INFRAVATION SCOPE

DEFINING THE SCOPE OF THE INFRAVATION ERA-NET PLUS

14/2/2014

This document, drawn up by a Scoping Team of international road infrastructure experts between July-December 2013, defines the topics of the Infravation ERA-NET Plus programme within seven defined challenges.

Preamble

Infravation is a challenge-driven ERA-NET Plus (EN Plus) programme initiated as a pooled research fund to develop transport infrastructure innovations which address the challenges identified in the European Commission's White Paper on Transport: Smart, Green and Integrated transport. Its objective is to enable a high quality infrastructure offering high service levels to the user/economy/society through solutions for both new and existing infrastructure.

This Infravation Call is aimed at cost-effective advanced systems, materials and techniques in road infrastructure construction and maintenance, including repair, retrofitting and revamping. The solutions called for include materials technology, methods and processes, and supporting systems, such as for monitoring, communication and energy.

The Infravation Call falls under the scope of SST.2013.1-3. ERA-NET Plus 'Advanced systems, materials and techniques for next generation infrastructure'. Though the titles of the calls FP7 SST.2013.5-3 'Innovative, cost-effective construction and maintenance for safer, greener and climate resilient roads' (already closed) and H2020 MG.8.1-2014 'Smarter design, construction and maintenance' might suggest overlap, the detailed scope of the Infravation Call clearly identifies the technology targets that Infravation is aiming for. In some areas there could be some potential overlap, but applicants should then be aware that these are critical areas where the Road Authorities have identified a significant need for new and better solutions. The European Commission (EC) and Infravation will liaise closely to avoid funding duplicate research and to make sure research projects will be complementary.

The following scope description is divided into seven challenges each holding a clear focus. In the scope description, the word 'infrastructure' is used as an umbrella for the different constituting parts (i.e. pavements, bridges, tunnels). In the proposals it shall be clear for which infrastructure part or element the proposed solution applies and what specific problem is solved.

Expected impacts

To guide the proposers, the more detailed description of each challenge contains a paragraph that clarifies and quantifies the guiding objectives for that specific challenge. The expected impacts below give an overview of the overarching general impacts foreseen within Infravation.

Resource efficiency:
Better quality, improved recycling, and the application of circular economy principles (e.g. approaches like cradle to cradle, fully reusable materials) will reduce the extraction of scarce (construction) resources such as energy and raw materials (both mineral and fossil). In addition, advancements in modelling for design, construction and maintenance will allow further reduction of material need in infrastructure as contingency factors can become less conservative and modularisation and standardisation of structural elements will enhance their reuse after end of life.

Accessibility:
Transport flow will experience less intrusion through advancements in materials, systems and techniques for construction, inspection and maintenance. Interventions will be executed more swiftly and will allow more effective transport flow capacity during works. In addition advancements in predictive performance and deterioration modelling allows for interventions that are 'just in time'

and ‘just enough’. They will result in less degradation of the infrastructure as failure mechanisms are detected early in their occurrence, allowing earlier and more optimal response from the asset manager.

Cost efficiency:
The advancements from the seven challenges will result in a considerable improvement in cost-efficiency along the construction process chain, ultimately resulting in better value for money for the asset manager. Key factors for lowering infrastructure life cycle costs are the better prediction of performance and deterioration as well as a quicker introduction of cost saving innovations. The implementation of the advancements will improve the competitive edge that Europe’s and the United States’ construction industry has already which in turn will yield growth and high quality employment. On a higher level Europe as a whole will benefit from better transport accessibility as this is a key economic driver.

Safety:
Better roads that need less maintenance are inherently safer roads for both user and workforce. Key for road user safety is the reduced deterioration of infrastructure and the reduced need for barriers during works. Road worker safety benefits from swiftness in execution, for which automated and autonomous processes are key.

Challenge A: Advanced predictive infrastructure performance processes

To accommodate the performance of current and novel materials and/or design and construction techniques, as well as different conditions (such as different climatic and/or traffic conditions), a better prediction of how infrastructure assets will perform is needed. This requires the development and integration of performance and deterioration models into asset management systems. The role of advanced accelerated testing techniques to complement such models should be considered.

Guiding objectives

Current best practices in asset management systems have a large uncertainty in the prediction of infrastructure performance, which is largely based on empirical knowledge. As a result, contingency factors in design, construction and maintenance tend to be conservative. In addition, the introduction of new materials, systems and techniques is time consuming. Reducing these uncertainties would remove a key barrier for achieving optimal practices in terms of performance, cost and risk.

This specific challenge is aimed at enabling an improvement of factor 2 in the accuracy with which the (remaining) useful life of infrastructure is predicted in relation to applied materials, design, construction and maintenance techniques, and under a representative array of service conditions (e.g. traffic loads, climate).

An integrated suite of next generation predictive performance and deterioration models is needed for design, construction and maintenance practices. The models shall have accuracies that reflect the requirements of the asset manager's performance indicators (PI) and that are superior to current practices to the effect that it allows for *immediate improvement in current infrastructure practices* as well as for *the introduction of novel construction and maintenance approaches within the next 5 years*. The suite should be accompanied by complementary testing techniques and performance indicators during operation.

Research Questions

A.1 Next generation predictive models for infrastructure performance and deterioration, including updating leaps in current models:

New (e.g. probabilistic or deterministic)models need to be developed for the prediction of material and structural performance and deterioration. Their validation and demonstration in practice shall prove their ability to predict infrastructure performance with appropriate accuracy. This shall include various conditions, current designs and materials as well as novel road design materials for which no knowledge exists at present. The models should be based on sound physical principles and they might be either numerical or/and empirical methods, such as through the application of artificial intelligence, requiring a minimum of (time consuming) empirical testing. Cost and time shall be independent model parameters. Their validation shall, where relevant, be against life practice measurement data taken from a typical road infrastructure context. The models shall consider the various failure mechanisms (in current and novel materials), increasing traffic loads, recycling issues, and climate effects (see also CEDR Transnational Research Programme: call 2013, Energy Efficiency[1])

[1] http://www.cedr.fr/home/index.php?id=226

There are already various concrete examples of their application, such as capturing the effect of moisture on performance of bituminous mixtures, and correlation of damage models based on results from sensor monitoring of steel corrosion in reinforced concrete structures. On the level of the production-construction chain, it includes integrated process chain simulations in order to allow ex ante evaluation of maintenance requirements over the life cycle of the infrastructure.

Challenge B: Enhanced durability and life-time extension

Extending the life-time of infrastructure contributes to reducing both resource use and congestion. Materials and techniques that provide the cost-effective upgrading and rehabilitation of infrastructures will be developed. This could include maintenance equipment, coating and/or strengthening materials as well as the systems for retrofitting components.

Guiding objectives

The European road transport infrastructure network as a whole has reached maturity. Large sections of the current road infrastructure network are confronted with the consequences of ageing. Increasingly frequent and more intrusive interventions are required for regular maintenance, repair and strengthening.

Under the current practices and technologies, the cost and loss of transport flow capacity involved would be prohibitive. Novel materials and techniques are needed that can reverse this trend cost-effectively to the effect that the asset manager has considerably improved ability to steer 'target service life', optimised on cost and risk.

This specific challenge is aimed at enabling an extension of the useful life-time of existing infrastructure with up to 100% as compared to 2010 best practices and cost base lines. Proposals in addition may consider application of the solutions in the design and construction of new road infrastructures. The guiding objective then would imply a 100% extension as compared to current best practices.

Novel solutions are needed for rapidly restoring structural strength and functional properties in existing infrastructure when it has reached end-of-useful-lifetime, including the complementary application systems and equipment. Inroad infrastructure, the desired solutions relate to surface repair methods, strengthening for increased bearing capacity and extending transport flow capacity.

Research Questions

B.1 Surface repair methods:

Failure mechanisms are related to both structural strengths as well as to functional properties. For roads, properties such as skid resistance, ravelling and rutting determine the life time of a wearing course. For this purpose, technologies, materials and systems that are able to restore or extend these functional properties are of interest. This could include sealing techniques to restore the functional properties of, for instance, the binders applied. In some cases surface treatment in the form of paints or coating could be cost-effective. For example, surface treatments based on nano-technology could contribute to better durability and less maintenance as they could introduce self-cleaning characteristics. In bridge design and retrofitting, fibre reinforced polymers (FRP) are widely used in combination with traditional construction materials such as steel and concrete.

B.2 Strengthening for increased bearing capacity:

Within this scope the aim is to extend the structural life, including the use of new materials. Here we can find multi-material technologies where the material has been chosen based on function rather than traditional preference. Examples include improved steel reinforcement for reinforced and pre-stressed concrete structures, the use of durable reinforcement bars and the use of ultra-high-performance concrete (UHPC) and composite materials for strengthening and emergency repairs.

Introducing new materials and material combinations put focus on the development of joining technologies.

B.3 Extending the capacity of road infrastructure by geometric modification:
When it is not feasible to design new road infrastructure, a change in geometry could be used to accommodate new traffic conditions. Typically, this would include widening of roads and bridges through retrofitting. A successful project would include systematic evaluation and selection of the most appropriate solutions, including the construction process, for the modified structure.

B.4 Novel materials for increased durability and lifespan of new road infrastructures:
The application of novel materials in the retrofitting and revamping of existing infrastructure could also have an application in the design and construction of new infrastructure. The development validation and demonstration of the appropriate material technologies should be based on its projected functional performance in terms of reliability, availability, maintainability and safety. Hence the solutions should include a thorough assessment of their future repair and re-use/recyclability potential.

B.5 Rapid, non-intrusive construction and maintenance systems and techniques:
These are a key enabler for cost-efficiency in infrastructure asset management. The introduction of next generation ICT integration and automation in the process chain offer great potential to speed up the construction and maintenance lead times and would, in addition, allow for a reduction of safety measures for infrastructure workers. In turn this would decrease the overall intrusion on the transport flow of such interventions. The state of the art in automated and autonomous technology in other industrial sectors offers considerable potential for adoption in infrastructure construction industry. This could include adoption in production units, transport and on-site working methods in road pavement construction, bridges, tunnels, etc. for example in prefabrication, autonomous machinery and auxiliary equipment (autonomous machinery and robots) as well as in tunnel boring and jumbo drilling machines for tunnel excavation and construction. Solutions could include prefabrication and modularisation concepts and approaches as they would offer the benefit of uniformity.

Challenge C: Rapid and non-destructive methods for routine quality and performance checks of materials and construction

Traditionally, on-site controls of materials, mixes, compaction and other pavement and structure characteristics have been based on single-point, partly or fully destructive measurements. Innovative methods that result in a step-change will be developed that replace these tests. This could include self-monitoring materials and equipment (e.g. robotics), non-intrusive observation techniques or other methods of ensuring quality and performance control more safely, quickly and/or to a higher degree of accuracy and precision. The demonstration of the benefits in comparison to existing standards and specifications is needed.

Guiding objectives

In the construction industry, the traditional ways for quality control of materials, mixes, compaction and other characteristics for pavements and structures are based on single-point measurements that are partly or fully destructive. This traditional approach gives little or no direct feedback to production or execution procedures. The fact that both the control factors (input) and the characteristics that reflect the process (output) have a certain variation makes it impossible to produce two identical products in infrastructure construction. This variation in properties is reflected in the variation of the performance of the infrastructure itself. Infrastructure asset managers have a strategic interest in reducing this variation of performance in the production process as it is essential for them to have the right quality delivered at the right time.

This specific challenge is to enable an improvement factor 2 in the variation of functional properties of infrastructure construction products and processes through a next generation of integrated quality control system across the entire infrastructure construction process chain.

As well as considering the production phase, there is a need for a better, quicker and more reliable monitoring of the performance of new and present infrastructure in time. Addressing this challenge depends heavily on the adequate and timely availability of appropriate performance data and indices. Therefore, novel (non-destructive) monitoring methods, techniques and routines need to be developed, validated and demonstrated that can measure the performance of road infrastructure through appropriate parameters (see also CEDR Transnational Road Research Programme: call 2013, Ageing Infrastructure Management[2]). The demonstration of the benefits should be made in comparison with current best practices.

Research Questions

C.1 Performance indicators &systematic design for quality in the production phase:

In order to improve construction process performance in terms of variation and level, precise performance indicators are required for vital design drivers that are measured on a systematic basis and that can be fed downstream in the process in such a way that production and execution processes are controlled on the basis of those measurements. Better quality and less variation will enable designs that are less sensitive to small adjustments in later design stages, or during execution of the work and operation. For example, in road pavement construction such quality control system could integrate the production, transport and on-site working processes for relevant materials as

[2] http://www.cedr.fr/home/index.php?id=226

base course materials, subsoil, bituminous mixture and concrete. In the case of tunnel excavation such a system could include the check of ground quality and settlements. In general(for roads and bridges) typical parameters that determine the structural design and performance include traffic volume, load size, vehicle accelerations, temperature, strain and load bearing capacity.

C.2 Next generation testing and monitoring in the exploitation stage:
New methods need to be developed, validated and demonstrated for advanced performance monitoring during infrastructure use. In order to minimise intrusion in the transport flow such methods would be non-destructive, minimally invasive or from the proximity. The methods need to be capable of yielding rapid and accurate inspection results allowing an adequate response from the asset manager. When relevant, they should be able to cover large inspection areas in a minimum of time. Application domains include the detection of geometrical and visual anomalies on bridges, and evaluation of functional properties of road pavements, such as skid resistance and bearing capacity. Other application domains include inspection of road construction, ground quality detection and settlements during tunnel excavation, and corrosion of steel reinforcement in concrete structures.

This could include self-monitoring materials and autonomously operating equipment (*e.g.* robotics), non-intrusive (remote or proximity) observation techniques, such as image processing, data interpretation through artificial intelligence, Charge-Coupled Devices(CCD)or other methods that ensure quality and performance control of the infrastructure in time, more safely, more quickly and/or to a higher degree of accuracy and precision(see also CEDR Transnational Road Research Programme: call 2013, Ageing Infrastructure Management[3]).

In case the approach would be embedded or use add-on sensors and systems, their power supply needs and servicing or upgrading requirements will be part of the evaluation as key objective aspects are high reliability, availability, maintainability, speed of execution and minimal intrusion on the transport flow. Proposals could also take into account rapid developments of in-car data collection and the possible use of these data in predicting the condition of infrastructure.

[3] http://www.cedr.fr/home/index.php?id=226

Challenge D: Keeping freight routes open through zero-intrusive maintenance

Projects will focus on novel products/techniques with the specific objective of ensuring reliable corridors for heavy freight, also during infrastructure maintenance. This will provide systems and techniques that better cope with increased heavy-vehicle volumes. It could provide ways of overcoming current limitations on infrastructure usage, coping with bottlenecks and, where necessary, include links with other modes. Specific attention may be given to the challenges of infrastructure maintenance in heavily freight-used sections where alternative routes are not practical. Robotic techniques, prefabrication and the use of adaptive/temporary structures can be considered.

Guiding objectives

Approximately 1 % of the European Union's GDP is lost due to disturbances in the transport flow, part of which is on account of repair, maintenance, retrofitting and revamping. Under a 'business as usual' scenario, this part will rapidly increase as the need for such interventions increases due to ageing of the infrastructure and rapid growth in traffic (and freight) volumes.

Recent studies indicate that bridges are the largest bottlenecks as often alternative transport routes are not practical or available when the repair, maintenance, retrofitting or revamping of these bridges is ongoing. Similar issues occur in various congested sections of the trans-European road network, with a corresponding threat to an efficient trans-European freight transport flow. In particular for these specific bottlenecks advanced, cost-effective solutions are urgently needed that leave their freight capacity largely intact during maintenance interventions. It is obvious that not only freight traffic benefits from these new solutions, but the traffic flow as a whole as well.

This specific challenge is to enable at least 80% of the original freight transport flow capacity under revamping interventions on key bottlenecks in the trans-European road corridors.

Research Questions

D.1 Rapid repair, maintenance, retrofitting and revamping:

In order to enable a quick return to full freight service, novel solutions are needed for rapid repair, maintenance, retrofitting and revamping for future traffic requirements with minimum cost and minimum traffic disruption that do not compromise the end quality under current practice. Such solutions are concerned with all aspects of the intervention process, not excluding other out-of-the-box approaches. They can span from the use of fast curing products to integral process control through the application of advanced BIM (Building Information Modelling) and other advanced ICT tools and procedures, for example in combination with prefabrication and DFMA (Design For Manufacturing and Assembly) approaches. Also low impact maintenance techniques, such as automated and autonomous processes are included. In addition, solutions include advanced, cost-effective temporary provisions on location that redirect the transport flow away from the working activities without compromising safety and the environment. Cost-effectiveness analysis should be adequately comprehensive as to allow effective engagement of the asset manager with the key stakeholders in the logistics services sector, as well as with the road users.

Challenge E: Ensuring infrastructure performance under all weather conditions

Novel materials and techniques will be developed and demonstrated that allow roads to provide full service under wide-ranging weather conditions. These might include materials that are highly resistant to cold weather (e.g. freeze-thaw), survive extended flooding and other extreme events. Techniques and processes that reduce the adverse impacts of snow, icing, flooding, wind or heat-effects can also be considered.

Guiding objectives

Extreme weather events, such as intense rainfall and flooding, heat waves, extreme winds, increased freeze – thaw cycles and heavy snowfall in winter can have significant impact on our transport infrastructure network and hence, on our society's mobility and economy. It is expected that these events will increase over the coming years and decades with the changing climate.

Solutions are needed that mitigate these impacts to the extent that service performance levels are maintained regardless of the weather conditions. This requires advanced systems, materials and processes that strongly reinforce the infrastructure's resistance to the adverse impacts of extreme weather.

This specific challenge is to enable the enduring performance of the trans-European road network under extreme weather conditions, on a 2010 service level for its reliability, availability, maintainability and safety.

Research Questions

E.1 Next generation of weather-resistant materials for road infrastructure:

Already asset managers experience the adverse effects of the rapidly increasing frequency of frost-thaw cycles on the life span of roads. Similarly disruptions are caused by increasingly frequent cloud bursts and prolonged periods of drought. Therefore, a suite of next generation materials, processes and techniques needs to be developed, validated and demonstrated to mitigate or adapt to extreme events (precipitation, drought, frost, heat, wind). This includes super-pervious pavement concepts that are capable of handling or storing large fluxes of water.

E.2 Weather resilience in design, construction and repair:

In order to ensure adequate levels of reliability, availability, maintainability and safety (RAMS)under extreme weather conditions, the aspect of weather resilience needs to be incorporated in road infrastructure design, construction, maintenance, retrofit and revamp processes. Focus is on retrofitting existing infrastructure to improve its resilience to flooding or to high water tables as well as to prolonged periods of drought. In addition, focus is on the development of specific infrastructure assets that enable rapid repair actions in case of major disasters and emergency situations, such as through the use of composite lightweight materials.

E.3 Real time observation of critical weather events:

Advanced sensing and signalling systems and techniques need to be developed, validated and demonstrated for the real time detection and interpretation of critical events that would jeopardise the reliability and availability of the infrastructure transport flow capacity. Such solutions are required to feed in to the overall management system of the asset manager allowing his optimal response to the situation arising. For example, in case of sudden events such real time information in combination with results from advanced weather and traffic prediction models could enable more flexible traffic management strategies to cope with current and projected weather related disturbances on affected sections of the infrastructure network. Solutions can include data gained through infrastructure-to-vehicle communication as well as through communication channels other than traditional ITS.

Challenge F: Resource and energy efficiency in road construction and maintenance (Eco-design)

Techniques and systems may be developed that allow considerably lower environmental impact during the construction and maintenance of infrastructure. This will focus on processes that do not compromise the required performance and affordability, whilst reducing resource use, energy consumption, water pollution, etc.

Guiding objectives

Current practices in road infrastructure construction and maintenance have considerable potential for resource efficiency improvement in terms of raw materials, energy, water, air, land and soil.

Novel solutions that find root in circular economy concepts and life-cycle (costing) approaches are needed in order to enable optimisation of infrastructure resource efficiency, starting from the design stage and spanning the whole value chain in the construction sector.

This specific challenge is to enable compliance to the objectives and targets as specified in the 'Roadmap to a Resource Efficient Europe'[4].

The focus in this challenge is on enabling eco-balanced road infrastructure designs and energy neutral road infrastructure operations. Proposals that address challenge F and G should align their work with the work that is being done in the ECOLABEL FP7 project*(SST.2013.5-3. Innovative, cost-effective construction and maintenance for safer, greener and climate resilient roads)*

Research Questions

F.1 Eco-balanced design:

Novel, e.g. ICT-enabled solutions need to be developed, validated and demonstrated that enable cost-effective optimisation of designs on their life-cycle use of raw materials, energy, water, air, land and soil, including their use in maintenance and operation stages. For example, such solutions should optimise various designs on dominant material and structural characteristics in order to optimise on material usage which includes raw material extraction, material degradation over the life cycle, and the application of novel materials. Similar examples apply to the other resources involved. Proposals for this topic can benefit from and follow up on the models developed in the ERA NET ROAD II call 2011; Energy[5]. However, care shall be taken not to duplicate with the CEDR Transnational Research Programme: call 2013, Energy Efficiency[6].

This requires development of appropriate methods, and definition of corresponding key performance indicators that are supported by consistent experiments and models. In particular the solutions should enhance the sustainable application of novel, more sustainable resources, such as bio-based materials[7]. In addition the solutions should enable optimisation on the sustainability of existing infrastructure and the materials applied herein. Finally, the solutions should enable optimisation of design on the consequences for transport energy consumption. Examples are

[4] http://ec.europa.eu/environment/resource_efficiency/pdf/com2011_571.pdf
[5] http://www.eranetroad.org/
[6] http://www.cedr.fr/home/index.php?id=226
[7] In the case proposals consider bio based materials, they shall show that the material proposed does not compete in any way with other core societal challenges such as food.

increased fuel efficiency of transport through optimised tyre-pavement interaction and influencing the aerodynamic resistance of transport through infrastructure adaptations.

F.2 Energy neutral operations:

A suite of novel solutions needs to be developed, validated and demonstrated that enables the asset manager to improve the overall energy-efficiency of its infrastructure operations towards *at least* energy-neutrality in the medium/long term. The solutions can include upgrades of current energy applications, such as next generation lighting and signage systems for roads and tunnels using state of the art LED technology as well as they can introduce entirely new concepts for utilising waste energies in the infrastructure system, or its immediate environment. For example, through piezoelectric systems, vibration energy can be converted into electricity. It is imperative that the proposed solutions do not compromise the reliability, availability, maintainability or safety levels of the infrastructure assets in which they are applied nor should they compromise the energy-efficiency of the other components of the transport system, such as vehicle fuel-efficiency.

Challenge G: Virgin material reduction by substitution or recycling

The development of innovative approaches to utilising advanced materials and techniques in products/services will result in a reduction in the usage of virgin materials and/or the maximisation of the recycling of waste and end-of-life materials. This could include the application of material processing techniques or additives which require the use of substantially less existing materials or which enable the use of substitute materials currently deemed as inadequate by enhancing their quality and performance characteristics.

Guiding objectives

The infrastructure construction industry is a bulk consumer of extracted raw materials. Due to geological and societal constraints, the supply of these materials is diminishing and their prices are on the rise. The limited availability of certain mineral aggregates and crude oil that are fit for the production of bitumen has become a major concern to the industry with the effect that recycling and reuse have become well established practices in many countries.

In certain cases, recycling rates as high as 95% have been achieved. This has been accomplished by introducing demolition wastes and certain reusable industrial wastes (e.g. fly ash, blast furnace slag) in production processes, thereby facilitating a reduction in the consumption of virgin raw materials. These best practices may serve as precursors to a future in which similar rates are common practice across the European infrastructure construction industry. Reuse and recycling are only possible when the quality of the end-product, process or service in question remains uncompromised. According to the principles of circular economy, care must be taken to ensure the future reuse, recycling and substitution of materials.

This specific challenge is to enable compliance to the objectives and targets as specified in the 'Roadmap to a Resource Efficient Europe'[8]. In particular, this implies a short term guiding objective of reusing and recycling at least 70% of non-hazardous construction and demolition waste.

The solutions sought concern techniques and procedures for 1) upgrading materials which, in their current state, are unfit for reuse and recycling, with awareness of and insight into the consequences of current and future construction and maintenance practices (from a cradle-to-cradle perspective) and for 2) identifying materials in terms of their nature and properties.

Research Questions

G.1 Advanced techniques and procedures for reuse, recycling and substitution.

In order to close the material cycles in the construction industry, it is necessary to avoid downgrading as much as possible. This can be done on several levels. The highest level is the re-use of structures or elements of structures. The next level concerns the reuse or recycling of materials. This calls for specific approaches:

- Design of infrastructure in such a way that complete structures or relevant elements of structures can readily be reused.

[8] http://ec.europa.eu/environment/resource_efficiency/pdf/com2011_571.pdf

- Design for reuse on a material level. Materials that are designed to be taken back into the same product without the risk of downgrading. This also calls for a circular economy approach.
- Substitution of recycled materials from external sources for scarce virgin materials in the production process without jeopardising the possibilities of future recycling or re-use (see also CEDR Transnational Research Programme: call 2013, Energy efficiency[9]

Solutions are needed that enhance the take-up of these approaches in the production chain, aiming first at the reuse of structures or relevant elements (as this constitutes the highest level from the viewpoint of sustainability) followed by the recycling of materials within the construction process chain and the substitution of materials from external sources. As a general rule, the cleaner the material is, the higher its sustainable, economic and technical value. In order to bring current reuse, recycling and substitution practices to a significantly higher level, novel solutions are needed which enable the production of superior infrastructure construction materials from construction waste materials as well as from suitable industrial by-products.

This can include the application of solvents and additives to upgrade and enhance the appropriate high value constructive application of a material without compromising the possibilities of reuse, recycling or substitution in later stages of its lifecycle.

In particular, this topic focusses on the recycling of concrete and other materials for high performance construction applications. This includes the ability to manage and control uniform end product quality – which is a major barrier for current concrete recycling efforts. Proposals on asphalt concrete recycling shall be clear on their added value as compared to the CEDR Transnational Research Programme: call 2012 on the subject of recycling[10] . In addition, the focus of this topic is on reuse of complete structural elements through appropriate retrofitting/upgrading procedures and techniques to avoid their demolition.

G.2 Labelling for re-use and re-cycling.

The applicability of an element or material for reuse, recycling and substitution in the construction process chain, would be enhanced by the industry having prior knowledge about their nature, properties etc. This requires smart solutions for labelling and future identification and determination of their recycling route after end of use, such as through radio frequency identification (RFID) technologies. For new materials this could be combined with challenge 3 in order to achieve data bases with all relevant information on the produced infrastructure. For already existing infrastructure, the focus in this topic is on rapid, smart and reliable solutions for identification and determination of the nature of materials and constituents to be able to handle the materials in such a way that high value recycling or re-use can be obtained and pollution of recycling circles can be prohibited.

Proposals that address challenge F and G should align their work with the work that is being done in the ECOLABEL FP7 project *(SST.2013.5-3. Innovative, cost-effective construction and maintenance for safer, greener and climate resilient roads)*

[9] http://www.cedr.fr/home/index.php?id=226
[10] http://www.eranetroad.org