COOPLAND CONSULTANCY LIMITED

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The Use of Waste-derived Materials in Road Construction

Briefing Report

SCOTTISH ROAD SRRB RESEARCH BOARD

November 2021

Prepared for the Scottish Road Research Board
through the Roads Collaboration Programme under a contract placed by Improvement Service

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The cover image shows construction of the Echline Recycled Road c. 2000.

INTRODUCTION

The Scottish road network is diverse, ranging from motorways, trunk roads and 'A'-roads, through city and town streets, to remote rural roads, including single-track roads with passing places. Roads are key facilitators for socio-economic activity and growth, linking industry and markets, supporting tourism and providing communities with access to employment, health, educational, social and leisure opportunities and activities.

Road authorities must ensure an adequate level of service, including that the road is safe and fit for purpose. In order to achieve this aim published standards and specifications are used to define, or specify, the required quality, performance, compatibility and compliance of materials and products used in road construction, operation and maintenance.

The use of recycled and waste-derived materials in road construction has been a key topic of discussion within the roads construction and maintenance industry for several decades. In recent years the use of waste-derived glass, rubber and plastics in bitumen or asphalt has been promoted, sometimes with claims of dramatically increased performance and/or as an effective means of managing such wastes that would otherwise be destined for landfill or used as fuel.

A great deal of focus is currently placed, nationally and internationally, on the creation of new construction products incorporating wastes or waste-derived materials that can substitute for virgin raw materials or enhance product performance. Manufacturers, some with little or no construction and/or materials background, are driving this 'innovation' often without robust processes being followed to ensure the technical efficacy and performance of products, thorough assessment of their whole life environmental impacts and costs, or the development of robust standards and specifications.

For those who procure road surfacing materials, the volume and credibility of information is a cause for concern. With constrained budgets and political pressure to increase the green credentials of infrastructure construction and maintenance, a single authoritative reference, pulling together the outcomes, results and conclusions of recent studies, is required to inform decision-making so that costly and environmentally damaging mistakes can be averted.

The work focuses primarily, but not exclusively, on road surfacing materials containing waste-derived glass, rubber and plastic, referencing information from the past five years or so, from within Scotland and the rest of the UK, as well as internationally where relevant. The full Technical Report can be downloaded from the Scottish Road Research Board website[1].

CURRENT USE

In this report the use of waste-derived glass, rubber and plastic in road surfacings is examined from the viewpoint of technical efficacy, waste regulation and environmental impact. In the Technical Report[1] a series of questions was posed as a means of evaluation of the use of such materials. These questions are now answered for each material in the following paragraphs.

[1] https://www.transport.gov.scot/our-approach/industry-guidance/scottish-road-research-board/

Is the waste-derived material a direct substitute for virgin material?

- Glass: Yes. The glass is a substitute for aggregate.
- Rubber: Yes, it can potentially be used as a binder modifier.
- Plastic: Yes, potentially as a bitumen replacement and is marketed as a binder extender/enhancer depending on the type of plastic but the amounts used are very small. It is also being trialled as an aggregate replacement in some countries, but no waste-derived plastic products marketed for use in asphalt in the UK currently meet MCHW 1 aggregates criteria.

Does it enhance the properties and quality of the binder/asphalt?

- Glass: Potentially. Improved workability and resistance to thermal cracking of asphalt are reported, but there may also be increased bleeding, stripping and sensitivity to water damage.
- Rubber: Yes. Rubberised asphalt is reported to be more resistant to rutting and cracking, extending the life of the asphalt, as well as reducing tyre noise.
- Plastic: Unproven, but there is potentially improved resistance to moisture damage, cracking and rutting performance. This is dependent on the type of plastic used and whether it melts fully in the asphalt mix. Some plastics are however, reported to increase moisture damage potential. More work on this is required to provide evidence of benefits and research must clearly identify the type or mixtures of component plastics and their ratios in the material marketed.

Are there any additional health and safety precautions during manufacture and construction to consider?

- Glass: No.
- Rubber: No.
- Plastic: Potentially. It has not been possible to obtain details on the 'activators' (compatibilizers) used in materials marketed in Scotland, so it is not possible to provide a definitive comment. Further work on fume analysis is also required.

Are there any additional environmental impacts associated with the use of asphalts containing the waste-derived material?

- Glass: No, but it prevents waste glass from being remanufactured so is not the best environmental option.
- Rubber: Yes, there is the potential for the release of nano and microplastics as a result of road wear as well as during planing and processing at the end of the pavement life, albeit that the amounts used, and thus the emissions will be small.
- Plastic: There is potential for nano and microplastics to be released during road surface wear as well as during planing and processing at the end of pavement life. However, the quantity of waste-derived plastic, and thus the emissions, will be small.

Is the use of the material cost-effective for the road industry?

- Glass: No.
- Rubber: No, but it is an inexpensive means of managing a problematic waste when compared with other options for end of life tyres such as closed-loop recycling activities.

- Plastic: Where waste plastic types are separated (either at source or after collection to fulfil product quality criteria) they have more value than co-mingled plastics due to their potential for use in plastic remanufacturing. The costs may therefore be higher than the virgin equivalent it is being used to substitute. This is obviously dependent on waste reprocessing capacity, proximity and demand. For mixed plastic types that have not been separated and therefore have not been through a quality control procedure, the cost may be lower than the virgin equivalent but material performance within an asphalt mix is unlikely to be guaranteed.

Can the asphalt subsequently be recycled at the end of life and are special precautions necessary?

- Glass: Yes it can be recycled at end of life and no special precautions are necessary.
- Rubber: Yes, but currently in limited quantities. Little is known about the interaction of old (rubberised) binder with new binder and subsequently the impact on long-term performance and pavement longevity.
- Plastic: Potentially, but no evidence is available to demonstrate this and the interaction between aged plastic binders and new binders needs to be investigated. Potential release of nano and microplastics to the environment during reprocessing must also be considered particularly as they have been found in human tissue.

The potential for the use of waste-derived glass in asphalt is primarily limited by the efforts of the UK glass industry to undertake closed-loop recycling and to maintain the value of the resource. However, for rubber and plastic the situation is rather different.

FUTURE USE

It is proposed that waste-derived plastics and rubber should not be further used in road surfacing, in bound layers of road construction, at the present time, unless in a trial situation.

It is further proposed that waste-derived plastics and rubber should not be further used in the unbound layers of road construction, including the foundations layer(s), or in earthworks other than as fully-accredited geosynthetic materials.

These statements are based on the current state-of-the-art and its application. While this closes opportunities for such use in the short-term it is fully-accepted that this may change in the future. It is entirely possible that the use of waste-derived rubber and/or plastics could successfully meet the requirements of the protocol described in the Technical Report[1]. However, in order for that process to commence the following criteria must be met:

- Performance of the modified and/or extended material must be demonstrated to be at least at the level expected of conventional materials. While international research and trials provides helpful background, variations in the composition of waste-derived additives, asphalt mixes and processes and climate mean their relevance to Scottish road construction and maintenance is not assured.

- Issues surrounding the emission of microplastics (and other plastics) to the environment must be satisfactorily addressed, including in the context of planer removal of the material that has reached end of life.
- The end of life recyclability of the material must be demonstrated to be satisfactory including the performance of the recycled material.
- Any additional health and safety requirements should be identified together with measures for their management.

In terms of the development of waste-derived materials used in road construction and maintenance it is important to consider the technical, financial, environmental, and health and safety criteria set-out in Table 2 of the Technical Report[1]. Taking an honest and open approach when engaging with the local authorities and Transport Scotland will make the decision-making process easier and, most likely, lead to more timely decisions on the potential way forward.

KEY CONCLUSIONS

The use of glass in road surfacings, or other parts of the road asset, is unlikely to progress further in the context of the strong lead being provided by the UK glass industry towards a system of closed-loop recycling that effectively keeps waste-derived glass within that industry.

The use of waste-derived rubber may increase if the claimed performance benefits of rubberised road surfacings can be proven in the UK, particularly as currently there is a lack of capacity for sustainably treating end of life tyres. However, concerns remain regarding waste-derived material quality control (including the potential for contaminants and the suitability of tyres for processing into asphalt additive materials) and the potential for the release of microplastics during pavement service and at end of life.

The case for waste-derived plastics to improve the performance of bitumen or asphalt is far from proven. There are also concerns around the quality control of mixed waste-derived plastics and this needs to be addressed to prevent batch and ultimately pavement performance variation.

Uses of plastic in roads in Scotland to date largely constitute demonstration projects rather than formal trials to assess technical performance. These demonstrations all appear to use the dry process, in which plastics are added to the asphalt mix as a binder extender or enhancer. No evidence is available to suggest that a formal design process has been undertaken to optimise the performance of the final mix.

In addition, and as for rubber, there are significant concerns around the release of microplastics to the environment. The Scottish Government has signalled its intention to tackle the microplastic problem and has gone so far as to introduce legislation to prevent the sale of goods such as cosmetics and personal hygiene products which contain plastic microbeads (The Environmental Protection (Microbeads) (Scotland) Regulations 2018). Scotland is also a signatory to the Ellen MacArthur Foundation's New Plastics Economy global

commitment to end plastic pollution and it is questionable therefore whether the use of waste-derived plastics in road surfaces is aligned with government policy.

Modular plastic roads made with waste-derived materials have also been trialled, most notably in the Netherlands. These also raise concerns regarding the release of microplastics to the environment, particularly as a result of wear during their service life.

The issue of microplastics is one that is of great concern to society and in isolation would point to a decision to cease the use of waste-derived plastics in road surfacings. In combination with the lack of clear performance benefits from the addition of waste-derived plastics to bitumen or asphalt a decision to not use such materials seems straightforward.

The use of waste-derived rubber or plastics in pavement foundations, earthworks and unbound and bound lower pavement layers is also not recommended due to the same concerns surrounding the release of microplastics at the end of the service life. It is perhaps noteworthy that Highways England ceased the use of fibre reinforced soil in late-2018. For footway, cycleways and car parks, where increased performance is not required, the use of such materials can only be described as a means of linear landfill. This is not intended to include fully-accredited geosynthetic materials that form discrete layers within the structure rather than exist within the mix in a random distribution.

Where there does seem to be some potential to allow for the use of waste-derived plastic in parts of the road asset is where these are non-composite/single-material, quality-controlled products. These might include drainage elements, kerbs, street furniture, signs, barriers, traffic cones and environmental barriers. Indeed, the authors are aware of moves within the industry to promote, trial and use such products. Notwithstanding this, there is a need to ensure the control of the potential release of microplastics, particularly if the products may need to be cut during construction. In addition, as with all such products particular attention would need to be paid to ensuring in-service durability, including resistance to the deleterious effects of UV-light on material stability, and end of life applications. Closed-loop recycling of such products is to be encouraged.

A protocol for the introduction of innovative materials and processes, including those containing waste-derived materials, to the road network has been proposed. This is tentative and intended as a starting point for further development prior to implementation. The protocol considers technical, financial, environmental, and health and safety aspects of innovative materials and processes. The focus is on pavement surfacing materials, but it could be extended to encompass other asset features albeit that other disciplines, earthworks for example, would require a rather different approach to the detailed evaluation process.

This work will help Scottish roads authorities to continue to assist and contribute to the delivery of government priorities, including those related to climate change.

RECOMMENDATIONS

Recommendation 1

Based on the evidence currently available there is, as yet, no viable technical, environmental or economic case for the use (addition or replacement) of waste-derived glass or plastic in asphalt.

Recommendation 2

While the research is further advanced for waste-derived rubber (addition or replacement) than for plastic, the available technical and environmental case for its use in asphalt does not yet fully-support its use. Further research and trials are needed in this area including through the use of the protocol described in the Technical Report[1].

Recommendation 3

It is recommended that waste-derived (or virgin) rubber or plastic not be used in unbound pavements layers, including the foundation layer(s), or in earthworks other than as fully-accredited geosynthetic materials.

Recommendation 4

It is recommended that in the future the use of waste-derived materials in road surfacing and other structural and foundation layers should be subject to the scrutiny of the Transport Scotland Pavement Forum (TSPF) under the protocol described in Recommendation 6.

Recommendation 5

Opportunities should be sought to use waste-derived materials and products in other non-composite/single material-type, quality-controlled products. These might include drainage elements, kerbs, street furniture, signs, barriers, traffic cones and environmental barriers. Such use should be subject to a full evaluation of the technical, financial, environmental, and health and safety efficacy and impacts of the product.

Recommendation 6

A protocol to steer the appropriate and constructive use of waste-derived materials and products in pavements should be introduced.

Recommendation 7

That the protocol in Recommendation 6 be extended to include innovative (non-waste) materials, products and processes that are proposed for use in pavements and innovative (waste-derived and non-waste) materials, products and processes in other elements of the road asset.

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