
# The Benefits of Concrete Highways

CONCRETE ROADS
FOR THE LONG HAUL

# Canadian Highways

With mounting stress on transportation infrastructure, Canada must consider the construction of concrete highways rather than traditional asphalt surfaces. The United States already recognizes the benefits of a concrete infrastructure and has incorporated concrete pavement into over 30% of its interstate highways.[1] In Canada, however, only a small percentage of the highway network takes advantage of concrete pavement's many benefits. Quebec has the greatest number of kilometres of exposed concrete highways in Canada, estimated at 4%. It must be understood that concrete provides not only economic and environmental benefits, but also direct user benefits as outlined in this report.

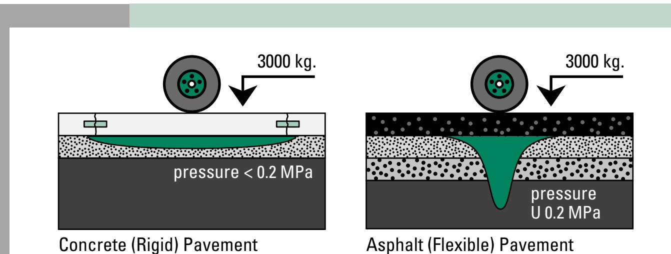
# Difference between concrete and asphalt pavements

There is one major difference between concrete and asphalt road surfaces. Concrete pavement is a rigid structure and asphalt is a flexible structure. Historically, pavements have been divided into two broad categories, rigid and flexible. These classical definitions, in some cases, are an over-simplification. However, the terms rigid and flexible provide a good description of how the pavements react to traffic loads and the environment.

The flexible pavement is an asphalt pavement. It generally consists of a surface of asphalt built over a base course and subbase course. Base and subbase courses are usually gravel or stone. These layers rest upon a compacted subgrade (compacted soil). In contrast, rigid highway pavements are made up of portland cement concrete and have only a base course between the pavement and subgrade.

The essential difference between the two types of pavements, flexible and rigid, is the manner in which they distribute the load over the subgrade as illustrated in Figure 1 below. Rigid pavement, because of concrete's rigidity and stiffness, tends to distribute the load over a relatively wide area of subgrade. The concrete slab itself supplies a major portion of a rigid pavement's structural capacity. Flexible pavement, inherently built with weaker and less stiff material, does not spread loads as well as concrete. Therefore flexible pavements usually require more layers and greater thickness for optimally transmitting load to the subgrade.[2]

**FIGURE 1 – HOW PAVEMENTS CARRY LOADS**




Concrete's Rigidness spreads the load over a large area and keeps pressures on the subgrade low.

# Concrete pavement lasts twice as long

One of the most well known advantages of concrete is its superior durability and longer structural life. This durability aspect translates into less road delays due to construction and maintenance. A 1998 life cycle cost report by ERES Consultants Inc. indicates that the expected life of an asphalt road is 17 years compared to 34 years for concrete.[3]

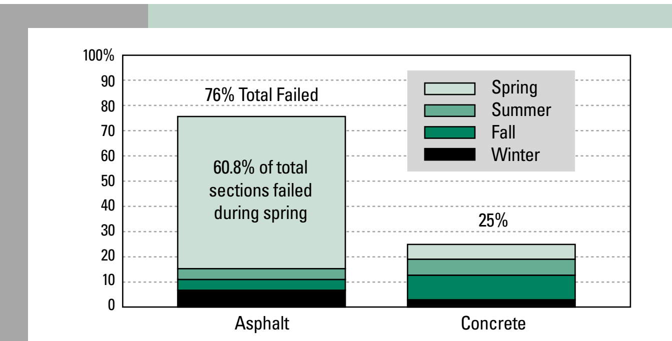


The report also indicates that asphalt highways require maintenance activities every three to five years and major rehabilitation becomes more and more frequent after the initial 17th year overlay. Concrete on the other hand, requires its first minor maintenance after 12 years and retexturing of the concrete surface at year 18.[3] The concrete highway user therefore has a better chance of reaching their destination without experiencing road construction or rehabilitation delays.

# Concrete pavement eliminates spring load restrictions

Concrete's durability is most evident during Canada's spring thaw season. Simply put, concrete is not affected by seasonal weakening of the subgrade during spring thaw, as are many asphalt pavements. A study by the AASHO* Road Test showed that 61% of asphalt roads fail during spring conditions compared to 5.5% for concrete as shown in Figure 2.[4] (*Note: AASHO is now known as AASHTO)

**FIGURE 2 – SEASONAL FAILURE OF CONCRETE VS. ASPHALT PAVEMENTS**




Although asphalt pavement design has changed since the original AASHO tests, there is still concern with the strength of asphalt structures during spring thaw periods. This is evident in the fact that provincial Departments of Transportation (DOTs) still put spring weight restrictions on truck traffic to minimize road damage during this period. In fact, the Ministère des Transports du Quebec (MTQ) employs spring weight restrictions on all their highway systems including the TransCanada Highway (TCH). In addition, although the New Brunswick Department of Transportation does not reduce allowable weight on the TCH during the spring thaw period, it does not allow the extra axle tolerances that it does at other times of the year.

Due to the way concrete pavements distribute vehicle loads to the underlying aggregate structure, concrete is not vulnerable to spring thaw conditions in the same manner as asphalt. Therefore, heavy vehicles can maintain full weight on concrete highways during the spring thaw period. In fact, the City of Winnipeg releases an annual media advisory indicating when asphalt road restrictions begin and specifically notes that the restrictions do not apply to concrete roads.[5]

# Concrete pavement doesn't rut, washboard or shove

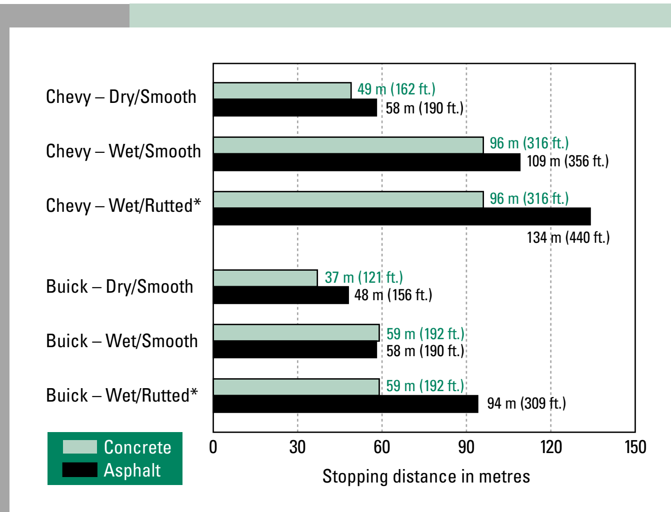
Heavy loads can create ruts in asphalt roadways, while the stopping and starting motion of a heavy vehicle can create a washboarded surface. Turning at corners or intersections on asphalt can also cause the flexible asphalt material to shove out of its original position. The rigid surface of concrete, however, prevents these types of deformation from occurring in concrete roads – they do not rut, washboard or shove.

## Concrete pavement provides shorter vehicle stopping distance

For the user, a concrete pavement's rigid surface is important when considering personal safety. During wet weather, ruts in asphalt roads will collect water and increase the potential for hydroplaning. Furthermore, wetness trapped in the asphalt ruts can turn to ice during freezing temperatures.

A study by the University of Illinois entitled, "Safety Considerations of Rutting and Washboarding Asphalt Road Surfaces" demonstrates that overall stopping distances on concrete surfaces are shorter than for asphalt surfaces, especially when asphalt is wet and rutted, as shown in Figure 3. The values in this figure do not take hydroplaning into account. By including the hydroplaning effect, asphalt stopping distances would increase.[4]

**FIGURE 3 – MEASURED STOPPING DISTANCE OF TWO DIFFERENT VEHICLES ON CONCRETE VS. ASPHALT SURFACES, AT 100 KM/HOUR**




Measured stopping distances of two different vehicles on various surface conditions. Note that since concrete does not rut, data for the wet-rutted condition are the same as for wet smooth condition.
*Concrete does not rut

## Concrete pavement provides fuel savings for heavy vehicles

Heavy vehicles cause greater deflection on flexible pavements than on rigid pavements. This increased deflection of the pavement absorbs part of the vehicle energy that would otherwise be available to propel the vehicle. Thus, the hypothesis can be made that more energy and therefore more fuel, is required to drive on flexible pavements.[6] Concrete's rigid design reduces road deflection and corresponding fuel consumption.

The difference in fuel consumption performance of heavy vehicles operating on concrete and asphalt pavements was first identified by Dr. John P. Zaniewski. In 1982, Dr. Zaniewski was part of an independent team which conducted a study for the Federal Highway Administration (FHWA) to update vehicle operating costing tables of an earlier study by the World Bank and Brazilian Government. This comprehensive study of the relationship between highway design and vehicle operating costs looked at several cost components, one of which was fuel consumption. Based on this analysis, it was found that the savings in fuel consumption for heavy vehicles travelling on concrete versus asphalt pavements was up to 20%.[6]



Detroit Diesel considers pavement type when determining vehicle fuel efficiency in their Spec Manager™ 2.1 computer program. The program assigns factors for the surface type of 1.0 for concrete, 1.2 for cold asphalt and 1.5 for hot asphalt. When performing a typical truck configuration program run with all variables constant except the surface type, the resulting estimated fuel consumption is 8% lower on the concrete surface compared to the cold asphalt, and 17.5% lower than on the hot asphalt when traveling at 100 km/hr.[7]

To confirm the potential fuel savings in the Canadian climate, a year long study was performed by the National Research Council of Canada (NRC) for the Cement Association of Canada. This study concluded an average of 11% fuel savings for trucks travelling on concrete roads*.[8]

Table 1 below summarizes predicted fuel savings estimates from these various studies.

**TABLE 1 – ESTIMATED FUEL SAVINGS WHEN OPERATING ON CONCRETE PAVEMENT COMPARED TO ASPHALT PAVEMENT**

| Source | Vehicle Type | Highway Fuel Savings |
|---|---|---|
| Detroit Diesel Spec Manager™ Program | Trucks | 8 – 17.5% |
| Dr. Zaniewski Study | Trucks | Up to 20% |
| NRC | Trucks | Average 11%* |

*Comparative research conducted by the National Research Council of Canada, August 2000. Based on a fully-loaded tractor semi-trailer traveling 100 km/hr on a horizontal surface with the temperatures spanning -18° to +40° C, on test sections of Quebec concrete Hwy. 440 and Ontario asphalt Hwy. 417. Note that fuel economy results vary for asphalt pavements.

## Concrete pavement improves nighttime visibility

Concrete pavement is known to improve visibility for drivers at night. Concrete is naturally a lighter colour and will deflect light from a vehicle or lamppost better than the darker asphalt pavement. The difference is demonstrated in comparative photos in Figure 4 below.

**FIGURE 4 – LIGHTING ON CONCRETE AND ASPHALT SURFACES**

Concrete | Asphalt

Both concrete highway 407 in Ontario and 440 in Quebec require less lighting per kilometre than a comparable asphalt pavement due to their reflective surface.

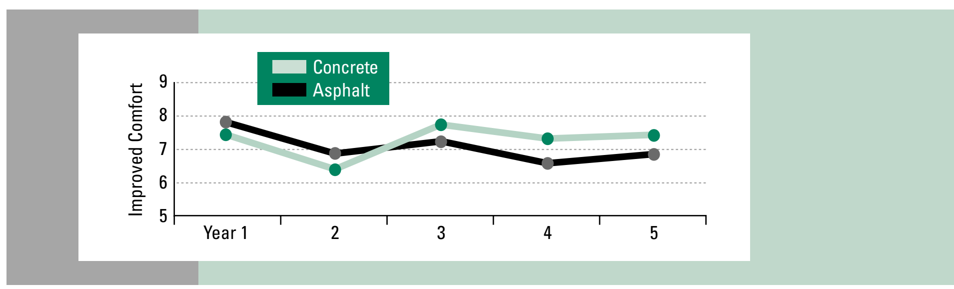
## CONCRETE PAVEMENTS PROVIDE ENHANCED RIDE COMFORT AND QUALITY

The Nova Scotia Department of Transportation and Public Works (TPW) completed a five-year study on an adjoining section of asphalt and concrete pavement built in 1994 on Highway 104 TransCanada Highway.[9]

Results of the study, which concluded in 1999, showed concrete performed well in terms of ride quality, and in fact out performed the adjoining asphalt pavement in riding comfort and road smoothness. This study also demonstrated that asphalt ride quality falls below concrete after a very short period of road life.

Data from the comparative study by the TPW indicates that although new asphalt is higher on the riding comfort index (RCI) initially, it quickly deteriorates leaving concrete's durable surface to provide long term improved road comfort as seen in Figure 5. The RCI reading at year five on the concrete pavement was 7.4 compared to 6.9 on the asphalt pavement.[9]

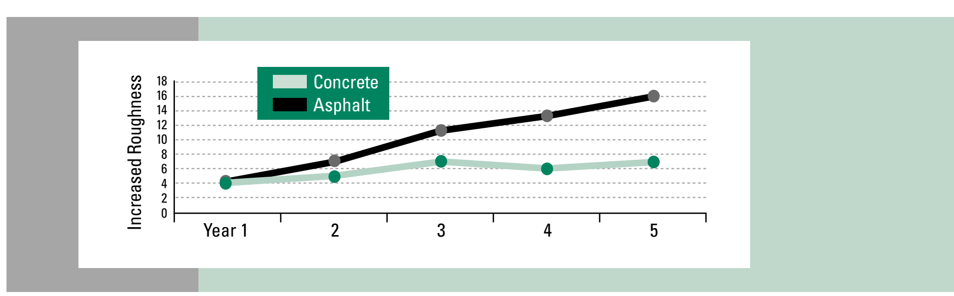
**FIGURE 5 – COMPARISON OF TEST RESULTS OF RIDING COMFORT INDEX**




Note: The higher the RCI value the more comfortable the ride.

The Nova Scotia Department of Transportation and Public Works also used a California profilograph to measure the profile ride index (PRI) which is a measure of the pavement smoothness where higher numbers represent increased roughness. Results from these measurements over the first five years indicate that the new concrete and new asphalt had approximately the same smoothness after one year. However, over the next four years, the concrete pavement maintained much of its original smoothness, while the asphalt section showed increased deterioration. Figure 6 illustrates how the two pavement structures have performed. Note, the roughness of the asphalt pavement has more than doubled that of the concrete after five years of service (i.e., 6.8 mm/100 metres on concrete versus 16.2 mm/100 metres on asphalt).[9]

**FIGURE 6 – COMPARISON OF TEST RESULTS OF PROFILE RIDE INDEX (SMOOTHNESS)**




Note: The lower the PRI the smoother the ride

Based on this data it can be said that initial riding comfort and road smoothness are maintained for a longer period of time on concrete versus asphalt highways.



## CONCRETE PAVEMENT PROVIDES A QUIET RIDE

Roadside noise levels are also a public concern when determining highway surface material. Results of the Nova Scotia study confirm that concrete roads do not create significantly more noise. In the five year study the concrete pavement's roadside noise level was on average 2-4 decibels higher than the asphalt pavement.[9] To put this into perspective, normal conversation registers at 60 to 70 decibels and a human whisper registers at 20 decibels.

In fact, a report by EPA entitled Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety, states that changes less than 5 decibels are considered insignificant.[10]

A report by the U.S. Department of Transportation in 1996 concludes that, "Properly constructed PCC (Portland Cement Concrete) pavement, with transversely tined surface, matches the performance of dense-graded asphalt considering both safety and noise factors."[11]

A report by the Wisconsin Department of Transportation concludes that, "It is possible (very simply and at no extra expense) to build a PCC pavement that does not "whine" and has the desired frictional properties. Such a pavement is a "good neighbor", is safe, provides user comfort and is durable."[12]

1 Highway Statistics 1997, Office of Highway Information Management and Office of Policy Development, Federal Highway Administration, 1999.

2 *American Concrete Pavement Association*, www.pavement.com

3 *Review of Life-Cycle Costing Analysis Procedures*, ERES Consultant for the Ministry of Transportation of Ontario 1998.

4 American Concrete Pavement Association, "Whitetopping – State of the Practice", Engineering Bulletin 210P.

5 City of Winnipeg, Public Works Department, *News Release – Spring Weight Restrictions Take Effect*, March 22, 2000.

6 Zaniewski, J.P., *Effect of Pavement Surface Type on Fuel Consumption*, SR289.01P, Portland Cement Association, Skokie, Illinois, 1989.

7 Detroit Diesel in their Spec Manager Computer Program.

8 Portland Cement Association, SN2437, *Effect of Pavement Surface on Fuel Consumption*, National Research Council of Canada, Centre for Surface Transportation Technology, Ottawa, Ontario, August 2000.

9 Nova Scotia Transportation and Public Works, *Asphalt Concrete Pavement and Portland Cement Concrete Pavement, Highway 104, Cumberland County, Year 5 of 5 year study*, October 1999.

10 *Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety*, EPA/ONAC 550/9-74-004, March, 1974 – Condensed Version, www.nonoise.org/library/levels/levels.htm.

11 *Tire Pavement Noise and Safety Performance*, Serial No. FHWA-SA-96-068, United States Department of Transportation, Federal Highway Administration, Washington DC, 1996.

12 *Impacts Related to Pavement Texture Selection*, Serial No. WI/SPR-06-96, Wisconsin Department of Transportation, Final Report, 1997.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