OVERVIEW ON CONCRETE HIGH-RISE CONSTRUCTION IN CANADA

Interview with: Adam Auer, Vice President, Environment and Sustainability and Richard J. McGrath, Director Codes and Standards – Buildings

Concrete is often seen as an "old" if proven technology for residential and commercial construction over six storeys. How has it evolved over the last decade in the digital age and the application of new technologies? What changes are taking place or will take place in the near future that will keep concrete in the forefront?

***Richard McGrath*:** [Before we started] you mentioned the use of maturity embedded sensors in poured concrete. That is just one of the technologies being applied today more and more in the construction of our larger and more demanding concrete projects to reduce both labour and construction schedules. One of the biggest innovations that I have personally been involved with over the last decade is the introduction of Portland Limestone cement by the Canadian concrete industry. This reduces our emissions from both the fuels used in the manufacture of the cement and in the calcination reaction process in the limestone itself. We are reducing greenhouse gas emissions by 10 per cent with the manufacture and the use of Portland Limestone cement.

Nothing gets into the marketplace or into the industry until it's approved by relevant standards. And we have just recently standardized ultra-high performance concrete manufacturing in Canada. We expect to see more use of ultra-high performance concrete that is incredibly durable and allows us to construct concrete structures in the most aggressive environments while providing the longest service life possible. This is certainly an advancement that has gone from being an ultra-specialized product to now being more mainstream.

We are also improving with every code cycle the economics of our concrete mix designs by recognizing finer grading of aggregates, which reduces the demand for cement in concrete mixes. This improves environmental sustainability while providing the same quality concrete. We are also adapting to the use

of higher strength reinforcement for reinforced concrete that allows us to improve the constructability of these buildings and to utilize more economical concrete designs for our most demanding design projects.

We were talking about prefabrication as being an innovation in the construction industry. Yes, in the future many more projects because of the constricted sites in highly dense urban areas will require more prefabrication than on-site construction. But this competency has been practiced in precast concrete construction and prefabrication for decades in Canada. This technology is reaching new heights as you have pointed out with the [27-storey] Marriott Hotel in New York. And we also have on-site, precast tilt up construction that is being used extensively on both the east and west coasts of Canada.

We saw just recently the emergence of 3D concrete printing for residential housing in some applications. And although this isn't currently recognized in our codes in North America, in the coming [code] cycles I would expect that they will recognize this new technology as well. There is also self-healing concrete. These are rich cement content mixes that are demonstrating some self-healing capabilities after cracks form. These cracks can heal themselves because of the additional cement in these mixes. It hydrates with any ingress of water and serves to seal the concrete.

In each code cycle there is developing an increased flexibility in our design capability for our structures. You are now seeing structures with inclined columns and spiralling facades of a more complex architectural nature. These never would have been possible years ago if not for the advancement in the computerized design techniques for concrete structures and in the capability of concrete to accommodate these increased design demands.

These are just a few of the advances in concrete technology that we have seen utilized in the industry and there are more to come no doubt.

The Wood vs Concrete Debate: Cost of building tall

How does concrete compare with tall wood structures in terms of project cost from a) start to occupancy as well as b) total life cycle cost? Have you looked at it in terms of what is the cost implications between concrete and wood for taller buildings?

First I would point out that many, if not all of the recent tall buildings are really not all-wood structures. There is a fair degree of concrete construction [in these buildings] to handle the heavy lifting. Anywhere you have a concentration of loads or high stress levels, invariably you will see steel connections or concrete employed to take these high stresses and high loads. So it's relatively easy from an engineering point of view to hang a gravity-loaded frame off of these concrete cores such as you see in Brock Commons [at UBC] as just one example. All of the heavy lifting is done with the foundations and the podium level providing a solid base for the structure and all the lateral loads due to wind and earthquake are being resisted by the concrete cores. Now, you simply secure the wood framing back to the concrete core and let it support gravity loads only, removing any need for moment-resisting connections or torsional resistance. In other words, concrete is counted on to do the heavy lifting while the wood frame goes along for the ride.

That is the first thing. You are never going to see an all-wood, 12-story building in Canada, not from this next code cycle. The limitations that are recognized for tall wood buildings will limit solutions to six-stories in our high seismic zone if you want an all-wood building [including the core]. So your [all] CLT wood building will only be six stories in high seismic zones and no higher than ten-stories in the rest of Canada. For fire safety purposes, the code will permit 12-stories, but they will all be hybrid structures where you'll see concrete elevator cores, stairwells, and podiums supporting the gravity frame wood in these structures. Any all-wood building design greater than 10 stories will fall outside the scope of the 2020 NBCC and will have to be approved as an alternative solution by the authority having jurisdiction.

Adam Auer. I think that in terms of cost it is difficult to say since most of the taller wood buildings, six stories and up, have been underwritten at least in part through federal and provincial subsidies. So there aren't enough of them yet to determine what the cost comparison will be at the end of the day. But it certainly seems at the moment that these buildings cannot be built unless they have at least some support from government funding.

Richard: That is an interesting fact. When the proposals were being made at the National Building Code level, the proponents failed to recognize that all of these projects demonstrating the capability of the material had been subsidized projects and there was no cost savings. In fact, in many instances there were cost premiums being paid to build these structures. They never would have gone ahead had it not been for the subsidies provided.

Are you aware of the Japanese architect Ban's proposed 17-story condominium tower in Vancouver? It will have 2-storeys above ground podium and a core in concrete and the top 15 stories will be wood with exposed mass timber framing on the top six stories. It also uses concrete curtain wall panels on the first six stories hung on the wood frame.

Richard: That's an interesting observation. As you see in most of these structures concrete is used for not only the foundations but the first couple of floors. That gets the wood component of the structure up and out of the high exposure area and the damage prone zone, not only from the environment but from impacts around the structure or damage by fire. It just improves the durability of the structure by getting the most vulnerable component up and out of the way of the high hazard areas.

One of the issues raised around wood structures is that it requires higher maintenance than concrete in areas associated with material deterioration from water, rot, insects, etc. Do you see these as valid concerns that haven't been fully resolved?

In the latest code cycle – I've been at it for 37 years with the association – everybody was talking about the speed of construction and how much cheaper it was going to be. Nobody was talking about improving the building envelope on these structures to make sure that you didn't have any moisture ingress. It is very interesting that many of our first high-rise wood projects are being built in British Columbia, which as you know is a jurisdiction that suffered from some of our worst serviceability construction losses in Canadian history. As a condo developer, I would find it very difficult to rush to adopt this line of construction in this perilous region of the country in regards to wood frame construction.

The argument is made that one advantage to wood is it takes less time to construct a wood structure. While this may be so onsite, how does the timeline look when the off-site fabrication of components is added? Alternatively, Marriott Hotels has started construction on a 27-storey hotel in New York using prefabricated concrete modules that will go into place completely finished in 90 days (not including foundation and two storey podium). Can/is concrete module technology thus already competing with wood in this area?

You are exactly right. There is greater emphasis being placed on this form of construction as constriction increases for on-site construction. One of the advantageous attributes of concrete construction is that you can modularize the construction process so effectively. I could look back to Habitat 67 in Canada and all the design innovations that it brought to the world stage. Habitat 67 was one of the first attempts of modularized residential construction here in Canada. While it didn't take off at that time, its time may have come, and if projections are accurate, more structures will be built in the future using this design concept.

The Marriott hotel is a more recent example, but the beauty of this form of concrete construction is that these living units can be constructed and assembled in climate controlled factory conditions with all of the services built in. All of the services and finishes are embedded in the concrete. Concrete construction, as you know, facilitates embedment of services within the structural frame protecting it from all elemental deterioration as well as providing a long service life. So the short answer to your question is "Yes." This is a coming trend recognized by more than our industry and we will see more of it. The concrete industry will continue to evolve and accommodate more and more of these types of building construction practices.

There are those that I've read who have said concrete is worried about losing market share to tall timber for buildings over 6-storeys. But Marriott has for years been building low- or mid-rise hotels with concrete modules. In this case, concrete has moved into a traditional wood frame sector. If we can produce cost-effective low-rises, mid-rise using concrete modules and if 3D concrete printing of houses in four days is a future option, how much effort is being made to promote these potential expanded concrete markets?

Well, as you know, the construction industry is a very conservative industrial sector and a lot of people like to stick with the tried and true. Currently, all 3D concrete printing that I am aware of is unreinforced concrete, which means it depends on the tensile capacity of the concrete itself. Concrete is 10 times stronger in compression than in tensile. When we design a reinforced concrete structure we disregard the tensile strength of the concrete and we make sure that we have reinforcement in all the areas required for tension.

If you want to construct a house, you have to be sure that you can take all these tensile stresses. So while demonstration projects have been put in place and some tract homes have been printed, a lot more work has to be done to a) make sure you can apply this technology to real-world scenarios with marketable house construction and b) have structural capacity to accommodate the forces that the house will see. Houses don't require a whole lot of strength. There are minimum specified gravity loads and there are

both wind and seismic loads that are significant in certain areas of the country. But all these things will have to be worked out.

In discussing the use of embedded sensors in concrete that indicated that shorter curing times were needed and could be assessed through these sensors, I was told it was very difficult to get the construction industry to accept digital advancement over historic knowledge of curing times.

It is. I think, understandably, the construction industry is very conservative. You don't want your buildings to collapse or to fail in any way obviously; and so maybe we should take some comfort in the fact that there is some resistance or hesitation to adopting new technologies too quickly without proper due diligence. As the carbon question becomes all the more urgent however, there is going to be a need for those types of technological advances to help us be a lot more efficient in the way that we both build and operate structures.

The Wood vs Concrete Debate: Environment/Green/Sustainability

One of the more contentious debates to emerge is over which building material/approach is best for the environment and reduction of carbon emissions. Recently the IISD's Emission Omissions study argues that the carbon impact of wood construction may be higher than that of concrete in some cases if a proper life cycle analysis is applied. Do you defend these findings?

Adam: It's important to note that embodied carbon a big question right now, and there is a growing debate in the green building community about how to best address it. For a long time, there was an unquestioned belief that wood was naturally more sustainable. We are now seeing quite a few voices in the green building community starting to question whether the assumed carbon benefits of wood have been overstated. We think that is the fundamental question that the IISD study, *Emissions Omissions* answers. It doesn't provide a conclusion ultimately on which is the better material; but, it does validate emerging questions and concerns about the presumption that wood is inherently better for the environment, in particular better on carbon and impacts on climate change, than other materials.

The most significant finding is what IISD's modelling suggests is missing from current commercial lifecycle assessments. They modelled scenarios that basically look at the existing suite of life cycle assessments that are out there and the assumptions they make about materials. Lifecycle assessment is the main tool that builders, architects and others are using to make comparisons across materials. The IISD report looks at those life cycle assessments (LCA) and then it looks at the scientific literature around carbon emissions from [concrete, steel and wood]. It finds that up to 3/4 of wood products' carbon footprint might not actually be accounted for in the common life cycle assessments that are used in the market to advocate for the use of more wood in taller buildings.

We think that is an important finding that suggests there are real questions that remain unanswered and that we need to explore if we really want to make sure that we're making the right choices around the strategic use of different building materials to reduce emissions in the built environment. Buildings are a big focus obviously because there is this debate around the role of materials in designing or optimizing green buildings. But of course steel and concrete and other materials are also used in other types of built

environment infrastructure. So it is a critically important question and one that we think needs the benefit of more scientific research.

The other learning I think that we take from the IISD study and other research that we've done is that a lot of the folks who are championing the carbon benefits of wood over other materials discount existing and emerging strategies to improve the carbon footprint of cement and concrete. The effect is to exaggerate the potential differences between wood and concrete and potentially other materials when it comes to greenhouse emissions. There's a lot of low hanging fruit in terms of lower carbon cement, in terms of the use of supplementary cementitious materials in your concrete, in terms of material efficiency opportunities based on how buildings are designed and constructed. All of those offer tremendous opportunities to reduce the emissions from cement and concrete. They are not often considered in these conversations about materials and the different roles that they should play in low carbon buildings.

Our advocacy efforts around this are not to disparage wood or even to suggest that wood's role in fighting climate change is entirely unfounded. We simply believe that all materials should be subject to the same level of scrutiny and transparency when it comes to the question of carbon emissions; and when it comes to wood, we don't think all the questions have been satisfactorily answered.

I have a final point also made by the IIDS study. The reality is all buildings use concrete, steel and wood in varying proportions. Even tall wood buildings are in most cases hybrid buildings, using significant volumes of concrete and significant volumes of other materials. This is all the more reason that we need to understand how to optimize the use of each of those materials in different types of designs to get the greatest benefit to the atmosphere in terms of climate impacts.

I understand that in the six scenarios it was only in the sixth that wood actually was higher than concrete and that the key finding is more that there tends to be more equality rather than that one material is superior. Is that correct?

The IISD analysis is summed up into two graphs that consider various scenarios around biogenic carbon. The study asked what is the level of uncertainty associated with biogenic carbon in three main [biogenic carbon] pools that IISD identified as significant. First, it looked at the biogenic carbon losses that come when you harvest first growth or old growth forest and that forest is converted to a second-growth forest. The total "capacity" of that second-growth forest to store carbon is diminished. So that carbon is not accounted for in current LCA [models].

Second, [the study] also looked at potential [carbon] losses from the soil and estimated a range of potential losses that might come from the soil disturbance that takes place during logging activities. Third, it then looked at the regeneration rate [because] a lot of life cycle assessments appear to assume that the harvested forest grows back a hundred percent. Science suggests that's not the way it actually works in nature. [The researchers] calculated conservatively what the carbon losses would be if we assumed only a 90 per cent regeneration rate.

The study also looked at end-of-life emissions as well as emissions that might come from other parts of the lifecycle, but based on their modelling these were deemed less significant than the three biogenic carbon pools I just noted.

When they aggregated all these uncertainties for each of those biogenic carbon pools, you end up with a scenario where the embodied carbon of the concrete building switches from conventional wisdom [where the wood building has lower embodied carbon] to one where concrete outperforms wood.

Then the next scenario IISD considered basically took that analysis and [combined] it into a full life cycle assessment of that same model building. That is, it was combined with emissions from the operational phase of the building. [This includes] all the energy for light, heating, cooling, etc. that the building would use over its projected lifetime. That is where you see that the difference between concrete and wood structures at the end of the day is relatively small.

The researchers suggest that when you layer on the operational [carbon] component, even with all the advantages that some claim wood has, the carbon difference between the two buildings would be negligible. The [embodied carbon] question is still important because there is this presumption, and we certainly hope that it's true, that we are getting much better at building energy efficient buildings. Those operational emissions we understand pretty well how to reduce. We know how to design more efficient buildings. There's even lots of conversations about transitioning our buildings away from the use of fossil fuels, electrifying our buildings while making sure that that electricity comes from non-fossil sources. The presumption is that as we move forward our buildings are going to become so energy-efficient that the embodied impact of the materials and all the energy that goes into constructing those building is going to become the more important consideration when it comes to climate change.

Today, you don't necessarily see a huge difference on carbon between buildings out of different materials. However, the decisions about how to reduce carbon from the materials in our buildings is going to become more important as we make advances in low carbon buildings. Our objective is not to disparage any other materials in the market. We just want to make sure that the conversation shifts to look at how to de-carbonize ALL materials and how to make the best choices around low carbon materials by using the best information possible based on using transparent processes. As a sector, we are communicating all the strategies that are out there that builders and architects can use to lower their carbon in the type of concrete they use.

As I understood what you've said, looking just at the material is not what is most significant. In the end, how we build, how we heat, how we situate, how we maintain these buildings is equally or more important over the full life cycle than just the material itself.

Yes, over the life cycle it's still the case that those other impacts are more important. But again, we don't diminish the importance of looking at materials. But like other sectors, we have lots of solutions that we are working to implement in the marketplace. We welcome attention on the strategies we are employing that reduce concrete's carbon footprint. We just want to make sure that the same level of scrutiny is applied to all materials equally.

[On this} there are a variety of different courses of action, a suite of technologies that are available. One of the best resources is the technology roadmap developed by the Cement Sustainability Initiative, run out of the World Business Council for Sustainable Development, which has recently been transferred over to the new Global Cement and Concrete Association. It's not regionally specific so it doesn't account for the fact that some regions like Canada are further advanced on the road map than other parts of the

world. But it does give you a sense of what the primary levers are for the manufacturing process to reduce embodied carbon.

One of the points of us playing a strong advocacy role around lowering carbon for the built environment is we want not only to draw attention to those innovations well described in the roadmap, but also to develop more collaborative relationships with the building community to help identify what strategies we can work on together to decarbonize buildings.

As a final point in answering this question, we'd like to point out that we also have an impressive track record in cutting emissions from cement, which is concrete's key ingredient. This includes reducing cement manufacturing process emissions by 20 per cent over the last 20 years. Adopting "circular economy" innovations by, for example, replacing fossil fuels with non-recyclable waste including non-recyclable single-use plastics, biomass and waste from the construction stream – this represents another cut in emissions by another 20-30 per cent or about 3 MT across Canada. Breakthrough carbon capture, storage and utilization technologies are putting concrete on a path toward carbon neutrality and could even transform concrete from an emitter of carbon into a carbon sink. Finally, our industry is also looking further down the road, studying how we can use data technologies, automation and construction technologies to further improve construction with concrete in the years ahead.

At the same time, many of the decision-making points for low carbon strategies for concrete and other materials are outside our sector's control. A lot of the specifications that builders have to meet for certain building elements are not optimized for carbon. For example, we have building elements that are designed to achieve a certain level of strength long before that strength is actually required. One lever for reducing carbon from concrete on projects, therefore, is to design your concrete to be optimized for the function that it is going to play in that building. Those are decisions that we maybe have the technical capacity to advise architects and builders on; but it is ultimately outside our direct control. It is around such issues that we want to develop these kinds of conversations over the full suite of value chain opportunities.

The Wood vs Concrete Debate: Safety

The safety of tall wood structure is an issue you have raised as not being yet fully adjudicated and this is probably the main concern affecting the general public's acceptance of tall wood. The first issue is fire, the second structural integrity. What are the weaknesses you see in the assessment of tall wood's ability to meet acceptable fire standards for tall buildings?

Richard: One of the biggest liability or risk areas of tall wood construction is the construction phase. The very first six-story wood frame building built in Canada in Richmond BC burnt to the ground just a month from completion. More disturbingly, they never found the exact cause of the fire but they ruled out arson. That tells you how vulnerable these projects are to fires and that is reflected in insurance costs when you are developing these projects. Costs are around 7 to 10 times more than they are for non-combustible forms of construction because of increased risk and susceptibility for damage and fire loss during the construction phase. This is why, with our code process, we had to institute a myriad of additional fire code provisions in addition to the building codes to manage the increased risk on these very susceptible

combustible construction projects. So this is an example of the insurance industry responding to the realities of the susceptibility of this form of construction over traditional non-combustible construction.

The indication in your March press releases was that the fire issue has not been adjudicated enough. Yet some of what I'm reading from fire sector people suggests this is really not an issue anymore, that the burn rate for wood is acceptable. How do you feel about that?

Let me just clarify something here. Our concern with the awarding of building permits for this form of construction in certain jurisdictions [stems from] the fact that these permits are being given out ahead of the completion of the National Building Code requirements for these tall structures. One can only hope that these jurisdictions are aware of the proposed changes for the 2020 NBC with regard to tall wood and will enact them. There is no indication though that this is the case. That was our concern that these jurisdictions were simply getting ahead of the National Building Code process. As I have said, I have been writing building codes in Canada for 37 years now and this was a very laborious last cycle where we implemented a myriad of additional provisions to attempt to make sure that we had adequate safety in designing and constructing these structures.

To make a long story short and without all the verbiage of the code, you don't have to be an engineer to appreciate that you are building with a more fragile material. It's susceptible to both water and fire, two of the biggest environmental load increases that we're going to see with climate change. So you don't have to be a climatologist or an engineer to appreciate that with a more fragile material you have to protect it better to make sure you don't expose it to [these elements] in service conditions.

This is what we have attempted to do in the provisions of the 2020 NBC; and, this is why I was arguing against using exposed wood in these tall structures because all the testing indicates that you have higher compartmental temperatures and more destructive fires with the exposed wood. You are adding fuel to the fire, whereas concrete absorbs a fire's heat with a given fuel load and the internal temperatures are lower for a concrete structure than they are for an exposed wood structure.

Are you saying BC's new provincial code of 12-stories and Vancouver's approval permitting buildings up to 18 stories, are premature? What issues remain in terms of structural integrity of wood? Are the use of concrete foundations, base podiums and/or central stair/elevator shafts in tall wood buildings enough to ensure integrity? What are the seismic implications of tall wood buildings vs concrete?

I haven't seen 18 stories but I have seen up to 12 in the National Building Code. But there is a distinction I want to make. The 12-storeys in wood is only for fire safety purposes. When you go to the structural design section of the code, it will tell you a maximum six-stories in high seismic zones and a maximum 10-stories throughout the rest of the Canada. If you want to exceed either of those limits in their respective zones you have to incorporate concrete into your structure to provide the stability that you need. So in the draft code it isn't a blanket statement to say twelve stories. That is only for fire safety. There's other provisions that you have which limit the heights of those structures

If I have concrete foundations and core, what will be the limits in the 2020 code?

In 2020, 12-stories will be the limit on CLT construction under those conditions because even though you have got all your structural positions met from the fire safety point of view, the code is only comfortable with 12 stories now [even with a concrete core].

There are a number of buildings proposed in BC and Ontario that are up to 17-storeys. Will that require special dispensation at the provincial level to proceed?

That is exactly what is going to have to happen. They have to go to the regulatory authority, in this case the province of British Columbia, and ask for a dispensation for an alternative solution, which is permitted under the code. If you can produce a design and demonstrate that you've provided equivalent safety in your 17 or 18-story structure that you would have in your 12-storey building, you are allowed to build it. But recognize that you have to apply special provisions to that structure over and above the existing code requirements to accommodate the additional height.

BC, Alberta, Quebec and Ontario don't completely adopt the NBC provisions, rather they have their own building codes that are only partially based on the NBC. Am I right?

It is a bit of a misnomer nowadays. The provincial jurisdictions are looking at doing away with their own codes and simply referring to the National Building Code of Canada. But that is a matter for the next code cycle. Right now several of our provincial jurisdictions do have their own building codes. But recognize that these building codes are based very heavily on the National Building Code, and they usually differ in areas of fire safety and some serviceability requirements. All of the structural design requirements in those jurisdictions are virtually identical to what is required in the National Building Code. When I talked about the height limitations for an all-wood solution based on seismic design, these would apply in those provincial jurisdictions as well. And hence you would require a special alternative solution permit from the building jurisdiction to build outside of the code.

Now the move to tall wood Construction is really an international trend in many developed countries. I think Brock Commons in Vancouver has been surpassed in height in Norway. Somebody has designed an 80 Story Tower for London and similarly in Japan. Are you working with the cement and concrete associations and other countries? I know there's been similar concerns raised in the United States by the cement people there.

I have enough to do with the Canadian and North American Market. I will let Adam respond to that.

Adam: I think we are really just starting that kind of level of global communication with other associations. Last year, a new group called the Global Cement Association was established and the CAC is an affiliate member, as are cement and concrete associations from other parts of the world. So I think there is a recognition among the industry that we need to do a better job of coordinating our own efforts… and, not just on codes and standards but on communication and on technology advancements as well as a whole range of other issues. So yes, there is an awareness that jurisdictions around the world are facing a lot of the same pressures, whether it be around wood specifically or climate more broadly or other issues. But in terms of formal collaborations or cooperation among different jurisdictions, I would say that is something we are working toward but it has not fully matured yet.

Construction is a dangerous occupation. Is there an argument to be made that tall wood construction is safer for workers than concrete.

Richard: I was a little taken aback by that question. Construction is construction; you can get killed digging ditches as easily as when building a high-rise. Federal and Provincial government Health and Safety regulations specify the regulations for on-site construction safety. And those regulations protect the construction workers regardless of the material they are dealing with, whether they are directing high steel rigging, pouring concrete or placing a CLT slab. Construction safety is everybody's concern and I think it's inaccurate to try and classify one form of construction as more risky than another form. Having said this, one has to be cognisant, as recent events have shown, of the implications of fire on a large combustible construction worksite.

I'm not trying to put across a viewpoint but I have seen in my research an argument that tall wood construction takes fewer workers employed over a far shorter time with a lot more of the work done in an enclosed factory environment.

Well again, if you want to get into precast concrete you are dealing with the same thing with commercial workshops. We are also dealing with tighter tolerances given the increased accuracy afforded by the prefabrication form of construction. And that is recognized in our design codes as well. We can pre-manufacture everything in a precast concrete plant the same way as the CLT manufacturers pre-manufacture their product. But concrete has greater flexibility as far as accommodating service conduits, voids and everything else. We can bury those in the structural elements while the CLT panels are simply a solid wood element.

The other thing I should mention is that when you design a concrete element, these elements in most cases inherently provide the required level of fire-resistance, regardless of the dimension of the member required for structural purposes. What's happening in many of these tall wood buildings, is that they are actually oversizing the exposed wood members in order to provide sacrificial char layers of wood for consumption in the fire. This is done in an effort to leave a sufficient section size in place to resist the structural loads for the fire rating period.. The fire is eating the wood section away. You have to make sure that you have provided enough wood section to accommodate this deterioration of the element. Concrete doesn't have to do that. If you require an 8 inch wall, the eight inch wall provides the fire resistance that you want. If you are exposing a similar wood structure, you might need a 10 or 12 inch wall to provide both the structural and fire resistance required.

One of the arguments in favour of concrete I have heard is that it tends to have a more universal application when building in any region, e.g. a 20-story building in Edmonton versus Vancouver versus Quebec City. Is this a positive factor for concrete over tall wood structures?

Concrete is produced in every area of Canada. Depending on where you are in Canada you have to import a lot of these wood building products, particularly because the infrastructure and production for these products is not that deep right now. The other thing is concrete can be used for any size, any type of structure in any of the seismic zones in Canada. That's not necessarily the case with wood. There are significant design limitations on wood structures with regards to how flexible they can be and how many irregularities you can build into a wood structure. Concrete is capable of accommodating all of these

irregularities, whereas there are some prohibitions on building some of these irregularities into a wood structure.

Concrete as an aesthetic material doesn't have a strong reputation with the public. People tend to see wood as a richer and a more natural material, etc. How would you respond to that argument?

As long as we have been building houses, there has been no prohibition about having exposed wood frame walls in houses, but I don't see a rush to expose those frame walls. We sell wood framing panelling and people use it sparingly. We don't use it generally throughout our residential structures or in our commercial structures. If someone wants to imply that the public wants to see this type of design, I [would counter] that this is more of a professed desire rather than something the public is demanding. I'm not aware of any demand from the public for more exposed wood.

Sidewalk Labs is proposing wood throughout the whole plan for Toronto. Nearby the Danish firm 3XN has designed a 10-story commercial wood building next to Moriyama's competition winning Humber College tall wood building, etc. Some seem to be pushing wood in tall buildings; do you think there is a need for a pushback on the aesthetic qualities of concrete?

For years we have had concrete solutions that provide exposed concrete finishes of any type that you want, whether it was rustic log cabin look or a wood grain finish or different colours with depicted reliefs. Concrete could do any of those things. It's just a matter of what you want to see in your structure. And as you know, many of us see exposed concrete work as an architectural feature whether it is required or desired in that structure. I think the argument for exposed wood is more a fabricated story than a real one.

Noise transfer is a major negative in both residential commercial buildings. Do you see this as always being an advantage for concrete?

Well, you only have to look at the various applications of concrete in our most demanding acoustic applications such as in theatres, gymnasiums, schools where you want acoustical isolation in different areas of the building. You always use concrete The mass of concrete dampens out the airborne sound transmissions, producing the best acoustical separation that we have in our structures.

Tall wood advocates tout the positive impact of tall wood buildings in terms of economies of often distressed, wood-based communities. You have argued that this ignores how these and other like communities also rely on concrete related industries such as quarries, sand pits and ready mix plants.

The idea of artificially suppressing jobs in one sector to create a few jobs in another is not a net gain in job creation. Nor should our codes be viewed as job creation program tools. We should always be using the best material for the application to ensure that we build the most robust infrastructure that we possibly can for our tax dollars here in Canada, full stop.

The federal government has the Green Construction through Wood Program. Is this a leg up for tall wood or does concrete also have its own public programs, etc.?

That is an interesting point you make. To our knowledge, there is no sustained government support program for concrete in Canada. We could point to a number of significant governmental, both federal and provincial, supportive measures for construction with wood-based products. And of course it is a tremendous leg up to those industries to have government backing and government support for their initiatives. You can only imagine competing in the marketplace with your solution only to find that your competitors are being supported by the provincial government. It is quite an advantage.

Adam: I think that we don't have all the answers or insights on the full funding envelope for the wood industry. But as Richard says, there are a number of sustained sources of funding to advance innovations in the [wood] sector and even to help them promote themselves in the market. For example, there is the Wood Council, there is Wood Works, there is FP Innovation and there is the Forest Products Association. If you took a cursory look through the past decade of federal budget announcements, you would find probably on average $50 million plus in almost every federal budget that is going towards supporting the wood industry in some capacity. As an industry, we don't disparage governments that want to support local industry and local jobs. But when it's supporting one industry in a way that harms another important Canadian industry, that is of course where it becomes an issue for us.

A lot of government funding of the wood industry used to go to support jobs and small communities to deal with trade pressures like softwood lumber. It is hard to criticize those types of moves. But, from the sustainability angle, when the funding is supporting wood as a climate solution without regard for all the solutions that exist in other sectors, that is harder for us to digest. Some of our sector's solutions we think are actually much larger in terms of total capacity to reduce emissions in the built environment on an economy scale. – that is why governments' preoccupation with wood becomes a difficult budget policy challenge for us. We are, like other industries, trying to work with and educate governments on the types of policy and regulatory reform that are required to unlock some of the technologies and other solutions that we have to offer on the climate change front. Yet a lot of those efforts are, I don't want to say rebuffed, but don't get the same attention that these governments seem to be directing toward the wood industry.

It's important to understand that our concerns are not a question of market share impact. There are a number of tall wood buildings that exist or are planned in Canada, but they don't constitute much of a market share threat for us. That is not the driving factor. It's really about wanting to ensure that as governments are looking to Industry for climate solutions and to other challenges, including challenges around housing shortages and affordability, that they are looking across the spectrum of opportunities that exist out there and not ignoring important ones to favour one particular solution.

Ban's Vancouver building uses concrete for its basement, podium and even for its lower floor cladding. While wood may take some of the structural market in tall buildings, at the same time concrete is moving back into lower rise buildings with module construction and soon we may be able to build a complete house in one month through 3D printing. Can concrete take back some of the market share at the lower levels while wood moves up to take some at the upper end? Is cooperation and coordination between sectors the real future?

Richard: I would say that, as in all sectors of the construction industry, it's a little bit of an evolutionary process of natural selection as new and better construction systems come along with traditional or new innovative materials. The rule is the industry is going to gravitate towards these better solutions and so it will be with mid-rise construction as new and innovative concrete systems come along and probably with the taller buildings as wood continues to bring [on line] products like CLT panels.

There is no need for our association to work with the wood industry on these solutions. The design community will use and adopt these materials that are at their disposal to best manage each of their projects. That's what we're seeing with the composite buildings because when the wood sector went to the designers in BC and talked to them about Brock Commons, the designers said: "Look, forget about your all wood solutions, this is the way it should be done." And that's the product that you see there. It was not altruistic motivation on behalf of the wood industry to put the concrete core and the concrete podium level in that structure. That was the only way they were going to get their building permit. So that's how that came about. It is a process of natural selection

Adam: You referred earlier to concrete being seen as an old technology. We prefer to see ourselves as a time-tested technology, but one that's ever evolving to meet the changing demands of society and to match the innovations that are happening in the building sector, including from other materials.

I would say on collaboration, ultimately the market decides as Rick has eloquently expressed. But when it comes to specific debates on shaping policy, and certainly when it comes to popular discussion in the media about the role of different materials in mitigating climate change, I think people on the outside see a bit of an antagonistic relationship between wood, concrete and steel. In reality, I do think that our industries are all equally committed to rising to that challenge and putting our best foot forward. In terms of working together as industries on regulatory policy related to climate change, we actually work very collaboratively around carbon pricing and other related policies.

It is in the area of measuring carbon in the built environment where we still have some questions around whether we have got the science right and whether there is enough transparency yet to guide these market driven decisions around low carbon structures. In that one area, you will continue to see some debate and friction. Hopefully, there will be some constructive advancements in the academic and life cycle assessment community to resolve these issues. But it should be noted that when it comes to the bigger questions about working towards the goal of reducing carbon in the environment, you will find a lot of commonalities between the sectors.