BUILDING GREAT ROADS POSES GREAT CHALLENGE

CAN SCIENCE, PLANNING FINALLY TRUMP MOTHER NATURE, FINANCIAL PRESSURES?

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On a cool and cloudy September evening last year in Winnipeg, a basement meeting room of a Polo Park-area hotel became a showcase for the woeful, collective ignorance about road construction.

The room had been booked for a civic election debate on infrastructure. It was

FIXES TO FINANCING

The big equalizer in the push for better, longer-lasting roads is still money. Lots of it

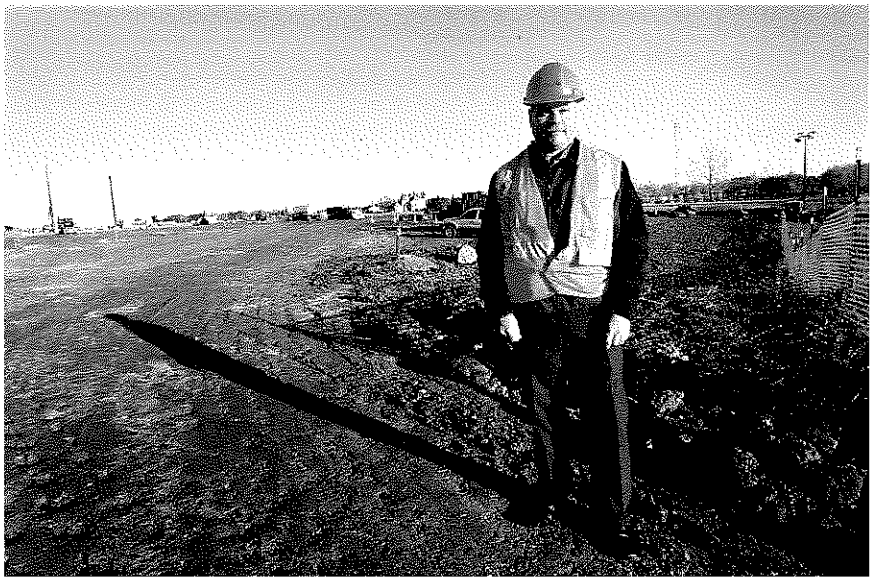
The room had been booked for a civic election debate on infrastructure. It was organized by the Association of Manitoba Municipalities and CAA Manitoba to put all the mayoral candidates on the record about what they would do to fix the province's crumbling roads and bridges.

For about two hours, the seven candidates spoke about how worried they were about the state of the roads, how they would use innovative methods and materials to build better and smarter, drive higher standards with contractors and stretch each tax dollar to get the upper hand.

The candidates were impassioned. They were all deeply committed to finding solutions. But most of all, they were profoundly, hilariously ignorant about what goes into building a road.

In their speeches, the candidates — which included political veterans and neophytes alike — demonstrated they didn't know much about the materials used in road construction or the contracting techniques or the true costs. They all seemed to imply improving Manitoba's roads — all of them, seemingly at the same time — was purely a matter of political will.

They can hardly be blamed for their ignorance. In general, people all pretty clueless when it comes to the reality of road construction. That does not mean, however, they don't have opinions about it.



JOE BRYKSA / WINNIPEG FREE PRESS
Building roads is complex and costly, says Lance Vigfusson, deputy minister of Manitoba Infrastructure and Transportation.

"The reality for us is that everybody who has a driver's licence is a roads engineer," Lance Vigfusson, deputy minister of Manitoba Infrastructure and Transportation, said. "We all seem to know better because we drive. From behind the wheels of our cars, it always seems obvious what we should be doing to improve the roads.

"The simple fact is that it's just not that simple."

Indeed. A deeper examination of modern road construction reveals a world of ancient materials and modern techniques. It's an area of pressing and expensive public policy where every political decision to build a new bridge or twin or extend a road immediately results in fewer repairs to existing roads.

Over the last decade, Manitoba has spent nearly $4 billion repairing the 19,000 kilometres that make up the provincial road and highway system, a network that includes nearly every main street in every town and small city, and many of the major arteries in the larger cities.

Even with all those expenditures, most of us would consider basic infrastructure to be in a state of crisis.

This year, Manitoba will spend more than a half-billion dollars on replacing and repairing roads. That figure does not include the millions more spent maintaining the northern network of winter roads or snow clearing on the 19,000 km of roadway maintained by the province.

And yet, even with all that money being spent, there is no one in this debate — public or private sector — that would argue the province is getting ahead of the problem. In fact, it's widely, if only quietly, acknowledged that each year Manitoba has a bit bigger problem to fix.

Building higher-quality roads that last longer is certainly part of the equation. But so, too, is a more stable method of financing.

Canadian provinces pay for the gross majority of infrastructure costs, both directly and through transfers to municipalities. The missing player in this equation, many provinces would argue, is the federal government.

Ottawa is contributing billions of dollars, but once it is spread out across the provinces and territories on projects that range from new recreational facilities to new highways, it makes a very small dent in the overall problem.

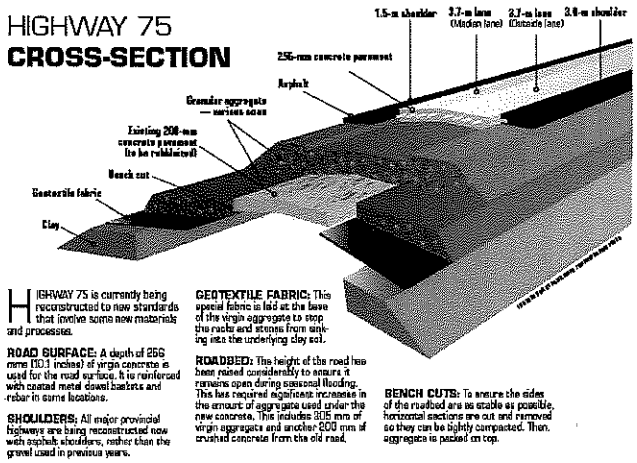
It has gotten to the point more robust, more predictable funding is being seen as the greatest innovation that could be applied to road construction.

"In many instances now, we are getting the roads we can afford," said Shalaby. "In most communities, the budgets for roads are finite, but the need is always growing. That means trying to stretch existing dollars as far as we can get them, without regard to whether we're spending it in the best way."

Vigfusson, the deputy minister of Infrastructure and Transportation, noted that like most provinces,

Manitoba received a huge benefit from the federal government when it ratcheted up infrastructure spending in 2009-11 to combat the global recession. However, the sudden and massive increase in funding to the provinces was difficult from an engineering and project-management perspective

Why are roads so darned expensive, and why do they seem to fall into disrepair so easily? More importantly, what, if anything, can be done to make Manitoba's roads better?



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The magic global formula

Dirt. Gravel. Concrete. Asphalt.

Regardless of continent, climate or purpose, this is the universal formula for road construction.

There are variations, of course.

Certain additives find their way into the concrete and asphalt in particularly warm or cold climates. Concrete is poured at different depths in different jurisdictions. Metal is used to reinforce concrete in many roads, but not in all. Contracting processes can vary, as can elements of the basic engineering.

And yet, the techniques, materials and technology used in building roadways is not only venerable, it is strikingly similar across the globe: rock and gravel at the base, with (typically) re-enforced concrete on top. As the concrete ages, it is usually overlaid with asphalt or other materials to extend its service life.

Concrete — a mixture of water, gravel and powdered binder — is one of the oldest building materials on the planet. Ancient Greeks and Romans used a mortar made from burnt lime and gravel that bears a striking resemblance to modern concretes. In the 18th and 19th centuries, inventors developed, and in some cases patented, binders that were the direct forerunners of today's Portland cement.

You would think that after hundreds of years of trial and error, we'd be entering a period now where we would have completely decoded concrete to the point where we'd have the perfect building material — something that could be built efficiently and effectively to last forever.

If it were only that simple.

perspective.

Ottawa required the money to be spent on "shovel-ready" projects. That meant it could not be used on major reconstruction efforts, many of which require years of engineering work and preparation, Vigfusson said. "The rule of thumb in these instances is 'make it black, Jack.' Rather than rebuild roads, we lay down a ton of asphalt."

The current federal election campaign certainly holds promise of increased infrastructure spending — notably the Liberals and NDP have proposed larger, longer-term funding models that should allow for more predictability.

Still, many believe Canada has a long way to go on the path to building better roads.

"Right now, for many jurisdictions, it's the choice between putting Band-Aids on failing infrastructure rather than repairing it to the highest standards," Shalaby said. "In that scenario, it doesn't really matter much if we have better materials or standards if we can't plan for it and find the money to do it right."

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Better understanding of how materials react to conditions will lead to improved road designs, says Ahmed Shalaby, director of the University of Manitoba's pavement research group.

"We are only now becoming better at knowing the properties of these materials," said Ahmed Shalaby, civil engineering professor and director of the University of Manitoba's pavement research group. "Knowing the properties, how it reacts in different conditions, is what will allow us to come up with a proper design. We haven't always had a handle on that."

Shalaby said if concrete is always poured in a consistent, controlled environment, it would be predictable in terms of its performance. But concrete is poured in uncontrolled environments, where the elements that exist during construction play a big role in determining how it performs.

For any road construction material to perform up to specifications, it must be applied in a consistent fashion, Shalaby said. Even the best materials will underperform if laid improperly.

The public (and many politicians) tends to focus heavily on innovations in materials — advanced concrete, asphalt and reinforcing materials — that hold the promise of better, longer-lasting roads. And there are examples where these advanced materials have produced better results.

However, to the people who have committed their professional lives to designing, building and studying roads, a smooth and durable road is really a byproduct of proper design and engineering, use of top-quality materials and a construction process that ensures consistency of material and application.

"Normally, when we say we are building a better road, we are talking about improving standards in design," said Shalaby. "We want a stronger structure, yes, but we also want one that has uniformity in the finished product."

BORIS MINKEVICH / WINNIPEG FREE PRESS
A fresh layer of concrete is poured near Ste. Agathe during Highway 75 reconstruction.

This is why in Manitoba, there is usually a team of more than a dozen provincial officials overseeing the construction of a road. These officials record the timing of the delivery of materials and then test on site to ensure it is consistent with the performance standards specified in the original contract. They are also on site to ensure work is discontinued if the weather becomes too cold or too hot.

All that said, there have been some important improvements to materials, Shalaby said. Researchers have experimented with different mixes of concrete and asphalt and the addition of materials to make the surface materials stronger and less resistant to cracking. However, Shalaby noted, there is no universal formula that works in every jurisdiction.

There has been a lot of intensive research around asphalt, one of the world's oldest construction materials. Asphalt is a mixture of aggregate (stones, gravel or sand) and a binder (bitumen). When combined, it creates the black, lumpy oatmeal-like material poured and compacted on all kinds of roadways.

There have been advances with the addition of polymers and recycled materials to the asphalt mix, Shalaby said. In warmer climates, for example, it is not unusual to have recycled tires or roof shingles added to asphalt to increase its design life and lower the overall cost, Shalaby said. However, in colder climates (like Manitoba) those materials freeze and shatter, weakening the asphalt.

However, while the materials and proportions in the asphalt mix are important — including the type of bitumen and the ability to weed out contaminants — it is often issues such as the temperature at which the asphalt is applied, and a consistent compaction, that determine how long the surface will last without cracking. This can be difficult when, as is the case in most instances, the asphalt plant is located some distance away from the construction site.

In other words, use of the best bitumen and aggregate can still result in a bad road surface if the truck got stuck in traffic, or mix was too hot or cold during construction or if it was not compacted properly, or if there were huge variations in the properties of each load of asphalt as it arrived on site.

Shalaby said the best roads involve meticulous attention to such details.

Interestingly, the thickness of the concrete or asphalt is not always a guarantee of a better-performing road surface. Research conducted around the world on roads that doubled or even tripled the normal depth of concrete showed, over the long term, they did not last two or three times longer.

"Road construction is a manufacturing process at heart," Shalaby said. "But it is a manufacturing process that is difficult to control because you are subject to elements and traffic conditions. Improving the construction process is a huge part of improving the finished product."

A most-challenging environment

It's arguable that no one knows more about asphalt and its properties than Queen's University chemistry professor Simon Hesp. For several decades, he has done ground-breaking research into custom asphalt mixes that match the construction materials with location.

Over his research career, he has come to understand the greatest enemies of a road surface are temperature (particularly the variation between hottest and coldest), moisture and the load capacity of vehicles. And when he takes a look around the globe for the most challenging places

BORIS MINKEVICH / WINNIPEG FREE PRESS
Top: A bench cut is made near the base of a new road bed. The cut allows heavy equipment to more tightly compact soil. Middle: Geotextile fabric covers the packed-down bench cut to prevent aggregate from sinking into the clay soil. Bottom: Aggregate is packed on top of the fabric just prior to demolition of the old concrete.

the globe for the most challenging places in which to build a road, one place in particular stands out.

"Manitoba is arguably the worst place in the world to build a road," said Hesp.

That is not to say there aren't others. Certainly, there are remote areas where traditional road construction is extremely challenging, however, when you look at major populated areas, Manitoba ranks right up there.

The challenges here are obvious: summer temperatures that can push 40 C and winter temperatures that dip down to -40 C; a high water table with gooey, clay-based soils; frequent seasonal flooding; and extremely heavy truck traffic. Add them together and a near-perfect set of conditions for road failure emerges.

Hesp said new standards for road construction can combat most of these conditions. However, the underlying challenge is to ensure moisture does not seep into the base materials underneath the concrete or asphalt surface. When moisture gets into that level of a road, it will freeze and expand in the winter, and shrink in the summer. A process that inevitably destroys the surface.

That is why in Manitoba and similar jurisdictions, the base materials and the manner in which they are layered is just as important, perhaps even more important, than what goes on top.

Roadbeds typically involve, at the bottom, crushed rock or "rubbleized" concrete, with increasingly smaller and finer grades of aggregate packed on top. The base is critically important because it will determine how much cracking eventually takes place on the hard surface of the road.

Steve Penner, a project manager with Manitoba Infrastructure and Transportation, said the soil/aggregate base of a highway in Manitoba is considerably deeper than it is in other jurisdictions, including southern neighbour North Dakota. In Manitoba, the total depth of rock and virgin aggregate is 18 inches (45.7 centimetres); in North Dakota, it is only eight inches (20.4 cm).

Manitoba uses base materials that are about 50 per cent deeper than standards for U.S. interstate highways.

For the past few years, the province has also installed a specialized fabric in the base between the clay soil and the first layer of crushed rock/concrete. Penner said this helps stop the rock from sinking into the clay — a chronic problem that has caused untold damage to Manitoba roads.

Are there new products and methods that could be used to dramatically improve the performance of Manitoba roads? "That's really a question for the decision makers," Penner said with a smile.

The blessing and the curse of innovation

In 1958, Montrealers welcomed the opening of the Champlain Bridge, a six-kilometre behemoth that was meant to carry vehicles cross the Saint Lawrence River and Saint Lawrence Seaway, connecting the boroughs of Verdun and Le Sud-Ouest with Brossard, Que.

It was one of the most complex and expensive public infrastructure projects of its time. To help contain the cost, the federal government, which was overseeing the project, opted for a design that featured a relatively new innovation in bridge

construction: concrete spans that would replace steel, the material of choice for bridge architects.

The proponents of the pre-fabricated concrete spans argued they were just as strong but much less expensive. This design feature alone would cut the total cost of the bridge from $10 million to roughly $8 million, an enormous savings at that time.

The bridge architects maintained, however, salt should never be used to de-ice the bridge deck, lest it eat into the concrete spans. Unfortunately for all involved, the province, which was responsible for maintenance and snow clearing, didn't get the memo. Over decades, it proceeded to dump tons of salt on the structure.

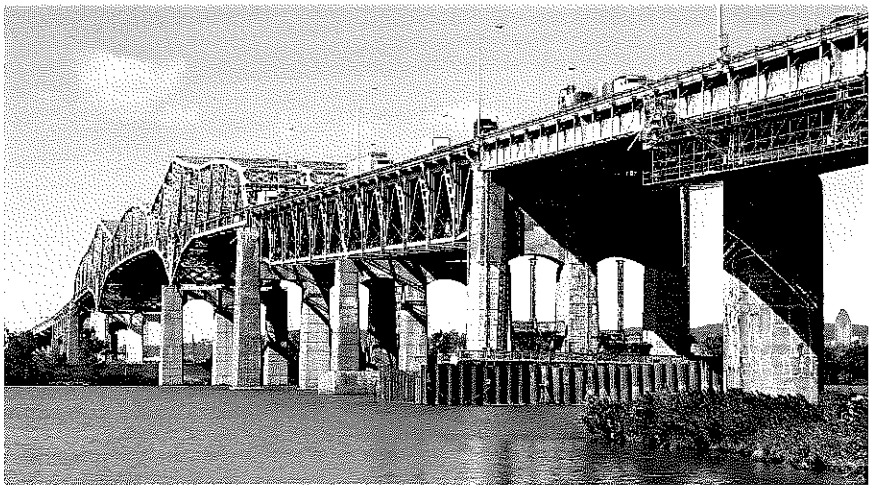
The impact of that miscommunication has been profound. A 2011 engineering study determined the bridge it was near complete failure and could not be saved. A structure that was supposed to last a century had lasted barely 50 years.

The decision to opt for a new material and process did save a fair bit of money at the outset. However, the replacement cost of a new bridge is estimated at between $3 billion and $5 billion.

This is not an entirely new story. Talk to people in the public infrastructure community and you will find similar tales of decisions made to find better — and often cheaper — products to stretch tax dollars a bit further. And in many of those instances, the long-term cost turned out to be much higher.

Take dowel-less concrete construction. For a period in the 1980s and 1990s, it was fashionable for highways to be built without any kind of metal reinforcement. The metal rebar and dowels are expensive, and add additional time to the construction cycle. In addition, as the metal corroded, it caused certain parts of the road to fail.

Engineers began to glom on to the idea that properly laid crushed rock, interlocked in a particular way at the base of a road, could do much of what the



PAUL CHIASSON / THE CANADIAN PRESS
Montreal's Champlain Bridge was built with concrete spans. It was believed they were as durable as steel spans, but cheaper. However, no one warned the province snow-clearing salt would dramatically reduce the bridge's lifespan.

metal reinforcement did — namely hold the structural integrity of the roadway but at a lower overall cost.

Inside of 20 years, however, many jurisdictions learned the hard way dowel-less is not a particularly effective method. The result has been time-consuming and expensive retrofits that involve manually cutting notches in the concrete and installing metal dowels across the pre-cut seams of the concrete.

Even then, thousands of kilometres of highway on both sides of the U.S. border had to be prematurely replaced. That was the case in the summer of 2014, when Manitoba reconstructed 16.5 km of Highway 75, the largest single stretch of that road to undergo a complete replacement.

road to undergo a complete replacement.

Although much of the concrete in that section reached its 50-year anniversary, a good portion north of Ste. Agathe was only 30 years old. Not only did it have no metal reinforcement, but it also had an inadequate base with little gravel or rock. The result was a huge waste of initial resources, and a huge outlay for replacement. The cost for a two-lane single kilometre of new concrete roadway is now $1.7 million.

BORIS MINKEVICH / WINNIPEG FREE PRESS
Crews grind out Highway 75 near Ste. Agathe for reconstruction.

"In retrospect, we can look back and say, 'Wow, why did we do that?' " said Penner, the project manager from Manitoba Infrastructure and Transportation who oversaw the recent Highway 75 reconstruction. "But that was the way highways were done at the time. It was the best application of technology at that time."

Missteps such as the Champlain Bridge and dowel-less concrete have certainly had an impact on the governments charged with maintaining infrastructure. Today, there is a deep mistrust of moving too far, too quickly in adopting new materials or methods to improve the overall performance of roads and highways.

Chris Lorenc, a former Winnipeg city councillor who now heads up the Manitoba Heavy Construction Association, said there are many new and promising technological advances that could help add to the life cycle of a road. However, government is loath to adopt them out of fear of failure — and because they are often more expensive at the outset.

In the long run, it could very well be these advanced materials and methods could save money, but government often does not have the time or the political will to do the detailed cost-benefit analysis needed to justify a shift in construction techniques. "There isn't a municipal government in this country that tests operating or capital budgets for return on investment," Lorenc said. "It's all based on how much money can we get, and how much road we can fix."

That attitude casts a political pall over the people who design roads and materials, Lorenc said. The public sector does invest money in the development of new materials, but politicians require decades of field-testing to adopt even a single new material or process.

"The people that sign off on all the design specifications and capabilities simply don't like taking chances," he said. "They know their political masters would rather get a few kilometres of plain old asphalt laid than worry about shifting things to get a longer-lasting project.

"We're doing a ton of research into new materials, but there isn't any money to commercialize it, so it sits on shelves collecting dust. That makes the public sector

one of the biggest proponents of innovation, and one of its stiffest opponents as well."

Shalaby agreed innovation is a double-edged sword for political decision makers. Over the past 30 or 40 years, the engineering professor said, there have been major improvements in overall design that have produced much better results. Interestingly, however, many of these changes have been fairly simple and subtle, including better base construction involving deeper layers of rock and gravel to allow for better drainage.

One of the biggest innovations in road construction was the decision to shorten the panels of concrete. Decades ago, it was vogue to cut seams in the concrete to allow for some cracking and movement in 28-foot (8.5-metre) sections. Over the years, however, it was found these panels were too long, allowing for abundant cracking between the seams.

The solution, Shalaby said, was to shorten the panels to between 12 feet (3.7 metres) and 15 feet (4.6 metres). "This one change has improved the performance of many roads in a significant fashion and it didn't involve any profound changes," Shalaby said.

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