Annals of the Academy of Romanian Scientists
Series on Engineering Sciences
ISSN 2066-8570 Volume **15**, Number **1**/**2023**

LITTAR: ASPHALT CONCRETE MADE WITH AGGREGATES DERIVED FROM WASTE GLASS AND WASTE PLASTICS

Dennis DEBIE[1], Sebastian TUDOSE[1], Miron ZAPCIU[2], Nicoleta-Mariana ENE[3], Flavius-Valeriu CLADOVEANU[2], Cătălin DIMA[2], Nicoleta-Adaciza IONESCU[4], Monica COSTEI[2]

Rezumat. *Littar este un material de fundație din beton asfaltic fabricat din deșeuri de plastic și sticlă, care combină nevoia de infrastructură durabilă și accesibilă, cu posibilitatea utilizării unor cantități enorme de deșeuri de plastic și sticlă gestionate greșit și nereciclabile.*

Abstract. *Littar is an asphaltic concrete foundation material made with plastic and glass waste combining the need for durable and affordable infrastructure with the enormous amounts of mismanaged and unrecyclable plastic and glass waste materials.*

Keywords: Sustainable Waste Management, Eco-friendly Roads

DOI https://doi.org/10.56082/annalsarscieng.2023.1.112

1. Introduction

Plastic and glass waste represents a significant global environmental challenge, worsened by the inefficiencies and constraints of conventional recycling methods. To address this issue, we present Littar, an innovative technology designed to repurpose all types of plastic and glass waste into a valuable and sustainable resource for road construction.

Littar offers a versatile solution for "negative value waste", converting it into an eco-friendly alternative for traditional asphalt in the formation of roads, sidewalks, and other traffic surfaces. The utilization of Littar provides superior mechanical and thermal properties compared to its conventional counterparts, alongside significant reductions in weight, transport emissions, and costs.

Its manufacturing process is compatible with existing asphalt production methods, enabling swift industry adoption. Furthermore, Littar demonstrates enhanced

---

[1] Eng. – The Climate Change Company, Str. Regele Ferdinand 22/26, Cluj Napoca, Romania, ZipCode 400110, E-mail: info@theclimatechangecompany.com
[2] Eng. – Transport Research Institute – INCERTRANS SA, Calea Grivitei 391-393, Bucharest, Sect. 1, ZipCode 010719, E-mail: incertrans@incertrans.ro
[3] Eng., Romanian Railway Authority, Calea Grivitei, Nr.393, ZipCode 010719, Sector 1, Bucharest, Romania, E-mail: nicoleta.ene@afer.ro
[4] Eng. PhD student, INCD Urban Incerc Institute, Sos. Pantelimon, nr. 266, ZipCode 021652, Sector 2, Bucharest, E-mail: adaionescu2002@yahoo.co.uk

durability and load-bearing capacity when subjected to standardized tests like the Marshall stability test. The environmental impact of Littar is significantly lower due to reduced landfill waste, decreased carbon emissions from incineration, and efficient resource utilization.

Littar is a solution addressing both environmental and infrastructure challenges, transforming waste into a valuable construction resource and offering significant advantages over traditional road materials. This paper presents an in-depth analysis of Littar's composition, production, and application, its potential for industry adoption, and its role in mitigating environmental concerns.

2. The problem with plastic and glass waste recycling

One of the most critical aspects of sustainability is waste management. Yet only a fraction of all produced plastics worldwide ends up in a recycling process. Common recycling of plastics involves an enormous number of resources to separate and clean a mix of waste plastics and turn them into usable pellets of their own specific type in order to make new plastic products, that in turn become waste after their recycled use. After which the complexity of recycling starts all over again.

Furthermore, not all plastic types are suitable for recycling and are discarded directly into landfills or burned.

Nowadays more and more consumer products are labelled with "fully recyclable packaging". While this sounds good in theory, the reality is quite different. In fact, the vast majority of waste materials cannot be recycled to make the same product again due to health, safety, technical, contamination, and esthetical reasons.

To illustrate this point, let's take the example of a toothpaste tube. While the packaging claims to be fully recyclable, turning an empty tube of toothpaste into a new one is an incredibly complex process with high costs and emissions. Consequently, manufacturers often use a bare minimum or no recycled materials at all, to keep the price of the final product within limits.

This is where upcycling comes into play. Upcycling is the process of transforming waste materials or discarded products into new materials or products of higher quality or value. Unlike recycling, upcycling does not require large amounts of energy to break down materials and reassemble them. Instead, it reimagines waste materials in new and creative ways.

Upcycling, unlike recycling, does not break down materials into their base forms. Instead, it enhances the value of waste by transforming it into something more valuable or useful. The complexity and low profitability of common recycling compared to the lower price of new plastics explains the minimal efforts taken to collect and use the enormous amounts of mismanaged plastics.

For glass waste recycling a similar complex process is involved, especially separating colors of glass waste in order for new products to be made. Most of the worlds glass waste collection is done in bulk where no difference is made between color, leaving the collector with a mix of un-usable waste that mostly ends up on landfills. Furthermore, the impurity or composite structure of the glass waste can be an issue for manufactures of glass products, resulting in no commercial interest for these huge amounts of glass waste.

3. Introducing Littar

Littar (see Figure 1) is derived from this viscous circle of complexity and in-effectiveness of common recycling and is designed to use all plastic and glass waste types without complexity. By transforming vast amounts of plastic and glass waste into a valuable and eco-friendly construction resource for road applications, Littar answers to the ever-growing infrastructure needs of society and improvement of the environment at the same time.

Littar is a technology to produce asphalt made with all types of plastic and glass waste including "negative value waste" such as fiber optics, composites, layered window glass and many others. It is used as green alternative for conventional base and binder layers of roads, sidewalks and other traffic surfaces.

Fig. 1. left: Littar cylinder test sample **-** right: Littar in optimal road structure

Littar has improved mechanical and thermal characteristics compared to its conventional, mineral based alternatives while having a significant lower density and therefore weight. This reduces the number of trucks needed to transport Littar from asphalt station to construction site, saving time costs and emissions.

Littar is produced by existing (local) asphalt plants using locally sourced plastic and glass waste aggregates. The production process of Littar compared to normal asphaltic base and binder mixtures is exactly the same, allowing for easy and fast adoption of the technology by the industry, increasing Littar’s social, economic and environmental benefits.

4. Compositions and characteristics

The primary function of plastics inside Littar is as structural aggregate and not, as has been done before, as binder additive. Littar's production process (see Figure 2) does not melt the plastics. The plastics are introduced to the asphalt mixer at ambient temperatures and are not preheated. Once inside the mixer the heat from other aggregates and hot bitumen transfer heat to the plastics making them soft and pliable but not melt.

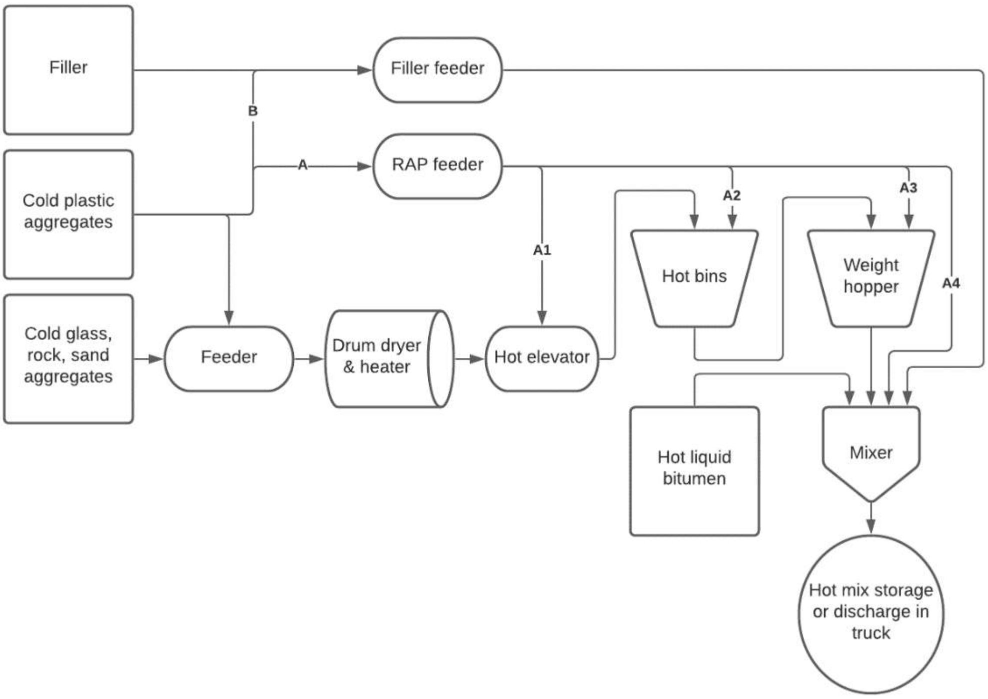

Fig. 2. Littar production flow example in batch mixing station.

This is important for two reasons: to ensure optimal compaction, interlocking and adhesion of all the aggregates and prevent "chunk" formation as a result of molten plastics which reduce workability of the mixture. An added benefit observed during development of Littar is its capability to hold heat during transport, even though cold plastic aggregates are added. The low thermal conductivity of both the plastic and glass constituents isolates the mixture during transport, preventing excessive heat loss. Making Littar as transportable over long distance as conventional alternatives.

Because Littar does not rely on melting and consolidating the plastics it can use all types which is important because the types of plastic and glass waste vary widely from one location to another. The plastic and glass in Littar may vary in ratios as shown in Table 1. Substituting part or all of the conventional mineral aggregates in asphalt concrete mixtures [1], [2].

Table 1. Littar mixture constituents

Constituents	**Littar A** Full replacement of mineral aggregats	**Littar B** partial replacement of mineral aggregats
	Mass Percentages	
Waste Glass aggregates	55 – 70 %	15 – 40%
Waste Plastic aggregates	25 - 40%	5 - 20%
Mineral aggregates	0	40 – 75%
Filler	0 - 5%	3 - 5%
Bitumen	5 - 10%	4 - 6%

To ensure the usability and manufacturability of any Littar mixture, every recipe needs to have a certain ratio between low density and high-density plastics as shown in Table 2. Additionally, as shredded plastics vary widely in their structure, density and compressibility, the mixture needs to have a specific, non-disclosable, volume per unit of weight.

This density of the plastic mixture is expressed in apparent density and bulk density. Depending on the technical class of the road or other application criteria and the available waste materials, an ideal ratio is determined.

Table 2. Allowed plastic mixture ratios

Resin Identification Code	**Plastic type**	**Bulk mix content by weight**
2	High-density Polyethylene (HDPE)	≥ 60%
4	Low-density Polyethylene (LDPE)	
5	Polypropylene (PP)	
6	Polystyrene (PS)	
1	Polyethylene Terephthalate (PET)	≤ 40 %
7	OTHERS	
3	Polyvinyl Chloride (PVC)	≤ 2 %

4.1. Littar 10-25 composition

The Littar composition shown in Table 3 is used as base and/or binder course for all high traffic 2-lane roads or similar applications [3], [4].

Table 3. Littar 10-25 composition

Consti-tuents	**Particle Size**	**Content by Weight**	**Marshall Stability at 4mm flow [kN]**	**Modulus of Rigidity [MPa]**	**Apparent Density [Kg/m^3]**	**Max. Density [Kg/m^3]**	**Field of application**
Plastic	0 /10 mm	10.0%	12.8	5,709	1,976	2,141	Technical road class 3, 4 & 5
Glass	0 / 4 mm	17.0%					
	4 / 8 mm	8.0%					
Sand	0/4 mm	15.0%					
Mineral aggregate	8/16 mm	23.0%					
	16/22.4 mm	23.0%					
Filler	N/A	4.0%					
Bitumen 50/70	N/A	4.6%					

4.2. Littar 31-61 composition

The Littar composition shown in Table 4 is used as binder course for driveways, sidewalks, parking or similar applications.

Table 4. Littar 10-25 composition

Consti-tuents	**Particle Size**	**Content by Weight**	**Marshall Stability [kN]**	**Modulus of Rigidity [MPa]**	**Apparent Density [Kg/m^3]**	**Maximum Density [Kg/m^3]**	**Field of application**
Plastic	0 - 10 mm	31.5%	4.8	1,571	1,258	1,402	Technical road class ≥5
Glass	0-4 mm	61%					
Bitumen 50/70	N/A	7.5%					

5. Increased durability

Determining the quality of an asphaltic concrete mixture is done using standardized test such as Marshall stability, water absorption, fatigue resistance, rigidity modulus, etc.

The most common test used to simulate the mixtures behavior and test its strength is through Marshall stability and flow. In this test a 60°C cylindrical test specimen is placed in the test stand (see Figure 3) and is loaded with an increasing force, square to the compaction direction. While the load increases, the specimen will flow or creep until failure occurs and the load cannot be increased anymore.

Fig. 3. Littar specimen in Marshall stability test clamp

The result of this test is a graph showing displacement as result of load increase up until failure, see Figure 4. For conventional, mineral based asphalt concrete mixtures, the flow or creep is fairly small before failure occurs, usually between 1 and 2mm. This is because rocks, unlike plastic, lack flexibility while being compressed [5].

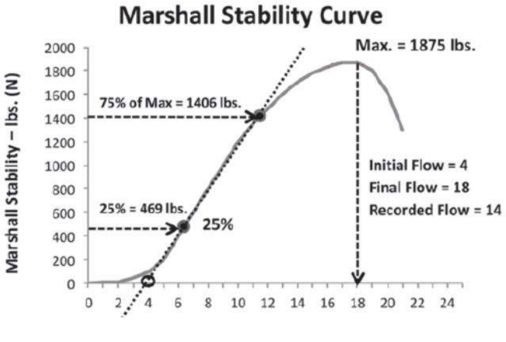

Fig. 4. Illustrative Marshall stability curve of conventional asphalt

The function of plastics and bitumen inside Littar is to form the flexible skeleton of the asphalt concrete that ensures optimal bonding and interlocking of the glass aggregates with the bituminous binder. This flexibility and elasticity allow Littar to withstand much higher loads as conventional mixtures before failing.

The maximum allowed flow during the Marshall test is 4mm according to harmonized standards described in AND 605-2016. To reach this maximum flow or less, the load applied needs to be at least 6 kN according to European standards.

Littar, with 10% plastic and 25% glass can hold a force up to 27 kN at this maximum flow, whereas conventional asphalt fails between 6 and 9 kN. Important to add is that Littar does not fail at 27 kN, it is only the point where the maximum allowed flow occurs.

During Marshall tests, Littar is still capable of holding an increasing load after excessive flow has occurred unlike conventional materials that crack and fail instantly. The maximum load observed during Marshall tests before failure of Littar is approximately 35 kN. The graph in Figure 5 below shows a comparison of Marshall stability between Littar and conventional asphalt.

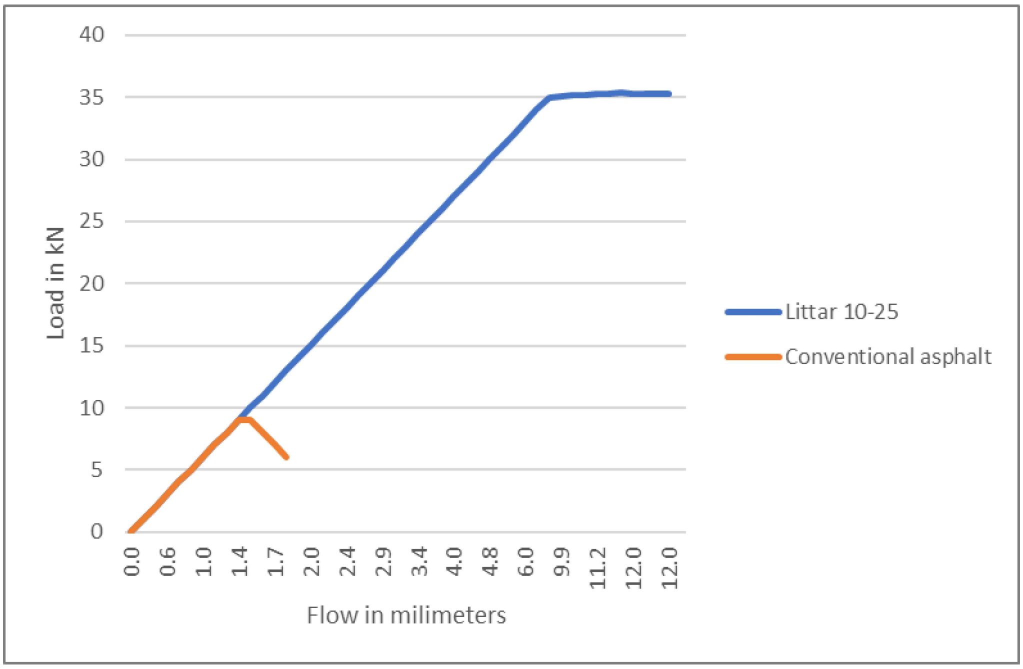

Fig. 5. Littar *vs*. conventional asphalt concrete Marshall curve

6. Reduced transport

Littar’s compacted density with 10% plastic and 25% glass is approximately 1976 kg/m^3. The compacted density of conventional asphalt concrete is approximately 2400 kg/m^3. Littar’s difference in density between uncompacted (during transport) and compacted is the same as conventional asphalt concrete and is therefore neglected in the following calculations.

When transporting conventional asphalt using a tipper truck with a maximum payload capacity of 24.5 metric tonnes and a transportable volume of 18m^3. Every truck can transport approximately 10.2 m^3 without exceeding its load limit. Using Littar gives approximately 12.4 m^3 of transportable volume.

The average required thickness of one square meter base and binder layer is 11cm according to European road standards. For a 1 kilometer, 2-lane road with 4 meters width per lane, a total of 880 m^3 of material are needed. Using conventional asphalt concrete would require a total of 87 truckloads. Using Littar would require 71 truckloads, a reduction of 18%. This reduction directly translates to faster execution times, lower costs and emissions.

7. Reduced Carbon emissions from landfill and incineration

Littar is made with plastic and glass waste that would normally be burned, landfilled or down-cycled at high costs and emissions. Up-cycling this waste in Littar reduces the emissions from conventional waste disposal drastically. Additionally, the reduction of mineral aggregates in road foundations by using Littar reduces carbon emissions even further.

Using Littar with 10% plastic and 25% glass for one kilometer of 2-lane road, 1046 metric tonnes of CO2 are reduced compared to the status-quo, see Figure 6. Littar’s carbon footprint and CO2 reduction have been determined using Climate Impact Forecast tools and principals from Life Cycle Analysis.

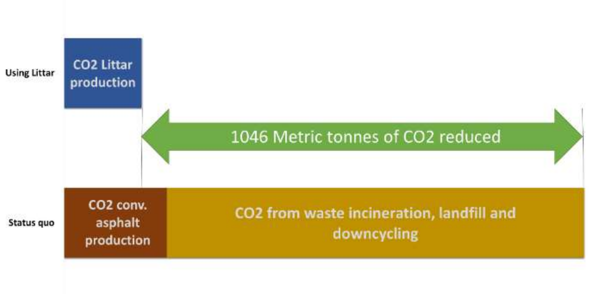

Fig. 6. Visualization of Littar’s carbon emission reduction

8. Any surface is as good as the foundation it rests on

Roads are generally constructed using an asphaltic base, binder and surface layers, see Figure 7. The base and binder layers account for more than 70% of the total mass including the surface. This mass directly translates to construction times, costs and emissions.

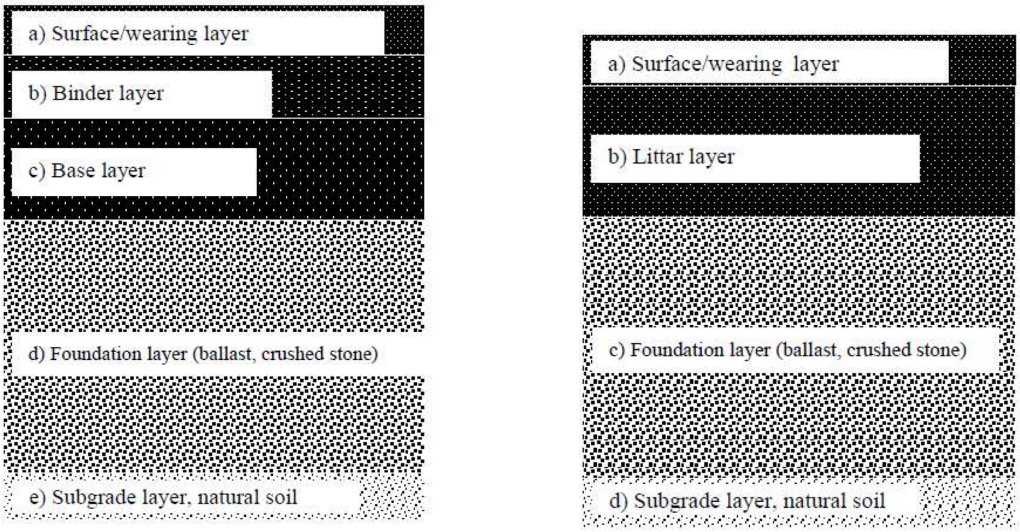

Fig. 7. left: conventional road structure – right: standard Littar road structure

Roads are subjected daily to moving traffic loads. This induces tensile stresses in the bound asphalt or concrete surface layer which, over time, causes irreversible deformations in the underlying, base and binder layers. Deformations of these layers in turn cause weak spots, and ultimately pot-holes or large cracks and deformations in the surface layer. It is clear that improvement of road durability starts with improvement of the foundation material.

Littar is used as base and/or binder layer and increases the durability of the surface layer through its improved load bearing capacity and shock resistance as a result of increased flexibility and elasticity. Additionally, Littar's lower thermal conductivity as a result of plastic and glass aggregates, reduces the influence of frost or heat.

Another important reason why Littar is not a surface layer material is the prevention of microplastics as a result of contact between tires and surface asphalt.

9. Pilot project

In October 2022, a Littar pilot project (see Figure 8) was successfully executed in Cluj-Napoca, Romania. For this 35 square meter driveway foundation project, Littar up-cycled plastic and glass waste equivalent to 70,000 single-use plastic bottles and 6,000 glass wine bottles while preventing 4 metric tonnes of CO2 from being created.

This project has successfully shown the turn-key production and application aspect of Littar as well as its circular-economy which connects local waste processors with local asphalt stations. Building local infrastructure with local waste while reducing CO2 emissions up to 83%.

Fig. 8. Littar pilot project

10. Conclusions

Littar is an innovative, sustainable technology that capitalizes on the underutilized resources of plastic and glass waste. Littar demonstrates substantial potential for reshaping traditional practices in the road construction sector, offering a viable alternative with superior mechanical and thermal properties.

Its utilization simultaneously addresses pressing environmental concerns related to waste management and reduces carbon emissions associated with conventional methods. With its compatible manufacturing process, Littar offers an opportunity for rapid and seamless industry adoption. However, as with any novel technology, the long-term performance of Littar in various climatic and load conditions should be investigated.

In addition, the study of societal and economic implications, such as the effects on local waste management policies and job creation in the recycling and construction sectors, would provide a comprehensive understanding of Littar's potential influence.

Nonetheless, Littar can play a critical role in building a sustainable future, turning the problem of plastic and glass waste into a valuable solution for infrastructure needs.

REFERENCES

[1] International Patent Application: Beton asfaltic din agregate și deșeuri derivat din sticlă și materiale plastice reciclate șl procedeu de obținere, WIPO Registration RO135744A0, 17-12-2021

[2] *Beton asfaltic din agregate și deșeuri derivat din sticlă și materiale plastice reciclate șl procedeu de obținere*, Technical Assesment delivered by INCERTRANS SA, 004-07_1738-2022

[3] Carbon footprint validation report Littar 2022 JKA869, www.impact-forecast.com

[4] www.theclimatechangecompany.com/littar

[5] Ene N., Gheorghe C., Dima C., Ionescu N.A, Costei M. - *Use of recycled glass and plastic materials in asphalt mixture recipes*, Annals of the Academy of Romanian Scientists, Series on Engineering Sciences, ISSN 2066-8570, Volume 14, Number 2/2022