CEDR Transnational Road Research Programme
Call 2012: Recycling: Road construction in a post-fossil fuel society

Funded by Denmark, Finland, Germany, Ireland, Netherlands, Norway.

International workshop on Recycling: Road construction in a post-fossil fuel society

Date: 24.-25.09. 2015

Location: Faculty of Civil Engineering, Czech Technical University in Prague

Address: Faculty of Civil Engineering CTU in Prague
Thákurova 7
166 29 Praha 6
CZECH REPUBLIC

NO REGISTRATION FEES – FREE ACCESSIBILITY
Background to the CEDR Call 2012 Recycling programme

This workshop is organised as the final event of the CEDR Call 2012 Transnational Research Programme. CEDR, the Conference of European Directors of Roads, initiated this programme in response to the common research needs of its National Road Administration (NRA) members. The Recycling programme was formulated by CEDR’s Technical Group Research and is being managed on behalf of CEDR by the National Roads Authority in Ireland. The participating NRAs in this Call 2012 are Denmark, Finland, Germany, Ireland, Netherlands and Norway who provided the funding and technical management for the programme.

The overall aim of the Transnational Research Programme “Road construction in a post-fossil fuel Society” is to develop concepts and strategies for road construction with limited resources of construction materials. The solutions must be feasible, valid and cost-effective.

It therefore aimed to develop new concepts for road construction especially for pavements in the context of the finite nature of fossil fuels and other resources. Recycling and a minimised use of resources is therefore inevitable and of increasing importance.

The programme is based on three objectives which were developed with the concepts of:

A: Investigation of recycling and multiple recycling of construction materials
B: Creation of technological replacement solutions for currently used resources of construction materials
C: Availability of the road network in a post-fossil fuel society

EU land transport policy recognises the importance of road transport through its stated aim of promoting “sustainable mobility that is efficient, safe and with reduced negative effects on the environment”. Large investment in road infrastructure is being planned and performed across Europe each year, and this plays an important role in economic growth and improved welfare on one hand, and use high amounts of construction products on the other. These products are partly based on fossil resources (e.g. asphalt) which become increasingly scarce and expensive as the demand for petroleum products increases considerably.

Conclusions and recommendations arising from this research must be presented in a format that allows implementation in all EU Member States without significant alteration or investment. This should take account of the prevailing conditions of different road authorities, their responsibilities, their own national standards, maintenance strategies, etc. These should not be an obstacle to the implementation of research findings from this programme. Proposals should also outline the strengths, weaknesses, opportunities and threats of their findings so that Member States can determine with a reasonable degree of certainty how such findings can be integrated into their respective national road programmes and plan accordingly.
Objective of the workshop

This workshop is the final event of the programme which brings together three research projects (EARN, CoRePaSol, AllBack2Pave) that were procured under the CEDR Transnational Road Research Programme Call 2012: Recycling. The objective of the workshop is to present the results of these projects and provide a forum to discuss implementation at both national and European level.

Reasons to attend

The participant will get condensed practical information related to asphalt pavement recycling focused mainly on:
- effective implementation of reclaimed and secondary materials in terms of their durability and life-cycle effects;
- combination of asphalt recycling and potential of warm technologies;
- effective design and testing of cold recycled mixes including possible use of functional test methods;
- environmental aspects of asphalt cold recycling (leaching, eco-balance, multiple recyclability)
- up to 100% recyclability of asphalt for surface courses (AC and SMA);
- design methodology and performance limits of asphalt mixes with increased reclaimed asphalt content.

For each of these topics the research conclusions will be presented: proposed practical guidelines and methodologies for implementation will be discussed.

REGISTER FREE: send email with your name and affiliation to recycling2015@seznam.cz

Workshop organisation

Technical Programme Team:
C. Nicholls (TRL)
A. Blasl (TU Dresden)
K. Mollenhauer (University Kassel)
J. Valentin (CTU)

Organization Team:
J. Valentin (CTU)
Z. Cizkova (CTU)
J. Suda (CTU)
P. Mondschein (CTU)
with support of O. Ripke (BASt) and A. Daly (NRA)
## Workshop programme

### 24th September 2015

<table>
<thead>
<tr>
<th>Time</th>
<th>Activity</th>
<th>Speaker</th>
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<tr>
<td>10:45 – 11:50</td>
<td>Registration, coffee break <em>(baguettes for a light lunch)</em></td>
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<td>11:50 – 12:30</td>
<td>Welcome address of the Dean of FCE CTU Prague&lt;br&gt;Introduction, objectives and expectations of CEDR&lt;br&gt;Transnational Research Programme, Call 2012: Recycling</td>
<td>Prof. A. Kohoutkova&lt;br&gt;O. Ripke (BASt) / A. Daly (NRA)</td>
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<td>12:30 – 15:00</td>
<td><em>Session I</em>: Effects on availability of road network related to increasing recyclability and reducing energy demand <em>(4 presentations)</em>&lt;br&gt;Discussion</td>
<td>Moderator: J. Valentin (CTU)</td>
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<td>15:00 – 15:20</td>
<td>Coffee break</td>
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<td>15:20 – 17:50</td>
<td><em>Session II</em>: Harmonised characterisation of cold recycled asphalt pavement solutions <em>(4 presentations)</em>&lt;br&gt;Discussion</td>
<td>Moderator: F. Wellner (TUD) or D. Lo Presti (UNOTT)</td>
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<td>18:30 – 21:30</td>
<td>Dinner</td>
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### 25th September 2015

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<tr>
<th>Time</th>
<th>Activity</th>
<th>Speaker</th>
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<tr>
<td>9:00 – 11:30</td>
<td><em>Session III</em>: Sustainable 100% recycling of reclaimed asphalt in road pavements <em>(4 presentations)</em>&lt;br&gt;Discussion</td>
<td>Moderator: K. Mollenhauer (Uni Kassel)</td>
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<td>11:30 – 12:40</td>
<td>Lunch</td>
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<td>12:40 – 13:50</td>
<td>Project EARN round table discussion <em>(session I)</em></td>
<td>Moderator: C. Nicholls (TRL)</td>
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<td></td>
<td>Project CoRePaSol round table discussion <em>(session II)</em></td>
<td>Moderator: J. Valentin (CTU)</td>
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<td></td>
<td>Project AllBack2Pave round table discussion <em>(session III)</em></td>
<td>Moderator: F. Wellner (TUD))</td>
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<td>14:00 – 15:00</td>
<td>Final discussion panel on actions, targets and strategies in the field of pavement recycling:&lt;br&gt;- key messages from the projects&lt;br&gt;- Identified synergies&lt;br&gt;- focus of road construction, maintenance and rehabilitation with respect to recycling</td>
<td>Moderator: C. Nicholls (TRL)&lt;br&gt;O. Ripke (BASt) / A. Daly (NRA)</td>
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<td></td>
<td>Closing remarks</td>
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*Each session will be organized by one CEDR project.*
What will be presented

Session I: Effects on availability of road network related to increasing recyclability and reducing energy demand

P1: EARN background data (K. Mollenhauer)

P2: EARN site trial (S. Cassidy)

P3: Laboratory testing for EARN (K. Varveri)

P4: Modelling for EARN (M. Wayman)

Session II: Harmonized characterization of cold recycled asphalt pavement solutions

P1: Harmonized advanced mix design for cold recycling (F. Batista)

P2: Durability related characterization of cold recycled mixes – stiffness, fatigue, cracking, moisture susceptibility (J. Valentin)

P3: RAP activity, ageing of cold recycled mixes and multiple recycling (K. Mollenhauer)

P4: Cold recycled mixes and leaching (C. McNally)
   Cold recycled mixes and carbon footprint/eco-balance (J. Valentin/M. Engels)

Session III: Sustainable 100 recycling of reclaimed asphalt in road pavements

P1: Allback2Pave background data + material selection (G. Canon Falla)

P2: Allback2Pave End-User-Manual (G. Di Mino)

P3: Material performance (A. Blasl)

P4: Sustainability Assessment (D. Lo Presti)
Summary of workshop topics

**Effects on availability of road network related to increasing recyclability and reducing energy demand (Project EARN)**

**Coordinator:** TRL Ltd. (UK)

**Partners:** University of Kassel (Germany), University College Dublin (Ireland), Technische Universiteit Delft (Netherlands), Lagan Asphalt (Ireland), Shell Bitumen (UK)

**Description:** This project was designed to assess the effect that changes in durability of road materials due to the inclusion of reclaimed and secondary component materials in the manufacture of new road materials will have on the cost of the construction, both financially and with regard to the environment. There is a need for engineers, particular the client’s engineers, to understand the full implications of using reclaimed and secondary materials. Whilst efforts to make highway construction more sustainable are laudable, they must be effective over the longer-term and not be just reduced cost and/or environmental impact on the construction phase alone. If the use of such components in the mixtures does affect the serviceability or durability of the mixture, then any savings may be transitory.

The project built upon existing knowledge, supplemented by limited site and laboratory studies, to develop a specific model to look at this issue and to provide indicatory values for use in the model. The existing knowledge was extended with an extensive literature search on the times for construction and the relevant effects that determine the service lifetime of the different pavement layers. The site trial looked at mixtures with and without reclaimed asphalt, but had to assess their durability from early-life properties. The laboratory trials concentrated on the combined effect of ageing and moisture damage on the performance of selected asphalt mixtures containing different proportions of reclaimed asphalt.

All three strands were fed into life-cycle analysis models to customise them for the effect of using alternative component materials on the availability of the network and their overall financial and environmental costs. From this modelling, a decision model was developed.
Harmonized characterization of cold recycled asphalt pavement solutions
(Project CoRePaSol)

Coordinator: Czech Technical University in Prague (Czech Republic)
Partners: LNEC (Portugal), University of Kassel (Germany), University College Dublin (Ireland), Wirtgen GmbH (Germany)

Description: This project focused mainly on harmonizing mix design of cold recycled bitumen stabilized materials (mixes) following the existing scientific and engineering experience and approaches. The key objective in this relation was to develop and recommend comprehensive mix design and characterization by studying compaction methods, curing procedures and performance (durability-related) tests. The output is applicable to all variants of cold recycled mixtures containing bituminous binders or combination with other hydraulic binders or alternative fines. Aspects considerable for defining durability of cold recycled mixtures were evaluated and specified as well. The existing practice has focused so far only on water immersion and partly stiffness. Both characteristics are not a standard part in all mix designs known in Europe. Nevertheless to vindicate and promote cold recycling as an alternative solution for hot mix asphalt bases the durability of these less-known materials must be predictable. For this reason the project focused on assessing stiffness, fatigue behaviour, resistance to cracking and moisture effects. Different test procedures were evaluated and the most suitable approaches recommended including proposed threshold limits – where reasonable. This makes performance-based cold recycled mix design for the future possible.

Further gained results were used for formulating possible inclusion of cold-recycled mixture in existing pavement design manuals or approaches. It is primarily not expected to modify the mechanistic calculation of pavement design, more important seems to be the definition of typical structures where cold-recycled bitumen stabilized materials are used for base or binder courses and critical parameters are defined. This should allow to road administrators and designer to use cold-recycled mixtures as a standard component of a pavement structure.

Multiple recyclability presents another key advantage of cold recycling techniques. In this connection activity of reclaimed asphalt, impact of material ageing and range of applicability not only in cold recycled mixtures but also as partial substitute of aggregates in hot (or even warm) mix asphalts was specified and most suitable practice recommended. Last part of the project focused on environmental stability/compatibility which becomes an integral part of building materials’ use and modern civil engineering. Leaching of cold recycled mixtures was studied with recommendations for suitable test methods and possible threshold limits. At the same time some hazardous or problematic materials in existing pavements were assessed in relation to their immobilization and most suitable reuse by cold recycling (tar, crumb-rubber modified asphalt). Last part of environmental stability was devoted to technically correct assessment of cold-recycled mixtures with respect to their carbon footprint. It is believed, that in the near future such energy equivalent will be considered in decision making for most appropriate technical solutions in pavement construction or rehabilitation including considerations on savings and other benefits achievable by recycling.
Sustainable 100% recycling of reclaimed asphalt in road pavements
(Project AllBack2Pave)

Coordinator: Technical University Dresden (Germany)
Partners: University of Nottingham (United Kingdom), University of Palermo (Italy)

Description:
Given today’s societal concerns with environmental protection and sustainable development in a post-fossil fuel era, road authorities in Europe are working together to make the dismantling and end-of-life strategies of asphalt pavements more energy efficient. In this context, the amount of recycling of reclaimed asphalt in new asphalt pavements has grown to the point that it is no longer simply an isolated green construction alternative but a common practice in almost all of Europe. However, in general the proportion of RA in new asphalt courses is rather lower than it could be technically, especially in wearing course layers.

The AllBack2Pave project focused on the research on the feasibility of going toward 100% recycling of asphalt pavements into wearing courses through an increasing percentage of RA within the mixes. To facilitate the deployment of lean concepts and lean production practices, the investigation was implemented in close collaboration with the private sector, including asphalt mixing plants, chemical additives producers and waste material managers.

The main objectives of the project are - to establish, through laboratory tests on binders and asphalt mixes, whether the use of high rates of RA is feasible in mixes with high level of durability, and - to develop an "AllBack2Pave end-user manual" on how to best produce cost-effective and high-quality asphalt mixes with high RA content. This will be complemented by a sustainability assessment of the practice of using asphalt surface mixes with high recycling rates based on chosen European case studies to identify the most cost-effective solutions, together with their environmental impact over the whole lifecycle of selected road pavements.

The mixes selected for the investigations are typical asphalt mixes for wearing courses of road pavements used in Germany (stone mastic asphalt - SMA - with polymer modified bitumen) and in Italy (asphalt concrete - AC - with paving bitumen). The proportion of RA within each mixture can vary from 0% (control mix) to the closest feasible amount to 100% RA. The comparison between the mechanical characterisation results of the control mix and the mixes with an increasing content of RA will identify the most sensitive factors - either good or bad - that affect the mixture performance.
TRANSPORT CONNECTION TO CTU

By plane – from Vaclav Havel Prague International Airport
Take the Bus line No. 119 (it stops in front of the arrival hall of both Terminal 1 and Terminal 2)
The journey by bus takes about 15 minutes
Transfer from the bus No. 119 to the metro line A at the Station Nádraží Veleslavín
Go 2 stops by metro in direction Depo Hostivař
Get off the metro at station Dejvická

By bus – from the Central Bus Station Florenc
Take the metro line C (at station Florenc) in direction Háje
Go 2 stops to the station Muzeum
Transfer from the metro line C to the metro line A
Go 5 stops in direction Nemocnice Motol
Get off the metro at station Dejvická

By train – from the Prague Main Train Station
Take the metro line C in direction Háje (entrance to the station Hlavní nádraží is inside the hall)
Go 1 stop to the station Muzeum
Transfer from the metro line C to the metro line A
Go 5 stops in direction Nemocnice Motol
Get off the metro at station Dejvická

On foot from station Dejvická
See map on the right
Get off the metro line A in direction Šolínova/Technická
Faculty of civil engineering is the to the building at the end of the Technická street
(Distance approx. 550 m / 10 minutes of walking)
City public transport – fares:
All tickets listed below are valid in all public transport vehicles (bus, metro, tram etc.)
Basic – CZK 32 (€ 1.2), ticket is valid for 90 minutes
Short-term – CZK 24 (€ 0.9), ticket is valid for 30 minutes
One day – 110 CZK (€ 4.1), ticket is valid for 24 hours
3 days – 310 CZK (€ 11.5), ticket is valid for 72 hours
– where to buy tickets?
At some bus and tram stops and in all metro stations, there are (usually yellow) ticket machines but you need CZK in cash
At most newsstands
At the airport there are public transport counters in the arrival halls of terminals 1 and 2 (open from 7 a.m. to 10 p.m.)
From the bus driver, but you can buy just the basic ticket for 90 minutes and it is a little bit more expensive – 40 CZK (€ 1.5)

Taxi service
Avoid problems and use services provided only by official taxi companies – we recommend e.g. AAA taxi or Radiotaxi (price to the venue should be about 400 CZK)
Entrance fee – approximately CZK 40.0 (€ 1.5)
1 km – approximately CZK 28.0 (€ 1.05)
1 minute of waiting – about 6 CZK (€ 0.25)

Car connection
DE - Southwest - E50 / D5: (Pilsen / Prague) - Prague Ring Road - Evropská
DE - Northwest - E55 / D8: (Ústí nad Labem / Prague) - V Holešovičkách - Milady Horákové - Evropská
PL - Northeast - E65 / D11: (Hradec Králové / Prague) - Štěrboholská spojka - Jižní spojka - Strahovský tunel - Evropská
A - Southeast - E50 / D3: (Brno / Prague) - Prague Ring Road – Evropská

Venue: CTU in Prague
Faculty of civil engineering
Thákurova 7
166 29 Praha 6 – Dejvice

GPS: 50.1037808 N
14.3896447 E

Parking
In the vicinity of the Faculty of Civil Engineering – Streets Bílá, Bechyňova, Kolejná, Kadeřávkovská
Paid secure parking – Šolínova street (7:00 a.m. to 10:00 p.m.)
– Vítězné náměstí (nonstop)
Hundred-Towered Prague is widely regarded to be one of the most beautiful cities in the world. For the richness and beauty of its monuments, the historical city center was placed on the list of UNESCO World Heritage Sites in 1993. It is especially the historic city centre with its narrow picturesque roads and many monuments that attracts every year millions of tourists from all over the world. Prague is the fifth most visited city in Europe.

Prague, the Heart of Europe, is the capital and largest city of the Czech Republic. It is the political, cultural and economic center of the whole country. Already since the pre-Christian era it has always been at the forefront of Czech statehood, the seat of Czech kings and emperors and after that the seat of presidents. Prague has over 1.2 million inhabitants.

Prague, Mother of Cities, developed into its present form for eleven centuries, but its origins date back perhaps even till to the 4th century AD. It still keeps its very attractive charisma of a city, where you meet history on every corner. It is no exception that the Baroque façade hides Gothic masonry and the same house has also Romanesque basements.
**Prague castle** towering above the historic city center is according to the Guinness Book of Records the largest castle complex in the world. It measures 570 m in length and 130 m in width. The oldest documented roots of Prague Castle date back to the year 880.

Part of the castle complex is among others the unique and monumental St. Vitus Cathedral. Its foundation stone was laid in 1344 by King Charles IV on the occasion of the advancement of Prague bishopric into the archbishopric. However the cathedral construction was not completed until the year 1929.

**Charles Bridge** is another monument that commemorates the flourishing period of Prague in the 14th century during the reign of Charles IV, when e.g. the world-renowned Charles University was founded as well. Charles Bridge is the oldest of 17 current Prague bridges connecting the city spread on both sides of the river Vltava. The gothic bridge is decorated by 28 mostly baroque sculptures. Together with the silhouette of Prague castle and the baroque church of St. Nicholas built by Christoph and Kilian Ignaz Dietzenhofer, forms the Charles Bridge one of the most characteristic views of Prague.