Canadian tunnelling

The Next Generation

Future Projects

Looking at the next generation of tunnelling in Canada, megaprojects are increasingly common and present the industry with additional challenges beyond the complexities of underground construction. Nicole Robinson reports

As Canada makes substantial investments in its infrastructure, spending billions of dollars to improve public transit, water and wastewater and more, the nature of tunnelling projects has changed. Megaprojects are increasingly more common, and these large-scale, complex undertakings are here to stay.

As the industry looks to the future, the next generation of tunnelling will need to be prepared for the impacts of megaprojects.

An academic context

Often, a minimum of U$1 billion is cited as defining a megaproject. However, there are many other characteristics unique to these large-scale infrastructure developments including long project durations, the presence of multiple stakeholders and the tendency to transform a city or region.

They are also incredibly high risk, with nine out of 10 megaprojects having cost overruns, according to research by Bent Flyvbjerg, Oxford University, who also points out this phenomenon is not exclusive to Canada. Megaprojects are "growing larger at an accelerating pace and are multiplying all around the world."

Tunnels come in at number 13 in Flyvbjerg's list of top 25 project overruns. Nuclear storage projects rank number one with a mean cost overrun of 238% and Olympic games take second place at 157%. Tunnels, meanwhile, have a mean cost overrun of 37%.

These data are published in his recent book *How Big Things Get Done* coauthored by Dan Gardner. He emphasizes that estimated costs will never be the actual costs of a project. "Estimates aren't intended to be accurate; they are intended to sell the project."

However, he points out, this fact is rarely acknowledged, let alone explained to the public.

Canada's experience

Over the last 20 years there have been notable changes in Canada's tunnelling projects. A long-established industry that had honed its skills working on bread-and-butter tunnels for water and wastewater as well as transportation has seen an explosion of growth.

Transportation infrastructure in particular has skyrocketed in demand with major programs such as Montreal's Réseau express métropolitain (REM) and numerous light rail and subway lines in both the Toronto and Vancouver areas.

"We're not just talking about larger tunnels," says Giuseppe Gaspari Vice President, Underground Infrastructures Leader - Canada, US East and Latin America for AECOM. "The asset is no longer just a tunnel that carries water. Now the asset is a tunnel that carries railway systems, track works, all the overheads for electrical mechanical and plumbing systems."

These works create another layer of complexity, and benefit from a more multidisciplinary project experience,

Gaspari explains, adding that Canada has very strong transportation and railway engineering experience. However, construction had often taken place from the surface level.

Consider historic photos of building Toronto's Yonge Subway, where entire city streets had been fully opened for cut and cover construction. There wasn't nearly the same demand for large TBM or SEM driven tunnels as the industry has seen in recent years.

In line with demand, companies and individuals alike have joined the Canadian industry from abroad to help design and build this much needed infrastructure.

Contractor STRABAG is celebrating 20 years in Canada, originally opening offices here to build the Niagara tunnel, which broke ground in September 2005. This landmark project of 10km length and using, at the time, the world's largest hard rock TBM at 14.54m was completed on time and budget. The firm has since put down roots in the Greater Toronto Area and across Canada.

"We definitely have seen an increase in megaprojects in the last 15 years since the Eglinton Crosstown project was advertised—that's when those big projects started coming to the market," says Gerhard Urschitz, STRABAG's Member of the Board responsible for Tunneling and International.

Increased risk

With owners taking on bigger and bigger projects, the costs are going up and risk is increasing. The industry needs to find ways to manage this for fear of tunnel projects being perceived as too risky and not going forward.

For Urschitz, the biggest challenges of building megaprojects are the multiple risks, specifically those very characteristic for megaprojects, as defined above.

"We don't like the trend of large infrastructure projects because they come with high risks and uncertainty. We have seen in the past, specifically in Canada, that most of these projects are, at least commercially, not successful, a big hassle to complete and with very unpredictable timelines."

The duration of megaprojects and the sheer complexity of managing collaborations across multiple contractors and subcontractors, schedules and budgets add even more risk, he points out. Especially with how unpredictable these timelines can be, which has been seen when projects are impacted by events like the COVID-19 Pandemic or the war in Ukraine.

There is only so much risk contractors can tolerate on megaprojects before it becomes too big to accept, with risk coming from all angles, such as permitting issues or working in complex regulatory environments.

"These are risks where external stakeholders are involved, where often the risk is shifted to the contractors and contractors can't manage or handle these risks but carry all the liability. We have to find ways to address these risks and make sure they are allocated to the party that can really impact the solutions and resolutions of these risks as well."

He calls for more collaborative contracts for megaprojects.

Stakeholder management

After graduating from university in Canada, Mike Mains, Senior Design Lead – Tunnels and Underground Structures, AECOM, worked on the WestConnex Highway System

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in Sydney, Australia, a design-build project with 10km of conventionally mined tunnels.

"From that point forward, I basically felt that this scale and calibre of project is what I want to do and in the pursuit of that, I found myself drawn to markets other than Canada," he says.

"Now, things have changed," he notes, "for example, Toronto is home to one of the largest subway expansions in all of North America and in Vancouver they are starting to design of the one of the widest immersed tube tunnels in the world."

However, the Canadian market doesn't have the experience of cities like Paris and Hong Kong, which have been consistently investing in their transit systems for decades.

"We're still in an experimental phase where we're trying out different delivery methods," he says, adding that the progressive design build model is popular at the moment, though many jurisdictions continue to use the design-bid-build model.

As these projects get bigger there are more impacts on stakeholders including the public.

"The public is not necessarily used to seeing these huge capital expenditures on transit projects, for example, and as a market we're still getting used to the actual delivery."

As these projects are increasingly built in densely-populated areas of Canada's largest cities, the industry no longer has the luxury of building shafts in brownfield space. Construction is happening on doorsteps, in business districts, in green space and in the middle of residents' commutes.

While the industry has the capacity, knowledge and

tools to overcome these technical challenges, having less experience dealing with stakeholder management can be a problem. Fortunately, Mains suggests the same approach can be used for addressing both challenges.

"The most important thing is having people on your team with experience in whatever the conditions are," he says, citing as an example the Ontario Line where AECOM is providing technical design leadership for the full length of the approximately 10km tunnel works and the three complex interchange stations.

"There are a lot of stations with constrained space and we need to prioritize the site layout, understand what permits are going to be required, the impact on certain utilities and what the cascading impacts of all these are. We have teams that are dedicated to just that."

When it comes to risk management, he says to do the same—throw everything at it.

"Risk is its own discipline," Mains says. "We as construction and engineering professionals have a very large role to play in those risk evaluations. We need to understand what the risks are from a technical standpoint, which I think most of us do intuitively. But more so, especially in these dense, urban environments, the actual risk management—the actual quantification and evaluation of those risks and how they are factored into the overall schedule and costs of the projects—has to be established as its own discipline."

He concedes that it's not that simple, and everyone on a project will have a different qualitative approach or assessment for each risk.

"It's not as straightforward as a structural calculation where you know your load and you know your capacity," he says. "Risk is a much more collaborative effort from all the disciplines, and teams need to be organized to manage that effectively."

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Whether more collaboration can ensure a more successful project may be tested by the progressive design build model.

"A lot of these contracts are in their development phase now so ultimately we'll see if it's a successful delivery model," Mains says.

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Conclusion

Collaboration and working toward a common goal are key to a project success, says Urschitz, as well as ensuring the industry can attract younger engineers to build the projects of the future.

In the following article *Canadian Tunnelling* looks at how the next generation is being prepared to meet these challenges.

Megaprojects are, at least in the engineering community, still attractive for their size and their legacy and can offer young tunnellers an exciting career.

However, Urschitz warns, these projects will not be so captivating for new entrants if they are perceived as overly contentious or even as breeding grounds for a hostile working environment where parties are mostly fighting over claims.

"This is an environment that young people don't like. They want to build, they want to create, they want to innovate, they want to work on digitalization," he says.

"If we want to attract young people, we need to create an environment where they want to see themselves working, trying to find solutions and creating something great together."

The Next Generation - Part 2

Future-proofing the workforce

Educating, training and even understanding young engineers is key to successfully ensuring the industry can retain a sufficient workforce and meet the challenges posed by the next generation of tunnelling projects. Nicole Robinson reports

"We can't expect the current generation to think the way we do" was the consensus of the TAC editorial board while planning the theme for this issue. This message is straightforward but not at all simple. It applies to everything from seeking work-life balance to embracing sophisticated digital tools.

Facing a future with increasingly complex tunnel projects, the industry needs to better prepare the next generation of tunnellers. However, numerous challenges need to be overcome before a young person even arrives on site or in the office.

Exposure

One significant roadblock is the likelihood students even know careers in tunnelling are available. When Ashley Galagusz, Tunnel Practice Lead – Northern California and Pacific Northwest for Black & Veatch, started applying for jobs around 12 years ago, she had hoped to work in soil remediation. She ended up in tunnelling simply because that's what they did at the small Ontario-based firm that hired her out of school.

"I didn't even know that tunnelling was an option for me," she says. "By chance I found this tunnelling job and that shouldn't be the case. We should find a way to create more visibility around tunnelling."

This sentiment is whole-heartedly shared by Davide Elmo, Associate Dean, Students and Professional Development, The University of British Columbia, who laments the loss of geology and earth science programs, including at his alma mater, due to a lack of student interest.

He points to a media landscape that has meant the demise of well-researched television programming that showcases what's possible in the field.

"It seems like no one has the curiosity anymore," he says. "I grew up with documentaries that were showing how things are built—bridges, tunnels, even how ancient civilizations built structures."

In a world where everyone can curate the content they consume on social media and video streaming platforms—and in increasingly shorter bursts of information—there are fewer opportunities for younger people to discover they may have a passion for rocks and landforms or the curiosity of how to build the world around them. It's also worth noting there are misconceptions that may deter potential entrants, which is the topic of this issue's TACym article on page 32, where the group presents solutions to improve the industry's image.

Outreach efforts are underway across Canada to encourage more people to explore the world of tunnelling, "from elementary school to university lecture halls," in the words of Katie Champoux, Talent Acquisition Specialist at Mott MacDonald.

"Each year, we are committed to having a strong presence at career fairs across North America. Our technical teams engage directly with students, answering questions and describing a day in the life at Mott MacDonald. We often conduct on-the-spot interviews, lining up candidates for their next co-op or internship opportunities."

Outside of schools there are numerous organizations where companies or individuals can volunteer. Galagusz is active with The Society for Canadian Women in Science and Technology, which has youth programs and other initiatives to get kids engaged in STEM.

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in it from a young age in order to create that pipeline of new entrants," she says.

Education

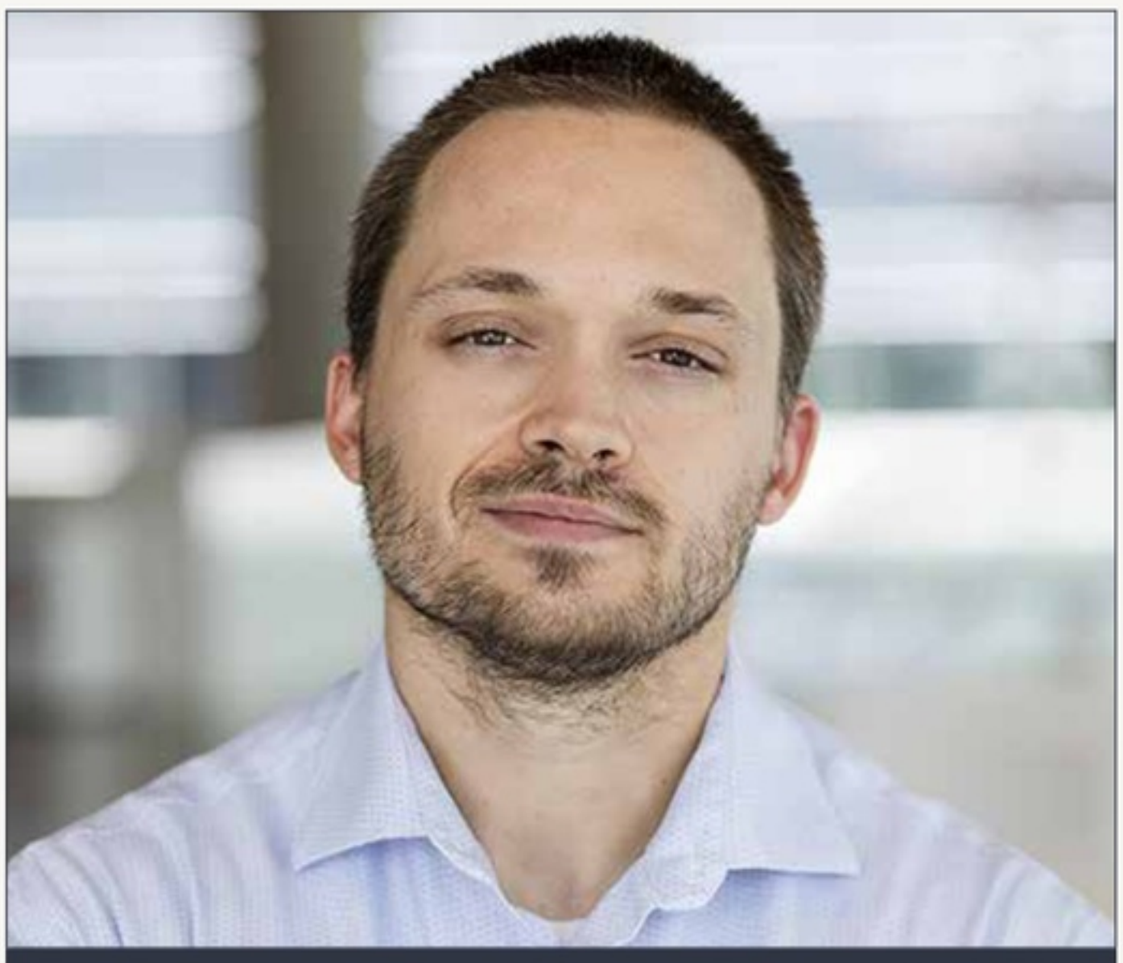
Should a high school student discover a passion for tunnels, there's potentially another pitfall ahead. Jonathan Aubertin, Professor, Department of Construction Engineering, École de technologie supérieure (ETS), points out there isn't a tunnel engineering program among North American universities.

At ETS he teaches a course that will often be civil engineering students' first academic exposure to rock engineering and tunnel practices. Typically, one or two students each year in this optional class show an interest in the field and ask about tunnelling programs. He encourages them to consider pursuing graduate studies.

In Canada, undergrads can enroll in mining engineering, although the popularity can be vulnerable to the boom-and-bust nature of the industry, and can then make their way to the tunnelling. Or they pursue degrees in other disciplines such as geological or mechanical and find their way here. That means—as many readers will be aware from their own careers—much of the training specific to tunnelling happens on the job.

"What transpires from this is that you become dependent on the experience you gain," he says, using Montreal as an example where there is currently a push for TBM and continuous miners over drill and blast excavation.

"Not only do you come into the tunnelling industry with limited knowledge of the whole business but there exists certain sub-entities, such as the type of excavation method or ground conditions, which further the limit what you're going to learn as part of your early experience."



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The ideal solution would be for universities to create dedicated tunnelling programs at engineering faculties, though Aubertin acknowledges this is easier said than done. A more realistic strategy is for the industry to facilitate ways for its young members to specialize in tunnel engineering through graduate degrees. He emphasizes this will require the industry to structure these studies as part of the job for recent graduates.

"The misconception, especially from students and recent graduates, is that pursuing a master's or a doctorate involves spending another two to six years with your head in the books, isolated in a computer lab. The reality is that specialization through graduate studies requires real data, empirical observations and field measurements."

While many pursue graduate studies part time while working or take advantage of industrial scholarships such as the popular Mitacs program, choosing to do a master's or doctorate is not a popular choice, Aubertin says. This is where industry promotion and support could do more to facilitate young workers advancing their knowledge—by allowing a portion of their work week to be dedicated to graduate research and development avenues, whether it's through data collection or other coursework.

"Employers can amplify the amount of knowledge coming into the industry by leveraging young professionals' appetite for advancement and active engagement through the promotion of specialized graduate training programs."

Retainment

Should this high school student who discovered a passion for tunnels become a graduate who finds a job, the industry and employers need to find ways to ensure job satisfaction to retain the next generation workforce.

From a recruitment perspective, Champoux says job candidates continue to prioritize flexible work schedules, such as hybrid working. "However, this flexibility is not always feasible for those working in the field, building our infrastructure. Candidates are also attracted to companies that share their values and recognize and take meaningful action to champion employee wellbeing."

Galagusz shared her experience of finding work-life balance at the 2024 TAC conference's Women in Tunnelling panel, as well as on page 14.

She points out that much of what falls under the umbrella of work-life-balance, such as flexible working hours, are really based on an individual's situation.

"Being adaptive is really key in order to retain people and not just the younger generation. Everyone has their own needs and desires for work-life balance and it's really important for companies to be able to adapt to each individual's needs."

Aubertin is quick to dispel a myth that the younger generation doesn't want to work. "That's outrageous," he says. "The only difference with the newer generation is that they're not shy of expressing what they want. Really, there's no difference between today's graduates and somebody that graduated 20 years ago."

He suggests this confidence—whether in demanding a different work-life balance or choosing to leave a job they find unfulfilling—is likely due to the industry's demographic gap combined with the increased opportunities for jobs. Those who graduated in an era with a higher unemployment rate

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may not be able to fathom graduating with three or four job opportunities as so many newer entrants currently do.

Instead, he advises senior engineers should focus their attention on coaching these younger engineers. "There are not enough trained engineers so the younger ones get promoted faster and they may be taking on roles that they never would have worked on 20 years ago," he says.

Citing his own experience in mining, when he accepted his second job at age 27, he replaced someone who very well could have been on site longer than Aubertin had been alive.

The advice also applies when it comes to technology. Newer entrants to the industry have a lot to offer, and the industry needs to leverage this, while still offering support and coaching them to ensure younger engineers are able to make sense of results they get from these tools.

"For them, digitalization is the norm. However, it necessitates a certain level of understanding and support to effectively apply these skills," says Giuseppe Gaspari, Vice President, Underground Infrastructures Leader - Canada, US East and Latin America for AECOM.

He illustrates a situation of finding balance. If younger entrants don't have the expertise from being on a job site, they can't make the best use of new tools and technology. But on the flip side, contractors with an older workforce set in its ways may not see the benefit of investing in new technology, and reaping the rewards.

A solution, Gaspari suggests, is the concept of reverse mentorships where younger employees are given the opportunity to share their seemingly innate grasp of digital tools and communication with more established workers.

Sense of Purpose

While high wages and improvements to work-life balance are important, there are other approaches to engaging newer entrants in the industry that cannot be overlooked at the risk of losing out on talented workers.

Elmo estimates of all the students he encounters maybe 10-20% demonstrate a passion for the industry, which must find ways to compete with jobs in high-profile industries including finance and tech. He acknowledges there are areas where academia, along with the private sector, can each improve the ways they engage with younger entrants and help them advance their understanding of the field.

"I've seen situations where future engineers ask questions and the answer is usually, 'that's what we do. This is the system we use.' If you want to retain the best people that's not what you should do. You need to have the courage to explain when things work and when things don't work, and acknowledge there are problems with some of the tools."

He points out sustainability as a prominent example. This is an area where the industry can attract the attention of students, though he warns just resting on the laurels of a tunnel's end use will not be sufficient.

"Sustainable doesn't just mean we build this tunnel and we're cutting down the distance, therefore there are fewer vehicles," he says. "We need to look at the carbon footprint of these empirical methods of building a tunnel. You also have to show that the industry is ready and willing to change. If you're so defensive with these old systems, you give the idea of an industry that is really closed."

For Gaspari it's also important that the industry considers how it incentivizes the next generation. With more jobs available compared to, say 10-20 years ago, younger tunnellers have more options and more opportunities to increase their compensation, but relying on high wages alone might be a mistake.

"We have to give them a different scope of purpose and reason for doing the work. Just putting money on the table

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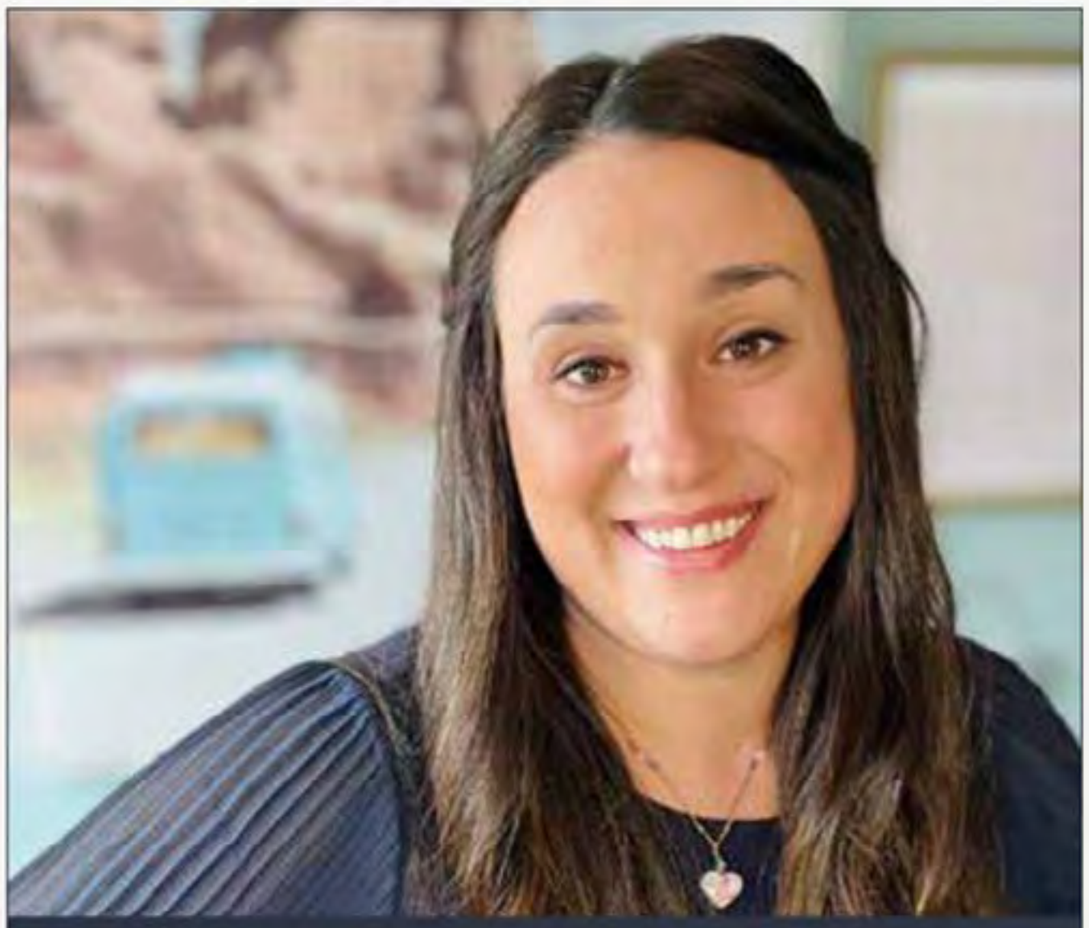
is faster and easier, yes, but if we're not educating them on why we are do ng this job, 10 years from now what are they go ng to do? They're going to move to McKinsey, PricewaterhouseCoopers or other consulting management companies because these are the only guys that can match a higher salary at that point, and they will take their knowledge with them."

Mentorship and continuing education, such as short courses and attending conferences, are valuable opportunit es for younger tunnellers that can also support the kind of professional development that helps the next generation envision a future in the industry

"To ensure the success of our future workforce, the engineer ng industry must actively cult vate a community where early career professionals can thrive," Champoux says. "From what I have experienced, early career professionals want v sible and diverse career paths so new employees can set some roots down somewhere that will invest in their developmental journey of becoming professional engineers."

She points out that mentorship should play a significant role in supporting the next generation of tunnellers, especially as skilled profess onals retire from the industry "By championing a mentorship program, it benefits everyone and helps empower others to reach their highest potential."

Along with company-specific initiat ves, TAC has seen increased demand for mentorship and is in the process of developing a program.



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