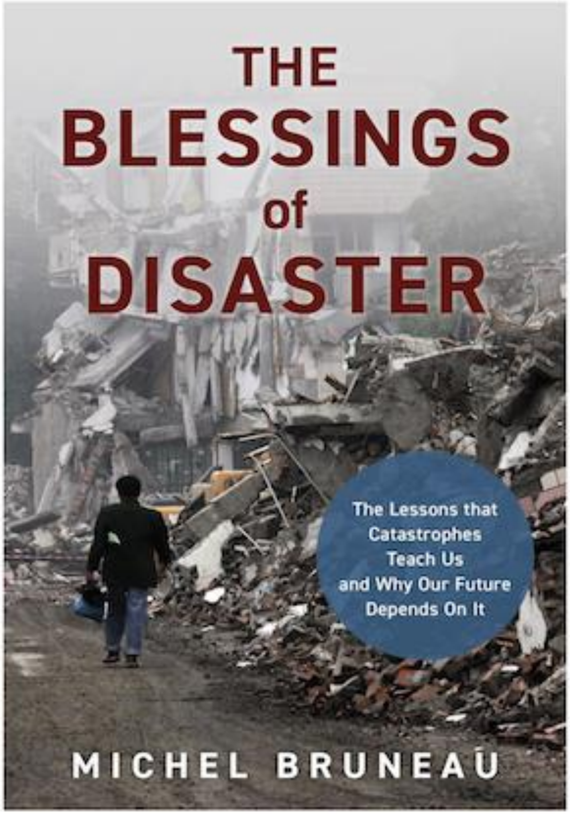
The expert view: the built environment & disaster risk

Interviewer: Gareth Byatt – Principal Consultant, Risk Insight Consulting
Interviewee: Michel Bruneau –SUNY Distinguished Professor, University of Buffalo & Author

September 2023



The Blessings of Disaster: The Lessons That Catastrophes Teach Us and Why Our Future Depends on It – by Michel Bruneau

Michel,

Thank you very much for making the time to discuss with me the relationship between civil and structural engineering, the built environment we create in cities and towns around the world, how people perceive disaster hazards and threats and how we might need to approach these hazards and threats differently in future.
I'd like to start by asking about your background, and the work and research you undertake.

***Michel:** Thanks for reaching out to have this discussion. I studied structural engineering at the University of California, Berkeley (UC Berkeley), and I emerged as an earthquake engineer, which was a primary focus of the university department at the time. During my undergraduate degree the devastating 1985 Mexico City earthquake happened. I was able to join a team of earthquake engineers who undertook reconnaissance activities soon after that tragic event to learn from the damage that had taken place. Think of these reconnaissance visits as a form of reverse engineering, to figure out why the observed damage occurred and what could be done to prevent similar damage in future earthquakes. Such visits provide important lessons for the earthquake engineering community, and as a structural engineer, I have been involved in this type of systematic analysis on several earthquake disasters.*

I have spent the past four decades conducting research developing seismically resilient structures – first, at the University of Ottawa, then since 1998 at the University of Buffalo, where I joined the Multidisciplinary Center for Earthquake Engineering Research (MCEER). The center at Buffalo was a national research center for the US and it was funded by the National Science Foundation and many other research sponsors.

In 2002 we held a strategic session to identify the most important matters for earthquake engineering to focus on for the coming decades (including the 2020s and beyond), and we came up with a framework to achieve seismically resilient communities. This was a good process (and pioneering work) as it was the first time of which I am aware that resilience was mentioned in earthquake engineering. This framework has been widely cited by multiple groups and organizations, and is the foundation for much of the work done on resilience nowadays.

Linked to my research work, I have also been involved in design work for a long time developing engineering systems and details to create seismically resistant structures – including steel plate shear wall systems for seismic regions, structural systems having buckling restrained braces, special types of eccentrically braced frames, resilient bridge systems, and an interesting initiative recently on Speedcore walls, which are composite walls that are becoming popular for use in high-rise construction, and which are relatively fast to repair after an earthquake. I have also been involved in lots of building codes and standards writing committees, having served on such committees for the American Institute of Steel Construction (AISC), the Canadian Standards Association for Standards for Structural Steel, the National Building Code of Canada, and served on similar committees for bridge design codes in Canada and the US. I find it valuable to be part of such committees, to have engaging conversations with people about how to achieve better seismic provisions and design of structures. We are always learning.

Gareth: Thanks for this overview, Michel. You mentioned your involvement in committees for building code standards. Do you see a lot of international knowledge sharing in standards and technical expertise relating to engineering and construction, including on seismic design and standards, and is there enough awareness around the world of experts that are based in many different locations?

***Michel:** Yes, we do see a lot of knowledge sharing taking place – it is a close-knit global community, and I liaise regularly with people all around the world. It's important that we discuss matters with people in different countries who are thinking about and working on new and different concepts and structural systems. It helps us all to reflect on how to approach problems in better ways and to challenge ourselves. The US and a few other countries are pioneering the development of seismic standards which are used in various parts of the world.*

Earthquake expertise definitely exists around the world, which the media sometimes forgets about. To give you an example of this, after the Turkey-Syria earthquake of February 2023, I was asked for opinions by various media organisations. While I can provide a viewpoint, I reminded journalists that Turkey (and many other countries that are seismically active) has very good earthquake engineers and experts who can and should be asked for their views.

Gareth: I can appreciate how the international network of engineers involved in seismic engineering collaborate together. I am keen to hear your views on how people who are involved in the built environment and construction around the world – including the private sector and local, state and national / federal governments – can leverage the expertise of earthquake engineers and to work together to avoid disasters when events such as earthquakes, and also storms, major flooding and wildfires occur.

On this point, I would like to understand more about your book, The Blessings of Disaster, which was first published in November 2022. What inspired you to write it, and how is it structured?

***Michel:** I wrote this book for the general public, and I hope it is an interesting and thought-provoking read. I decided to write it because I believe that if we are going to have a resilient society, a key and necessary step is to have a knowledgeable public. I don't think we can achieve a resilient society if people do not know what we need to do to achieve it, in many ways, shapes and forms. Any work we do to provide resilience in our built environment has to be done in concert with an educated public that understands what resilience is, what are options open to us to provide resilience, and the consequences of taking certain types of action, and also of not taking action. Part of my activities includes providing presentations on this subject (an example of which from October 2023 is available in this link).*

As it happens, I was initially writing a completely different book when the idea and structure to write The Blessings of Disaster came to me. The book is trying to answer the question: "Are we doomed?" The context for this question is that we face many existential threats, some that come to us, some that we as human beings are at least in part responsible for, and some that we have totally created. The way we deal and cope with disasters that have occurred might foretell how we will deal with the existential threats we face.

The book is structured into three parts: (1) the hazards we face and the ways by which we expose ourselves to these hazards; (2) the multiple reasons why we often don't act to prevent disaster for the hazards we face, until it's too late and (3) what does this all tell us about how we may handle our existential threats in the future?

With the first part of the book being about all the hazards we face, I wanted to explore why we expose ourselves to these hazards (in so many "creative" ways).

Consider this example. A law in California states that for new construction, it's a requirement to build a minimum of 50ft (15.25m) away from a known fault line. I came across an article (which I discussed in a LinkedIn post) noting that developers in the Bay Area were upset because of the 50ft limit. The article stated that certain developers wanted to build closer to the fault line, because they are under pressure and are running out of land to develop, so why not build closer to the fault and accept the risk? To me, this is an example of how people don't care about a hazard until the hazard becomes real for them.

Exploring these points leads on to the second part of the book, which asks "Why do we do this?" The answer is that there are many reasons. One of these is that risks are often presented to us in probabilistic terms, and people do not have a good intuitive understanding of probability. How many times do we hear that a 100-year flood only happens once in a hundred years, so if it just happened, we don't need to worry about it for another hundred years? Another is that people have a propensity for reaction rather than action – our brains work in certain ways towards this that we don't entirely understand.

Then, in the third part of the book is, we tackle some existential threats, such as global climate change, overpopulation, monetary collapse, and nuclear holocaust, and by extrapolating from how we have dealt with the "regular" hazards in the past, explore "What will happen when we face these existential threats?"

Gareth: Thanks for this overview about The Blessings of Disaster book, Michel. It is very interesting to try to understand how our brains look at risk and reward. There has been some very interesting work in this field by people like Daniel Kahneman. Your example of developers showing a willingness to accept the risk of building close to earthquake fault lines makes me think about the value people place on the scarcity of land in a society where maximising financial profit is the top priority and how it leads to actions that can have harmful consequences.

Michel: *The value of land is certainly interesting to examine. Continuing on the subject of California, I spent time looking at real estate data in San Francisco. I was curious to see if a house built right on top of the San Andreas fault was selling at equal, higher or lower value as an equivalent house (of the same size, same number of bedrooms and bathrooms, same size of plot, same year of construction etc.) miles away from the fault. I found that they were selling for the exact same price. The value of property in areas that are in demand keeps rising over the long term regardless of the potential to a disaster due to specific hazards, it seems. For example, the price of most homes in San Francisco has more than doubled between 2011 and 2020.*

While the value of homes has risen significantly because of market economics, they have not been made any more resilient to withstand earthquakes during this time. When people say: "It costs too much to implement earthquake resistance measures for our homes", there is surely a counter argument – certainly in San Francisco, which is overdue for an earthquake – to say: "The value of housing has mostly doubled in the last ten years; surely, the cost of good earthquake resilience measures is insignificant compared to that increase in property values."

Gareth: This point makes me think about the increase in property values in many parts of the world, certainly in developed economies, over the past ten years (whilst noting that in some parts of the world have been static or perhaps declining in 2023). When we think about the cost of adapting existing homes, and building new homes, to be resilient against hazards specific to their location – earthquakes in some, wildfire and / or flooding in some, for example – it is likely to be a lot less than the rise in value of their homes over time.

Michel: *There is a strong argument for this. I have a graph I use in a presentation that shows the median value of homes in the US (inflation adjusted to 2020 dollars) as a trend line that is rising over the long term, together with a trend line showing the median size of a home, which has increased from 1,000 sq. ft. (93 sq. m.) to 2,600 sq. ft. (241 sq. m.) over some 50 years from the early 1970s. The two lines are virtually in sync with each other. Homes have become bigger, and prices have increased. It doesn't necessarily cost more to make them more resilient to hazards that they face. It's a myth that we can't afford to provide resilience.*

Gareth: I agree on the value of making homes more resilient against hazards. I have come across some good examples of intelligent resilient home design around the world. For example, a UNDP/GCF project in central Viet Nam is providing approx. 4,000 homes for people that are resilient against flooding.

I wonder if we could focus on an aspect of the second part of The Blessings of Disaster and discuss the way people look at and respond to disaster hazards and threats before they occur, and after they experience them. I'm interested in looking at examples where there are opportunities to keep improving, and I'd like to focus on the Christchurch earthquake of February 2011 (which occurred six months after a previous earthquake in Canterbury) as an example of this. I know that it caused 185 deaths and injured thousands of people. I know it struck at lunchtime when people were on the streets. More than 130 people lost their lives in the collapse of the Canterbury Television and Pyne Gould Corporation buildings; falling bricks and masonry killed a further 11 people; eight died in two buses that were crushed by collapsing walls. Rock cliffs collapsed, with five people killed by falling rocks.

I read your paper about the reconstruction of Christchurch in New Zealand in the wake of the earthquake. As I understand it, as of 2023 there continues to be rebuilding work taking place.

The media has been covering the reconstruction situation, and I read an article published in November 2020 by the World Steel Association that talks about the use of structural steel to help the city to be more seismic resistant. Another piece published by The Guardian in February 2021 is interesting to read also.
In your paper about the rebuilding of Christchurch you describe how the heart of the city has been rebuilt using different structural methods and materials to those that were used in the original buildings that were impacted and damaged. Are there certain learnings to draw from the way Christchurch has been rebuilt after this tragic event, especially for cities and towns that are in known seismic areas? Many cities have a lot more concrete frames than steel for their buildings, and some old buildings are no doubt not earthquake resistant at all. There is of course a recognition that structural design and materials use should be undertaken in a way that maximises sustainability and minimises carbon emissions.

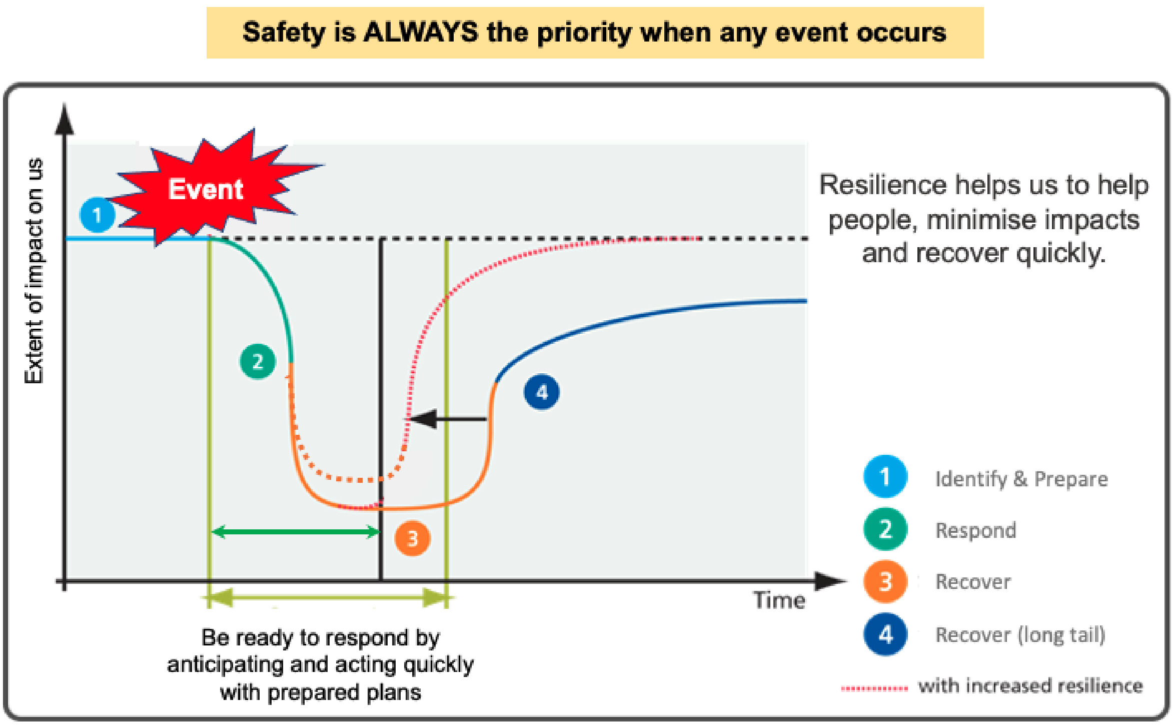
Michel: *The tragic Christchurch earthquake does offer some valuable lessons. New Zealand has had for some time and continues to have some of the best building standards for earthquake resistant design in the world. The event of February 2011 was of course an earthquake in an urban setting in a developed country. I happened to be in Christchurch in 2010, so before it happened, and I returned soon after the event a few times to see for myself the damage and what was being done afterwards.*

I remember commenting to a colleague at the University of Canterbury at the time that there was a lot steel being used in the structure of these new buildings. Christchurch had traditionally used a lot of reinforced concrete for its structures – the ways to do a ductile seismic design for such concrete was to a large degree developed and taught at the University of Canterbury, and engineers graduate and use what they have learned. As a result of the 2011 earthquake, only two older vintage reinforced concrete buildings collapsed, and these had been built decades ago at a time when the standards were not as advanced. The more modern buildings suffered damage in a way intended to absorb the energy of the earthquake (i.e., the ductile design approach), as they were designed to do, but they stood up, people were able to evacuate the buildings safely, and they performed as the standards required. When you asked engineers if this was a success story, they would typically say that it was – these buildings designed to the latest standards did not collapse, and people were kept safe (none of the tragic 185 deaths mentioned earlier occurred in such buildings). Yet the difficulties and costs in trying to repair the many damaged reinforced concrete buildings meant that most of them ended up being pulled down. It was easier to demolish them and build anew. I believe that more than 1,000 buildings in the Christchurch central business district (CBD) were demolished, by humans. The earthquake damaged them, and people then decided to knock them down to rebuild better. The process to rebuild of course takes a long time.

With my colleague at the University of Canterbury, Greg MacRae, we conducted a study talking to engineers who were working on rebuilds. The report we produced as a result of this study can be downloaded for free from both my ***website*** *and from the website of the Quake Center at the University of Canterbury. We asked them what drove their decision to select the specific structural system for each of 73 buildings that had been built at the time of the survey. We learned that the earthquake changed the momentum of how to design and construct buildings.*

It disrupted all existing processes in-place and led to a reassessment of everything and consequently new processes. A lot of clients started asking for buildings that could provide business continuity if there was an earthquake, something that wasn't on the radar or considered before the event. In other words, the hierarchy of priorities changed for everyone. The steel frame buildings in Christchurch that were impacted by and repaired after the earthquake were brought back into use quickly, and people could see this visibly against the reinforced concrete buildings that were being demolished. The tenants, developers, architects and engineering community looked closely at what their priorities were, and most new buildings ended up being steel frames. This case study shows how earthquakes can lead to major changes in engineering principles.

Gareth: I can see how the earthquake could have led to a larger death toll if more buildings had collapsed, and from an engineers' perspective the building designs worked as intended (noting that the Canterbury Television and Pyne Gould Corporation buildings that collapsed were built in the 1970s and the construction techniques used at that time were quite different to more modern buildings). So, the engineering for the majority of buildings worked as designed, but for building owners and occupants (e.g. retailers etc.), it led to a long tail recovery timeframe which had long-term impacts. I sometimes articulate this type of situation in resilience diagrams like the one below. Does this diagram make sense in this context?



Michel: *Yes. This diagram is similar to the one we proposed when we pioneered the seismic resilience framework in 2003 ([the framework is available on the Sage Journals website]). As it applies to Christchurch, it's true that people's livelihoods were impacted for a long time. Many plots that had previously had buildings on them became parking lots for a while.*

On the positive side, the public in Christchurch wanted something better during reconstruction, and the engineering community has responded.

Gareth: This event also seems to be an example, which relates to the point you made earlier about the value of engaging the public properly in discussions about resilience, of “societal cohesion” (good engagement with the public) supported by good governance.

Michel: *I do think that there has been some good listening after the event, and community involvement in the rebuilding process has been significant, although when it came to the choice of structural system and the outcome of a more resilient building inventory, a lot of it happened one-on-one, in discussions between tenants, developer, architect and engineer for each given project.*

Gareth: I know there are lots of people out there that are “flying the flag” for the good work that is undertaken to avoid disasters, and to recover in the most effective way possible when a major event occurs – be it an earthquake, a huge storm, a wildfire or something else. The more we can have this taking place, perhaps the more that we can hear of such work.

Michel: *The way our media system works is that they will focus on the casualties and as soon as the death toll is known and stories (which can be harrowing and tragic) are told, the media generally does not follow up in the mainstream about earthquake design or actions to rebuild better. It’s a similar case with disasters from other hazards.*

Gareth: Can we return to the sustainability and low-carbon point for a moment. Is it possible to achieve a good balance between structural resilience – which means human-made structures designed to withstand stresses in a way that allows rapid return to full functionality, whether caused by earthquakes, fires or torrents of water – and sustainability and “green and blue infrastructure” and nature-based solutions?

Michel: *It is of course important to think about sustainability and carbon emissions in design and construction. In that context, it is worth bearing in mind that the vast majority of steel used in construction is recycled steel. Steel holds a good recycling value; it can be recycled and reused many times while maintaining structural integrity. While there is energy involved in the recycling process, structural steel is being reused. With my own experimental research, when I test steel specimens, I can dispose of the destroyed specimens by selling them for recycling whereas remaining material from concrete tests is sent to landfills (and I must pay for that disposal). For sure, new steel is still being created for many purposes (as the World Steel Association* ***tracks monthly*** *– August 2023 was approx. 150 million tonnes of crude steel produced, and* ***40% of that production came from recycled steel****), but not in general for construction steel.*

As part of our sustainability commitments, we need to think about the potential amount of debris that results from major events like earthquakes that destroy large swathes of urban environments. Reinforced concrete remnants typically go to landfill. Steel can be recycled.

Gareth: I have worked with some businesses that are involved in parts of the steel lifecycle process including recycling, such as the details of recycled steel shipping and transportation at volume. The devil is in the details; the key is for it to be economically viable, and as you say, steel has this value.

As we look forwards to the future and how we can avoid disasters (whether by the definition I provided earlier or another one), does there need to be a greater focus on agreeing and enforcing better building codes and standards to reduce disaster risk, specific to local areas and environments? Is there always going to be, in a market economy, a trade-off between cost and risk for the private sector when buildings are being designed and built? You mentioned an example earlier of property developers in San Francisco wanting to build closer to a fault line. I also think of developers building knowingly on flood plains in parts of the world. Other times, people are forced to locate in known hazardous areas due to poverty and desperation.

I can think of many examples where cities and towns are struggling to deal with extreme heat, and/or flash flooding and/or major storms, with their built environment struggling to deal with these threats. One example of good governance and adherence to building codes that comes to my mind is Hamburg HafenCity and its work to be resilient against flooding. I also think of cities like Phoenix, Arizona that are continuing to look at measures to adapt to and cope with extreme heat. Together with Professor Ilan Kelman of UCL and Ana Prados of UMBC, which we are calling "Disasters Avoided", we are reviewing case studies of disasters that have been avoided, and we keep finding that good governance and defined accountability is critical to ensuring that good actions – which includes implementing good building codes – are undertaken.

Michel: *It's an interesting question. Going back to New Zealand for a moment, their building code did not change much after the 2011 earthquake, it was more the community that shifted its practices and started using different available and approved techniques (including structural steel) that were already in the code. Some systems were not in the code but could be used after a peer review or similar. I know they are looking at introducing some of these structural systems in the New Zealand code now to streamline the process further without needing so many peer reviews.*

In the US, a curious system is in place. In line with the US constitution, municipalities decide how things move forwards and are done when it comes to building construction. They can decide to have their own code (which large cities often decide to do); they can use a state code; they can use a model code (for example, one that has been provided by an organization such as the American Society of Civil Engineers); or they can decide to have no code at all. It's up to them.

As a result, some cities in the US have no building codes, and the federal government cannot enforce the use of one.

When they are used / enforced, they are typically used well. Some states have adopted the latest ones. Sometimes, states don't want to change or update their codes to the very latest standards, for one reason or another. As I describe in a LinkedIn post, in 2022, The Federal Emergency Management Agency (FEMA) https://www.scientificamerican.com/article/most-states-are-failing-on-building-codes-fema-says/based on the "stringency" of its building codes on a 100-point scale. 19 states received a score of 0. On the positive side, staring at zero, they can only go up in their score! This shows how much the United States is a patchwork of variance across its states.

A lot of times, building codes' definition of the severity of the hazards to consider rely on probabilistic calculations, but this doesn't mean that an engineering solution strictly adhering to science-based probabilities is the best one to use. The models inform us of possible outcomes, we need to combine this knowledge and look at what is practical in a specific area. For example, in Christchurch, the seismological models showed that most of the seismicity was in the western Alps far from the city. The further away from this area you were, the smaller the shaking, according to the models. The engineers looked at this and they decided to design buildings in the city to a higher standard than what the models indicated, because they took the view that Christchurch is a big city and given population density and urban economics, they deemed the risk high enough to warrant this decision.

As another example and looking at a different type of hazard, I have looked at the resilience of the built environment in Florida against hurricanes, which are of course a known hazard. Using Hurricane Idalia (which struck the US at the end of August / start of September 2023) as a case study, it made landfall in a part of Florida where the design wind speed according to the map in Florida's building code are lower than in adjacent parts of Florida east and west of it – which is odd. Digging further, one can find that there was a revision of the map, from the seventh to the eighth edition of the code, that was made such that the area near Mexico Beach (which was ravaged by Hurricane Michael in 2018) was "upgraded" to increase the design for wind speed from 120mph (193km/h) to 140mph (225km/h)). But in the "elbow" of Florida (where Hurricane Idalia struck in 2023), it had been left at 120mph. This is curious – why leave that part of Florida at 120mph? Just because a hurricane hasn't impacted a particular area before, or for quite a while (maybe decades), what's to stop it from changing direction and swinging in 50 miles (80km) further to an area that isn't designed to cope with 140mph winds (unlike its neighbouring regions), as Hurricane Idalia did? Perhaps in the ninth edition of the code that part of Florida will also be revised to be designed for 140mph winds. It's not that big of a difference and think about the implications to businesses that are involved in property supplies in that area. Consider a window manufacturer as an example. When they have to make hurricane-rated windows, they probably maintain production runs for one type of design to cover all wind speed areas rather than switch production techniques to address various wind speed ratings. Maybe there's a marginal impact on materials, products and construction costs, but there are likely savings avoiding manufacturing reconfiguration and inventory management.

Gareth: This example you have just given, Michel, about Hurricane Idalia in Florida and the wind design recommendations for different areas seems a really poignant case for using counterfactual thinking, which I have discussed with various people before including Gordon Woo, who has written and co-authored some excellent papers and reports, such as one published in Frontiers in July 2023 about downward counterfactuals and multi-risk cascades. Plus, I remember seeing a piece about the Florida property market being one of the most popular ones across the US (in September 2023 it overtook US as the second most valuable property market in the country) – so clearly people see it as a desirable place to live, knowing the hazards and threats that come with it.

Can we return to a point you made earlier, about governance and the enforcement of codes? You mentioned that, when codes are applied in the US they are generally enforced and used well. It is surely the same in New Zealand, Japan and other countries. Sadly, I don't think it is the case everywhere.

Michel: *That's right. Enforcement and good governance have been a problem in many countries for many years, and for a number of reasons. Consider the earthquake in Haiti, which was a total disaster. You could see photos of damaged or fallen concrete buildings that should have been reinforced concrete structures, but on seeing them in their fallen or damaged state, there was no reinforcement in place. A lack of reinforcement meant that the structures were only very brittle concrete, which is why they collapsed. Construction needs to be inspected, of course, so how does a failure to apply codes like this happen? Well, reinforcement has a value, and someone decides to save money. What can happen is that inspections of to-be-cast concrete columns can be performed, with a steel reinforcement cage in place as is expected, and when an inspector goes away, they take the reinforcement out before the concrete is poured and use it elsewhere.*

Consider the example of Turkey, which we know is a very active seismic region and it has a very good building code. The 1999 Izmit earthquake (which is believed to have caused 17,000 deaths and 250,000 people homeless) led to many revisions of their existing building code, which arguably made it state of the art in terms of seismic requirements. But it was not enforced. It's one thing to keep a code up to date, it's another to enforce it with strong governance. Not surprisingly, the Turkey-Syria earthquake of 2023 experienced similar types of structural failures as those that occurred in 1999.

Also, it's worth noting that reinforced concrete design to resist earthquakes is a fairly new idea in many countries – the work on it goes back a few decades, essentially for those buildings that are post-1980 design. This is as much the case for the US as it is for Turkey. So, when a sizeable part of the inventory of concrete buildings in an urban or a rural area pre-dates 1980, these buildings may not be capable of withstanding an earthquake. The US has a large inventory of fairly old concrete buildings that will perform poorly in the event of an earthquake. In California, for example. a lot of people have been pushing for such buildings to be retrofitted, but it's a challenge because who will pay for it (which goes back to our discussion point earlier about people's perception of risk and willingness to pay upfront to avoid problems or reduce risk)?

Decades ago, some people proposed new laws to enforce the upgrades of pre-1980 reinforced concrete buildings, but they couldn't get them through. After the Turkey earthquake, some US cities have "resurrected" these previous proposals and, this time, some seismic retrofit ordinances have been successfully enacted, but giving owners a few decades to retrofit their existing concrete buildings. You can read into that timeline whatever you think.

Gareth: This seems to be another example of economic drivers, and that we don't prioritise the impact of major events like earthquakes, floods, wildfires or something else until they are right in front of us.

Michel: *Nothing has an impact as much as when it actually happens to us personally.*

The populations of some countries seem more aware of the risk. Consider the case of Japan, where lots of hazards exist which occur regularly. The Japanese have put disasters into popular culture with Godzilla, the monster that can come up and destroy your city without warning.

Prior to the 1995 Kobe (Great Hanshin) earthquake, the Japanese thought their earthquake standards were appropriate, but they learned from the devastation and massive economical and human losses that happened in Kobe that they had to address many deficiencies. They were not expecting an earthquake in this city, but it happened. There has been a lot of improvements since this event in Japan on many fronts. Not just on building codes, but also for emergency management, communications, and international collaboration.

Fast forward to the 2011 Tohoku earthquake and tsunami, which led to a terrible loss of life and a great deal of damage. After the event, some people commented that it was amazing that the Shinkansen elevated high speed rail line (away from the region impacted by the tsunami) did not suffer damage. What a lot of people don't know is that, years prior to the Tohoku earthquake and tsunami, there was a smaller earthquake that damaged a lot of the columns supporting the rail line, and that columns along that line were all subsequently repaired and retrofitted after that smaller earthquake – therefore, prior to the Tohoku event. It's an example of regular events keeping the people ready, up to a point. It's works even better when combined to a mindset of respecting the hazard and knowing that if a very large event occurs, it will be damaging.

Gareth: Japan is an interesting example of a country that acknowledges that it also still has a lot of old buildings – many of them with very large cultural significance, not only in places like Kyoto but across the country – that are not resistant to an earthquake, some of them being timber which could easily catch fire in such an event. Given their shared collective mindset and societal togetherness to prepare as best they can for disasters, I am sure they take all of this into account.

Whenever I have visited Japan, I have appreciated the respect that people have for the power of nature.

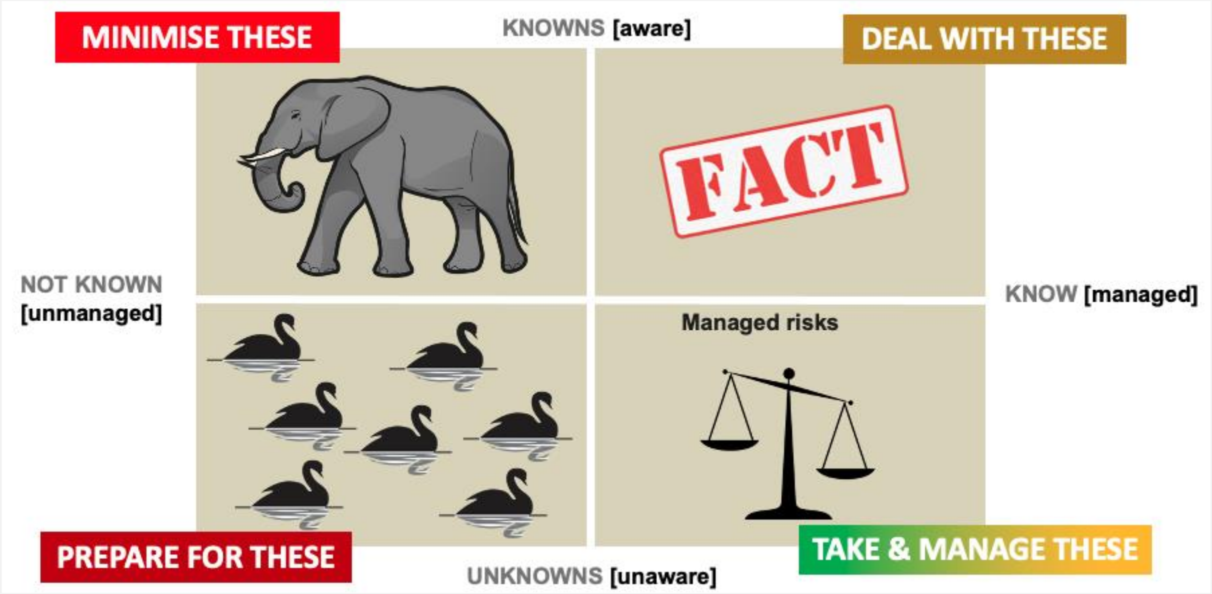
Michel: *That's right. We should remember that 2023 is the one hundredth anniversary since [the 1923 Tokyo (Great Kantō) earthquake] that killed over 105,000 people. The Japanese recognise that they still have a large inventory of vulnerable structures in their cities and towns, and the populations of many of them such as Tokyo has grown significantly. The next major earthquake to strike Tokyo will have a significant impact on the Japanese economy, and the world economy too.*

Gareth: I read a very interesting piece a few years ago about Tokyo and The Big One (i.e. preparing for a major earthquake). I appreciate that their mindset is one where they appreciate the threats and hazards that they face.

Michel: *They plan for a major earthquake, and they know they cannot prevent losses from a major one when it will occur. They plan as best they can, and they are world leaders in many aspects.*

An important first step is to be knowledgeable about what has happened before (i.e. learn from the past), taking into account how else it could have happened, to your point about counterfactual analysis. Then, think about what could happen now and in the future. The key is to make decisions with this knowledge rather than be ignorant about the threats and hazards. To give you an example, think of a tornado. It's a rare event. If you run a business that has a production facility which is 40 years old and not designed to withstand tornado-strength winds of around 150mph or maybe more, you may calculate that it will take, let's say, US$40 million to upgrade your premises. You may decide not to proceed with this upgrade and take the risk and self-insure. If your maximum foreseeable losses are US$100 million, maybe it's worth the financial risk to not spend any money on the upgrade. But what if your possible TOTAL losses could be in the billions of dollars because of supplier and client agreements that you have. If you have such a scenario, the equation changes. The knowledge must be there in order to be in a position to make a risk-informed decision. Making decisions in full knowledge and accepting the risk is one thing; making decisions and not knowing your risks is entirely another.

Gareth: This is an example to me of using risk appetite and a construct that I use a lot, called the Johari window, which is essentially about things we know we know (facts), things we know we don't know (risks), things we can't know about (so-called black swans) and things we should know about but don't (elephants in the room). I sometimes use this type of diagram to explain it:



***Michel:** When you build in flood zones, you know you may experience flooding. I looked at some streets that were flooded by the storm surge from Hurricane Michael in 2018. Many homes were flooded, with bungalow filling with water up to the kitchen counter. There were empty lots on some of these streets, which since sold and people have been building homes there five years after the hurricane. In one of those streets that previously flooded, I saw two houses being built at the same time: one that is entirely vulnerable to flooding due to storm surge – a bungalow and other one that is a more resilient building because its liveable first floor is elevated 12 feet (and, to make it an even more striking comparison, the second one was being built further away from the coast than the first on). It makes you wonder if the owner of the bungalow has thought about risks.*

Gareth: I have seen some good examples in Asia recently of applying good risk principles, for example in Viet Nam's central coast area, a UNDP / GCF project is providing some 4,000 flood-resilient homes and risk assessments are key.

Plus, it has been interesting to consider Bangladesh and how it is working to be resilient against floods. For example, in Cox's Bazaar there are many challenges, and many people in close proximity to each other knowing that the threat of cyclones is very real. At the time of the COVID-19 pandemic, it was even more difficult, they still act and prepare. When Cyclone Mocha skirted the area in 2023, they had the awareness to be prepared for it.

***Michel:** Yes, we have to appreciate that in some parts of the world, especially the developing world, people don't have the resources, the means or perhaps the capacity to deal with hazards that we consider high risk, because they are facing and having to struggle with foundation aspects of living, poverty and associated pressing problems.*

The key I think is to ensure we equip ourselves with knowledge, including the local context of where we are (to note our point just now about access to resources being different around the world). As one example of this, many people do not understand how much a building code can help to ensure resilience and avoid a disaster.

I can give you another example of the benefits of adhering to good building codes. In October 2022 Hurricane Ian blasted Fort Myers beach in Florida. This hurricane and its storm surge hit the beach head on. I saw a photo of a building standing up afterwards, and I posted a picture in a LinkedIn post of it, with a second post containing more analysis and a third post adding more context. It generated a lot of views and comments.

I then went to real estate and tax assessor websites, to look at the year of construction of buildings in the image I used / posted. According to this analysis, the buildings that had been destroyed were built prior to 2000; the one that was still standing was built in 2020 or thereabouts. So, I posted another message, stating that building codes were making an important difference in that area. Yet many people took issue with this statement. So, I then took an aerial photo of the entire coastline, looking at properties facing the ocean. Many were still standing; others had been flattened. All those that were standing were post 2000 in construction (with elevated first floors, etc.); the ones before 2000 were destroyed. Whether they still existed after the hurricane wasn't a question of property size and value either. The most expensive home had been completely wiped out because it was built to old building codes, showing that it's not about having the largest or most expensive home.

Gareth: You are reminding me of a well-known photo which has been widely circulated of a house in Lahaina, Maui that was still standing after the terrible wildfire event that this town experienced in August 2023.

Michel: *For that house in Lahaina, a news article cited a person who wrote a design guide on how to provide more fire resistance. It highlighted that this house had many of the features and conditions that are desirable to survive wild fires according to that design guide. I posted a link to the article, which has a link to the design guide that was used – which shows it wasn't a fluke.*

There is usually a reason for why disasters can be avoided, and much of it is structural.

Gareth: Lastly, I know that you write fiction as well as non-fiction. Any plans for another work of fiction?

Michel: *Well, I do like to write fiction and non-fiction. For me, the focus right now is on The Blessings of Disaster. There is some story-building in this book, as it happens. I have another non-fiction book in mind; I will see how it develops. I started The Blessings of Disaster while I was half-way through the writing of a fiction book, so clearly the book writing process works in mysterious ways…!*

Thank you very much for your time and your extremely useful guidance and examples, Michel. I look forward to seeing your continued writing being published.