EUPAVE
EUROPEAN CONCRETE PAVING ASSOCIATION

FACT SHEET
Higher Resilience

Concrete roads show better resilience to climate change and extreme meteorological events

"Concrete pavements, in comparison with asphalt, withstand better the effects of high ambient temperatures, bush fires, flooding and extreme traffic loadings."

Interstate highway I-95 submerged in Lumberton, NC (USA) © Greg Dean / Carolinas Concrete Paving Association

One of the aspects of climate resilience is the capacity of a system to absorb stresses and maintain function in the face of external stresses imposed upon it by climate change.

For roads and infrastructure, climate resilience efforts aim at addressing the vulnerability with regard to the environmental consequences of climate change.

The two main consequences of climate change that will affect roads are the increase of temperature and precipitation. Europe's road network can be expected to suffer various stresses as a result: flooding, erosion of embankments and foundations, loss of road structure integrity and loss of pavement integrity. Therefore, an appropriate adaptation strategy and a preventive long-term approach are necessary, providing robust, 'future-proof' solutions.

All types of concrete roads are long-lasting and are built to withstand changes in temperature or moisture. Concrete stiffness remains constant in the range of ambient temperatures, not suffering softening or rutting and no hazardous pollutants are emitted at high temperature. Thanks to its fire resistance, concrete stands up to the heat of forest fires. Concrete surfaces keep their properties over time and show no risk of delamination. In addition, cement bound base layers are high quality, erosion- and frost-resistant solutions.

The societal benefits of a robust and resilient road network are numerous. First of all, in case of disruptive events, lives are saved because of the positive impact on road safety and the traffic flow of emergency services (ambulances, firefighters…). Secondly, money is saved due to less cost of repair and to less impact on the functioning of the economy during extreme events.

SOME MORE INFORMATION

WHAT IS RESILIENCE

In IPPC, 2014, resilience is defined as 'the capacity of social, economic and environmental systems to cope with a hazardous event or trend or disturbance, responding or reorganising in ways that maintain their essential function, identity and structure, while also maintaining the capacity for adaptation, learning and transformation.'

Although any type of adverse event is considered, e.g. terrorist attacks, earthquakes etc., this fact sheet will focus on the negative effects of climate change.

THE EFFECTS OF CLIMATE CHANGE ON ROADS AND PAVEMENTS

The two main consequences of climate change that will affect roads are the increase of temperature and precipitation. Europe's road network can be expected to suffer various stresses as a result: flooding, erosion of embankments and foundations, loss of road structure integrity and loss of pavement integrity.

2011-2020 was the warmest decade recorded, with global average temperature reaching 1.1˚C above pre-industrial levels in 2019. Human-induced global warming is presently increasing at a rate of 0.2˚C per decade. [EEA]

An increase in the frequency and duration of extreme temperatures is also projected, mainly in the south of Europe. According to the European Environment Agency, this increase in hot days during the summer will lead to softening and rutting of asphalt pavements. Additionally, increased temperatures will intensify freeze-thaw cycles in the north of Europe, which could accelerate the deterioration of pavements and cause soil and slope instability and ground movement.

The number of large forest fires has also dramatically increased with serious impacts on environment and local communities but also on the pavements that are needed to give access to fire fighters. The projected increase in weather-driven fire danger in southern Europe is about 30-40 % by the late 21st century, compared with the period 1981-2010. [EEA]

Moreover, the projected change in heavy rain in winter and summer in the period 2071-2100 compared to the present climate (1971-2000), based on high emissions scenario, amounts up to 25 % for Southern Europe. The largest increases, up to 35 %, are projected for central and eastern Europe. [EEA] The increased frequency of storm surges and flooding will affect pavement surfaces, granular subbases and subgrades of pavements if drainage systems have not taken this into account, leading to damage to pavements.

Another consequence of nature disasters (flooding, forest fires, ...) is the necessary evacuation of debris. [Oyediji et.al.] [Chen&Zhang] [Signore] Unfortunately, debris carrying trucks are unavoidable in case of severe damage after flood or wildfire events. This transport mostly happens on roads which have not been designed for that kind of traffic. Researchers observed for asphalt roads, in comparison with concrete roads, a considerable increase in the IRI (International Roughness Index – measurement of unevenness) and a faster degradation. Rigid, concrete pavements are less impacted by overloading and provide the highest resilience to flood and wildfire damage.

PRECIPITATION - FLOODING

- Concrete roads are less susceptible to the swelling or shrinking of the subgrade compared to asphalt pavements. Therefore, concrete roads are the best solution in case of cohesive soils such as clay.
- Delamination is no issue for concrete roads as they are built as a monolithic slab. This is also the case for two-layer concrete pavements.
- Among the different types of concrete roads, continuously reinforced concrete pavements (CRCP) can be seen as the most robust, especially in the case of flooding. The continuous reinforcement creates a bridging effect: it distributes the load over saturated bases and enables the pavement to cope with a local subsidence. In Texas, several sections of

Road damaged after flooding, Gironde (France)
© Facebook page of Noaillan

Road damaged after floodwaters, Reading Drive, PA (USA)
© Rich Hawk / sauconsource.com

CRCP have been subjected to complete inundation on average every five years and to traffic loading four to five times expected levels, while incurring minimal annual maintenance costs, proving the robustness and resiliency of this pavement type. [Lukefahr]

- Not only concrete roads but also hydraulically bound base layers are robust solutions, which withstand better the effects of flooding in comparison with unbound granular layers. Indeed, cement bound granular mixtures including lean concrete and roller compacted concrete are known as high quality, erosion- and frost-resistant solutions.

EXTREME WEATHER CONDITIONS - BUSHFIRES

Concrete pavements have proven to be durable and long-lasting in many different climatic conditions all over the world.

- All types of concrete roads (jointed plain – jointed reinforced – continuously reinforced – roller compacted concrete) are long-lasting and are designed and built to withstand changes in temperature or moisture, e.g. through adapted concrete mixes for improved frost resistance.
- In some cases, special construction techniques are being applied to allow working in extreme weather conditions.
- Thanks to a well-thought design of joints and reinforcement, it is possible to cope with large temperature variations.
- Concrete stiffness remains constant in the range of ambient temperatures, not suffering softening or rutting. In fact, the surface of concrete is robust and it keeps its properties over time, independently of climate effects. This is true for most of the surface characteristics such as micro- and macrotexture, skid resistance and rolling noise production.
- Concrete is a fire-resistant material. This makes it the ideal material for pavements

Forest fires are a danger to citizens and emergency services
© Evan Collis, photographer of the Department of Fire and Emergency Services, Government of Western Australia

Heavily rutted asphalt pavement, due to heavy traffic and accelerated by high ambient temperatures © FEBELCEM

in areas where wildfires may occur. Due to climate change the number of forest fires has significantly increased over the past years, in all parts of the world.

MITIGATION EFFECTS

Concrete roads and their surfaces can have several positive mitigation effects on climate change: slowing down global warming thanks to their high albedo, reduced CO_2- emissions due to lower fuel consumption for heavy trucks, recarbonation of recycled aggregates, reducing the risk for flooding with water pervious concrete pavements… For more information on all of these benefits, we refer to the other available factsheets of EUPAVE.

Parking lot in pervious concrete pavement, Dreux (France) © CIMbéton

WHAT POLICY IS NEEDED?

The societal benefits of a robust and resilient road network are numerous. First of all, in case of disruptive events, lives are saved because of the positive impact on road safety and the traffic flow of emergency services (ambulances, firefighters…). Secondly, money is saved due to less cost of repair and to less impact on the functioning of the economy during and after extreme events.

A choice for resilience is a choice for a long-term approach for the procurement and construction of transport infrastructure, considering the consequences of climate-change. An ideal solution is building concrete roads, either as newly constructed pavements or as overlays upon existing asphalt pavements (with thin or conventional thickness, bonded or unbonded). They offer not only a higher robustness and better performance but also a long serviceability with minimum maintenance, reduced life-cycle cost and a safe, durable, and light-coloured surface.

More environmental benefits from concrete roads can be found on EUPAVE's infographic "Concrete Pavements Make Roads More Sustainable" (2019), https://www.eupave.eu/resources-files/infographic

References

Dealing with the effects of climate change on road pavements. (2012) PIARC Technical Committee D2 on Road Pavements, PIARC Technical Report 2012R06EN

EUPAVE (2016). A resilient road network for adaptation to climate change. Position paper

Signore, J. (2020). The unseen impact of California wildfires on affected roadway pavements - https://www.cacities.org/Resources-Documents/Education-and-Events-Section/Public-Works-Officers-Institute/2020-Session-Materials/The-Unseen-Impact-of-California-Wildfires-on-Affec

https://en.wikipedia.org/wiki/Climate_resilience

https://experience.arcgis.com/experience/5f6596de6c4445a58aec956532b9813d. European Environmental Agency [EEA]

Lukefahr, E. (2018) Continuously Reinforced Concrete Pavement Resiliency – A Case Study. Presentation at ACPA 55th Annual Meeting

Oyediji, O., Achebe, J., Tighe, S.L. (2019) Towards a flood-resilient pavement system in Canada – A rigid pavement design approach – TAC-ITS Canada Joint Conference, Halifax, NS

Willway, T., Baldachin, L., Reeves, S., Harding, M., McHale, M., Nunn, M. (2008). The effects of climate change on highway pavements and how to minimise them: Technical Report. TRL, PPR 184

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July 2021