EUPAVE
EUROPEAN CONCRETE PAVING ASSOCIATION

FACT SHEET
Economic Aspects

Building a concrete road is a smart and sustainable investment

Photo: Polish Cement Association

Sustainability discussions often highlight environmental aspects while underemphasizing economic and social dimensions.

This fact sheet looks at the financial and economic sides of choosing road pavements, focusing on both short-term costs and long-term benefits.

It compares different types of roads and construction methods, with a special focus on concrete pavements.

Considering the entire life cycle will show that the choice of concrete roads is the most cost-efficient and sustainable.

ABSTRACT

The economic viability of road pavement choices extends beyond initial costs to encompass long-term sustainability and efficiency. This fact sheet highlights the financial and economic impact of different road construction methods, emphasizing the benefits of concrete pavements. A key aspect is competition in the road construction sector, where inter-industry competition—between firms using different materials like asphalt and concrete—lowers costs more effectively than competition within the same industry. Research from the Massachusetts Institute of Technology (MIT) found that increasing concrete's market share can reduce unit costs by up to 29% for concrete and 8% for asphalt.

Concrete roads contribute positively to the local economy by supporting regional industries, reducing transportation needs, and facilitating circular economic practices such as recycling concrete aggregates. A fundamental economic assessment method is Life-Cycle Cost Analysis (LCCA), which evaluates long-term investment efficiency. European Union public procurement directives emphasize cost-effectiveness, yet LCCA remains underutilized in Europe. Proper application of LCCA demonstrates that durable, low-maintenance concrete pavements often provide better long-term value than asphalt.

Specific concrete pavement types like Continuously Reinforced Concrete Pavement (CRCP) and Roller Compacted Concrete Pavement (RCCP) offer notable cost advantages. CRCP's lower maintenance requirements increase road availability, reducing long-term costs. Studies show RCCP can be significantly more cost-efficient than asphalt, particularly on roads with high traffic or poor soil conditions. Public-Private Partnership (PPP) projects in Germany further validate concrete's economic benefits, as operators prefer durable solutions to minimize long-term maintenance costs.

Beyond direct cost savings, concrete roads enhance vehicle fuel efficiency due to their smooth, rigid surfaces, reducing fuel consumption and road wear. Moreover, they demonstrate superior resilience against climate-related disruptions such as floods and extreme temperatures, leading to lower repair costs and ensuring uninterrupted transportation.

In conclusion, while initial construction costs often drive decision-making, concrete pavements can in some cases be cost-competitive — or even more economical — from the outset. Adopting a whole-life economic perspective further reveals their long-term financial and societal benefits. By integrating LCCA and fostering inter-industry competition, public authorities can optimize infrastructure investment, ensuring cost savings and more sustainable road networks for the future.

IMPORTANCE OF COMPETITION

As stated in the report by Mack & Wathne (2023), increased industry competition has the potential to lead to reduced pavement expenditures for agencies. They make the distinction between:

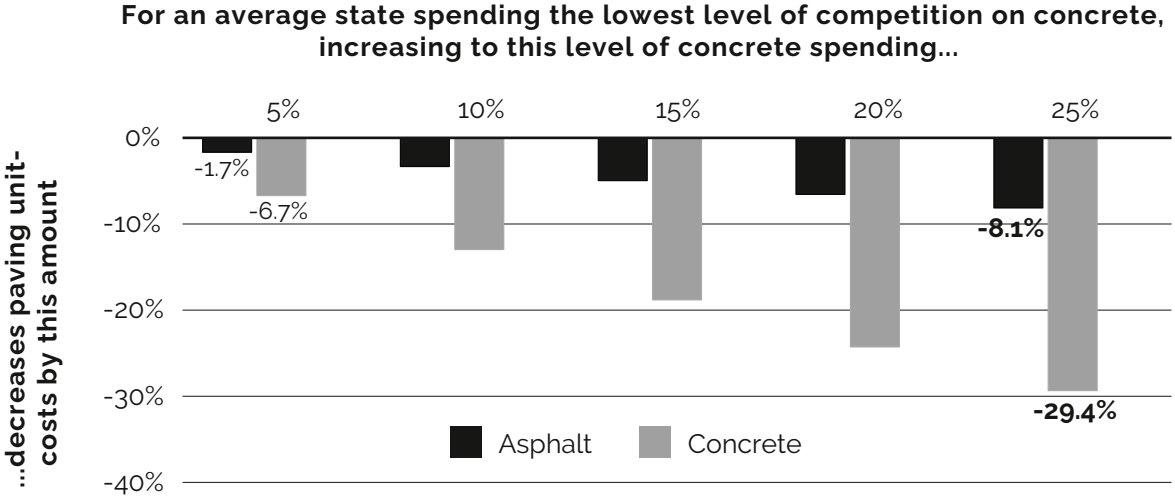
1. intra-industry competition: between firms that pave with the same material;

2. inter-industry competition: between firms that pave with different materials.

The inter-industry competition brings both additional contractors to the bidding process and a second level of competition into the supply chain between the material suppliers (e.g. asphalt – concrete), that would not otherwise occur.

In the U.S., the Concrete Sustainability Hub at the Massachusetts Institute of Technology (MIT CSHub) has been conducting a multi-year research programme to evaluate and improve the environmental and economic performance of concrete in pavements and buildings.With respect to pavements, one area of focus was on improving the economic analysis practices to better reflect the most likely expenditures for pavements over their lifetimes. Essentially, their goal was to determine if inter-industry competition between pavement industries did in fact lower the unit cost for both asphalt and concrete pavements, and by how much.A first part of the study was a statistical analysis to determine the factors influencing pavement costs. Construction bid and materials pricing data of approximately 30 000 projects were used in a statistical model. An initial observation was that inter-industry competition was the most important factor for concrete road construction, followed by the size of projects.

In terms of the impact on paving costs, MIT found that **as inter-industry competition increased, the unit costs of both concrete and asphalt paving materials fell significantly - particularly for concrete.** For example, if a state with a low concrete market share (e.g. 1%) increased its concrete market share to 25%, it would reduce the unit cost of concrete and asphalt paving materials by approximately 29% and 8% respectively. In comparison, increasing intra-industry competition (same material) from 3 bidders to 5 bidders reduces the cost of an average project by only 5% (MIT, 2020).



Estimated impact of increased inter-industry competition on asphalt and concrete paving costs [Mack & Wathne]

To develop this competition, road agencies must be willing to involve both the asphalt and concrete paving industry in their construction and rehabilitation programme. This process of creating competition should consist of the following steps:

- Announce the intention to have both industries participate in the programme.

- Adopt and use all cement based/ concrete solutions in multiple market applications: concrete is not only viable for new construction or reconstruction of motorways and high-volume expressways but also for regional roads, local roads and streets, arterials, intersections, parking lots, industrial yards, etc., creating more opportunities for contractors of all sizes. That is also a signal to the contractors that they should start investing in equipment and training as there will be multiple, new opportunities.

- Purposely let a given number of concrete projects each year and develop a Project Pipeline that covers several years: just as agencies let projects that are only asphalt, agencies should routinely let projects that are only concrete. Some successful projects policies that have been used in the U.S.:

    - designate a given percentage of projects each year that will be concrete;

    - programmatically balance the market based on some metric such as volumes;

    - use traffic or road classifications to designate specific markets for each product.

- Develop technical task forces to address issues with specifications, design procedures, and other policy/design/ construction issues. Good policies, specifications, and practices lead to lower costs and good construction, and ensure that the agencies get a pavement that will last and serve them cost-effectively.

- Use Life Cycle Cost Analysis and Alternate Pavement Bidding on specific pavement projects, to further drive down costs on these projects. This can be done once both the concrete and asphalt industries are participating and effective intra-industry competition can take place.

As a conclusion, increased inter-industry competition – between firms that pave with material substitutes – offers high-potential for road authorities to maximise the performance of pavement sections and make their limited infrastructure budget go farther. Therefore, they should proactively purse policies that increase inter-industry competition as they will over time significantly lower unit costs for both paving materials and assure the highest return on investment of taxpayer euros.

Local road in concrete - Photo: Polish Cement Association

LOCAL ECONOMY

The cement and concrete markets are mainly local or regional markets and that is important. First, that has financial importance; it provides income for citizens and for the government through taxes. But the importance is much broader; local economy also has social and environmental importance. When local production and use are closer together, there is less need for transport with its attendant drawbacks. It also enables a circular approach more easily; just think of recycled concrete aggregates that can be reused in certain concrete applications and soon also the use of fine concrete particles in the production of new types of cement. And looking at the previous item about competition, that is well ensured thanks to a wide geographic availability of concrete batching plants.

Recycling of crushed concrete aggregates as part of a local and circular economy - Photo: Luc Rens

A LIFE-CYCLE COST ANALYSIS (LCCA) IS THE ONLY RIGHT METHOD

The EU Directives on Public Procurement and Concessions[1], which are applicable since 18 April 2016, establish rules on the procedures for procurement by contracting authorities with respect to public contracts as well as design contests, whose value is estimated to be not less than certain thresholds. One of the goals of this legislation is to have bids assessed on the basis of the best price-quality ratio, which should always include a price or cost element using a cost-effectiveness approach, such as life cycle costing and foreseeing the possibility of including the best price-quality ratio.

Unfortunately, life-cycle costing is rarely used in the procurement of transport infrastructure in Europe today, despite the savings it can bring over the life of an infrastructure asset such as a road.By focusing on the initial cost of construction in assessing bids, as is currently often the case, authorities fail to capture cost savings that are possible thanks to durable, low-maintenance solutions. Thanks to the EU Directives, there is an opportunity for Member States to update their procurement practices and save taxpayers' money, while also benefiting the environment. Furthermore, as explained earlier, promoting healthy competition by means of open tendering processes has proven to reduce costs for public authorities.

For this reason, EUPAVE is committed to providing further guidance by offering its technical expertise and know-how to its members and to all contracting authorities in the European Union who wish to use life cycle costing approaches to deliver better value for money and more sustainable infrastructure. For this reason, EUPAVE also decided to draft a guide on LCCA of pavements (Diependaele, 2018) to provide a general insight into the approach and good practices for carrying out such analyses. This guide was written by Mr Manu Diependaele, consultant in LCCA, who reviewed and collected a large amount of information and reference documents and transformed them into a new, clear and concise European guide explaining the principles and procedures to be followed. Here are some basic concepts and decisions from the examples shown, both from a motorway and a local rural road.

LCCA is an analysis technique based on well-founded economic principles used to evaluate the long-term economic efficiency between competing alternative investment options. LCCA can be applied to different types of assets and to a wide variety of investment-related decision levels. LCCA for pavements is typically performed to compare competing pavement designs, over a defined analysis period, taking into account all significant present and future costs (agency, user and other relevant costs) over the life of the pavement and expressing these costs in present value.

Because much of the pavement networks consist of either asphalt or concrete pavement, many publications focus on LCCA of these two alternative types of pavement and on their subsequent comparison. However, LCCA can as well be conducted to evaluate and compare the economic worth of alternative designs of the same type of pavement.

[1] Directive 2014/24/EU of the European Parliament and of the Council of 26 February 2014 on public procurement (replacing Directive 2004/18/EC), Directive 2014/25/EU of the European Parliament and of the Council of 26 February 2014 on procurement by entities operating in the water, energy, transport and postal services sectors (replacing Directive 2004/17/EC), and Directive 2014/23/EU of the European Parliament and of the Council of 26 February 2014 on the award of concession contracts

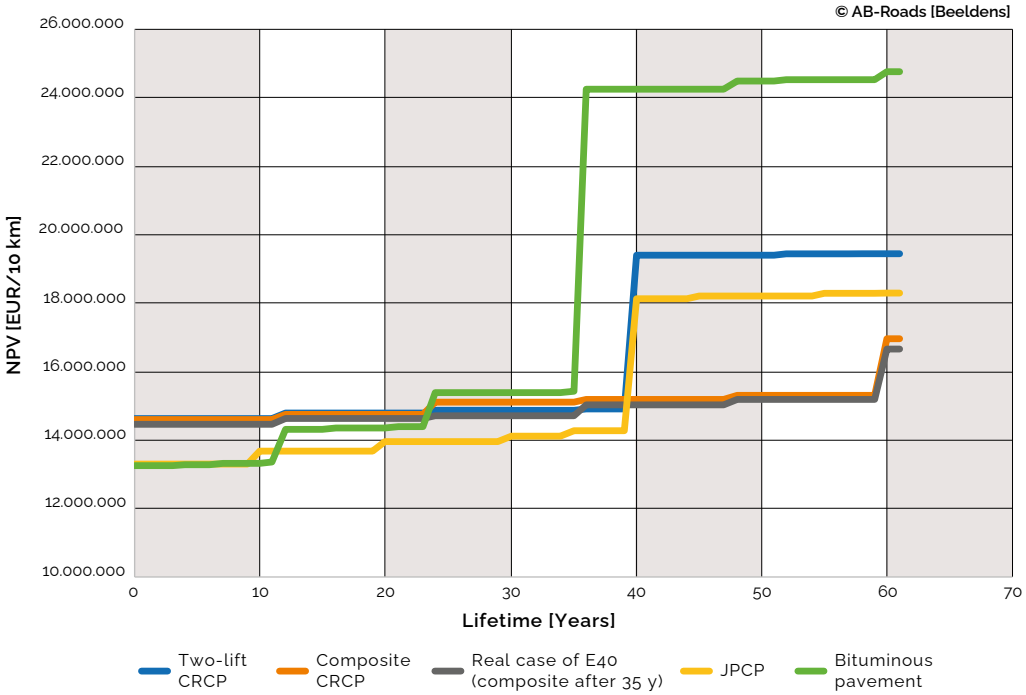
Important parameters in an LCCA of pavements are:

- the design of the pavement structures for a given service life;
- the maintenance scenarios;
- the unit prices, leading to the initial construction cost and the later maintenance costs;
- the analysis period;
- the discount rate;
- possibly social costs, e.g; due to lane disruption;
- ...

Motorway in concrete and asphalt - Photo: Luc Rens

Special case for CRCP (Beeldens, 2019)

The life cycle cost analysis of a continuously reinforced concrete pavement reveals that CRCP is competitive with or more economical than JPCP and bituminous pavements. This is due to the low maintenance cost, taking place at a later stage in the lifetime. This not only reduces the overall cost of the pavement structure, but also increases the lane availability, with a positive impact on the social cost of the pavement. A comparison of the structures for CRCP, JPCP and bituminous pavements, designed according to German standard RStO-12 shows that the construction and rehabilitation costs for the asphalt pavements are higher than for the cementitious pavements due to the increased cost of the base course. By increasing the stiffness of the pavement, the base layer thickness can be reduced and the overall cost for the structure will be reduced.



Comparison of the life-cycle cost (construction – maintenance – reconstruction) over an analysis period of 60 years with a discount rate of 4% for different motorway structures in concrete and asphalt.

CRCP = Continuously Reinforced Concrete Pavement. JPCP = Jointed Plain Concrete Pavement.

Comparison of the different CRCP-structures looked at in this LCCA indicates that the initial cost keeps on playing an important role in the end result. However, if the lifetime can be prolonged, more optimal results can be obtained. From an economic point of view, it makes more sense to extend the life of a structure by carrying out work at a later stage after installation. For example, structures with an asphalt overlay after 40 years have a life extension of 20 years. These structures perform better than the composite structure where the asphalt overlay is placed at the start. That is illustrated in the graph above by the grey line, representing the real case of motorway E40 Brussels-Liège in Belgium.

The E40 was built in 1971-1972 as a CRCP and overlaid with an asphalt wearing course after about 35 years. It is still in service today after 53 years. The discount rate also plays an important role in the end result and the impact of the different phases. If the discount rate increases, the initial cost will be more important for the NPV at infinite. On the other hand, at lower discount rates, the reconstruction cost becomes more important. The later this reconstruction can be done, the lower the NPV will be. The results indicate that up to a discount rate of 6%, the choice for concrete (all solutions) is economically more favourable than the asphalt solution.

Construction of a CRCP - Photo: Luc Rens

In this calculation, the social costs due to lane closure are not directly considered as they depend to a large extent on the congestion due to construction or maintenance of the pavement. While during construction, an optimal deviation plan can be foreseen, the construction time does not necessarily result in a higher social cost. The influence of the maintenance can be reduced by optimising the period of intervention. The calculation of the lane disruption time for the different types of pavements indicates the important unavailability of the JPCP, the doweled slab concrete pavement. The difference between bituminous pavements and CRCP is limited if the longevity of the CRCP is not considered. However, if the lifetime of the CRCP can be extended up to 50 or 60 years by an asphalt overlay, a significant gain in lane availability is achieved over the lifetime with CRCP.

The considerations and assumptions made in this LCCA are, off course, only valid if the foreseen construction quality is obtained and the foreseen lifetimes will be achieved.

Special case for RCCP

A Turkish study (Akbelen et al.,2023) comparing RCC pavements to asphalt pavements reveals significant cost advantages for RCC. It compares the initial construction costs of hot-mix asphalt (HMA) and roller compacted concrete (RCC) pavements for the same service life, same traffic categories, same road classes and same soil classes, using official unit prices of public authorities for 2023. RCC pavements are always more economical for the First- and Second-Class Roads (Motorways, National Roads and Regional Roads with an Average Annual Daily Traffic (AADT) mostly between 500 and 5000). The economic efficiency[2] increases with increasing traffic loading and decreasing bearing capacity of soils as expected, with an average of 29% for First Class Roads and 18% for Second Class Roads. For Third Class Roads and when the AADT ≤ 100, the initials costs for HMA and RCC are comparable; only when AADT ≤ 20, HMA pavements become more economical.

Similar results were found in an Austrian research project (Eberhardsteiner et al., 2020). A RCC pavement and an asphalt pavement, both 20 cm thick were compared over an analysis period of 50 years. Considering a 30-year service life for the RCC, its lifecycle costs were around 30% lower compared to the asphalt solution, with a standard service life (replacement of top layer every 15 years).

[2] Economic efficiency is defined as $(ICC_{RCC} - ICC_{HMA})/ICC_{HMA} \times 100$, with ICC= initial construction cost.

Construction of a RCC road - Photo: Türkcimento

PPP-PROJECTS SHOW THAT A WHOLE-LIFE ECONOMIC APPROACH RESULTS IN MORE CONCRETE ROADS

In Germany, several highway sections have been built with the Public-Private-Partnership formula. The basic contractual aspects of such projects combine both construction and operation, with the following effects:

- due to the contractual combination of construction and (30+ year) operation, the usual contractual warranty clause of two to five years is changed into direct responsibility for the quality for the entire duration of the operating contract.

- due to high contractual penalties for shutdown periods, the operator has a strong economic self-interest in ensuring maximum availability of the routes at all times.

Due to these contractual requirements, almost all construction and operator consortia and the financiers behind them have chosen concrete pavements, as this meets the contractual requirements with a secure, long-term prognosis.

Another economic importance is that at the end of the contractual operating time of mostly 30 years, these roads are not at the end of their service life but are still available to the public sector in a contractually defined, good condition for use. The motorway can therefore be used immediately and without restrictions and have a high residual usage potential.

BENEFITS DURING THE USE PHASE

An important cost, not for road authorities but for road users this time, is the fuel that is consumed during driving. Many parameters have an influence on the fuel consumption but the ones that are related to the pavement surface are smoothness and deflection. Concrete roads, when properly constructed, have smooth surfaces; they retain their evenness over time and don't show any problems with rutting. In addition, the stiffness of concrete means that the surface does not deflect under heavy wheel loads, preventing excessive fuel consumption. This is a clear advantage over flexible pavements, especially in warm climates and slow traffic.

The cost of traffic jams due to maintenance was already discussed within the paragraph on LCCA. But another major reason for traffic disruption is climate change, or rather its effects: floods, forest fires... A robust and resilient road network is needed to withstand the consequences of such disruptive events. It helps save lives because of the positive impact on road safety and the traffic flow of emergency services (ambulances, firefighters, etc.). Secondly, it helps save money due to lower repair costs and, finally, the increased availability of the road means a lower impact on the local economy. Concrete roads, newly built or as an overlay on existing asphalt pavements have proven to be very resilient.

CONCLUDING REMARKS

The economic analysis of different pavement types highlights the importance of assessing both initial construction costs and long-term performance. Indeed, in many cases a full LCCA will show that a concrete pavement is the most economical solution compared to asphalt due to its slow maintenance and long service-life. The analysis must be carried out on a case by case basis in order to adopt the design with the lowest cost for society over time.

Continuously Reinforced Concrete Pavements (CRCP) and Roller Compacted Concrete (RCC) pavements are special cases that offer significant advantages in different contexts. CRCP, known for its high durability and low maintenance requirements, is particularly advantageous in high-traffic roads, where its long lifespan justifies the higher initial investment.

Similarly, a Turkish study shows significant cost advantages for RCC pavements, based on initial construction costs, especially on roads where traffic intensity and poor soil conditions can make traditional hot-mix asphalt (HMA) pavements less viable.

Public-Private Partnership (PPP) projects, as demonstrated in countries such as Germany, further highlight the long-term economic benefits of using concrete pavements. These projects, which combine construction and maintenance under one contract, tend to favour concrete solutions due to their lower lifecycle costs and superior durability.

In conclusion, adopting a whole-life economic perspective rather than focusing solely on initial costs reveals the clear potential for different types of concrete pavements to optimise public infrastructure investment, ensuring long-term sustainability and reduced maintenance costs.

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