deteriorate and differential, vertical displacements take place under traffic load. These vertical movements are the main phenomenon, which are causing reflective cracking of the overlaying asphalt layers.

Observations of possible improvements

In recent years it has been demonstrated that similar materials (CTB) with a lower strength, develop a much different crack pattern.
Materials composed of weak (soft) aggregates or weak binders have been applied in base course layers, which eventually have proven to be ‘crack-free’.

By introducing a concept of low strength materials and fully dispersed crack patterns (i.e. all crack widths < 0.1 mm under all climatic conditions) the total pavements shall be designed on the basis of structural failure instead of reflective cracking in the asphalt layers. Such a design will allow for much reduced application of asphalt and increased use of local materials meeting the low strength and relevant durability requirements, which may be formulated for the CTB material.

Design of Pavements with Stabilised Layers

Contemporary design methods for pavements are chiefly based upon the Mechanistic, also known as the Analytical-Empirical design method.
This method is based upon the following elements and assumptions:

- It is assumed that fatigue deterioration, observed in the field, can be related to so-called "critical" stresses or strains, induced in the pavements by the traffic loading
- It is assumed that the relationship between deterioration rate and critical stresses or strains can be determined through laboratory testing
- It is assumed that the laboratory-determined fatigue relationships can be transferred to field conditions by "transfer functions" that account for the effect of climate, rest periods between loadings, differences in dimensions etc.

These assumptions are by and large confirmed by the fact that deterioration, as observed in e.g. the AASTHO road test showed that the rate of deterioration increased with the axle load raised to the 4th power. This agreed well with laboratory tests showing that asphalt fatigue cracking and unbound materials' permanent deformations were functions of dynamic strains or stresses with exponents that ranged between 3 and 5.
Design of pavements with stabilized layers is generally carried out according to similar methods.
An up-to-date design process could be based on a combination of some of the more developed design methodologies, such as

- The French Method, which is intended to keep the stabilized layer intact throughout the design period.
- The Australian Practice, which also considers the cracked period as part of the service life.
- South African design for fatigue crushing at the top of the stabilized layer.

Problems in existing design methods

The descriptions of the methods available for design of pavements with stabilized materials highlight the problems associated with this process:

- The condition of the stabilized layers in the pavements is not sufficiently known, whether the material is continuous (unbroken) or partially cracked
- Due to the uncertainty about the condition of the material, it is difficult to determine a "correct" method for calculating critical stresses or strains in the pavements.
- The deterioration mechanics of stabilized layers is not sufficiently known – is all fatigue caused by tension at the bottom of the layer, or does some of the deterioration originate from load effects at the top of the layer?
- The introduction of pavements with a crack-free appearance, which probably is the result of numerous very fine cracks, is not covered by any existing design

methodology unless such materials can be designed in accordance with the contemporary design rules described above.
- Over the pavement's functional life, the condition of the stabilized layer is under all circumstances certain to change from a less to a more fragmented state. A uniform definition of what state that is to be considered "failed" has not been agreed upon.

A research and development programme on pavements with stabilized materials must seek to gain a full understanding of the physical processes of the deterioration of this type of pavements. Such research must then establish deterioration models that can describe and predict these processes in order to set up suitable design criteria.

These reflections clearly indicate the need for an integrated approach where all stakeholders are represented.

It is, therefore, a necessity that mapping of stakeholders is being performed. But also, that a dialogue with these stakeholders is being established and based on this that research activities on national or collateral basis are being introduced.

Cluster 4 lends itself to initiation and co-ordination of such activities.

5.2 Plan of work and innovative aspects

It is the technical objective to describe semi-rigid pavement concepts, which facilitate the use of local aggregate with their given quality. To such goal, it has been considered essential to reduce the strength requirements compared to those, which are usually applied in Europe, thereby allowing for the use of marginal quality materials. Recently, two major pavement contracts using contemporary design rules, have resulted in low strength materials and have as such, on an experimental basis, introduced a pavement, which to some extent follow the ideas behind the work in this network. Unexpected benefit has been the absence of discrete contraction cracks in the pavements. *This advantage was not exploited in said contracts by reduction of the asphalt layer thickness because the analytical/empirical background does not exist. Nevertheless, the potential was definitely present.*
Also experience from a.o. Denmark indicates that large, unexploited potential exists if such uncommon strategy is applied.

The technical challenges in the exploitation of these observations are:

- To control the intrinsic cracking through a controlled low strength level, i.e. introduce max. requirements to strength.
- To assure the durability of the base course even at low strength level, which probably means that also minimum requirements to the strength shall be defined.
- To develop a design methodology for these low strength base course materials taking into account the absence of discrete cracking together with the consequence that a large number of finely distributed cracks will be present (and influencing the elasticity of the material, i.e. low modulus elasticity materials)

- To verify that asphalt layers are only required to establish a desired wearing course quality and not as part of the structural layer.

To meet all these challenges a comprehensive research approach will be required as illustrated in the original proposal for WP5.

Work in a network does usually not include direct research work.
In cluster 4 it has, therefore, been chosen to adapt an approach of dedicated studies of vital elements of the pavement concept.

These studies will be performed in task groups, which within a limited budget and time will prepare *assessment reports or reports on best available technology.*

Based on such deliverables it will be decided by the cluster to initiate verification activities, also performed by small task forces within the cluster and at limited budgets.

Such activities may be:
- Development and description of one type of material
- Fatigue testing of one type of pavement in semi-full scale
- Accelerated testing of one type of pavement in full scale.

It is realized that such approach is not optimal because a trial and error strategy must be applied. Within the proposed cluster budget there is, however, no room for error.

It is believed that cluster 4 comprises some of the best scientists in this field in the world and it is hoped that a fruitful merger between science and practical experience may prevent fatal errors.

In the proposed process there is only room for one 'shot' at each level. In case of failure the development process must be aborted completely.

However, in the event of success, the findings will be transformed into guidelines. Attempts will be made to authorise such recommendations through CEN. Rilem, FEHRL or other relevant organisation, which may facilitate the implementation of the networking results.

This networking and development strategy is reflected in the work plan below.

5.3 Work content and organization

As indicated above the cluster is structured in networking tasks and dedicated verification tasks.
An overview of these tasks and their interrelation is illustrated in figure 1.

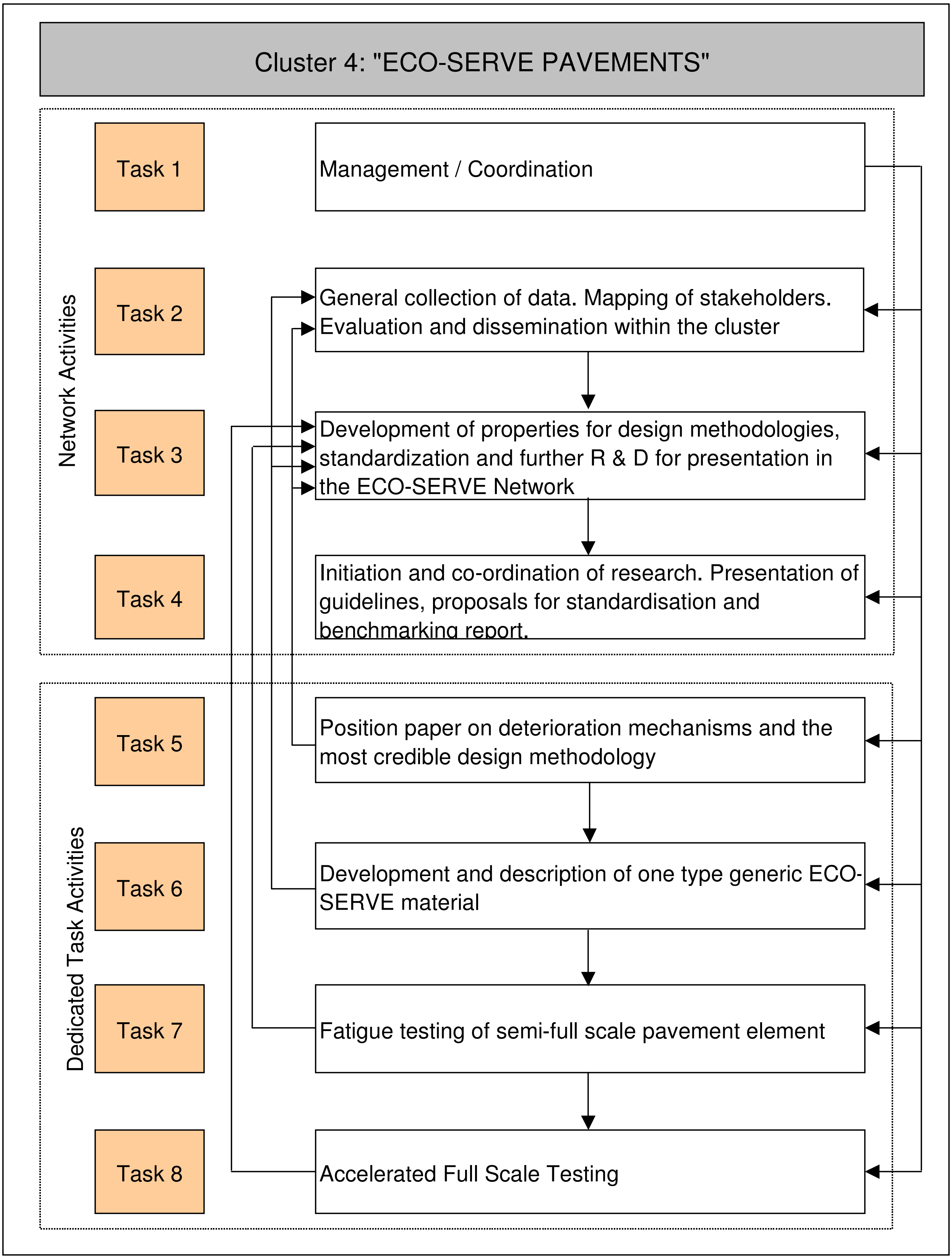

Figure 1; Overview of cluster 4 activities

5.4 Task description

Task 1; Management and co-ordination

Dura Vermeer Group will manage and co-ordinate all networking activities in cluster 4 and, further, assist in co-ordination of the dedicated task activities.
DBT and Intron will assist Dura Vermeer in this task as members of the cluster management group.

Task 2; Stakeholder mapping. General collection of data. Evaluation and dissemination within the cluster

In this task cluster 4 will aim at establishing stakeholder mapping activities jointly with the activities carried out in the management cluster.
The result of these activities, which will be performed using the ECO-SERVE website and the inter-active platform of E-core will be an inventory of stakeholders, basis for benchmarking and input to the environmental indicator work in the field.

All members of cluster 4 will be responsible for collection of data within the following fields:

- Available design methodologies
- Available information on 'ECO-SERVE type' pavements. Case stories and performance records
- Available information on physical data of CTB and related materials with enhanced performance
- Available information on test method statements and standard specifications for these materials.

All members of cluster 4 will receive assess and comment on the above information and the reports, which are generated in the dedicated tasks 5-8.

All reports will be communicated electronically between the members of cluster 4.
An overview of the present technology will be published including recommendation for research on national or European level.

The communication will be managed and co-coordinated by the task leader the Danish Road Institute.

Task 3; Development of proposals for design methodologies, standardization and further R&D for presentation in the ECO-SERVE Network.

The ECO-SERVE Network will arrange Annual Workshops. It is the intention of cluster 4 to arrange cluster workshops in relation to these network events.

It is the objective to present all work produced in the cluster at these annual workshops and to prepare written documentation.

It is, further, an objective to present design methodologies, which may be alternative to commonly accepted designs and which may contribute to the objectives of the ECO-SERVE Network.

The assistant cluster co-coordinator, Intron, will be the leader of this task.

<u>Task 4; Guidelines, recommendations and implementation approach</u>

A report giving an overview of all technical activities of cluster 4 during the networking period will be prepared as a 'Final Technical Cluster Report'.

One of the objectives of cluster 4 is to identify the European and international state-of-the-art and to identify areas where further research is needed – all within the scope of work of cluster 4.
Based on the final technical report, the cluster members will prepare guidelines and recommendations for presentation to relevant organisations such as CEN. Rilem, FEHRL a.o.

The final report shall evaluate to which extent the objectives of the cluster have been fulfilled.

Another vital part of the final report will be an assessment of the outcome of the dedicated tasks and a recommendation for implementation of the results.
Eventually, the report shall contain an assessment of the added value, which has been created during the networking period.

The cluster co-coordinator Dura Vermeer is responsible for collation of contributions by the members to this report, for the final presentation at the final Network Annual Workshop and for contacts to all relevant organisations, which may contribute to the implementation of the results.

<u>Task 5; Prepare a position paper on deterioration mechanisms and most credible design methodology</u>

The pavement research institutes of the cluster form a specialist group, who will prepare the following documents:

- State-of-the-art on design of low strength cementitious pavements
- Survey of roads built with poor quality materials during the 1950's. Determination of pavement thickness and base course strength. Assessment of traffic load
- Survey of more recently built semi-flexible pavements with a service record. Compare service performance with model predictions.
- Recommendation for a preliminary guideline for design based on an assessment of SOTA and selection of most feasible design theory.

<u>Task 6; Development and description of one type generic ECO-SERVE material</u>

During task 5 requirements to a generic type ECO-SERVE base course material will be defined.
In task 6 such a material will be produced based on sand/gravel from e.g. the northern part of Poland.
This generic base course material will the basis for the fatigue-testing specimen dealt with in task 7.

The material properties of this material will be fully documented, e.g. compressive and tensile strength, strength development, elasticity, elongation at rupture, shrinkage, creep, relaxation, frost resistance, resistance towards drying and wetting.

<u>Task 7; Fatigue testing of large-scale structural components</u>

Testing of materials and pavement design in almost full-scale has often proven useful in the past. Expensive mistakes and misconceptions may be avoided before the stage of 'Full-scale testing'.

This is particularly valid for the work in cluster 4 because the budget does not allow for a scientifically based research approach. Based on best available opinion, the scientists of cluster 4 will recommend a design methodology and apply this in the accelerated fatigue testing experiment. If this approach proves successful, a major step forward in pavement design has been taken.
The details of the test will be worked out by the task force of task 5.

<u>Task 8; Accelerated Full-Scale Testing</u>

Provided the fatigue test of task 7 performs as expected, the task force of task 5 will reconvene for assessment of theories and possibly introduce corrective measures in the preliminary guideline for design of ECO-SERVE pavements.
The revised guidelines will be tested in an accelerated testing facility.
This testing may be performed in DK, NL, F, UK or other European countries with accelerated testing facilities available.
The decision of the test location will be taken based on a tender procedure and lowest qualified bidder will be given the task to perform the test.
It must be assumed that additional funding need to be secured as the budget of the cluster will only contribute marginally to the performance of the test.

6. Members, time schedule and deliverables

6.1 Overview of partners and relation to the tasks

Participant				Status	Role in Cluster 4, contribution to task no.
No.	**Name**	**Activity code**	**Country**		
41	Dura Vermeer	IND	NL	C	Cluster Co-coordinator 1, 4, 7 and 8
2	Intron	SER	NL	C	1, 3, 6, 7 and 8
1	DBT	IND	DK	C	1, 5, 6, 7 and 8
42	LCPC	OTH	F	M	5, 7 and 8
43	COWI	SER	DK	C	5, 7 and 8
44	DTU	HES	DK	M	6, 7 and 8
45	DRI	OTH	DK	M	2, 5, 7 and 8
46	IBDiM	OTH	PL	M	5, 7 and 8
47	TRL	SER	UK	M	5, 7 and 8
24	Heracles	IND	EL	M	6, 7 and 8

Table 1; Overview of cluster members

6.2 Overview of deliverables

Deliverable		Related to task no.	Nature of deliverable and description
No.	Month		
D1	18	1	Arrange annual cluster meeting
D2	30	1	Arrange annual cluster meeting
D3	42	1	Arrange annual cluster meeting
D4	18	2	Summary report on data collation. Overview of techn.
D5	18	3	Present contribution at annual network meeting
D6	30	3	Present contribution at annual network meeting
D7	48	4	Guidelines & recommendation to CEN a.o.
D8	12	5	Assessment report on semi-rigid pavements
D9	17	5	Preliminary Design Methodology
D10	20	5	Recommendation for fatigue test
D11	30	5	Recommendation for accelerated testing
D12	45	5	Proposal for design methodology
D13	20	6	Material recommendation and test report
D14	30	7	Test report by completion of test
D15	43	8	Test report by completion of test

Table 2; Overview of deliverables

ECO-SERVE NETWORK — WORKPACKAGE / MANPOWER BARCHART — CLUSTER 4 PAVEMENTS

Task descriptions		Identification of Partners by Cluster number Man Month Consumption										Duration: 1st year				2nd year				3rd year				4th year			
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
T4.1	Management and Co-ordination	6	1	1																							
	Deliverables																	D1				D2				D3	
T4.2	Collation of Data							1																			
	Deliverables															D4											
T4.3	Existing Design Methodologies		3																								
	Deliverables																	D5				D6					
T4.4	Final technical Cluster Report	1																									
	Deliverables																										D7
	Milestone																										M1
T4.5	Deterioration and Design			2	4	4		4	4	4																	
	Deliverables															D8		D9		D10		D11			D12		
	Milestone																					M2			M3		
T4.6	Development of Material		2	2																							
	Deliverables																		D13								
	Milestone																		M4								
T4.7	Fatigue Testing		1	1					1																		
	Deliverables																					D14					
	Milestone																					M5					
T4.8	Accelerated Full Scale Testing	2																									
	Deliverables																					D15					
	Milestone																					M6					
TOTAL MAN-MONTH		9	7	6	4	4	0	5	5	4	0																

☆ **Mx** Milestone • **DX** Deliverable

Reporting Periods: 12 m — Mid-Term — 36 m — Final

Reporting Periods

7. Task descriptions

The 8 tasks of cluster 4 are described in the following tables

TASK DESCRIPTION		
Management and co-ordination		**Task No. 1**
Starting month 0	Duration: 48 months	Total effort: 8 mm
Partners involved	Activity of partner	Effort (months)
41 Dura Vermeer	Co-coordinator	6
2 Intron	Member Management Group	1
1 DBT	Member Management Group	1

Objectives
It is the objective of task 1 to co-ordinate the cluster in such a way that the resources are being applied in the best possible manner.

Description of work
The cluster co-coordinator is responsible for the detailed co-ordination, planning, monitoring and reporting of all cluster activities and for the communication with the overall network co-ordination.
He shall collate data from the cluster partners and submit these to the ECO-SERVE Network Management.
He is also responsible for the cost statements, periodic reports and the follow-up of the budget.

Deliverables
- Arrange annual cluster meetings – D1, D2 and D3
- Periodic reports of cluster activities
- Annual cost statements
- Final consolidated cost statement

Milestones
There are no milestones apart from the timely delivery of periodic reports and cost statements.

Interrelation with other tasks
Co-ordination of tasks in cluster 4. Flow of information between cluster 4 and the Network Management.

ECO-SERVE NETWORK – CLUSTER 4; PAVEMENTS

<table>
<tr><td colspan="3">TASK DESCRIPTION</td></tr>
<tr><td colspan="2">Collation of data.
Evaluation and distribution within the cluster</td><td>Task No. 2</td></tr>
<tr><td>Starting month 6</td><td>Duration: 12 months</td><td>Total effect: 1 mm</td></tr>
<tr><td>Partners involved</td><td>Activity of partner</td><td>Effort (months)</td></tr>
<tr><td>45 DRI</td><td>Collation and distribution of reports</td><td>1</td></tr>
</table>

Objectives
It is the objective of task 2 to collate all available information regarding pavement design methodologies and to communicate this in electronic from to all participants in the cluster.

To co-ordinate research in Europe, assess the results, disseminate and implement in the network deliverables.

Description of work
All members of cluster 4 will be responsible for collection of data within the following fields:

- Available design methodologies
- Available information on 'ECO-SERVE' type pavements
- Available information on physical data of CTB and related materials with enhanced performance
- Available information on test method statements and standard specifications for these materials

Deliverables
Summary reports of above when all information has been made available – D4.

ECO-SERVE NETWORK – CLUSTER 4; PAVEMENTS

TASK DESCTIPTION		
Design methodologies, standardization and further research		**Task No. 3**
Starting month: 6	Duration: 24 months	Total effort: 3 mm
Partners involved	Activity of partner	Effort (months)
2 Intron	Prepare reports for presentation at Annual Workshops	3

Objectives
It is the objectives of the present task to prepare an overview of available technologies and to map competencies. These objectives are considered of importance in the dialogue with authorities, standardisation bodies and national funding agencies.

Description of work
Based on the summary report generated in task no. 2 and the reports on dedicated work in task nos. 5-8, the cluster will prepare position papers and technical reports for presentation at the ECO-SERVE Network Annual Workshops and to relevant organisations.
It is the aim of this work to contribute to the final report of the cluster (task 4) with ad-hoc contributions to the state-of-the-art.

Deliverables
At least 2 contributions of high standing for each of the workshops during the first 3 years – D5 and D6.

Milestone
There are no milestones for this task

Interrelation with other tasks
Task no. 3 will draw information from task nos. 2, 5, 6, 7 and 8.
Task no. 3 will contribute to task no. 4.

TASK DESCTRIPTION		
Final technical cluster report		Task No. 4
Starting: Month 42	Duration: 6 months	Total effort: 1 mm
Partners involved	Activity of partner	Effort (months)
41 Dura Vermeer	Prepare final report	1

Objectives
It is the objective of the present task to gather all technical reports produced by the cluster participants during the networking period and on this basis to give a realistic assessment of the work carried out.

It is, further, an objective of the task to identify research, which is required for implementation of ECOS-ERVE methodologies and to suggest actions towards the European standardization system.

Eventually it is an objective to conclude and recommend in regard to the technological development.

Deliverables
Final Technical Report – D7.

Milestone
Final Technical Report shall be available by month 48 – M1

Interrelation with other tasks
All other tasks will contribute to the final technical report.

TASK DESCRIPTION		
Deterioration mechanisms and design methodology		Task No. 5
Starting: Month 6	Duration: 30 months	Total effort: 22 mm
Partners involved	Activity of partner	Effort (months)
1 DBT	Task Co-coordinator	2
42 LCPC 4	Collect data and assess	4
43 COWI	Collect data and assess	4
45 DRI	Collect data and assess	4
46 IBDiM	Collect data, describe Eastern European experience and assess results	4
47 TRL		4

Objectives
To collate existing information about semi-rigid pavements.
To recommend a probable design methodology
To advise on accelerated testing
To conclude after each test phase
To recommend a design methodology

Description of work
In the first phase, the researchers will collect all available date. Particularly data regarding pavements with known performance, e.g. quality of sub-grade, pavements design, service time without repair or strengthening, deterioration mechanisms, records of traffic loads, etc.

Based on these data existing design methodologies will be applied and their reliability will be measured against known performance.
Deterioration mechanism of ECO-SERVE pavement concept will be addressed and preliminary guidelines for design will be prepared.

The guidelines will be applied:
- in design of ECO-SERVE materials (task 6)
- in design of fatigue testing pavement (task 7)
- in design of accelerated testing pavement (task 8)

Evaluation in regard to proposed deterioration mechanism and design methodology/guidelines will be made following each of the above steps.

Deliverables

- Report on semi-rigid pavement data – D8
- Preliminary report on design methodologies – D9
- Recommendation for fatigue testing – D10
- Recommendation for accelerated testing – D11
- Proposal for design methodology – D12

Milestone

The milestones of this task are related to the deliverables:
Evaluation of results of fatigue test and recommendation for accelerated test by month 30 - M2
Evaluation of outcome of accelerated test by month 42 – M3
Proposal for design methodology by month 45 – M4A

Interrelation with other tasks

This task is a vital task for the success of the cluster work.
The interrelation of the task with other tasks is illustrated in figure 1.

TASK DESCRIPTION		
Development and description of material		Task No. 6
Starting; Month 12	Duration: 8 months	Total effort: 4 mm
Partners involved	Activity of partner	Effort (months)
2 Intron	Co-ordination, laboratory testing	2
1 DBT	Laboratory testing	2
44 DTU	Review of material properties	0

Objectives
To develop and document a generic material, which meets the requirements defined by task no. 5

Description of work
During task 5 requirements to a generic type ECO-SERVE base course material will be defined.
In task 6 such a material will be produced based on sand/gravel from e.g. the northern part of Poland.
This generic base course material produce don the basis of marginal quality materials will be the basis for the fatigue-testing specimen dealt with in task 7.

The material properties of this material will be fully documented, e.g. compressive and tensile strength, strength development, elasticity, elongation at rupture, shrinkage, creep, relaxation, frost resistance, resistance towards drying and wetting.

Deliverables – D13
- Composition of ECO-SERVE material and specification for work
- Documentation of ECO-SERVE material properties

Milestone
Material development report by month 20 – M4B

Interrelation with other tasks
Task no. 6 requires input from task 5. Preliminary requirements to material properties must be available by month 12. Task no. 6 gives input to task nos. 6, 7 and 8.

TASK DESCRIPTION		
Fatigue testing of structural components		Task No. 7
Starting: Month 20	Duration: 10 months	Total effort: 3 mm
Partners involved	Activity of partner	Effort months
41 Dura Vermeer	Observer/QA review	0
2 Intron	Analysis of pavement	1
1 DBT	Analysis of pavement	1
42 LCPC	Observer/QA review	0
43 COWI	Observer/QA review	0
44 DTU	Observer/QA review	0
45 DRI	Observer/QA review	0
46 IBDiM	Co-ordinator	1
47 TRL	Observer/QA review	0
24 Heracles	Observer/QA review	0

Objectives
It is the objective of the task to test one (1) large scale material unit exposed to pulsation or repeated wheel loads in accelerated exposure facility

Description of work
The consortium has secured access during the research to a testing facility consisting of a bridge test stand with necessary back-up facilities. This set-up forms a complex facility for the complete testing of the whole scale engineering structures and their components. The facility is owned and operated by one of the partners.
During the initial stages of work, final decision will be taken in regard to location of the test.

Fatigue testing of large scale structural components
Testing of materials and pavement design in almost full-scale has often proven useful in the past. Expensive mistakes and misconceptions may be avoided before the stage of ‘Full-scale Testing’.
The fatigue properties will be monitored on-line and expressed as deterioration of modulus of elasticity in experiments, which are either guided by force or deflection.

Analyse pavement degradation and crack propagation due to repeated loads
This will be performed on the chosen test run in the accelerated testing facilities. The technique of applying fluorescence impregnation of samples in combination with macro- and microscopical assessment of conditions of materials is usually giving a very accurate image of the load history and the ability of the pavements to carry such loads.

At the present stage it cannot be realistically decided how and where the accelerated fatigue test will be performed.
For the purpose of establishing a budget, an amount of EUR 50,000 has been allocated for the test.
Further funding may be required. If so, additional funding will be applied for through National or industrial programs.

Deliverables

- Test report by completion of test – D14

Milestones

Test report by month 30
Criteria: Test results meet expectations – M5

Interrelation with other tasks

Task 7 receives input from task nos. 5 and 6
Task 7 delivers output to task nos. 3, 4, 5 and 8.

TASK DESCRIPTION		
Accelerated Full Scale Testing		Task No. 8
Starting: Month 30	Duration: 12 months	Total effort: 2
Partners involved	Activity of partner	Effort (months)
41 Dura Vermeer	Co-ordinator	2
2 Intron	Observer/QA review	0
1 DBT	Observer/QA review	0
4 LCPC	Observer/QA review	0
43 COWI	Observer/QA review	0
44 DTU	Observer/QA review	0
45 DRI	Observer/QA review	0
46 IBDiM	Observer/QA review	0
47 TRL	Observer/QA review	0
24 Heracles	Observer/QA review	0

Objective

It is the main objective of the task to verify all assumptions, which were made during the previous task.

Description of work

Based on the design of generic materials and the outcome of the test performed in task no. 7, an accelerated test in a Road Testing Machine will be planned and carried out.
Due to budget restrictions there will not be room for extensive instrumentation but a required minimum will be planned and installed.
The Scientific group of task no. 5 will be responsible for this planning.
The location of the test facility is not yet determined. This will be chosen based on availability during the test period (month 30-42) and on the basis of costs.
It is foreseen to call for tenders for the service based on specifications of the test.
A contingency amount of EUR 50,000 has been set aside for this test. As for the fatigue testing this amount may not be sufficient, in which case additional funding must be secured.

Deliverables

Test report by month no. 42. – D15

Milestones

Compiled report of all full-scale tests by month no. 42.
Criteria: Successful outcome of the test – M4

Interrelation with other tasks

Task no. 8 requires input from task nos. 5, 6 and 7
Task no. 8 provides input for task nos. 4 and 5.

8. Presentation of cluster participants

8.1 Overview of the cluster

The work in cluster 4 is performed by 10 partners with complementary skills but all with links to the pavement construction sector.

The partners represent all elements in the value chain, i.e. owners, clients, consultants, material suppliers, pavement contractors, testing laboratories and QA/QC certification bodies.

This provides for a good interaction between the partners and contributes to reduction of the risks, which are related to the research.

The very strong participation of agencies with direct or indirect affiliation to governmental bodies shall be emphasised. Four of the partners belong to this group. These partners, i.e. Transportation Research Laboratory, UK (which is a research institute now), the Polish Road and Bridge Research Institute, PL, Laboratoire Central des Ponts et Chaussées, F and Danish Road Institute, DK are all very qualified stakeholders in the R&D process and in addition hereto, these partners provide the necessary flow of information to the public end-users and pavement owners, which is a condition for the successful communication and eventual additional funding of the work in cluster 4.

Considering that the European paving industry consists of more than 10,000 companies, it is believed that the very best information and dissemination strategy for the ECO-SERVE concept towards all these companies, which are almost all SME's, is the chosen strategy with a heavy representation of public bodies engaged directly in the research.
It is visualised to open the cluster for more members on a non-funded basis during the lifetime of the network.

8.2 Description of the participants

8.2.1 Partner No. 41; Dura Vermeer Group NV

The Dura Vermeer Group NV was set up in 1998 as a result of the merger of the Dura Bouwgroep B.V. and the Vermeer Groep BV. The new company can boast many years of experience in the development and realisation of home and utility construction and infrastructural projects; it ranks among the leaders of the Dutch construction sector. The Dura Vermeer Group, in co-operation with its partners, offers mostly integral, innovative and trend-setting solutions. The company acquires projects through construction teams, multiple tenders and its own real estate development. Furthermore, co-operation between the public and private sector is increasingly important.

The Dura Vermeer Group is organised in two divisions, one for Construction and Real Estate and one for Infrastructure and in two clusters one for Advice and one for

Services. Within this framework, the company is made up of largely independently operating working companies, covering all areas in the Netherlands.
Activities in above mentioned divisions and clusters are carried out throughout the entire building sector. Dura Vermeer has proven extensive experience in the field of (re)construction of roads, railways, airports, preparing urban and business areas for building and living, carrying out soil sanitation activities, utilitarian building, hydraulic engineering of concrete constructions, building of industrial installations, pipeline systems and storage facilities, plan development and engineering. Dura Vermeer employs 3200 employees and averages an annual turnover of 800 million Euro (2000).

Vermeer Infrastructure BV
Vermeer Infrastructure is part of the division Infrastructure and is specialised in (re)construction of all infrastructural projects. As a leading construction company, Vermeer Infrastructure is now involved in many large infrastructural projects. The Research & Development Department is responsible for advice and product development. Ir. Robbert Naus is head of this Department and will be project leader for Vermeer in the Roads and Pavements part of the project. This department is carrying out the work for the project.

8.2.2 Partner No. 2; Intron BV

Intron is an independent private company with special services for the building industry. It is the aim of INTRON to be leading in this field in the Netherlands and to play a dominant role in Europe with approximately 100 people Intron assesses, improves and predicts the quality of building materials. Activities are consulting and development, measurement and inspection, certification and technical approvals.

- Intron has a fully equipped laboratory to test safety, durability and environmental aspects of building materials and components.
- Intron consults not only in technical aspects (damage assessment, waste problems, immobilisation, durability) but also in the potential harmfulness and the environmental load with life cycle assessment (LCA).
- Intron makes technical approval guidelines as well as forwards certificates (ETA, KOMO and ISO) if the criteria are met.

Intron's policy is to invest in clean processes and products, which can be fully exploited after development

At Intron four people are employed to perform daily on a routine basis LCA’s for materials and products in the construction industry For the Dutch and the European Concrete industry Intron made both a database and an assessment tool to perform Life cycle assessments. Dr. Agnes Schuurmans, Prof. Jan Bijen and Prof . Charles Hendriks can be seen as opinion leaders in this field. Intron also participated in the TESCOP project

In the field of product development Intron participated in numerous national and several European projects f.e. Tolerant Concrete, low noise porous concrete road pavements, development of radar techniques to determine the quality of concrete in the fresh state. Key personel in this area are Ir. Rico van Selst and Dr. Gert van der Wegen

8.2.3 Partner No. 1; Dansk Beton Teknik A/S

DBT is a 100% subsidiary of the Swedish construction company NCC AB. The annual turnover of the construction group is 4-5 billion EURO. NCC is strongly involved in Build Operate and Transfer Contracts (BOT) and has recently started working on such a large contract in Poland in joint venture with the German contractor Strabag AG.
It is evident that any construction company with BOT strategy will benefit from the research proposed in this work package but also from the results of the entire project (see also presentation of NCC AB).
DBT operates as an independent company in the NCC group delivering services in terms of risk assessment, quality planning, technical consultancy to road and concrete sites and strategic planning for overseas engagements.
The technical activities are concentrated within the field of concrete research, evaluation of concrete structures, their deterioration and estimation of residual service life based on micro structural analyses.

The key personnel assigned to the project will be:

Anders Henrichsen, M.Sc., Professor h.c.

AH has worked with R&D during the last 20 years along with his task as Managing Director of the two companies Dansk Beton Teknik A/S and Dansk Vejbeton A/S.

He has more than 25 years of management experience from construction and research companies and he has been responsible for construction of more than 15 mill m^2 of pavements.

Tine Aarre, Ph.D.

Dr. Tine Aarre has been employed by DBT for the last 12 years during which period she primarily has been engaged in research related to structural behaviour of cementitious pavements. She obtained her Ph.D degree while in this employment. Dr. Aarre is today a specialist in all areas of concrete technology including durability assessment of cementitious materials.

8.2.4 Partner no. 42; Laboratoire Central Ponts et Chaussées

LCPC is a State research organisation ("Public Science and Technology oriented Research Institute"), working for the State and the local authorities in connection with professionals, in the domain of civil engineering, transport, urban engineering and environment. LCPC has 550 employees of whom 200 engineers and researchers divided mainly into two sites: Paris and Nantes. Its annual budget amounts to 278 million francs. Its activities are carried out in connection with the network of *Laboratoires Régionaux des Ponts et Chaussées* (LRPC) spread over the whole of

France; LCPC leads and co-ordinates the scientific and technical activities of this network.

Design of ECO-SERVE pavements

LCPC, as the main author of the French pavement design methods, will bring his experience into the activities of the network and will particularly contribute to the work in task nos. 4.5, 4.7 and 4.8.

Material development and testing
LCPC has gained a large experience in the past 15 years in concrete mixture proportioning. This experience is condensed in a recent book, and in a mix-design software. A research programme is on going for applying these concepts to cementitious materials for road. Therefore, this network fits well with this field of expertise.

Application in accelerated testing facility

LCPC has a long experience in pavement fatigue testing. It owns a circular fatigue installation, with four independent 40-m dia. rings. Moreover, it has recently acquired two linear fatigue machines (called FABAC machines), which are transportable, and suitable to test a smaller structure. LCPC contribution could be basically to perform one 'light' test with FABAC machine, in the beginning of the project, and one test with the full ring fatigue machine (which allows to test up to four different structures at the same time). A total number of 10^6 load repetition can be applied within three months. As for this last test, there is now the possibility to control the water level in the pavement foundation. Also, given the local climatic conditions, it is likely that the structure will be submitted to frequent rainfalls during testing. Hence, the role of water in the durability of ECO-SERVE structure has to be investigated, since water is one of the main causes of degradation of unbound granular base pavements. Finally, the various materials could be also produced at LCPC, with excellent conditions for careful control of materials and mix-composition.

C.V. for the key researchers

Name	Tasks	Position at LCPC	Competence with regard to ECO-SERVE project
Jean BALAY	1, 3, 5, 6	Head, 'Accelerated Load Testing Facility' Section, MSC Division	Pavement structural testing and design
Yves BROSSEAUD	4, 5, 6	Research engineer, 'Road Binders and Materials' Section, MSC Division	Pavement bituminous materials, wearing courses
Pierre HORNYCH	2, 3	Research engineer, 'Road Geotechnics and Pavement Design' Section, MSC Division	Geotechnics, unbound materials testing and modelling
Jean-Michel PIAU	1, 3, 6	Division chief, 'Pavement Materials and Structures' (MSC)	Mechanical/structural analyses and modelling
Bogdan CAZACLIU	2	Research engineer, 'Material Elaboration' Section, TGCE Division	Civil Engineering materials mixing technology
Thierry SEDRAN	2, 3	Head, 'Material Elaboration' Section, TGCE Division	Optimisation of cementitious materials
François de LARRARD	2, 3, 6, 7	Division chief, 'Civil Engineering Technologies and Environment' (TGCE)	Mix-design of cementitious materials and cement-based materials in pavement

8.2.5 Partner No. 43; COWI

COWI, Consulting Engineers and Planners AS is one of the largest consultants in Denmark within a permanent staff of more than 2,000. The company was founded in 1939, mainly operating within the field of traditional civil engineering, specialising in bridges and similar structures. Over the years, the field has been widened to embrace oil, gas and other industrial engineering as well as environmental and planning activities.
Within the fields of pavement engineering, COWI puts great emphasis on innovative and environmentally sound methodology. The proposed project has prospects for utilising low-production of high-quality construction materials. The benefits will be realised in conservation of high-quality raw materials, reduction of construction materials' transportation and the possibility of solving industrial waste problems.

COWI sees the network as enhancing its competence in the identification of suitable materials at the feasibility study stage of large-scale (re)construction projects as well in the actual materials engineering in the design and construction phases. This competence will be utilised in marketing the company's service vis-à-vis donor and financing organisations as well as contractors, entering into e.g. BOT projects.

During the research, the following **key personnel** will be allocated:

Christian Busch, M.Sc., Ph.D
Dr. Busch has background in civil engineering but during recent years he has been mainly involved in pavement design theories and the study of deterioration mechanism.
Dr. Busch has prepared the state-of-the-art, which is presented in WP5 of this project.

Kirsten Eriksen, M.Sc., chemical engineering
Mrs. Eriksen has been engaged in the study and design of road pavements for more than 20 years.
Mrs. Eriksen has, further, a broad experience in designing materials for base course layers from her work in East Africa involving marginal quality materials as well as natural pozzolana.

8.2.6 Partner No. 44; Technical University of Denmark

At DTU we have worked for a number of years on test and design methods for fibre reinforced concrete (FRC). This work is based on the non-linear fracture mechanics theory by A. Hillerborg called the fictitious crack model. This theory was developed for concrete fracture but it also applies to FRC, in fact it applies to any material with a quasi-brittle matrix. Thus, we are confident that it will also apply to the special materials considered in the present cluster. In this respect the main advantage of the fracture mechanical approach is that it distinguishes between strength and ductility/toughness and gives guidelines for testing as well as design taking toughness into account.

Based on the fictitious crack model we have developed analytical and numerical design tools for FRC, which may possibly be adopted for the materials considered. The input for the design tools are the tensile characteristics of the material. These are the uni-axial tensile strength, the elastic modulus and the tensile softening curve, also known as the stress-crack opening relationship.

8.2.7 Partner No. 45; Danish Road Institute

Danish Road Institute (DRI)
DRI is the public materials research laboratory of the Danish road sector and a branch of the national road administration - the Road Directorate. The institute 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. The aim of the Danish Road Institute is to develop new knowledge on materials and method, which can improve the economic efficiency in the construction and

maintenance of safe, sustainable and effective road systems.
DRI has specialist teams working on the technology of road materials: natural aggregates, bituminous materials, stabilised materials, recycled materials and by-products. It has a fully equipped, accredited asphalt and soil mechanics/concrete laboratory for routine and research testing programmes.
DRI has participated in several EC funded R&D-projects during the last 10 years, including ECO-PAVE, NEWPAVE, MIAF, STAR, PAVE-ECO, POLMIT, ALT-MAT, SMART STRUCTURES.

The Danish Asphalt Rut Tester
The Danish asphalt rut tester (DART) is a stationary, full-scale, heavy wheel tracking ALT facility, which was designed by the DRI and installed at the Institute in 1997. The technical specifications in brief:

- Stationary heavy vehicle simulator with linear travel 0-5 km/h.
- Wheel load up to 67 kN load (single and dual wheel load).
- Testing of multi-layer samples.
- Test sample 1200 x 1500 mm, thickness 50-250 mm.
- Temperature control cabinet, 25-60 °C.
- Temperature gradient in sample optional.
- Automatic rutting and macro texture measurements with laser.

Full-scale Accelerated Pavement Testing (APT) in the Danish Road Testing Machine - the RTM

The Danish Road Testing Machine (RTM)
The Danish Road Testing Machine, is jointly owned, managed and used in road pavement research by the Danish Road Institute (DRI) and the Institute for Planning of the Technical University of Denmark (DTU). It is a linear track, accelerated pavement testing (APT) facility, with a width of 2.5 m and a length of 27 m. The central 9 m is the actual test section, which is 2 m deep. The RTM is enclosed in a climate chamber, 4 m wide and 3.8 m in height. Internally mounted heating and cooling equipment make it possible to maintain a surface temperature range of -10° C to + 40° C. The groundwater in the test pavement is fed from a well alongside the RTM pit, which is connected directly to the porous granular materials at the bottom of the pit. The groundwater level in the test pavement may be adjusted by varying the water level in the well.

The RTM loading cart
This is a cable towed, dual (or super single) tire loading cart that can apply bi-directional accelerated loading to test pavements constructed in the RTM. The wheel load is hydraulically applied by single or independent dual wheels. The maximum dual wheel load is 65 kN and the maximum velocity is about 25 km/h. Approximately 5,000 load repetitions may be applied during a normal working day at this load level. Since the 65 kN dual (or super single) wheel load is a half axle load, using a fifth power relationship (derived for the two RTM test pavements), this corresponds to approximately 57,000 passes of a standard 80 kN axle load. The lateral position of the dual wheels can be automatically changed during testing to give a desired transverse

wheel load distribution (wander).

Instruments installed in the RTM test pavements
The pavement to be tested in the RTM can be instrumented with the following sensors, which have been developed through previous research projects:

- Asphalt Strain Gauges (ASGs) measure the horizontal strains in a bound material such as an Asphalt Concrete or a Portland cement stabilised pavement material.
- Soil Deformation Transducers (SDTs) measure the dynamic strains and permanent deformations in unbound materials.
- Soil Pressure Cells (SPCs) measure the vertical and horizontal stresses induced by dynamic loading in unbound materials.
- Soil Pore Pressure Sensors (PPSs or Tensiometers) measure the negative pore water pressures in the soil, giving an indication of the fluctuations of moisture contents in the subgrade.
- Thermocouple probes (TMs) monitor the temperatures in the pavement layers. The TMs in the subgrade are normal temperature range sensors, whilst the TMs in the Asphalt Concrete surfacing (AC) are temperature-resistant sensors capable of withstanding high AC laying temperatures.

The surface profiles of the test pavement are measured with a Profilometer that is specifically constructed for profile measurements in the RTM. In principle, the Profilometer runs on the loading cart rails and measures the vertical distances from a fixed reference point (the Profilometer beam) to the pavement surface with a high precision digital transducer. Longitudinal profiles and transverse profiles are recorded for each measurement. From the measured longitudinal profiles, Slope Variance (SV) and International Roughness Index (IRI) are computed. From the measured transverse profiles, Rut Depth (RD) is calculated by applying a 4-foot (1.2 m) straightedge in a spreadsheet-based analysis.

Key Personnel allocated to the project will be Finn Thøgersen, M.Sc., civil engineering, Department for Road, Environment and Pavement Materials.
Mr. Thøgersen has an extensive experience in testing or road base materials.

8.2.8 Partner No. 46; Polish Road and Bridge Research Institute

Road and Bridge Research Institute (IBDiM) founded in 1955, is a state owned, self-financed, subordinated to the Ministry of Transport and Maritime Economy. It is a leading research institution in Poland, in the field of roads and bridges, including construction and maintenance of roads and bridges, railway subgrade, railway bridges, underground structures. The Institute's research covers materials, methods, equipment, economic problems and environment protection, the management strategies and others. Research is performed in several laboratories with modern equipment for soil, material, road pavement or structure testing. The scientific and technical research is ordered by road and railway administrations, municipal authorities, contractor and consulting firms, and private clients. The research is practice oriented on improving efficiency, quality and productivity of construction. The results are employed in advising and consultancy activity. They are disseminated

in many booklets, papers and in the quarterly journal "IBDiM Proceedings", also by organised conferences and courses.
The activity of IBDiM includes also development of Polish standards, codes of practice, specifications, as well as technical approvals and quality certificates for new materials and methods.
The Institute closely co-operates with Polish and foreign research and technical organisations, such as: PIARC, IABSE, OECD, ECMT, ERRI, ECS/CEN, FEHRL, RILEM, EUROBITUME, AAPT, ISSMGE, FGSV, DECHEMA. Active contacts are maintained with many researches in West and Middle-East European countries.

Full scale testing facility - Bridge Test Stand
The bridge test stand together with the necessary back-up facilities form a complex facility for the complete testing of the whole scale engineering structures or their components. The stand is located in Żmigród near Wrocław at the branch of Road and Bridge Research Institute.
The stand consists of two main parts:
- ✓ an Operational Test Stand (OTS) (the so called "Tub") situated on the line of the main loop of the experimental railway track and
- ✓ a Destructive Test Stand (DTS) located beside the OTS.

In addition, a test stand (STS) for the static testing of small structural components of bridges and for model testing is situated in the research building.
A wide range of tests of bridge and road structures can be carried out. Whole simple-supported or continuous ($l_t$max. = 60 m) bridge spans (for deck or through bridges) and single elements made of concrete, pre-stressed concrete or metal may be tested on the BTS. The stand allows to test elements under variety of simulated static or dynamic loads.
The system comprises:
- ✓ *two servos with the maximum exciting force of 1000 kN and the maximum shift of 400 m which can excite dynamic loads of ± 800 kN, equipped with displacement and force gauges having the accuracy of 0.1% of the full range;*
- ✓ *one servo with the maximum exciting force of 250 kN and the shift of 500 mm which can excite dynamic loads up to ± 200 kN, equipped with gauges measuring displacements and forces with the accuracy of 0.1% of the full range, for higher frequency (1-100 Hz) dynamic tests;*
- ✓ *a hydraulic feeding unit of 130 l/min. capacity with an automatic air-cooling system;*
- ✓ *a Hydropuls S-59 electronic system which allows one to control independently two servos on the basis of the measured in real time values of piston pressure and travel. It is also possible to subordinate the excitation program to any gauge (e.g. a displacement gauge) not connected with the servos.*

A data collection and acquisition system makes it possible to measure several quantities describing the course of changes in, for example, displacements, strains, stresses, forces, weights, moments and temperatures, that occur in the tested structures. The measuring system comprises:
- ✓ *a Hottinger Baldwin Messtechnik UPM 100 measuring device which allows one to measure 100 quantities simultaneously, and which works together with strain gauges measuring displacements or accelerations, and with thermocouples which measure temperatures;*

- ✓ *two twelve-channel DMC 9012A digital amplifiers, very useful when conducting dynamic tests because of their high measuring speed;*
- ✓ *a Macintosh computer with software controlling the UPM 100 and DMC 9012A devices and allowing one to manage and analyse the measured data;*
- ✓ *30 displacement induction gauges with the measuring range of 100, 50 and 20 mm;*
- ✓ *two C6 force (weight) gauges which can measure forces up to 2000 kN (200 t) with the accuracy of up to 1%, adapted to the measurement of the bearing reaction of the tested bridge spans;*
- ✓ *two U2A force (weight) gauges, which can measure forces up to 200 kN (20 t) with the accuracy of up to 1%..*

Curriculum Vitae of key personnel of IBDiM to the ECO-SERVE Network
Dariusz Sybilski, D. Sc, C. Eng., Professor and Deputy Director at the Road and Bridge Research Institute and Chief of Pavement Technology Division. His professional interests concentrate on flexible road pavements and materials in particular bituminous binders and mixes, and polymer modifications. He was a leader of several research projects, lately, among others, *Catalogue of typical flexible and semi-rigid pavements* and *Catalogue of strengthening and rehabilitation of flexible and semi-rigid pavements.* Author and co-author of over 100 technical papers and several patents. Member and IBDiM representative to:

- ✓ World Road Association (WRA-PIARC/AIPCR), Technical Committee “Flexible Roads” C7/8
- ✓ Réunion Internationale des Laboratoires D’Essais et Récherches sur les Matériaux et les Construction RILEM (International Union of Testing and Research Laboratories for Materials and Structures, TC PEB (Performance Testing and Evaluation of Bituminous Materials) (leader of TG 1 Bituminous Binders)
- ✓ Association of Asphalt Paving Technologists AAPT, USA
- ✓ Civil and Hydraulic Engineering Committee of Polish Science Academy: Section of Construction Materials and Section of Transportation Engineering Poland

In 2000 was employed at Arizona State University, USA as Visiting Professor. He was involved in the research project of bituminous binder characterisation for the new method of pavement design AASHTO Guide 2002.
Adam Wysokowski, Ph.D., C. Eng., Head of the Bridge, Concrete & Aggregate Research Centre at the Road and Bridge Research Institute. Basic tasks of the Department are works in the fields of Durability of Bridges, Bridge Management System and Supervision of Stand for Testing of Bridges and Roads at Natural Scale. The principle field of scientific and technical activity are the problems of fatigue and durability. Author and co-author of number of publications for various aspects of durability. Rewarded with several professional rewards for his research works.

8.2.9 Partner No. 47; Transportation Research Laboratory Ltd.

TRL Limited is an internationally recognized center of excellence providing world class research, advice and solutions for all issues relating to land transport. TRL has worked at the leading edge of innovation in the transport field for over 65 years. Our science and understanding continues to underpin the development of the transport solutions we deliver to clients around the world. TRL's mission is to assist the public sector to develop effective policies, transport operators to improve efficiency and industry to generate shareholder value and national wealth.

Employing over 400 specialists may of whom are world recognized experts, TRL is ideally placed to undertake research to develop new types of cementitious materials for pavements and to carry out accelerated testing on test pavements. Besides this, TRL has undertaken work to achieve sustainable construction by making the best and most efficient use of aggregates and alternative materials to replace them.

In the following a number of our **key personnel** is being presented:

Sally-Jane Ellis, Principal Research Engineer

Sally Ellis is a Chartered Civil Engineer and has been in the Pavements Department at TRL for six years. She currently manages and undertakes her own research work and in addition contributes to several call-off contracts to provide advice and consultancy services to Network Maintenance Engineers. Through this combination of research and consultancy initiatives Sally is familiar with problems associated with pavement design, construction and maintenance of highways and the effective implementation of research in these areas. In particular Sally's area of expertise is semi-rigid pavements, since joining TRL she has been research these from the view point of eliminating reflection cracking by pre-cracking and considering design procedures for them. She is currently finalising a doctorate thesis using finite element modelling to theoretically prove the design rationale for pre-cracked semi-rigid pavements.

Prior to joining TRL, Sally worked for two leading international consultants, namely the Halcrow Group and Hyder Consultants. With these organisations she has been involved with the development of highway schemes from initial conception through environmental appraisal, Public Inquiry, detailed design and construction. In relation to the DMRB she has been involved with the assessment of schemes, and the design of structures, road layouts / geometrics and drainage.

James Clifford Nicholls, M.Sc., Ph.D Civil Engineering

After working in various aspects of civil engineering, Cliff has been involved with research into asphalt surfacings since 1988. He has been heavily involved with the approval with the approval of many proprietary thin surfacings, the acceptance of porous asphalt as a surfacing material on trunk roads and revisions to Road Note 39 for the design of surface dressings. He is involved on a range of British Standards Institution, Institute of Petroleum and British Road of Agrément committees with particular emphasis on test methods for which he is the Convenor of the Comité Euroepéen de Normalisation task group on test methods for asphalt materials.

Barry Chaddock, Research Fellow, Ph.D, Physics

Experienced in monitoring the condition of road pavements and in developing foundation designs and methods for their assessment. Also, competent in the assessment of the structural properties of materials. Practical knowledge of sub-surface and surface road drainage. Current projects include the establishment of a databank on the condition of selected trunk roads, the development of specifications and designs to encourage the wider use of stabilised road foundations and the investigation of quality assurance techniques for the compaction of PQ concrete. Previous work on road materials involved the structural assessment of primary and secondary materials, both unbound and stabilised, and the ageing of asphalt materials.

8.2.10 Partner no. 24; Hellenic Cement Research Center Ltd.

Heracles group of companies is a large group active in the production and sales of cement and other building materials. It belongs to Blue Circle Group. The companies of the Group are described below according to their activities.

A. **CEMENT:** HERACLES General Cement Co. SA covers the 54% of the Greek cement production.

B. CONCRETE: Two companies of the Group, ASTIR LATO and SKYRODEMA, produce and distribute concrete from 27 ready-mix plants all over Greece.

C. QUARRIES AND MINERALS FOR CONSTRUCTION: LAVA SA is engaged in the exploitation and processing of industrial minerals since 1952. Its main activity is the production of graded pumice. The company fully meets the demands for the Greek market and, in addition, is the largest pumice exporter in the world. The main field of application of pumice is construction and building materials: structural masonry elements, lightweight concrete, lightweight prefabricated building elements, lightweight ready-mix mortar and wall plasters. EMMY - Building elements SA is a producer of the ALFAMIX dry ready mixed mortars and plasters, as well as special types of binders.

D. OTHER ACTIVITIES: EVIESK SA construction and engineering company in Greece in the area of metal constructions, industrial works and maintenance of equipment and industrial installations.
AIGIS SA, producing paper bags for industrial and other uses.
HERACLES PACKING SA, producing packing products from recycled paper.
HERACLES SHIPPING SA .

AMBER computer Services HERACLES Group of companies will be represented in ECO-SERVE by **EKET**, Hellenic Cement Research Centre Ltd. EKET is the Technical Centre of the Group. It carries out research relating to development and technical improvement of raw and processed building materials: industrial minerals, clinker, cement, concrete, building elements. It is involved in the area of research programmes subsidised by EC and the Greek government. EKET provides Consulting and Quality Control Services in the Group, to a number of independent Ready-Mix companies as well as to technical and construction companies involved in public and private works. The laboratories of the Centre are accredited according to EN 45001 for 23 test methods for cement, concrete and aggregates.

Key personnel qualifications

Dr. Malami Chariklia is a chemical engineer from NTU, Athens and PhD from the Technical University, Vienna. Dr. Chariklia' main fields of activity since 1982 are in chemical analysis of raw materials, cement, concrete and aggregates, ceramic materials and fuels, characterisation and evaluation of raw materials for clinker, cement and concrete production. Dr. Chariklia has also been involved in the development of new cementitious products (energy-saving clinker, new types of cement), studies on their hydration and the qualities of their hydrated products, surveys of concrete structures, durability studies on the influence of the type of cement on the corrosion of steel reinforcement, wear studies of the Rotary Kiln and repair materials. Dr. Chariklia has furthermore experience in management of projects and supervision of students. He has 26 scientific publications on research subjects referring to the above fields.

9. Information on Resources and Budget

The personnel resources, which will be installed during the networking in cluster 4 are described in the previous chapter.

A tabular overview of the networking costs is given in table 3 below.

In the budget a flat rate of EUR 8,000 per month has been applied for all personnel costs. The budget item 'Other Costs' totals EUR 100,000, which has been allocated with EUR 50,000 to the cluster co-ordinator and EUR 50,000 to IBDiM.

These costs are related to task 4.7; *Fatigue testing* to be performed and to task 4.8; *Accelerated Full Scale Testing.*

It is not known where these tests will be performed and the budget costs have, therefore, been allocated to the cluster co-ordinator.

Cluster member ECO-SERVE, Cluster 4	No. of man-month	Personnel Cost	Durable Equipment	Consumables	Travel and Subsistence	Computing	Other Costs	TOTAL
41 Dura Vermeer	9	72,000	0	0	5,000	0	50,000	127,000
2 Intron	7	56,000	0	0	5,000	0	0	61,000
1 DBT	6	48,000	0	0	5,000	0	0	53,000
42 LCPC	4	32,000	0	0	5,000	0	0	37,000
43 COWI	4	32,000	0	0	5,000	0	0	37,000
44 DTU	0	0	0	0	5,000	0	0	5,000
45 DRI	5	40,000	0	0	5,000	0	0	45,000
46 IBDiM	5	35,000	0	0	5,000	0	50,000	90,000
47 TRL	4	32,000	0	0	5,000	0	0	37,000
24 Heracles	0	0	0	0	5,000	0	0	5,000
TOTAL	44	347,000	0	0	50,000	0	100,000	497,000

Table 3; Budget and cost overview, cluster 4