Road Asset Management for Sustainable Development

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The lack of appropriate and timely maintenance produces increase in the cost of future treatments and vehicle operating costs with negative impact on environment in terms of use of natural resources, GHG emission and energy consumption.
There is a need to provide recommendations for Road Asset Management leading identify and prioritize measures that effectively address Mobility, Safety and Environmental sustainability.
The paper object is to augment environmental sustainability and resource efficiency issues in Road Asset Management with particular emphasis on pavement maintenance. The pavement issues which have the greatest potentialities for an environmental sustainable and resource efficient Road Asset Management, are presented in the paper.

Keywords: Road, Management, Sustainability, Pavement.

1. Introduction

Roads are the core of an integrated transport system and their performance is essential for all citizens in terms of quality of life, economic competitiveness and sustainable development. European Road Federation defines sustainable roads as "Effectively and efficiently planned, designed, built, operated, upgraded and preserved roads by means of integrated policies respecting the environment and still providing the expected socio-economic services in terms of mobility and safety" [1]. Some efforts are currently being made to identify low Greenhouse gas (GHG) emission solutions and life cycle energy reduction in road planning, design and construction. However, for most Road Authorities (RAs) this is still an area for considerable development especially in the framework of the management of the existing road network.
The European road network consists of 5.5 million Km mainly managed under local and regional responsibility. In the last decades, and more is expected in the future, approximately 90% of works involves the maintenance and upgrades of existing roads, only 10% of road construction works involves the construction of

new roads. The annual maintenance spending in road infrastructures in the European Union (EU 25), like in other developed countries, accounts for a share of about 40% of the total road expenditure with an annual budget of about 30 billion euro [2]. Despite this huge amount of expenditure, lack of information and political awareness on the importance of sufficient and appropriate investments for the maintenance of the road infrastructure lead to its chronic underfinancing and deterioration [3]. The lack of appropriate and timely maintenance, making the road network decay, produces increase in the cost of future treatments and vehicle operating costs are also increased (figure 1) with negative impact on environment in terms of use of natural resources, GHG emission and energy consumption.

As example, it is possible to decrease the rolling resistance for passenger cars by approximately 10%, providing smooth (no skidding) pavement surfaces. Considering an influence factor of 20-30% for the rolling resistance on the fuel consumption a reduction of 2-3% in fuel consumption and carbon dioxide equivalents (CO2e) emissions can be estimated.

Traditionally the objective of asset management is to "*achieve and sustain a desired state of good repair over the lifecycle of the assets at minimum practicable cost*" [4]. More specifically, PIARC [5] defines Road Asset Management (RAM) as: "*A systematic process of maintaining, upgrading and operating assets, combining engineering principles with sound business practice and economic rationale, and providing tools to facilitate a more organized and flexible approach to making the decisions necessary to achieve the public's expectations*". In this context, there is still a need to provide recommendations for Road Asset Management leading to environmental Sustainable infrastructures [6]. Road Authorities (RAs) to effectively contribute to the long-term vision of sustainable development should identify and prioritize measures that effectively address:

Accessibility and Mobility: Roads must maintain their essential role in the global future transport framework.

Safety: reduction of number and severity of crashes for all the road users.

Environmental sustainability: reduced energy consumption and associated reduced GHG emissions from road transport.

Relevant topics for environmental sustainability to be considered in RAM include not only use of recycled and environmentally-friendly construction materials but also water pollution, best practices for road equipment, better use of existing infrastructures, implementation of ITS and lighting retrofitting. In this framework, the paper deals with pavement management because pavement maintenance is the main part of RAM covering the majority of routine maintenance works.

2. Pavement Management

In the following paragraphs, the pavement maintenance issues which have shown great potentialities for an environmental sustainable Road Asset Management are presented with regards to energy savings and emission reduction potential, but also to technical and economic concerns.

2.1. *Perpetual Pavement*

It is possible to design long-life asphalt pavements that will allow the pavements to withstand almost infinite numbers of load repetitions. [7]. The perpetual asphalt pavement design philosophy can be summarized as follows:

• The asphalt layers need to be of sufficient thickness to keep the horizontal strain below the endurance limit such that bottom-up fatigue cracking will not occur in the pavement.

• The asphalt layers has to be designed to be sufficiently rut resistant and to avoid rutting phenomena into the underlying granular layers.

• In the maintenance process, the surface layer will be replaced periodically to improve friction, evenness and to remedy surface distress such as top-down fatigue cracking, thermal cracking, rutting, and surface wear remain confined to the wearing course.

Long-life asphalt pavements have been shown to have lower life cycle costs than conventionally pavements. Although the greenhouse gas emissions from initial construction are greater for the Perpetual Pavement than for conventional asphalt, it still has lower greenhouse gas emissions over the 50-year life cycle (fig. 1) [8].

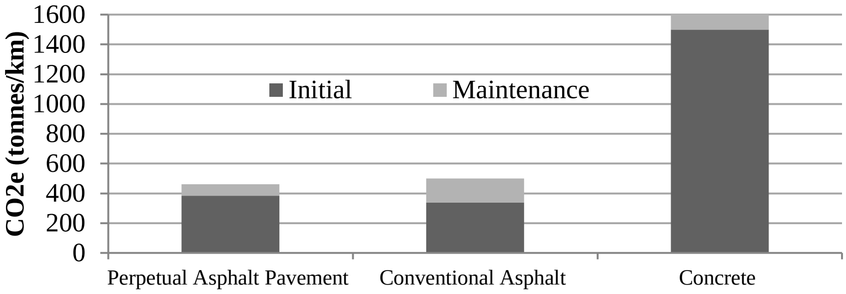

Fig. 1. 50-year life-cycle greenhouse gas production of different pavements [8]

2.2. *Low Energy Asphalt Concrete*

Low energy asphalt concrete (LEAC) refers to the generic name of technologies that allow the producers of hot-mix asphalt pavement material to lower the temperatures at which the material is mixed and placed on the road. Plant foaming, representing the highest percent of the market (about 80%), is the most commonly used warm-mix technology; additives accounted for a reduced percent of the market (about 20%).

The conventional Hot Mix asphalt (HMA) mixtures are produced and mixed at temperatures roughly between 120 and 190 °C depending on the bitumen used.

The Warm Mix Asphalt (WMA) mixtures are produced and mixed at temperatures roughly between 100 and 140 °C.

Half-warm mixtures are produced with heated aggregate at a mixing temperature between 70 °C and 100 °C.

Cold mixtures are produced with unheated aggregate and bitumen emulsion or foamed bitumen.

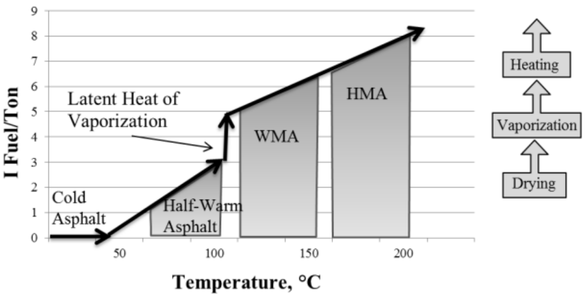

Fig. 2. Energy consumption for different asphalt mixtures production [10]

Such drastic reductions in the temperatures have the obvious benefits of cutting fuel consumption and decreasing the production of greenhouse gases. A temperature reduction of 30 degrees yields savings of 9 kWh of energy per ton of asphalt mix produced. This corresponds to 0.9 litres of heating oil per ton of asphalt mix. Accordingly, GHC emissions also drop. Based on a rough estimate, a 10 degree temperature decrease leads to a 50% emission reduction [9, 10]. The benefits of LEAC technologies, other than reduced fuel usage and emissions, include also improved field compaction and ability to place thick lifts, which can facilitate longer haul distances with less effort, cool weather pavement placement (between -3 and 4 °C implementing with various technologies, [10]), open to traffic in a short time period, the potential to incorporate higher percentages of RAP, better and safer working conditions.

Cost reductions may arise from lower production temperature and less fuel consumption to dry and heat the aggregate, less wear of the asphalt plant due to the lower production temperature. Cost increases may arise from the plant modification (if needed), the costs of the additives (if additives are used) and technology licensing costs. Dependent on the interaction of these factors the costs of Cold/Warm mixtures should be expected to be slightly higher than that of normal hot mix. In terms of performance, it is expect that WMA performance is the same than the performance of HMA [9].

2.3. *Recycling*

When asphalt pavement is reused in a new asphalt mix, the old asphalt cement is partially rejuvenated so that it becomes an active part of the glue that holds the pavement together, just like the old aggregate becomes part of the aggregate content of the new mix. Every kilo of reclaimed asphalt pavement (RAP) used in new asphalt, saves a kilo of new natural resources such as minerals and oil product. Moreover, during maintenance works, RAP can be reused in situ reducing energy costs (no transport, no storage, no reproduction, no transport to jobsite again). While RAP is the material mainly used in asphalt recycling, materials from other industries may be routinely recycled into asphalt pavements instead of going into landfills. Some of the most common are rubber from used tires, glass, asphalt roofing shingles, and blast furnace slag.

The emissions of a “25% re-used” asphalt mixture is almost 20% less than those of “all virgin materials” asphalt mixture. If the future recyclability of this asphalt material is additionally considered even get further reductions of the CO2e emissions up to almost 60% [11].

It is estimated that the average use of RAP is 12 percent. However, there is the potential to use up to 30 percent RAP in the intermediate and surface layers of pavements. A study comparing virgin and recycled asphalt pavements using data from the LTPP program [12] concluded that, in most cases, using 30 percent RAP in an asphalt pavement can provide the same overall performance as virgin asphalt pavement. In general, there is little difference in designing asphalt mixtures with RAP compared to virgin asphalt mixtures until high RAP is used. However, with RAP contents greater than 25 percent, careful consideration should be given to the selection of the grade of asphalt binder added to the recycled asphalt mixture. Moreover, when increasing RAP use, performing quality controls throughout the entire production process is critical and the RAP material must be properly characterized for mix design purposes.

3. Conclusions

Appropriate and timely maintenance is a key factor to reduce use of natural resources, GHG emission and energy consumption. The pavement maintenance treatments which have shown great potentialities for an environmental sustainable RAM may be related to the introduction of perpetual pavement design, recycling and low Energy Asphalt concrete. Average reduction in CO2e emission are estimated of 10% for perpetual pavement, 20% for RAP and 40% for WMA. Fuel consumption may be reduced from 30% using WMA technologies to 100% with cold mixtures. When the huge annual production of mix asphalt is considered (e.g. about 300 million tons in EU) the relevance of the problem is evident.

Despite the evident environmental benefits, higher construction costs and needs for new technologies and equipment limit the spreading of sustainable treatments. To concretely facilitate the market implementation of green materials and techniques, new Life Cycle Costing must be developed and some advantage must be given in the procurement process to encourage their use.

References

1. Sustainable Roads and Optimal Mobility ERF, 2009
2. European Road Statistics, 11th edition ERF, 2013
3. Road Asset Management - An ERF position paper for maintaining and improving a sustainable and efficient road network, 2014
4. MAP-21, the Moving Ahead for Progress in the 21st Century Act in USA, 2009 Source: http://www.fhwa.dot.gov/asset/plans.cfm
5. Source: PIARC, Asset Management Practice, Technical Committee C4.1 Management of road infrastructure assets, Paris, 2008.
6. Sustainability and Energy Efficient Management of Roads - ERA-NET Road – Energy, 2014
7. Newcomb, D, Willis, R & Timm, D, Perpetual asphalt pavements: a synthesis, Asphalt Pavement Alliance, Lanham, Maryland, USA, 2010.
8. Carbon Footprint – How does asphalt stack up. Asphalt Pavement Alliance (APA), 2010
9. Warm-Mix Asphalt: European Practice. FHWA, 2007
10. The use of Warm Mix Asphalt. EAPA position paper, 2010
11. Reclaimed Asphalt Pavement in Asphalt Mixtures: State of the Practice, 2011
12. Asphalt Technology News, 21, 2, National Center for Asphalt Technology, Auburn, 2009.