Concrete Pavement: Building Better, More Sustainable Roads

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When paving heavy-traffic roads, the right material makes all the difference. Concrete is characterized by its proven durability, reduced maintenance, lower carbon footprint, recyclability, ease of construction, and safety benefits — and it is a local material. Concrete pavement delivers superior value and performance — and a lower environmental impact — over a road's service life.

This is why many municipal and provincial departments of transportation across Canada are actively exploring the use of concrete pavement for their high-traffic, high-wear intersections, interchanges, streets and highways. It is a proven, "best-in-class", greener solution of choice that is typically more cost-effective over the lifecycle than the alternative paving material for these applications, and ideally suited for Canada's climate.

Advantages of Concrete Pavement

Long Term Durability and Reduced Maintenance

With an average service life of 30-50 years, concrete pavement lasts longer and requires less maintenance over its lifetime than asphalt:

- Its rigid surface does not rut, washboard or shove; it minimizes the potential for potholes; and it provides better load distribution, making it less susceptible to damage from heavy vehicles.
- It stands up to seasonal stresses: concrete mixes are tailored to specific applications and conditions — including cold weather and de-icing agents — to ensure strength and durability throughout the life of the pavement.
- It retains its structural integrity and performance better than asphalt, even when inundated by floods. This is because concrete doesn't rely on the strength of the granular materials as much as asphalt does, and is therefore less affected by the saturated subgrade.

Concrete's durability reduces costs and the additional CO_2 emissions associated with resurfacing and reconstruction operations. It also minimizes the use of scarce aggregate resources compared to asphalt and creates less disruption for the travailing public and commercial truckers.

Lower Carbon Footprint

- Concrete has a superior environmental performance on many metrics, such as durability, reduced use of raw materials, and carbon uptake, and a clear action plan to achieve net-zero by 2050.
- Its carbon footprint has been reduced by well over 20% over the last 30 years: the manufacture of modern cement is more energy-efficient; lower-carbon cements such as Portland-limestone cement (PLC) reduce emissions by up to 10% compared to traditional cement; and the use of supplementary cementitious materials that would otherwise be destined for landfills replaces 20% or more of the cement required to produce one cubic meter of concrete.
- Through a natural process called carbon uptake, concrete sequesters carbon dioxide from the atmosphere over its entire life, further reducing its carbon footprint as well as nearby pollution levels. Studies show that up to 20% of cement process emissions are re-absorbed into a concrete product.
- Being an inert material, concrete doesn't emit fumes, which means less air pollution.

Improved Energy Efficiency

- A concrete road requires less energy to build than an asphalt one, due to requiring substantially less granular material in the subbase layer.
- Its lighter-color, highly-reflective surface reduces night-lighting needs while improving visibility.
- It also absorbs less heat, which helps lower ambient air temperature and keep communities cooler, reducing the need for air conditioning and lowering smog.

Improved Fuel Efficiency

The rigid surface of concrete pavement improves the fuel efficiency of commercial vehicles by up to seven percent[1]. This yields potentially significant reductions in carbon emissions.

Improved Safety

- Concrete's strength means virtually no potholes, ruts or low-temperature cracking, which means safer driving conditions.
- Its tined surface creates a superior tire pavement interface in wet weather conditions, allowing for better braking and handling performance, and reduces the potential for hydroplaning caused by pooling surface water.
- Its heat retention property means less potential for flash freezing and "black ice" in winter.
- Its brighter quality makes roads and parking lots safer at night.

Improved Construction Timelines

State-of-the-art paving processes and innovative concrete mix designs such as fast track concrete allow concrete roads to reopen within as little as six hours after work completion, reducing time-in-traffic auto emissions and adding convenience.

A Local, Recyclable and Reusable Material

- Concrete is produced locally, using both locally-available aggregates and regionally-manufactured materials including cement. This minimizes transportation energy consumption.
- It is 100% recyclable and re-usable: at the end of its service life, it can be crushed and used as a natural aggregate for road base. This reduces the need to dispose of old material in landfills and to extract new virgin aggregate material.

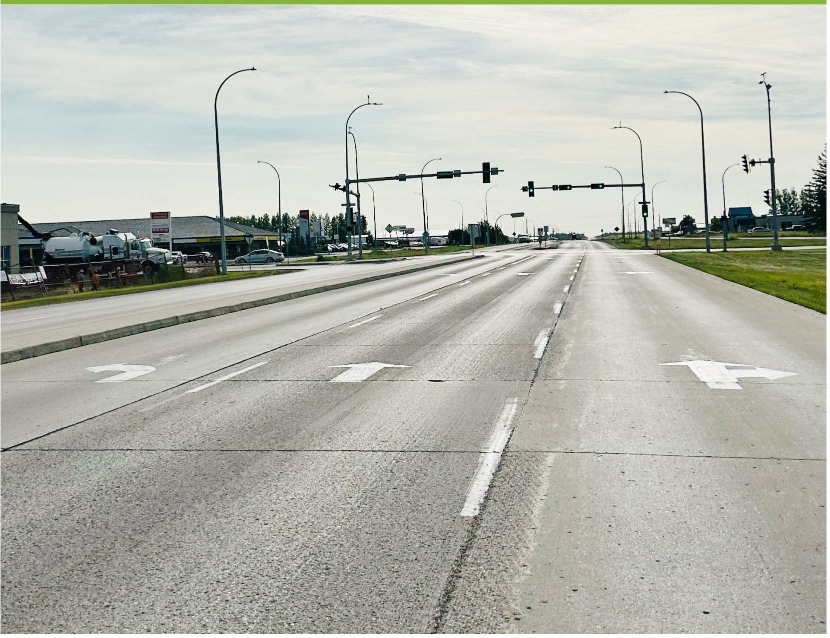
Reduced Long-Term Costs and Environmental Impacts

- Durable and environmentally-friendly over the course of its long lifespan, concrete pavement reduces the need for expensive maintenance and repairs. In turn, this also reduces the additional CO_2 emissions associated with asphalt resurfacing and reconstruction operations.
- It requires a thinner granular base than asphalt pavement, reducing the need for new virgin material and the associated costs and environmental impacts.
- Life-cycle cost analyses (LCCA) — which take into account the estimated costs of a project over its entire service life, including initial costs, maintenance, rehabilitation, reconstruction and salvage value of pavements — consistently rank concrete as "best-in-class" when compared to asphalt.

[1] Effects of Pavement Structure on Vehicle Fuel Consumption - Phase III, CSTT-HVC-TR-068, Taylor and Patten, January 2006.

Concrete Highway Examples

Highway 10 Reconstruction,
City of Yorkton, Saskatchewan



Project Details:

Reconstructed road length: 650 meters

Asphalt Milling and Reuse: 200 mm of the existing asphalt pavement was milled off across four traffic lanes and two turning lanes, for a total of 2,600 m^3. It was stockpiled on site and used below the concrete instead of bringing in virgin granular materials.

Concrete pavement type: 200 mm Joint Plain Concrete Pavement with 25 mm x 410 mm epoxy-coated steel dowels @ 300 mm o/c were used.

Joint Filling: All longitudinal and transverse joints were saw-cut and Sikaflex -1c SL high performance sealant was applied.

Performance to date: According to the City, the reconstructed section has performed extremely well.

The Challenge

In 2016, the section of Highway 10 between Highway 9 and Mayhew Avenue in Yorkton, Saskatchewan, required reconstruction due to the poor condition of the existing asphalt pavement. Geotechnical testing attributed the condition of the pavement to inadequate substructure — a common issue for many of the City's roadways.

The Solution

With more and more pavements reaching the end of their service life, the City of Yorkton recognized the importance of conducting a life-cycle cost analysis (LCCA) for new pavement projects.

Due to its durability and reduced maintenance over a pavement's 30 – 50 year service life, a concrete surfacing option was included in the project tender.

While the concrete option had a marginally higher capital cost than the asphalt options submitted, its long-term maintenance and rehabilitation cost savings led to its selection for the project.

Seven years later, the City of Yorkton's Public Works department reports that the reconstructed section of the road has performed extremely well to date.

Spragues Road Rehabilitation, Region of Waterloo, Ontario

The Challenge

Spragues Road is a rural highway in the Regional Municipality of Waterloo in Southwestern Ontario [2]. In 2015, its traffic level was approximately 8,400 vehicles per day, 8% of which being heavy trucks. The road was a composite pavement with a concrete base of approximately 180 mm, topped with up to 180 mm of asphalt. The existing asphalt condition was assessed to be poor-to-very-poor, so a rehabilitation project had to be undertaken for a 1.2 km stretch of the highway.

The Solution

Given the traffic considerations and long-term performance requirements, the highway was identified as a candidate for a concrete overlay rehabilitation.

The existing asphalt was milled from the surface of the concrete to the depth needed to correct the profile. A hot mixed asphalt (HMA) padding and a 30 mm HMA separation layer were placed then topped with a 160 mm concrete overlay over a 3-day period.

Maturity testing methods were used to measure the strength of the concrete. The specified strength of 20 MPa for opening to traffic was reached in approximately 15 hours after placement. The field cure cylinders on average took four hours longer to reach the 20 MPa strength. The concrete pavement design strength of 32 MPa was obtained in less than 5-days. Some 20 to 24 hours after concrete placement, the contractor reinstated all driveways for local residences and businesses.

A manual condition survey of Spragues Road conducted in the summer of 2023 concluded that, after eight years in service, the pavement is considered to be in good overall condition, with only 1.5 percent of 3,666 slabs showing any kind of distress and only one slab showing severe distress.

Project Details:

Road Length: 1.2 km

Number of Traffic Lanes: Two lanes (3.35 m)

Number of Bike Lanes: Two (1.5 m)

Concrete Pavement Placed: 1,700 m^3

Concrete Overlay Thickness: 160 mm

Exposure Class: CSA A23.1 Class C-2

Concrete Design Strength: 32 MPa

Length of Curb and Gutter: 135 m

Construction Time: 35 days

Performance to date: As of 2023, the pavement is considered to be in good overall condition.

[2] Innovative Design, Traffic Management And Construction Of Concrete Overlay Technology: A Canadian Municipal Application, Daniel Pickel, Hassan Baaj, Susan Tighe; Transportation Research Record: Journal of the Transportation Research Board, No. 2573, Transportation Research Board, Washington, D.C., 2016, pp. 107–114. DOI: 10.3141/2573-13

About Jointed Plain Concrete Pavement (JPCP)

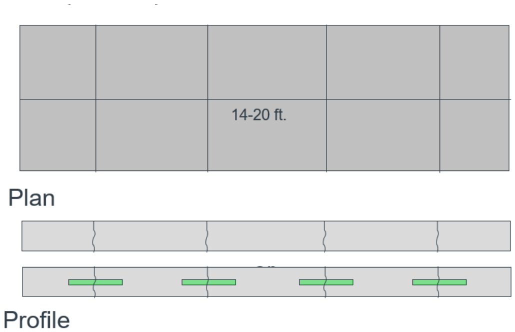
Jointed Plain Concrete Pavement (JPCP) is the most common conventional concrete pavement. With JPCP, concrete slabs are typically constructed directly over a prepared aggregate base structure. Transverse joints separate the concrete into panel sections and are located where the concrete would be expected to crack naturally (typical panels are 4 – 6 meters long, depending on the thickness of the concrete pavement; the pavement width is typically 3.7 m and is usually extended on the outer lane to eliminate edge loads — or a tied concrete shoulder is used.) Transverse joints are installed perpendicular to traffic and allow load transfer between the panels according to two different methods:

Undoweled: Typically, for pavements 175 mm thick or less, joints do not require dowel bars, and load transfer is achieved through aggregate interlock.

Doweled: For pavements 200 mm thick or greater, smooth steel dowel bars are placed at the mid-point of the pavement thickness parallel to the direction of traffic. Dowel bars enhance the load transfer between slabs to prevent potential faulting issues.

Tie bars (deformed rebar) hold the pavement lanes together and are placed perpendicular to traffic direction along the longitudinal joint.

Jointed Plain Concrete Pavement



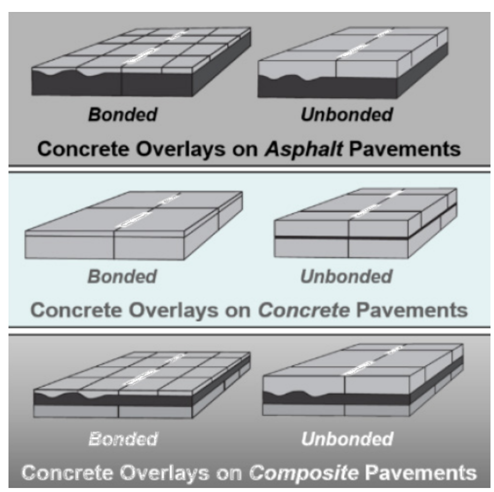
About Concrete Overlays

The overlaying of concrete on asphalt, composite or old concrete pavements provides an environmentally friendly, long-lasting and cost-effective rehabilitation pavement solution. There are two types of concrete overlays:

Bonded: A relatively thin concrete (50 to 125 mm) is placed and bonded directly on existing pavement surfaces that are in good to fair structural condition, adding structural capacity and eliminating distress such as rutting and shoving of the asphalt.

Unbonded: Usually thicker than bonded overlays, unbonded overlays restore structural capacity to existing pavements that are moderately to significantly deteriorated. Prior to overlay, a separation medium or stress relief layer is placed on the old pavement to isolate the existing deterioration and prevent reflective cracking. A layer of concrete (normally 100 to 275 mm depending on the traffic loading) is then placed over the thin separation layer.

Concrete Overlays



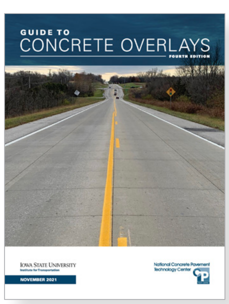
A Few Little Known Facts About Concrete Pavement in Canada:

- **In Alberta**, several intersections, roundabouts and interchanges are paved with concrete, including in Edmonton, Red Deer, Lethbridge, Lloydminster, Grande Prairie, Camrose and Medicine Hat. And of course, the Calgary airport is home to the longest concrete runway in Canada, at over four kilometers.
- **In Saskatchewan**, concrete intersections, roundabouts, lanes, commercial parking lots and pads can be found in Regina, Saskatoon, Prince Albert, Yorkton and Meadow Lake and many surrounding residential developments are also opting to pave with concrete.
- **In Manitoba**, which has a long history of paving with concrete, 87% of Winnipeg's road network contains a concrete layer; across the province, some 355 km of the road network is concrete pavement.
- **In Ontario**, the Ministry of Transportation (MTO) has adopted an alternative bid (AB) process for freeway reconstruction contracts. Every alternate bid project has gone concrete since the process was adopted by MTO.
- **In Quebec**, the Ministry of Transport has identified that 5% of the province's roads network should be paved in concrete. Stretches of Highway 20 linking Montreal to Quebec City and Highway 40 linking Montreal to Ottawa are paved with concrete.

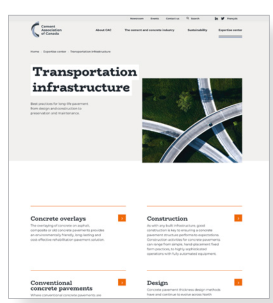
Find out more about concrete pavement:

Concrete Pavements: Key Technical Resources Directory, Cement Association of Canada

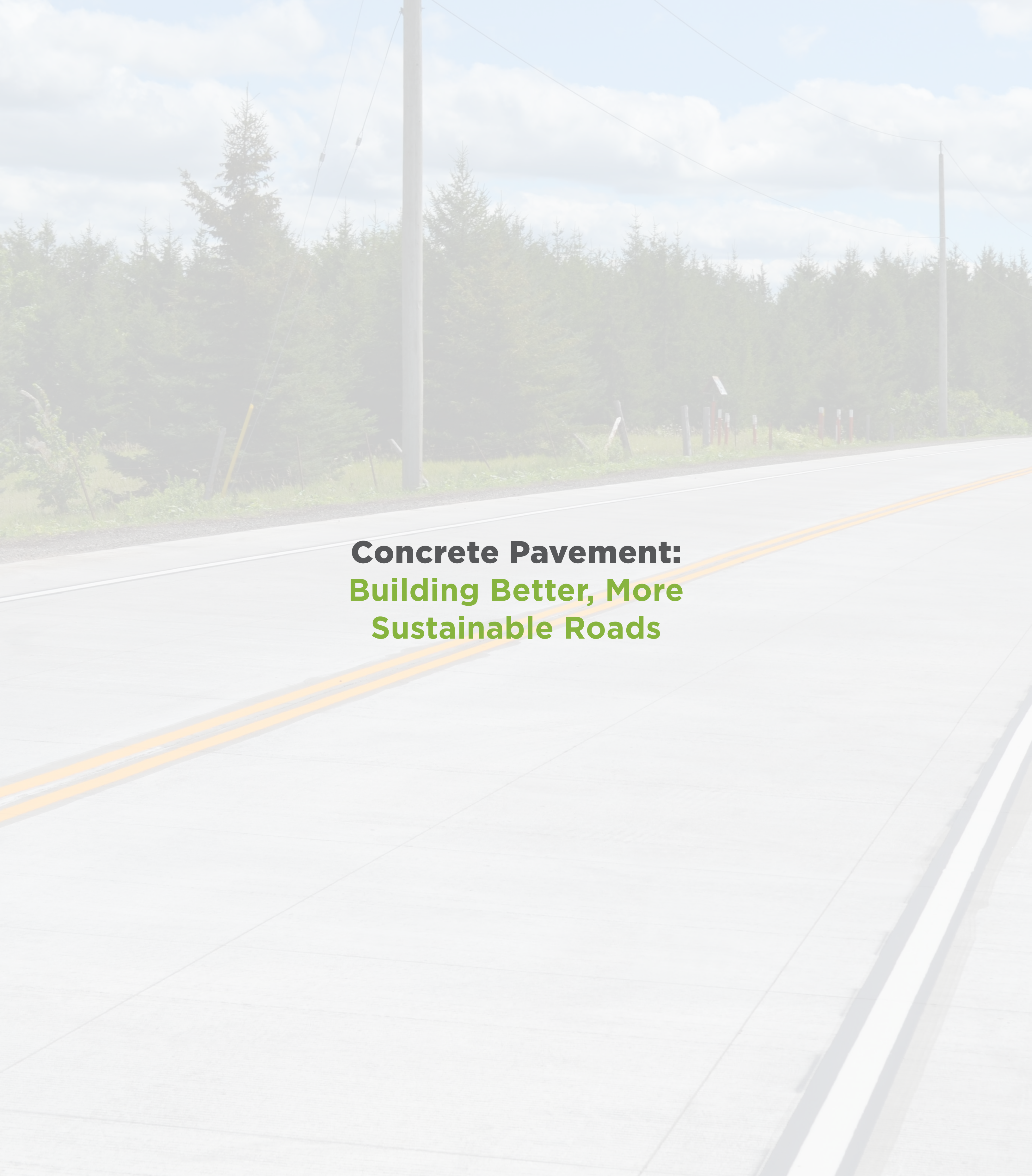
Guide to Concrete Overlays Iowa State University and National Concrete Pavement Center



Cement Association of Canada Expertise Center — Transportation Infrastructure



Technical Introduction to Portland-Limestone Cement Cement Association of Canada



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