Resources, Conservation and Recycling 116 (2017) 32–44

Contents lists available at ScienceDirect

Resources, Conservation and Recycling

journal homepage: www.elsevier.com/locate/resconrec

Review

Harvesting the unexplored potential of European waste materials for road construction

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ARTICLE INFO

Article history:
Received 29 December 2015
Received in revised form 22 August 2016
Accepted 6 September 2016
Available online 17 September 2016

Keywords:
Road materials
Waste
Steel slag
Plastics
Construction and demolition waste
Glass

ABSTRACT

This paper demonstrates how a considerable amount of waste produced in the urban and peri-urban environment can be recycled in asphalt roads. The example presented is from Europe, however, the barriers and conclusions are universal. It was shown that various waste materials such as glass, asphalt, concrete, wood, plastics etc. have a potential for re-use in asphalt roads. The available quantities of the European target waste materials that would otherwise be incinerated or disposed in landfills were considered. It was shown that there is high potential in Europe for recycling in road construction, in particular, under the hypothetical scenario where 33% of new roads would be made of the target waste materials (excluding RAP which is already recycled), it is estimated that 16% of the available waste quantities could be recycled in roads. Four hypothetical roads were analysed showing a considerable savings in costs, CO2 and energy in comparison to conventional asphalt mixtures using all virgin components.

Contents

1. Introduction 33
2. Waste materials suitable for recycling in road pavements 33
   2.1. Concrete 33
   2.2. Reclaimed asphalt pavement 34
   2.3. Glass 34
   2.4. Scrap tyres 34
   2.5. Plastics 34
      2.5.1. PET 34
      2.5.2. PE 35
      2.5.3. EVA 35
      2.5.4. Polyurethane (PU) 35
      2.5.5. Carbon black 36
      2.5.6. Other polymers and blends 36
   2.6. Ceramics 36

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http://dx.doi.org/10.1016/j.resconrec.2016.09.008
0921-3449/

2.7. Municipal solid waste incineration (MSWI) bottom ash 36
2.8. Steel slag 37
2.9. Textiles 37
2.10. Wood 37
3. Sources of target waste materials 37
3.1. Construction and demolition (C&D) waste 37
3.2. Bulky waste 38
3.3. Material recovery facilities (MRF) 38
3.4. End-of-life vehicles (ELVs) 38
3.5. Waste appliances 38
3.6. Thermal waste treatment plants 38
3.7. Steel and ceramic industries 39
4. Discussion 39
4.1. Use of waste in roads- a possible scenario 39
4.2. Sustainability consideration 42
5. Conclusions 42
Acknowledgements 42
References 42

1. Introduction

It is well established that industrial countries are producing a considerable amount of waste (Sousa and Way, 2000; Proparco; Solid Waste Management) and a major part of the resources are wasted through the mainly linear process of material use in our economies. Materials are extracted, used or further processed into products where they are used and then disposed of in landfills and incinerators. There is a clear need to improve EU resource efficiency and reduce climate and environmental impacts, through promoting waste reuse and recycling and by phasing out disposal or incineration of waste, according to the waste hierarchy of the European Waste Framework Directive 2008/98/EC (European_Parliament, 2008). A significant share of waste materials is recycled back into the same product where they came from (closed-loop recycling). However, despite considerable progress in recycling of waste materials generated in the urban environment, in several instances their quality or technical requirements do not allow for the materials to be recycled into the same product and as a result the waste materials are landfilled or incinerated. This provides a substantial opportunity to recycle wastes produced as precious raw materials for example in road pavements.

Roads are the dominating transport infrastructure in Europe and an important contributor to the economy. The total inland freight transport in the EU-28 was estimated to be close to 2′100 billion tonne-kilometres (tkm) in 2012; three quarters (75.1%) of it transported by roads (http://ec.europa.eu/eurostat/statistics-explained/index.php/Freight_transport_statistics, assessed 11.12.2015). Similarly, every year a considerable amount of new and rehabilitated roads are built amounting to a total of 4.7 million kilometres (Mkm) corresponding to the production of more than 276.4 Mt of asphalt mixtures (EAPA, 2012). This entire road network demands a substantial amount of aggregates, bituminous and cementitious binders and performance enhancing additives to withstand the ever increasing demands in terms of axle loads and frequency of traffic. At the same time, with the increase of heavy vehicles on the road and scarcity of raw materials depending on the region, the road pavement industry is facing new challenges in terms of resources and mechanical performance that have to be met.

Various types of waste materials have been successfully used in road pavements. However, as the literature search that follows shows, this use has remained for the most part at the research level or limited to some countries and therefore, there is an urgent need to develop and broadly demonstrate such solutions in real-life environments in order to promote widespread market uptake. A survey on the barriers impeding the use of recycled materials in the construction industry revealed that the number one reason why companies don't use recycled materials is cost followed by lack of education, while less frequently stated reasons referred to the product quality (Bolden et al., 2013).

This article aims to facilitate the use of waste materials for road construction by giving an overview of the urban and peri-urban waste problem and present a solution in terms of recycling in roads. Furthermore the paper demonstrates, by presenting some examples, what types of materials have shown to work and their use should be encouraged through a combination of proper standardization, legislation and incentives. The paper gives the waste statistics in European urban and peri-urban environment as an example, however the results and conclusions are universal.

2. Waste materials suitable for recycling in road pavements

Asphalt concrete is a complex three phase material consisting of aggregates, a binder and air voids. In addition, performance enhancing additives such as fibers and polymers are used as modifiers.

The motivation for recycling in pavements is two-fold: either to save resources or to improve material properties. In the resource category, re-use of old pavement or non-pavement materials such as construction and demolition (C&D) or marginal materials which are low quality, in new pavements can be named. Regarding material improvement, the following can be listed: replacing traditional components such as bitumen with polymers; tailoring pavement performance using selected materials to fulfil increase in performance requirements; using traditional materials to pool different properties.

In this article, certain waste materials have been chosen as substitutes for traditional virgin raw materials. In order to have any real impact on the reduction and re-use of urban waste through recycling in roads and, at the same time, producing standard quality roads, the following criteria were used to choose the waste materials: (i) demonstrated comparable performance in road pavements compared to virgin materials; (ii) available quantity; (iii) absence of higher value alternatives for their exploitation; (iv) waste collection systems in place enabling secure access and (v) high treatment and disposal costs. A review of the selected waste materials is provided below.

2.1. Concrete

Concrete is one of the most important construction materials nowadays and its production has reached 25 billons tons a year (World Business Council for Sustainable Development (WBCSD,