



Memorandum of Understanding
For the implementation of a European Concerted Research Action
Designated as
COST 351
"Water Movement in Road Pavements and Embankments"
(WATMOVE)

The Signatories to this Memorandum of Understanding, declaring their common intention to participate in the Concerted Action referred to above and described in the Technical Annex to the Memorandum, have reached the following understanding:

1. The Action will be carried out in accordance with the provisions of document COST 400/01 "Rules and Procedures for Implementing COST Actions", the contents of which the Signatories are fully aware of.
2. The main objective of the Action is to increase the knowledge required for improving the highway performance and minimising the leaching of contaminants from roads and traffic.
3. The economic dimension of the activities carried out under the Action has been estimated, on the basis of information available during the planning of the Action, at Euro 4 million in 2002 prices.
4. The Memorandum of Understanding will take effect on being signed by at least five Signatories.
5. The Memorandum of Understanding will remain in force for a period of 3 years, calculated from the date of the first meeting of the Management Committee, unless the duration of the Action is modified according to the provisions of Chapter 6 of the document referred to in Point 1 above.

COST Action 351

**“Water Movement in Road Pavements and Embankments”
(WATMOVE)**

A. Background

A1 General

Many billions of EUROS are spent on road construction and maintenance each year, and road transport is the primary method of mobility for European people and goods. Transport constitutes about 10 % of the Gross National Product of the European Union and more than 80 % of the total transport of people and goods is provided by the road infrastructure. Investment in road construction and maintenance in Europe is therefore at a very high level and any improvements can have a significant effect on the overall cost benefit ratio.

Well-maintained roads and highways are essential for the economic and social development of Europe. Deterioration of roads as well as inadequate pavement maintenance and rehabilitation can also have serious consequences for the safety and comfort of the road users. There is a continuing requirement for more efficient methods of pavement construction, maintenance and rehabilitation, aimed at producing solutions, which are less disruptive to the environment and to the road user, as well as being more economic and of higher quality than those presently in use.

In many countries premature break down of especially low volume asphalt roads is an accelerating problem. The origin is usually increasing traffic, higher axle loads and an increasing use of super single tires, but also distresses like rutting and cracking caused by heavy traffic under the influence of climate and thermal movements. Water in pavements and embankments plays a primarily role giving shorter service life of pavements and increasing the need of rehabilitation measures. The resources for maintenance works are limited and often not sufficient to keep the roads in a proper condition. Much work therefore is needed to develop new cost effective maintenance methods. The activities within this COST Action face the problem of transport system efficiency, developing new knowledge about water movement in pavements and creating a more efficient methodology of road construction and rehabilitation.

Water or moisture is one of the most important and partly unsolved parameters related to the deterioration of roads. Water has influence on the E-module of pavement layers and on the resistance against permanent deformation or rutting. Various kinds of drainage systems and their efficiency influence the moisture conditions of a road pavement. The problem with water in pavements is often related to the fact that it is difficult to predict and control the levels and fluxes. The majority of highway engineers seem to be convinced that the water and drainage conditions of a road are perhaps the most critical parameter regarding bearing capacity and service life. If more accurate research can identify those factors related to moisture that are critical for the long-term performance of a road, that would create a better background for more relevant, innovative and efficient engineering solutions for road construction in the future.

Knowledge of moisture conditions in unbound pavement layers and subgrade soils is essential to predict the mechanical behaviour of these materials in pavements, and improve the design of pavements and of their drainage systems. The effect of different kind of drainage systems is not known.

In a sustainable society recycling of road construction material is of increasing importance. In many countries the use of alternative materials has increased but there are still questions to be solved regarding the functional properties as well as the environmental impact. These questions were approached within the EU-project ALT-MAT. The mechanical behaviour of alternative materials used in pavement structures and the inherent environmental risks associated with their use depend on the water saturation conditions of the materials. Their setting, as well as the potential release of pollutants can be affected. Understanding of water movements in pavements is also very important as regards the use of alternative materials, to understand possible leaching of pollutants.

A2 Preconditions

Conditions related to water and moisture in pavements are:

- water movement and moisture conditions are associated with the soil properties, the terrain, the precipitation (seasonal variations) and the groundwater regime,
- water movement and moisture conditions in a road construction depend on the vertical infiltration (permeability) through unpaved roads or damages on paved roads e.g. cracks or joints,

- capillary rise from the groundwater level influences the moisture content,
- infiltration of surface water through the shoulders of a road increase the moisture content in the pavement layers,
- shoulders composed of fine-grained material may cause water to be trapped in the pavement,
- transfer in the vapour phase is associated with infiltration,
- various kinds of drainage systems and their efficiency influence the moisture conditions of a road pavement.

A3 Solutions

The subject of pavement design, road material behaviour, alternative materials and pollution from roads has been addressed in part by previous COST Actions and Framework RTD projects. COST Action 333 and the 4th Framework AMADEUS project worked on pavement design models in an European perspective from a system level without going into deep analysis of different variables like water conditions. COST Action 337 and the 4th Framework COURAGE project worked with the mechanical and functional behaviour of unbound granular materials. The 4th Framework ALT-MAT project dealt with the behaviour of alternative materials and their environmental impact. The topic of POLMIT, a 4th Framework project was the pollution of groundwater and soil by road and traffic sources. *The complete list of related projects is under paragraph A4.*

Giving this background there is one remaining gap in the desired knowledge of pavement design and performance concerning the water and moisture in roads and embankments and the water movement. Better knowledge of water conditions will improve the structural design of pavements and increase the service life of roads. Drainage of the road is one very important parameter in pavement performance and various kinds of drainage systems and their efficiency influence the moisture conditions of a road pavement. Better knowledge of different drainage systems and their efficiency will improve pavement performance. The influence of water movement on contaminants from alternative materials and other road construction materials can also be investigated and controlled in a much better way.

It is envisaged that the output of this COST Action will be used at national level to guide policy for and to improve the design of pavements and technical specifications of road construction. Further it will guide policy on the use of different road construction materials, primarily alternative materials and measures against the leaching of pollutants. Appropriate legislation can then be drafted to formally implement the results from this Action.

A4 The Benefits of WATMOVE Co-operation

The potential benefits arising from the Action are substantial. There are major costs associated with water in roads. These costs involve both the cost due to shorter service life because of deterioration by water and also the user cost due to bad pavement performance and road closures because of weak roads and subgrades.

The benefits of this Action will be:

- Better understanding and prediction of water movement and moisture conditions in roads and their surroundings.
- Improvement of the pavement design (especially for flexible and low volume roads) and the drainage systems e.g. the effect of closed or open drains.
- Better and more accurate identification and control of contaminant leaching from soils, natural aggregates and by-products in roads and their surroundings.

This COST Action would be a natural complement to previous and on-going COST actions and EC FP projects like:

COST 333	New Bituminous Pavement Design Method
COST 337	Use of Unbound Granular Materials in Road Pavements
COST 343	Reduction in Road Closures by Improved Maintenance Procedures
COST 347	Improvements in Pavement Research with Accelerated Load Testing
COST 348	Reinforcement of Pavements with Steel Meshes and Geosynthetics
AMADEUS	Advanced Models for Analytical Design of European Pavement Structures

COURAGE Construction with Unbound Road Aggregates in Europe
POLMIT Pollution Mitigation
ALT-MAT Alternative Materials in road construction

A5 Why COST?

The COST framework co-operation provides the benefit of stimulating the contacts and the transfer of knowledge between various types of institutions involved in research and practice. A COST action makes it possible for a large number of European countries to participate, and it also provides an opportunity for international observers.

This COST Action has the purpose to enforce international co-operation between road authorities, research institutes and the industry. Construction, reconstruction and maintenance of pavements is a substantial market in the EU and this Action will result in more cost-effective control of pavement performance, deterioration and environmental impact of road and traffic. The Action should also benefit from the existing and potential new links with the U.S. and Canadian institutes, which already expressed their interest to collaborate.

B. Objectives and Benefits

B1 Main Objective

The main objective of the Action is to increase the knowledge required for improving the highway performance and minimising the leaching of contaminants from roads and traffic. Improvement of pavement performance will lead to less road closures, better use of the road network, longer service life and more effective transportation of goods and people.

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B2 Secondary Objectives

The aim of the Action can further be divided into the following four secondary objectives:

- to identify water movement and moisture conditions in unbound pavement layers and subgrade for different types of road constructions in various climatic conditions,

- to investigate the relationship between the mechanical behaviour of materials/soils and their hydraulic conductivity and moisture condition,
- to implement finite element modelling based on laboratory analysis and field studies in order to simulate water movement and moisture conditions in road construction.
- to identify, investigate and control contaminants leaching from soils, natural aggregates and by-products

Besides those technical objectives, the Action's results will contribute also to the environmental and road safety improvement.

C. Scientific Programme

C1 Description of the COST Action WATMOVE

Five Work Packages have been identified, each producing results as reports and deliverables:

The Forum of European National Highway Laboratories (FEHRL) prioritised the proposed research project, which consists of the following work packages:

1. State-of-the-art: Literature review

- a) Observations and results obtained in laboratory experiments and field investigations;
- b) Tests and use of models for prediction and design purposes.

2. Modelling and Monitoring of water flow and moisture within pavements and subgrades

- a) Inventory and survey of existing models.
- b) Selection of models appropriate for hydrology, hydrogeology, prediction, design and implementation.
- c) Inventory and survey of technologies for measurements of water movement and moisture content in roads with various materials and pavement structures

3. Environmental aspects of water in road pavements and embankments

- a) Identification and quantification of pollutants leaching from soils, natural aggregates and by-products.
- b) Mechanisms and factors affecting the leaching and transport of pollutants.
- c) Remedial measures

4. Performance related properties

- a) Inventory and survey of water related factors relevant for an appropriate pavement performance
- b) Investigation and evaluation of relationship between bearing capacity (i.e. modulus and permanent deformation) and water flow and moisture content in roads with various materials and pavement structures
- c) Investigation and evaluation of relationship between frost susceptibility and water flow and moisture content in roads with various materials and pavement structures
- d) Investigation of relationship between laboratory and field analysis

5. Final Report and Dissemination

- a) Summary
- b) Conclusions
- c) Recommendations
- d) Dissemination

Each Work Package has been further subdivided into separate tasks that cover individual topics or subjects, which are substantial issues in themselves. Separate interim reports may be produced for each of the Tasks identified and these will form a part of the final report for the Work Package of which they are a part.

C2 Work Programme

The work programme of the COST Action WATMOVE will be organised in work packages containing sub-tasks and a brief breakdown of the Work Packages into the Tasks identified is given in the following table:

Work Package No.	Contents	Task	Contents
1	State-of-the-art, Literature review.		
2	Modelling and Monitoring of water flow and moisture within pavement and subgrades	2.1	Inventory and survey of existing models
		2.2	Selection of models appropriate for hydrogeological considerations in highway design
		2.3	Inventory and survey of technologies for measurements of water movement and moisture content of pavement structures
3	Environmental aspects of water in roads	3.1	Identification and quantification of pollutants leaching from pavement structures
		3.2	Mechanisms and factors affecting the leaching and transport of pollutants
		3.3	Remedial measures
4	Performance related properties	4.1	Inventory and survey of water related factors relevant for an appropriate pavement performance
		4.2	Investigation and evaluation of relationship between bearing capacity and moisture content of pavement structures
		4.3	Investigation and evaluation of relationship between frost susceptibility and moisture content of pavement structures
		4.4	Investigation of relationship between laboratory and field analysis
5	Final Report and Dissemination	5.1	Summary
		5.2	Conclusions and Recommendations
		5.3	Dissemination

Work Package 1 will include a **State-of-the-art: Literature review** with the sub-divisions: a) Observations and results obtained in laboratory experiments and field investigations; b) Tests and use of models for prediction and design purposes.

Work Package 2 will consider **Modelling and Monitoring of water flow and moisture within pavements and subgrades**. A review and survey of existing models will be carried out as well as evaluation of models appropriate for hydrogeological considerations related to highway design. Parameters for models are important and need to be investigated. Furthermore there will be an inventory and survey of technologies for measurements of water movement and moisture content in roads with various materials and pavement structures. Testing and validation of a model or models in full scale, as well as water movement monitoring could be a part of this WP as field experiments.

Work Package 3 will deal with **environmental aspects of water in roads**. A review and classification of pollutants leaching from road construction materials will be done. Furthermore mechanisms and factors affecting the leaching and transport of pollutants will be studied and finally a review and evaluation of remedial measures will be given. This will include an inventory of methods for handling and treatment of highway drainage.

A central issue for the leaching process in the road structure is the quantity of water infiltrating through the pavement. Over a period of time, bituminous pavements undergo cracking, which probably leads to very high infiltration capacity. High salt concentrations in the water infiltrating the road structure will affect the chemical state and mobility of metals in several ways.

Work Package 4 will discuss **performance-related properties**. This will include an inventory and survey of water related factors relevant for an appropriate pavement performance.

Both bearing capacity and frost actions will be studied and related to the moisture content of the pavement structures. Included in the investigations will be moisture versus compaction and moisture versus fines (plasticity, type etc.). Finally a review and investigation of relationships between laboratory and field analysis will be given. Within this WP field experiments could be a part to investigate relevant factors in full scale.

Work Package 5 will result in the **Final Report** that will draw together the essence of the preceding Work Packages. It will summarise, draw conclusions, put forward recommendations, and set programmes for disseminating the work of the Action. Dissemination is a very important part of this task and a special dissemination group will be responsible for this starting relatively early in the action. This will also include hosting and participation in workshops, seminars and relevant international conferences during the second and third years of the Action.

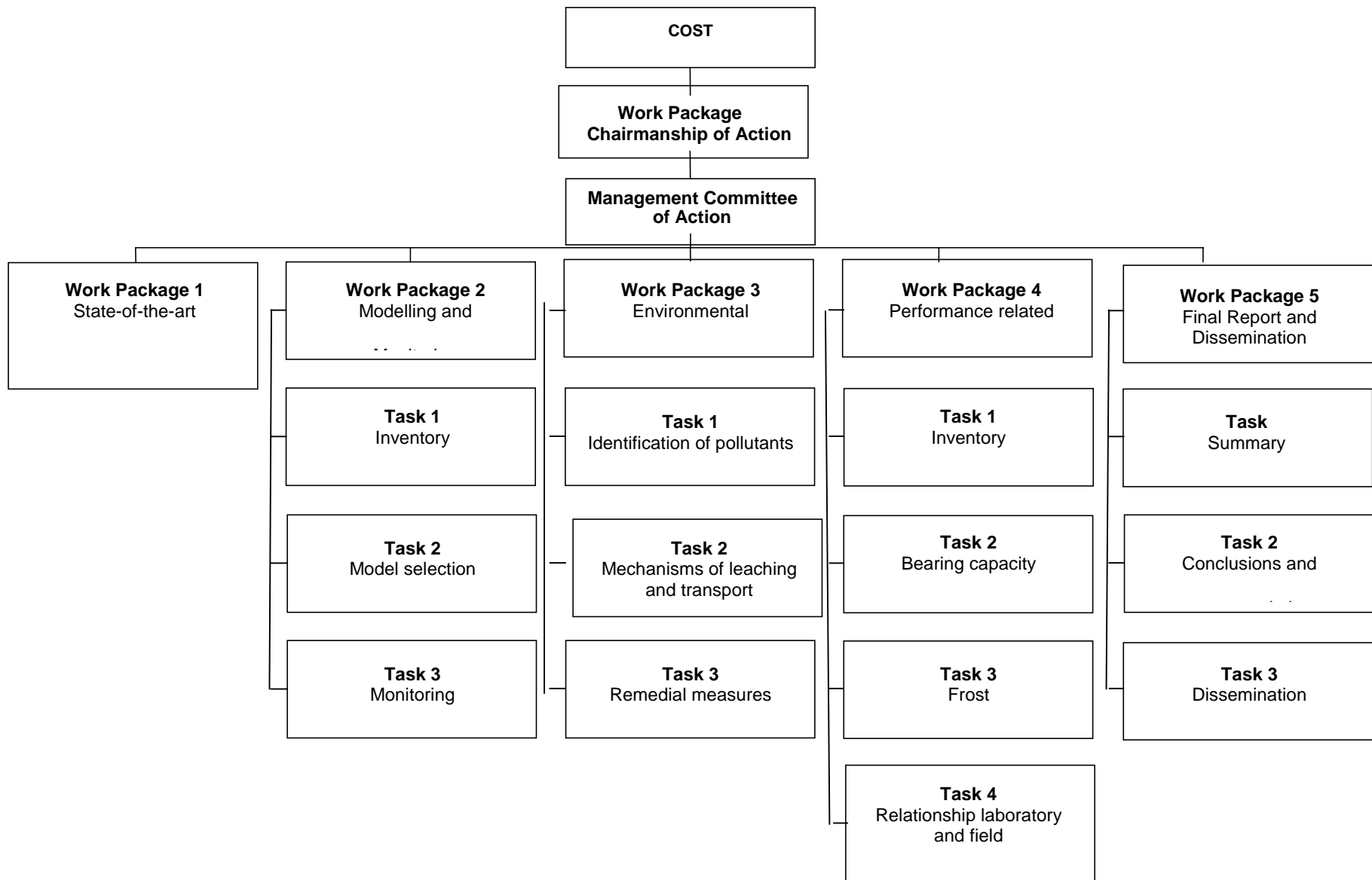
D. Organisation

Given their difference in contents, execution of the five Work Packages requires dedicated groups of experts to work on each of them. Such dedicated groups are also required because of the estimated large number of participants in the Action. Dedicated Working groups will be established to carry out the five work packages, submit the deliverables and findings for discussion with the Management Committee.

The work on the five Work Packages should be stimulated and directed by the Management Committee, which would comprise the Chairman of the Action, the Chairmen of the Work Package groups and the COST secretary to the Action. The Management Committee will report to the COST Technical Committee on Transport. In addition to its management responsibility, the Management Committee will be responsible for the Action's Final Report and for stimulating dissemination and implementation.

In Work Packages that have been split into Tasks, the Task Leader of each Task will report to the chairman of the Work Package. The organisation diagram for the Action is shown below. Balanced consideration will be given to time management, financial matters, organisation, information and quality assurance.

A technical review of the work and the products will be undertaken before being accepted as complete. A procedure for the technical quality assurance will be set up in which each Work Package has a Monitoring Group consisting of one or two partners, who are not involved in the particular Work Package. It is the obligation of the Monitoring Group (or Monitoring Person) to ensure that the quality of the work carried out is satisfactory and that the expected work of each Work Package is provided.



F Economic Dimension

With respect to the actual cost of the Action, a large number of European countries will participate. The following 14 COST countries have actively participated in the preparation or otherwise indicated their interest:

Austria	Iceland
Belgium	The Netherlands
Denmark	Portugal
Croatia	Slovenia
The Czech Republic	Sweden
Finland	Switzerland
France	The United Kingdom

On the basis of the national estimates provided by the representatives of these countries, the economic dimension of the activities to be carried out under the Action has been estimated, in 2002 prices, at roughly **Euro 4 million**.

The estimate is valid under the assumption that all the countries mentioned above but no other countries will participate in the Action. Any departure from this will change the total costs accordingly.

The background economic dimension of the Action is immense. The annual cost of pavement construction and maintenance across Europe is in the multi-billion Euro range, whereas the associated user costs are even higher. Therefore, an Action aimed at improvements and innovations in research tools that can lead to optimisation of road materials, road performance and structural design models for road pavements, will contribute to significant cost savings over the Europe-wide road network.

G **Dissemination**

The main input to this COST Action comes from experts drawn from national road administrations and road research institutes, whilst academia and the European road industry would also be strongly represented. The results from the Action will be disseminated directly to the national level through the participating experts and the participating administrations.

- Through the national road administrations results of the Action will be
 - implemented in the technical standards and specifications for road construction;
 - passed to engineers in charge of planning and execution of road construction and rehabilitation.
- It is further planned to formally disseminate the findings in the form of
 - special reports and a final report of the Action;
 - information on its activities and results on the Web;
 - conferences and seminars in the field of highway engineering.
- At the national level, meetings and seminars will be held to update engineers at different levels of road administrations and the road industry.

ANNEX to the COST 351 Action “Watmove”

The following countries and institutions have indicated their interest to participate in this COST Action (the Annex is not a part of the MoU, it serves only as an information):

List of Participants

AUSTRIA

Arsenal Research, Vienna
(B. Wimmer)

BELGIUM

BRRC - Belgian Road Centre, Brussels
(Eric Van den Kerkhof)

DENMARK

Danish Road Institute, Roskilde
(Knud A. Pihl)

CROATIA

IGH - Civil Engineering Institute of
Croatia, Zagreb
(Mate Srsen)

CZECH REPUBLIC

CDV - Transport Research Centre, Brno
(Karel Pospisil)

FINLAND

VTT – Technical Research Centre
(M.Huhtala)

FRANCE

LCPC, Bouguenais

ICELAND

Public Road Administration

THE NETHERLANDS

DWW, Delft
(G. Sweere)

PORTUGAL

Laboratorio Nacional de Engenharia Civil,
Lisbon
(Mrs. T.Leitao)

ICERR, Coimbra

(R.Lacerdo)

SLOVENIA

ZAG, Ljubljana
(B.Leben)

SWEDEN

VTI, Linköping
(L Bäckman)

SWITZERLAND

LAVOC, Lausanne

UNITED KINGDOM

TRL, Crowthorne