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Recycled materials hold the key to more eco-friendly asphalt production

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Pavements are traditionally constructed using hot-mix asphalt, a mix of bitumen and virgin aggregates produced at high temperatures. This requires large amounts of natural resources and energy and releases a large quantity of waste. However, technologies exist to create warm-mix asphalt — a substance produced, transported and compacted at lower temperatures than traditional hot-mix asphalts, resulting in a lower environmental impact and carbon footprint. This study explores the 'eco-profiles' of asphalt technologies used to construct urban pavements, assessing various scenarios based on their environmental impact and energy requirements across the entire pavement life cycle.

European efforts to lower the environmental impacts of pavement production have resulted in technologies that use more recycled materials and cleaner, cooler processes to produce warm-mix asphalt (WMA). Recycled materials are commonly derived from reclaimed asphalt pavement or 'crumb rubber' from end-of-life vehicle tyres. Such technologies also use a range of additives (including synthetic zeolite, organic components, emulsification agents or polymers) to enhance WMA production, aiming to form a suitable viscosity of bitumen so that asphalt can be mixed and compacted at lower temperatures with minimal reductions in performance or durability.

This study[1] uses life-cycle analysis (LCA based on ISO 14040 principles) to explore the energy use and environmental performance of several bituminous mixtures used for road pavement. Data was derived from literature, interviews with relevant enterprises and experts and web resources.

The researchers explore different pavement technologies and scenarios used in the paving of two-lane urban single carriageway (1 kilometre long, 9.5 metres wide and 230 millimetres thick; with 1 square metre of pavement used as a functional unit). Each step of pavement life was analysed and its impact quantified, taking into account production, transport, construction, maintenance and end-of-life, to identify relevant hotspots across the whole life cycle[2].

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Seventeen impact categories[3], including global energy requirement; climate change; land use; and human toxicity, were selected[4], to enable identification of the most energy-efficient and sustainable pavement technologies.

The analysis covered a base scenario (use of common paving material, namely porous hot-mix asphalt) and four other scenarios featuring different mixes and structures of hot-mix asphalt, warm-mix asphalt, reclaimed asphalt pavement, crumb rubber, waste plastics, mineral aggregates and asphalt binder.

The results show that the base scenario (traditional layering of hot-mix asphalt) produces the highest energy and environmental burdens; while the scenario with the highest proportion (45%) of reclaimed asphalt shows the best performance — a reduction of 19% in energy requirements compared to the baseline, and a reduction in the vast majority (all but two) of the environmental indicators.

The findings show that warm-mix asphalt technology reduces both the global energy requirement and environmental impacts associated with pavement production. When combined with the use of higher proportions of reclaimed asphalt pavement, WMA technology lowers the amount of raw material needed to produce the same quantity of concrete, which not only reduces the amount of energy needed to do so but lowers the amount of waste produced and the burden of disposal.

The study suggests that bituminous concrete production was the life-cycle stage with the highest impact (60 to 70% across the indicators). The materials used and extracted as part of this phase have critical energy consumption and environmental consequences, highlighting the importance and strategic value of using recycled, reclaimed, and waste materials (such as reclaimed asphalt pavement).

The researchers note the limitations of their study and call for further research to clarify these — for instance, data pertaining to specific processes used across the production cycle is currently limited and disparate, hindering full analysis. The researchers suggest their LCA approach is an effective tool to 'eco-profile' the asphalt technologies used in urban road pavements and can inform policy and strategy that accounts for cost and safety, as well as energy and ecosystem impact.

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[2] The 'use' phase was omitted because a) the pavement scenarios supported the same traffic conditions; b) energy consumption due to pavement ageing, traffic increase, and vehicular air pollution was not considered due of lack of comparative research; and c) pavement was assumed to have the same type of friction course and surface evolution over time (with no difference in rolling resistance).

[3] **Impact categories**: global energy requirement (based on cumulative energy demand, allowing quantification of renewable and non-renewable sources), climate change, ozone depletion, human toxicity (cancer and non-cancer effects), particulate matter, ionising radiation (HH and E (interim)), photochemical ozone formulation, acidification, terrestrial, marine, and freshwater eutrophication, land use, and depletion of water, mineral, and fossil resources.

[4] Categories were selected according to the JRC handbook: EC, Joint Research Centre, Institute for Environment and Sustainability: *International Reference Life Cycle Data System (ILCD) Handbook - General guide for Life Cycle Assessment - Detailed guidance*. First edition March 2010. EUR 24708 EN. Luxembourg. Publications Office of the European Union; 2010.**4.**