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Developing an Enhanced Thermoelectric Energy Harvesting Approach from Asphalt Pavement

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Abstract:

The importance of green technologies for generating renewable energy and sustainable development is widely accepted. Highway pavements which are exposed to solar radiation, absorb a large amount of heat that could be harvested. This study aims to design an innovative thermoelectric generator system that utilizes the thermal gradients between the pavement surface and the soil below the pavement and converts it to electricity. This system consists of a heat collector, a thermal electric generator (TEG) and a coolant module. A prototype was fabricated to embed directly into asphalt pavements. Several simulations using finite element (FE) analyses were conducted to evaluate the performance of the system components and determine their optimal design. The final design was also tested in the field. Based on the experimental and FE results, the efficiency of the system was enhanced by improving its coolant module by incorporating a phase-changing heat sink. The optimized prototype was able to generate an average of 29 mWatts of electricity for South Texas conditions, which appears to be a promising independent source of power for road-side wireless sensors and near-field data communications. Keywords: Thermoelectric, energy harvesting, asphalt pavement, finite element, phase change material.

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Prediction Model of Electric Energy output of Energy Harvesting Element for Traffic Monitoring

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Abstract:

To perceive traffic conditions, an energy harvesting element was developed and the electric energy output by energy harvesting element to simulated traffic conditions are calculated based on mechanical models, electrical model, and electromechanical coupling model. Results showed that a simpler mechanical-electrical coupling model of piezoelectric transducer for road can be derived by simplifying the vehicle load to half sinusoidal load. The modelling indicates that the energy output of the developed energy harvesting element is only related to parameters of piezoelectric material, loads, and speeds. The mechanical-electrical coupling model was supported by experimental results of piezoelectric transducer's electrical performance. The connection between piezoelectric ceramics also affects the energy output of energy harvesting element. Based on a daily traffic volume of highway, the daily energy output of piezoelectric energy harvesting element embedded in the surface of pavement can reach 950.6J. The six-axles truck contributes the most to the energy output who occupies as much as 52.3% if total energy output.

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The use of a large-scale prototype to investigate the actual performance of a Heat Exchanging Asphalt Layer

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Abstract:

In October 2017 a large-scale prototype for a Heat Exchanging Asphalt Layer (HEAL) was constructed in a cycling path, together with other innovative technologies, such as Fibre Bragg Gratings to monitor the stress and strains, and fiber-reinforced asphalt in the top layer. The HEAL prototype consists of 30 m², 8.5 m x 3.5 m, and includes four circuits of pipes, 50 m of length each, placed in a collector layer. Additionally, two boreholes with a depth of approximately 100 m have been installed next to the cycling path so that heat can be extracted from the HEAL during summer and is available during winter to keep the cycling path ice and snow-free. By using an additional heat pump an overall better efficiency will be obtained. Different sensors to monitor the temperature of the asphalt and fluid were installed, together with a weather station that captures the most important weather parameters, such as wind speed, outside temperature, solar radiation, … By changing the way the different circuits of pipes are connected, it is possible to investigate the influence of total pipe length and pipe layout. Also, the input temperature and flow rate of the water will be controlled and varied during the experiments. An overview of the complete design, including all sensors and electromechanical devices, is given in this paper. Furthermore, some details are included from an extended Finite Element Model which will be validated using the experimental results from the large-scale prototype.

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Colored coatings with synthetic binders : how to satisfy both aesthetics and performance

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Abstract:

Colored coatings are increasingly used for roads, in urban areas more specifically. They allow to create qualitative and colorful areas, to delimit places according to their different use and contribute to good visibility and lighting saving. The safety and comfort of users are therefore improved. The binder formulation requires first the selection of a pair of a resin and an oil which makes it homogeneous and possible to resist to aging. Homogeneity can be especially assessed by Light Microscopy and Atomic Force Microscopy (AFM). Then the resin/oil ratio as well as the action of other additives can complement the formulation to meet the intended applications. For instance binders can be formulated for the manufacture and application of colored pavement structures that can resist to high sollicitations such as bus lanes that are subjected to heavy, channelized and static traffic. The structure that constitutes them must integrate these damaging factors. The rutting performance has been assessed according to different conditions and meets the following specifications: o < 5% at 100 000 cycles (usual conditions) o <15% at 30 000 cycles (more severe conditions : 7 bars , 65°C , 0.1 Hz) Some feedbacks from different type of jobsites are reported . The color of the pavement contributes to the aesthetic. So it is a very important parameter to manage: simulation of UV aging is carried out in laboratory and the evolution of the color during aging is measured by a spectrophotometer which allows the determination of the L * a * b * components using the D65 illuminant (which reproduces daylight with a UV component). and an inclination of 10 °. Some recommendation will be given in order to enhance the laying, the maintenance , and the cleaning of such pavements.

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A sustainable solution to increase the service life of asphalt pavements by harvesting energy from roads

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Abstract:

The locale climatic conditions have a major impact on asphalt pavement structures. Higher temperatures within the construction lead to a reduction in durability. However, increasing temperatures in conjunction with the large road network possess a huge potential to use asphalt pavements as renewable energy sources. Thus, the use of heat from pavements can extend their service life and contributes to the reduction of fossil energy demands. Including a system of pipes into the binder course could be used to cool the paved road, generate electricity, and keep the pavement ice-free during winter. Two numerical models were developed to investigate the influence of thermal management inside the asphalt pavements. A thermal model was used to simulate the transient temperature distribution within the construction over several years. Characteristic temperature profiles were determined on a longtime scale. These representative temperature profiles where then used to simulate the mechanical behavior under consideration of traffic loads with a FEM model. Based on the results, a fatigue analysis of the road construction was done by using the German mechanistic design methodology (RDO Asphalt 09). It predicts an increased durability if high temperatures are reduced and of the amount of usable heat. This thermal energy can be transformed into electric energy by using an Organic Rankine Cycle with an estimated efficiency of about 4 % to 6 %. A test system was built at the Demonstration, Investigation and Reference Area of the German Federal Highway Research Institute. The main objectives were the examination of new installation technologies for the pipe collector and the implementation of a temperature measurement system inside the road construction. Comparisons were made between simulations and measured results. The mechanical properties of the asphalts were determined experimentally with the cyclic indirect tensile test.

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Fiber Bragg grating monitoring system for heavy-duty pavements

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Abstract:

Heavy-duty pavements have met new challenges over the past decades. Many pavements were not designed for servicing today's traffic frequency and axle loads, which impose loads much greater than those initially considered. Both factors result in an accelerated deterioration of the pavement structure. The accurate measurement of the strain and stress distributions in pavement is critical for understanding pavement behavior and modeling failures of pavements. With the development of information technology and digitization, traditional pavement monitoring systems have been integrated with other monitoring systems, including bridge monitoring, Weigh-in-Motion (WIM), traffic classification etc. In the present study, a fiber Bragg grating monitoring system for heavy-duty pavement health monitoring is introduced. The concept was designed by University of Antwerp and first installed together with Com&Sens in a test track demonstration project CyPaTs (Cycle Pavement Technologies) in September 2017. The same advanced system is installed in a larger scale project in a test track in the Port of Antwerp in June 2019. Numerous sensors (strain and temperature) installed between four asphalt layers allow better descriptions of the behavior of asphalt layers under heavy loading during real-time monitoring. This technology can provide strain data for the service life of the asphalt layers during a subsequent monitoring campaign under actual moving vehicular load. Since the accuracy is very high, this technology is appropriate for monitoring the deformation of the asphalt layers over time, considering aging, fatigue and rutting. The real-time monitoring data from the FBG sensors embedded in geogrid and three asphalt layers will be discussed in this study.

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Application of bitumen products for next-generation airports

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Abstract:

The rapid growth in the commercial aviation sector in recent decades has caused more than 40% of existing airports to operate above their planned capacity and will result in many new airports and upgrading projects in the next 5 to 10 years. Over this time, many airport owners are aiming to develop the so-called next generation airport to face challenges such as the operation of New Large Aircrafts (NLAs), increased air traffic volumes and to deliver positive impacts to airport users, neighbors and the environment in an affordable and sustainable manner. However, airfield infrastructure such as runways, taxiway and aprons, is struggling to keep pace with this new trend. The existing bituminous material requirements are lagging against the expectations of airport designers, consultants and operator/management teams. In this paper, the performance requirements for bituminous pavements for next generation airports are analyzed and proposed from different perspective, i.e. durability and sustainability, environmental-friendliness and reduced adverse user/neighbor impact, which are then compared against the existing requirements for bituminous materials from airport projects in the Asia Pacific region.

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Perpetual road pavements with a graphene-based supermodifier

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Abstract:

Developing an innovative super-modifier for enhancing the performance and mechanical properties of heavy-duty asphalt pavements/those that are laid in harsh climates was the motivation of full-scale research, which discussed in this paper. Basically, the studied additive is a polymeric compound modifier containing graphene nanoplatelets for being used by applying the well-known dry method as a sustainable road paving technology. This paper represents the data obtained from the tests, which have been conducted on the specimens reproduced of the samples collected from the first trial section in September 2018, in Rome. Aiming for providing comparative study, the trial section in this practice, which included both binder and wearing course, was divided into four segments made with different mixtures. These mixtures were:1)graphene-based additive containing,2)SBS-modified,3)polymeric compound (composed of both plastomers and elastomers), additive containing, and 4)a reference mixture without any kind of additive made with 70/100 pen-graded neat bitumen. The target was validating the results that were obtained during the three-year-long lab-scale research. The testing plan consisted of Heavy Weight Deflectometer(HWD), Indirect Tensile Strength(ITS), Indirect Tensile Stiffness Modulus(ITSM), permanent deformation resistance by means of Wheel Tracking WT), and fatigue endurance by means of Indirect Tensile Fatigue Test(ITFT). According to the results (in this paper just wearing course), the mixtures containing graphene-based additive showed significantly higher stiffness, superior rutting resistance, and better fatigue endurance compared to the other mixtures, which were tested in this study. In addition to the lab-scale works, the HWD results were also showed a significantly higher estimated stiffness modulus for the mixture containing graphene-based modifier when compared to other tested mixtures. Overall, it is of utmost importance that the obtained results were almost in line with the laboratory-scale research work, which would validate the data. Key words: Performance and mechanical properties;Heavy-duty pavements;Performance and mechanical properties;Graphene nano plateles;SBS-modified;Polymeric compound;Heavy Weight Deflectometer(HWD)

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Tempered road test sections supplied by geothermal energy on duraBASt

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Abstract:

The road performance is strongly influenced by climatic conditions. By limiting the temperature range of the pavement construction from 3°C to 35°C with a heating and cooling system in the pavement its lifetime will increase significantly. Furthermore additional aspects like higher safety level in winter time and the reduction of the use de-icing salt will have valuable positive economic and ecological effects. Different studies have been initiated to test, model and define the parameters for a tempered pavement construction with different variants for heating/cooling systems. An innovative approach is to use a porous polyurethane bound interlayer instead of a pipe register as heating and cooling system. The basic principles have already been evaluated using a model to study and define material and layer characteristics. Based on the research results the realization of a tempered road with different sections consisting of different heating/cooling systems is planned. The new duraBASt testing areal is chosen for the implementation of these test sections. To provide the heating and cooling system with energy the use of geothermal probes is envisaged. Therefore a model was created to study and define the characteristics to maximize the geothermal yield of each variant with the use of information of a nearby weather station, of the surrounding geothermal conditions as well as of the previously defined layer characteristics of the pavement construction. As result a geothermal system has been designed to operate the different variants of the tempered road. Finally, a monitoring system has been designed to evaluate the economic and ecological effectiveness of the variants of the tempered road and its geothermal heating and cooling system. The initial operation of five different test sections of a tempered road is planned at duraBASt in autumn 2019.

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MESHING NEW TECHNOLOGIES USE AND ROAD SAFETY – HUMAN FACTORS CONTRIBUTING TO ROAD ACCIDENTS

Léopold TZEUTON

APTH

Abstract:

A diagnostic study on the status of the introduction and use of new technologies in road and rail transport has just been completed. Furthermore it calls on governments to develop a long-term road safety plan, and emphasises the use of new technologies for making roads and driving safer. The road safety statistics since 1950 are revealing a significant reduction of accidents from 1973 to 2013, based on : Technological upgrading of vehicles Significant improvements to road infrastructure, in particular the development of roads with separate ways, Road safety information and communication campaigns, Stronger and more repressive regulation that has been more effective For the last 10 years, the trend has changed, hence more stable figures, but even a slow but steady increase in accidents and casualties. This phenomenon is a paradox : Despite of an improving technology and stronger regulations, road safety is deteriorating. It is probably at the level of the degradation of the driving behaviour of drivers that we must seek explanations or causes. There is indeed a negative impact of the recent technological innovations on the driving behaviour of drivers: Various and multiple assistance systems (anti-crash, ABS, stability control system, radars, etc.). Indeed these tools reassure drivers but can also relieve them of their responsibility and affect their vigilance. Finally, the proliferation of connected electronic devices (smartphones, tablets, GPS, television, etc.) have extremely harmful effects on the concentration capacity of drivers For technological innovations to be effective in improving road safety, steps and procedures must be put in place to reduce their harmful effects on driving behaviour. To achieve this, we must: Improve driver awareness of this new risk (communication campaign, training) Incorporate in the initial training (and refresher courses) of drivers, new sequences dedicated to the management of new communication tools.

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HOW CAN WE HELP TO TURN RESEARCH AND DEVELOPMENT INTO INNOVATION?

José Luis Peña

Spanish Road Technology Platform

Abstract:

The generation of knowledge by companies, universities and technology centers is very positive according to European Commission criteria. However, their opinion about how much impact R&D generates (innovation) isnot so positive. There are still many opportunities to improve in comparison with other leading countries in R & D, such as the US, Japan or China. The assessment of the level of impact shows that each economic sector has its own peculiarities. In the case of the road sector, since in the vast majority of customers are public administrations, access of innovation into the market becomes even more difficult due to strict regulatory norms. One of the tools that has been boosted to make R & D more fruitful is the use of innovation procurement. In the case of Spain, its development is very unequal. Thus, while in the health sector there is a routinely use, the road sector is quite reluctant to apply it. Traditionally, road administrations will define the technical needs of infrastructures: designs, materials, technical performance, type of maintenance, etc. The arrival of digital technologies and the upcoming incorporation of autonomous vehicles have meant that the technicians of public administrations have lost most of their leadership capacity. Therefore, the current environment demands an adaptation capacity to which our sector was not used to. This paper collects some of the experiences developed in Spain in the field of innovation procurement in the road sector, analyzing advantages, disadvantages, results and applied solutions. Although slowly, the results encourage to use innovation procurement as a lever for the use of technology in the world of road mobility. Keywords: innovation procurement, road.

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Asfalt Impulse program - A Dutch program to stimulate asphalt improvements

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Abstract:

If technicians and asphalt research employees talk about their business, all are eager for change and aiming for more sustainability. Most times people among themselves look to the other party to get progressions in our field of business. And budget for research is always hard to achieve, let alone the need for test-sections to experiment in the field. In The Netherlands this all plays as well; The contractor has wishes for the road-authorities, road-authorities ask new development options at the consultancy agencies, asphalt-plants need options for innovations within projects and so on. Out of this starting point, and the believe that our whole business can do a whole lot better if we get the right chances, a complete new initiative is born; an impulse to the asphalt branch as a whole. In 2018 a big project is started, the Asphalt-Impulse, with a combined budget out of the complete range of the sector. This project started in 2018 and will be continued for the next 5 years. Within the Asphalt-Impulse program all stakeholders work together with a common following aim: ”Doubling the lifetime of asphalt pavements, halving the scatter in lifetime, halving the CO2- footprint at same or lower cost”. All players in the market are asked for suggestions to get an impulse on asphalt. Six themes were chosen to gather the these wide range of ideas. The best projects are selected and these 8 projects will start: Demonstrable sustainable asphalt mixes, Better asphalt mixes in contracts, Asphalt quality counter, Grip on bitumen, Functional acceptance, Hightech = Lowcost, Quality assurance and Lifespan prediction model for asphalt mixes. In this paper more detailed will be looked into the drive to start this project and will explain of the eight selected projects, what this beholds and was is aimed for.