High-performance Asphalt Pavements – adapting for future road networks

EAPA Technical Briefing

March 2022

Published by the European Asphalt Pavement Association
Rue du Commerce 77
1040 – Brussels (Belgium)
www.eapa.org
info@eapa.org

The present document may be cited as:
European Asphalt Pavement Association (EAPA). High-performance Asphalt Pavements – adapting for future road networks. EAPA Technical Review (2021) 22 pages.
https://eapa.org/download/12745/

1. An increasingly challenging traffic

In order to give and answer to the current climate and environmental-related challenges, the European Commission included in The European Green Deal [1] the new growth strategy that aims to transform the EU into a fair and prosperous society, with a modern, resource-efficient and competitive economy, where there are no net emissions of greenhouse gases in 2050 and where economic growth is decoupled from resource use. For this, European policies forecast a future transport system that is resilient, resource-efficient, climate- and environmentally-friendly, safe and seamless for the benefit of all citizens, the economy and society.

In this sense, the bad state of road surfaces leads to higher fuel/electricity consumption, vehicles and road maintenance costs, emissions and delays in travel time. Therefore, in order to meet EU requirements, roads must be durable and require minimum maintenance operations and traffic disruptions. All this, while ensuring that sustainable materials, which guarantee the re-use and recycling at the end of the road's service life, are used.

However, numerous emerging factors are hindering these objectives. For example, extreme events, such as floods or record-breaking temperatures, are more and more frequent every year due to Climate Change. Hence, over the last decades, a great deal of European surface transport infrastructures has experienced an anomalously fast rate of deterioration, bringing them close to the end of their service life.

Moreover, the traffic demands keep increasing. According to Eurostat [2], the road freight transport in the EU-28 countries increased by 23.7% from the begining of 2015 to the begining of 2021 (figure 1). With the exception of the years of EU economic crisis and the second quarter of 2020 due to the Covid pandemic, this increasing trend has been present for decades.

In this unfavourable scenario, road transport is also nowadays experiencing one of the greatest revolutions of its history, with the arrival of new types of vehicles, such as the autonomous, electric and high-capacity vehicles. Such vehicles, expected to be among the main tools of humanity to reduce transport emissions (figure 2) and increase road safety, might also worsen the distress produced on our road infrastructures accelerating the road pavement deterioration over time, requiring specific designs and solutions, when a significant number of these is expected on a given road. For this reason, they can be named Vehicles with Enhanced Road Requirements (VERRs).

As approximately 90% of European road network is made of asphalt, the sector has assumed the responsibility developing high-performance asphalt solutions especially designed to deliver safe and durable roads in the above-mentioned scenarios. This document provides an overview of some of these solutions in order to show that the sector is ready for the new challenges, and with the aim promoting the correct use of these technologies among Road Authorities and the rest of involved stakeholders.

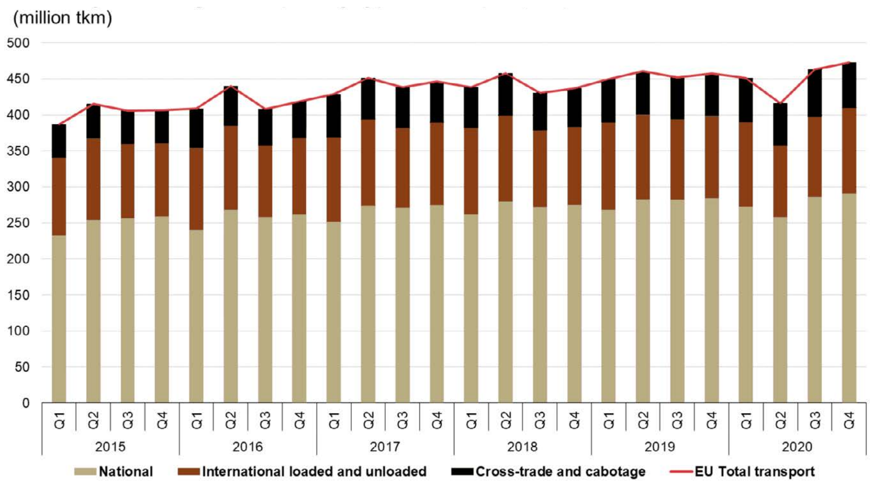
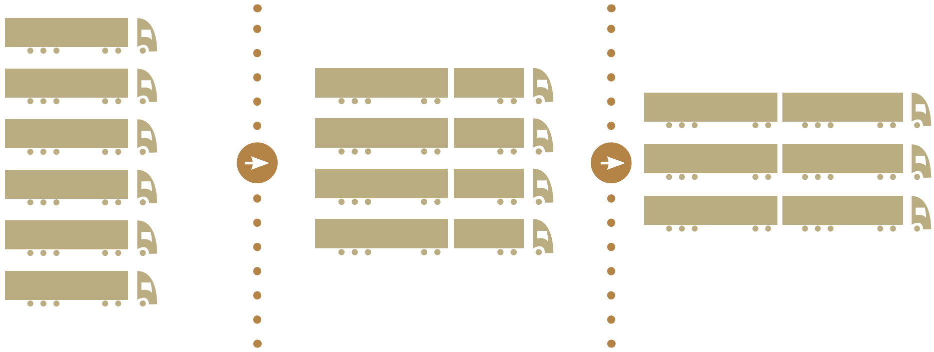


Figure 1. Quarterly rad freight transport by type of transport, EU-28, 2015-2020 [2]



Vehicles (and drivers)	**6**	**4**	**3**
Vehicle length	16.5m	25.25 m	32 m
Load per vehicle	100 m^3	150 m^3	200 m^3
Fuel consumption	3.5 ml/m^{3km}	3 ml/m^{3km}	2.5 ml/m^{3km}
CO2 emissions	100%	85% **= -15%**	73% **= -27%**
Road use	499 m	368 m	296 m

Figure 2. Transportation of 600 m^3 of volume limited goods with the same density (150 kg/m^3) [3]

Potential risks of new road users on the durability of pavements

Heavy vehicles. Improvements in transport efficiency and technical developments in the automotive industry have also contributed to increase axle loading as well as higher tyre pressures. Greater use of high pressure super single tyres is getting more and more usual, while the total weight of trucks keeps growing. This has potential to increase rutting and fatigue cracking.

Electric vehicles following a catenary (overhead system) or a conductive rail embedded in the pavement (in-road system) to charge batteries on-the-fly tend to “hit” always the same spots of the road cross section. This produces a concentration of stresses in these spots, reducing service life.

High-capacity vehicles (HCV) are vehicles especially designed to carry more freight than a standard vehicle. Depending on the configuration and usage, these vehicles have potential to reduce carbon emissions at the individual vehicle level in the range of 15%-40%. However, these vehicles will need to increase either the axle load or the number of axles, potentially leading to either higher pavement stresses or shorter recovering time between loads, increasing fatigue and/or rutting in the pavement.

Autonomous vehicles. The development of autonomous vehicles and the formation of groups of vehicles driving in line, at the same speed and at a very reduced distances between them (system also known as Platooning) is especially beneficial for the aerodynamics of large vehicles. Consequently, it has potential to reduce fuel/electricity consumption. However, these vehicles tend to self-position in the centre of the lane (spots of the cross section receiving most impacts) and reduce the recovering time between loads, which increases the risk of premature rutting and/or fatigue damage.

2. Market-ready asphalt solutions for upcoming challenges

Asphalt industry has developed over decades, specific solutions for pavements specially stressed, such as pavements in ports and airfields or highways supporting heavy-duty traffic. With the arrival of new challenges, it can be expected that future road designs progressively shift towards these kinds of solutions.

High-performance surface courses: The highest stability and durability in surface courses are obtained when Stone Mastic Asphalt (SMA) is used. This type of asphalt mix is composed of a strong coarse aggregate skeleton, which gives the high stability and resistance to permanent deformation, and stiff and elastic mastic, which provides an outstanding durability. More information about it can be found in the EAPA Position Paper on this topic [4].

High-performance binder courses: Depending on the pavement structure, the use of SMA in binder courses can improve the overall mechanical characteristics and protects the layers underneath against the effect of water. This is especially relevant when the surface layer is made of permeable materials, such as porous asphalt (PA).

High-modulus base courses are bituminous layers with a balanced combination of closed structure and hard bitumen, which increase the mix stiffness and resistance to rutting, and an increased bitumen content, which ensure workability, water resistance and fatigue durability. Traditionally used as base courses in long-life roads, with design periods of 40 or 50 years, they can become more and more frequent, as long as heavier traffic and VERRs circulate throughout our road networks.

New concepts for pavement structures:
Combinations of SMA wearing coarse followed by a thick high-modulus binder course and a 75-100 mm anti-fatigue layer made of asphalt concrete with highly polymer-modified bitumen PMB 45/80-80, or even the replacement of the traditional 3-layers structure by a triple-SMA have proven to be resistant to even extremely heavy and slow traffic in ports and industrial areas.

Advanced pavement execution: In order to ensure maximum performance in pavements subjected to high-stress conditions, it is crucial to undertake an optimum construction execution, which encompasses the use of the best techniques for every stage of the supply chain. These include, for example:

- Smart asphalt plants fully equipped with automatic production and control systems.
- Advanced transport vehicles, such as push-off trailers and advanced isolating materials, which help to deliver the mix with homogeneous temperature.
- Smart paving and compaction equipment with continuous and autonomous temperature and density monitoring.
- Job-site logistics tools to interconnect all previous stakeholders and optimise the production, delivery and functioning pace at which each of them is working.
- Intelligent asphalt quality and roads inspection to detect, at the earliest possible, weak points in the pavement and repair them before they create bigger concerns.
- Smart asset management systems to optimise the performance of the road network during its service life.

In this regard, asphalt industry is living nowadays its own digital revolution [5], hand in hand with the latest developments in robotics, machine-to-machine communication, sensors, big data, artificial intelligence and electrification, among others.

By means of these disruptive technologies, the sector is taking a huge step forward to increase and multiply production efficiency, while maximising product quality.
Unlike other materials, hot mix asphalt requires the coordination of all the stakeholders involved in road construction (mixing plant, delivery, paving, compaction, etc.) to reduce the temperature losses during the process. This collaboration facilitated that the mentioned digital technologies penetrated asphalt sector and road construction earlier than other construction sectors. As a result, asphalt industry is leading the way and being taken as a reference in construction when it comes to digitalisation.

3. Conclusions

In order to meet the current EU requirements, roads must be resilient, durable and require minimum maintenance operations and traffic disruptions.

However, emerging factors are hindering these objectives, such as Climate Change, increasing road transport demand and axle loads, or the arrival of new types of vehicles with certain characteristics, which might produce the premature deterioration of the pavements.

To prevent this, high-performance asphalt pavement solutions can be adopted, progressively shifting our current pavement designs towards technologies conventionally used in highly stressed pavements.

A wide range of technologies have been used over decades proving their effectiveness to significantly extend the service life of asphalt pavements. Others have been more recently developed to push the limits of asphalt pavements to a different new level.

For these reasons, the European Asphalt Sector is completely prepared and has capacity to give support to the traffic of new vehicles with enhanced road requirements, as well as to adapt the European road network wherever necessary.

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