LESSONS LEARNT FROM ENGINEERING FAILURES

MANAGING TRANSPORT PROJECTS IN DEVELOPING COUNTRIES

Webinar by Dr Christopher Bennet

engineering new zealand
te ao rangahau

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INTRODUCTION

This case study summarises the webinar by Dr Christopher Bennet reflecting on the lessons learned from transport projects he has been involved with in developing countries. Dr Bennet is a retired Lead Transport Specialist with over 18 years of experience at the World Bank, including working in South Asia, North Asia, Southeast Asia, and the Pacific Islands for over eight years. He ran the transport project programme in the Pacific Islands and gave his guidance on various projects in many African and Latin American countries. Now retired, Dr Bennet is optimistic and enthusiastic regarding World Bank investments and how transport projects can shape the new world.

WORLD BANK BACKGROUND

The World Bank's vision is to end extreme poverty by 2030 and promote shared prosperity by encouraging economic and social development in less-developed nations. In 2021 alone, the World Bank invested over $66 billion in new projects targeted toward developing countries, and since 1945, the World Bank has invested more than $1.24 trillion on various projects. Seven percent of the annual expenditure ($4 billion) is dedicated to transport projects. This includes a range of projects from urban transport to rural roads, to aviation, to institutional reform. Apart from investing in transport projects, funds invested by the World Bank also target education, finance, energy, agriculture, health, and other sectors.

The World Bank also lends money to developed countries. This is due to the technical expertise that the World Bank can provide for challenging projects with major environmental or social issues. New Zealand has been a borrower from the World Bank.

HISTORY OF NEW ZEALAND WORLD BANK BORROWING

Project	Date	Amount (US$ million)	Notable Investments
Development Finance Corporation	1972	$8.0	
Railway Project II	1971	$16.0	Arahanga and Aratika Ferries
Marsden Point Power	1965	$20.5	Marsden point thermal power
Railway Project I	1965	$42.0	Aranui Ferry
Interisland Transmission	1964	$32.5	Benmore to Wellington power transmission
Harbour Project	1963	$7.8	

When a country borrows money from the World Bank, it becomes a World Bank client, and the burden of responsibility lies on the country to implement the project. It is also up to the client to be on the ground and recruit consultants and contractors. The World Bank's role is to help clients and offer guidance on project designs. Often, the World Bank receives custom designs for technical review.

In the context of construction, client countries manage the construction projects. The World Bank often requires international consultants to assist with construction supervision, ensuring the client nations meet the World Bank's technical, environmental, and social standards.

IMPLEMENTATION OF WORLD BANK PROJECTS

The Client implements projects:

- recruits consultants and contractors
- manages construction
- ensures compliance with World Bank's technical, environmental and social standards.

World Bank's role is to assist clients to design and implement projects:

- provide technical guidance
- monitor compliance with technical, environmental, and social standards
- ensure the World Bank's money is spent appropriately.

LESSONS LEARNT

LESSON 1: YOU CAN'T CONTROL LOCAL POLITICS AND CULTURE

When you're dealing with developing countries and to a degree, developed countries, there can be pressure from politicians for results. This can lead to the practical challenges of working to a deadline being ignored.

Project examples

In some countries, officials may make promises that within a given period, say five years, 500 km of expressways will be built. By the end of the five years, the Highway Department will have moved heaven and earth to have that 500km open. Sometimes the expressway will be opened and slope stabilisation is still being completed, or only some of the interchanges will be completed. There is a real imperative to meet that five-year objective, regardless of safety implications.

In one, the President marked the opening of a significant highway by driving a race car down one side. The problem was that this was a cement-concrete road and the last sections had only been finished about five days earlier. This gave the road less than a week to cure instead of the 28 days needed for it to reach compressive strength. The President also insisted that the roads department open the road immediately after his drive. The good news for the contractor was this would make it impossible to enforce any defect liability on them.

The World Bank took responsibility for managing a re-housing project in a Pacific nation following a devastating cyclone. Under that country's Constitution, women cannot own land, and with nearly 50 percent of the beneficiaries in the project being women, there was concern in the World Bank team that the houses would be built for them and the nearest male relative would move in.

In a previous World Bank project 20 years earlier, this problem was addressed using 'occupancy licenses', where a person is given the right to occupy a house for 20 years, the lifetime of the house. On the new project the World Bank discovered some people had been evicted from their houses. After investigating the licenses it was discovered that the occupancy time on a number of licenses had been changed from 20 years to six months. When World Bank standards and policies come head-to-head with cultural norms, cultural norms will ultimately prevail.

In that same project, there was also a problem where the team noticed a disconnect between the rate of money going out and the slow construction process. After analysing the invoices, it became clear that the locals supervising the project were making 'incentive payments' to contractors for work they hadn't completed. That money was subsequently recovered by the World Bank.

Despite World Bank's best efforts, where there is a will there is a way. Locals may still manage to find a loophole to misappropriate money.

LESSON 2: CONSULTANTS – MISSIONARIES, MISFITS, AND MERCENARIES

A typical experience in a developing country is to have a project with international consultants involved, but when you go to the site, you often see that something is wrong.

What is wrong with this picture?

The answer to the question is at the end of this case study.

My experience has shown, when it comes to consultants working in developing countries, there are three types: missionaries, mercenaries, and misfits. Missionaries get the chance to work on unique projects in developing countries that are innovative and can change people's lives. Mercenaries often have a lifestyle they wouldn't have in their home country, with a driver, a large house, nannies, and living near a beach. Misfits might struggle to get a job in their home countries, have a local partner, are known to the local agency, and speak the language. They might have a great CV, but it's still difficult for them to land a good job in their home country.

No design should kill people

It's important to recognise the motivation of the consultants who are working on projects, as this can have a significant impact on project implementation.

Here are examples from a World Bank project where, when reviewing the project, it was found there were little to no safety measures in place.

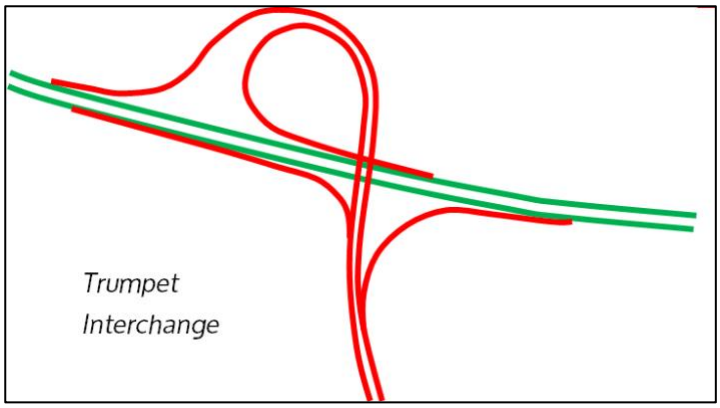
If you're heading to this petrol station, you may change your mind but if you do, there are two separate guard rails in your path. You can impale yourself on the left or the right one. There is also a deep open drainage ditch between them, and if your car flips after hitting the guard rail, this is where you could land.

Where is the roundabout? There is no traffic control and you can have head-on collisions either way you turn.

The following photos identify other safety issues found on the same project



This was a project with international consultants. However, although consultants might be experts at the macro fit, they often fail to cover and review the small details. This is where safety issues creep in that may kill people.



In the same project, when driving down the new expressway, a trumpet interchange was encountered which was built backward. If you drove straight on the trumpet design interchange, you ended up heading in the wrong direction on the expressway. Theoretically and practically, it made no sense.

https://images.app.goo.gl/dz2UUMnHEmxT6zsn6

When the consultants in charge of this project were tracked down, they admitted that the client didn't want them on site so they stayed in the capital about 100 km away and billed the $15,000/month fee. **These mistakes can be fixed, but it can be a frustrating process.**

Having suitable design standards

In many developing (and developed) countries, there is a battle to use suitable design standards. For instance, smaller countries often don't have their own design standards. In these cases, consultants have been known to apply standards they are familiar with, even if they are not relevant to the local conditions, especially in a time of climate change. Other countries may have design standards in place, but they are written into legislation. This makes it very difficult to use appropriate standards if those design standards are not suitable. The World Bank now regularly inserts a clause into legal agreements stating that in addition to local standards, other standards from the EU and North America can apply, giving more flexibility.

It can be hard for consultants to understand that a standard is a minimum level that you should apply, and there is a need to appreciate that standards can be based on conditions that might not apply in every circumstance. A good example of this is using chip seal as a pavement surface treatment. This works well with regular maintenance, but if this cannot be guaranteed, asphaltic concrete is better. Regardless, chip

seal designs were often submitted in countries where there was no planned maintenance, and the roads were being wrecked due to climate change-related factors.

It can also be difficult to get consultants to factor in climate change. In one example, the first designs for a climate-resilient road project used 300mm diameter culverts, even though it was clear that increased hydraulic capacity was needed. The consultant's response was 'you can only buy 300mm culverts so that is what we designed to'. **The culvert size was only increased after their design was rejected, and not surprisingly the industry responded by making larger culverts.**

Avoid over-the-top designs

This picture shows a runway at an airport with horizontal grooves on the runway to provide skid resistance. In one Pacific country the consultant included these in the design—at a cost on the order of $1million—because in New Zealand it was considered good practice to groove runways. However, there was no history of skid resistance issues in that country. To save money, we instead insisted that a target friction performance standard be adopted in the specification, and this left the contractor to decide how to meet it. **The one million dollars saved here could then be used for education, health, or other benefits.**

Power of innovation

In developing countries that don't possess a history of solid engineering recommendations, you need consultants to play an active role and give solutions. Ultimately, it is the missionary consultants on the projects that can add this value.

In one example, a geo-cell or Hyson cell was used to build new pavements. This is a great solution for climate-resilient paving, and it is simple to build. You prepare a base, put in edging, roll and stake the geo-cell and then fill with concrete. This also works well for low-volume roads.

The key is to have consultants that are looking for innovative solutions, and the degree of innovation can make all the difference.

Understanding local context

In the context of a local project, consultants may have the best intentions yet miss out on the big picture. They fail to assess that what might technically be correct isn't a good fit for the local context of the project.

In Tuvalu consultants recommended that the runway be provided with a fence to improve safety. This is a pretty standard solution for airports, except in Tuvalu the country's runway was only being used for four hours a week by aircraft. For the local population the runway is a place where they play sports such as soccer, rugby, and volleyball; some people just hang out in the area and some people even sleep on the runway at night. So, putting up a fence and other infrastructure may seem important to the engineer but could change the country's dynamic and directly impact the local population.

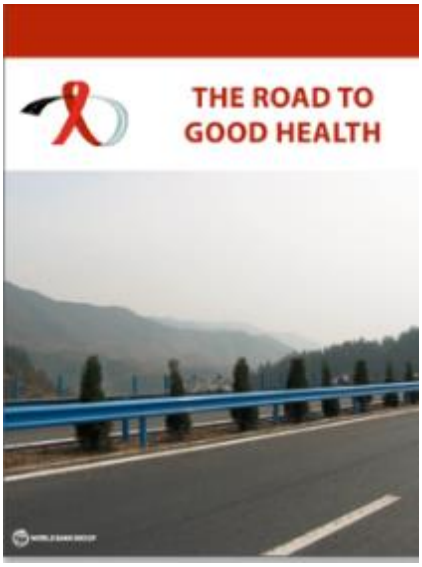
From an engineering perspective, the runway is a place for aircraft to land and take off. But in this case,

The World Bank's perspective is that there needs to be a balance to make the airport safe and secure without compromising the country's social fabric

When it comes to understanding social impact in a region, it's not always what you expect. Yes, the World Bank acts as a development bank, but it doesn't solely grant funds to build attractive and exciting transport projects. **In terms of development, it also takes into account the human element and social and environmental impact.**

LESSON 3: SOCIAL IMPACTS: NOT ALWAYS WHAT YOU EXPECT

STD – Sexually transmitted diseases



The World Bank is a development bank, and when it commits to projects anywhere in the world, it collects data from the area and reviews the risk of diseases and how it can impact the development of a project.

When construction projects bring in workers from places around the world, there is a high risk they will bring STDs with them, which is bound to have a social impact. Whether building projects in Latin America, Asia, or Africa, it has been found that diseases will migrate outwards from the transport corridor over time, whether from truck drivers or workers. Before starting a development project, a direct and thorough social assessment is required

In one of the social assessments carried out as part of a new expressway project found there were over 125 brothels within the 100-kilometre length of the planned expressway: on average, there was a brothel every 100 metres. With ten thousand workers were coming in to build the expressway it was assessed that there was a high risk of HIV/AIDS transmission. Funding was then received from the Global HIV/AIDS programme to educate workers on HIV/AIDS and provide STD counselling and testing. In this case, the team found that 8 percent of the workers had an STD and they received treatment. They then gave out over 100,000 condoms and playing cards with HIV/AIDS messages on them. As a result, in that general area, the number of STD cases was halved due to these programmes. The prostitutes in one area also instituted a 'no condom, no sex' policy. **This work is just as important as building roads.**

Gender-based violence and child abuse

Some parts of the world have had a major problem with gender-based violence. The World Bank conducted a study in 2015 and found that, in the Pacific Islands some 7 out of 10 women were victims of gender-based violence or intimate partner violence.

Transport projects impact on gender based violence in two ways. First, a development project hires local workers and that changes the traditional power dynamics in society. People have more money, and they can often manifest this in a manner that is not healthy for others in the local communities.

Second, when you bring in external people, this can cause issues. In one African initiative, a $265 million transport project was cancelled because the immigrant contractor workers had been engaging in improper behaviour with many underage local girls.

In some countries up to one-third of children are sexually abused. If you reviewed the profile for a paedophile – it would be male, better educated, older, appearing trustworthy and respectable in the community. This sounds like World Bankers, consultants, and construction workers. The World Bank found that on at least two occasions (that they knew of), registered sex offenders from New Zealand or Australia were sent on donor finance projects and then engaged in inappropriate behaviour.

This risk is addressed by putting in processes to sensitise consultants and contractors on who they send to projects, and also implement needed training. In one instance, a contractor implemented gender-based

violence training for workers as part of their health and safety programmes. They started with baseline surveys and found on average 9 out of 10 males and 3 out of 10 women felt it was okay for men to use physical force on their partners. By the end of the project, this changed to only 2 of 10 men so this was a huge improvement.

When working on the runway project mentioned earlier, the social development officer pointed out that half of the men in prison were there because of gender-based violence, and there was no counseling service. A budget of USD$80,000 was then approved to hire counsellors to set up the first gender-based violence counseling service in that nation. **So a great social outcome from a runway project.**

Look for opportunities

Engineers are generally not entrepreneurs and can often miss opportunities to amplify the benefits of projects. An example of this was in a project where over 250,000m^2 of buildings were demolished and 1,480 households and over 5,000 people were resettled. The new brick and concrete houses were designed with two levels, with the bottom level having a wide door, giving flexibility to be used as a commercial space. This led to many of the households opening shops and businesses that increased their financial well-being.

Brick-concrete		Brick-wood		Earth-wood	
before	after	before	after	before	after
26%	97%	16%	3%	59%	0%

One-floor		Two or More Floors	
before	after	before	after
84%	12%	16%	89%

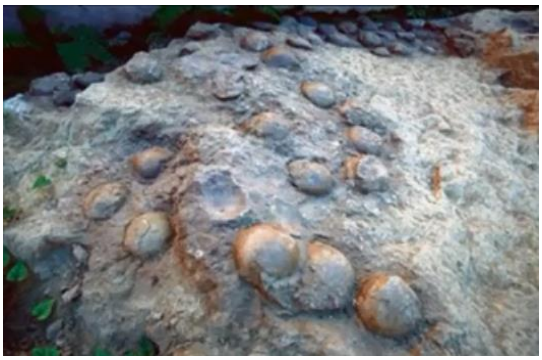
Another example is to use the spoil from tunnels to fill up ravines. The topsoil would be saved, then levelled out on the filled-in ravines to make more farmland to give back to the communities. In one project, 70 percent of the land that was acquired for the project was given back once the expressway project was complete.

LESSON 4: HIDDEN DANGERS AND BURIED TREASURES

Projects must have in place ‘chance find’ procedures in case something of value is found underground. In New Zealand, there is a common understanding that you can’t just dig anywhere, and local iwi participates during excavations of potentially culturally sensitive sites. At the World Bank, an advanced skillset is

needed, from palaeontologists to archaeologists to the military – you must be prepared for anything. You may be surprised by what the World Bank finds on its projects.

Dinosaur eggs



During a field visit preparing a new expressway project in a remote area of China, the World Bank team passed a large building seemingly in the middle of nowhere. The translator told them it was a dinosaur egg museum. The eggs looked like petrified round rocks embedded into underlying strata. Locals had used them for a long time as part of their foundations until at one point someone realised they were petrified dinosaur eggs. Where there are eggs, there may be dinosaur bones so the 'chance find' procedures had to be modified to include this as a possibility.

Bronze age burial site

In an expressway project in the Caucasus, a large bronze age burial site was found which included human remains and even a chariot. The project stopped and the archaeologists arrived with their paintbrushes to carefully excavate the site, resulting in delayed payments.

A side note on this. They also discovered seals from Mesopotamia, and this was the first evidence of contact between these regions from that point in history. What was disconcerting was that all the archaeologists wanted were the bowls, seals, the chariot, etc. The bones were all discarded!

The takeaway lesson is to have a larger delay contingency in countries with long histories. Anyone who has followed the stories of the metros in Rome and Athens will know why.

Photograph of two people found buried together at the Georgian site.

Karst cave ecosystems

Karst areas such as the Tākaka hills have caves. These caves are often self-contained ecosystems with a range of flora and fauna. When constructing an expressway through a karst area in China, the World Bank team arranged for flora and fauna sampling of the caves. The alignment and/or drainage was then modified to ensure that the caves would be protected, and permanent gates were also installed across caves that had never been entered.

After this project, Dr Bennett received a package from France with a technical article. They had found a new genus and species of blind cave beetle in one of the caves and decided to name it after him! Dr Bennett has no children, but his name lives on with this blind Chinese cave beetle.

Blind Chinese cave beetle

'Superbotrechus Bennetti'

Unexploded Ordinance (UXO)

A lot of people are aware that landmines and unexploded ordinances are an issue in places like Cambodia, but parts of the Pacific are worse.

The World Bank was looking at building a terminal at Munda airport in the Solomon Islands which, during World War II, was used by the Japanese to attack the Americans at Honiara. New Zealand Aid had previously resurfaced the runway and found an average of one UXO item per square metre. This, however, was only the UXOs close to the surface. As the World Bank was building a terminal, the larger 500-pound bombs, which didn't detonate but were buried deeper, were then the risk. On 27 September 2022, the NZ Defence Force found 22 of these bombs in Tuvalu (https://www.rnz.co.nz/news/pacific/475578/international-naval-team-finds-22-huge-world-war-ii-bombs-in-tuvalu-lagoon).

There is a lot of risk management with UXO. A British person recruited by the World Bank to help manage the Solomon Islands project stayed on after the project and was sadly killed in an explosion a few years later.

Underground services

Another challenge of transportation projects is with underground services as developing countries may have poor or no records of these. In one project a late-night call was received from the CEO of a construction company saying they were stopping work due to the risk to workers from underground utilities. On this project, there was a provisional sum of $50,000 on a 32 km long road project for installing underground services since the consultants had been told there were none there, but they didn't bother checking in detail. When excavations started, they found unprotected power cables, phone cables, etc. every metre.

This led to a three-way debate between the consultant who didn't see it as a health and safety issue, and the contractor and World Bank who did. In the end, there were major delays and additional costs in the order of $2 million. But at least the workers were protected.

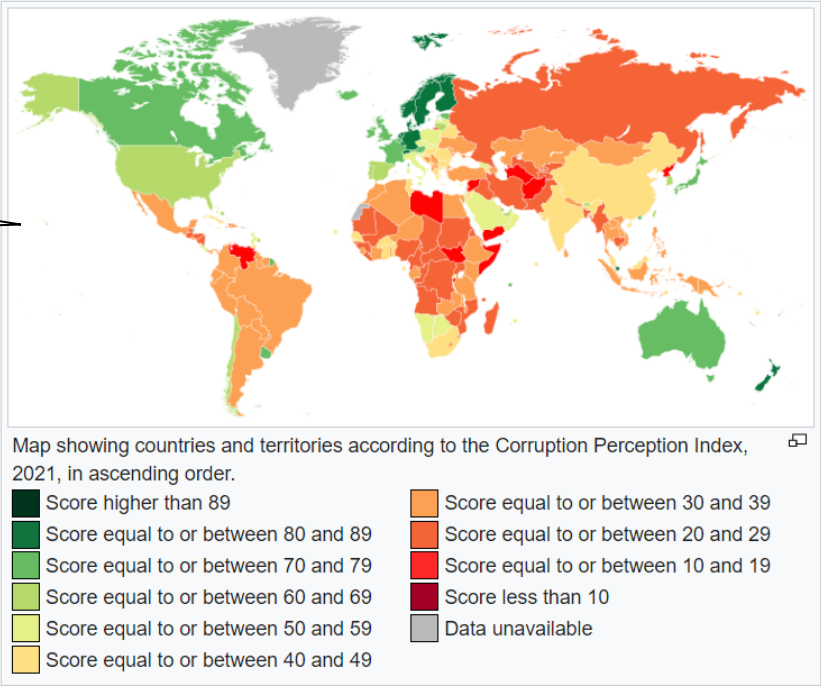
You shouldn't believe everything that you are told, particularly when you are working with a misfit consultant.

SOLUTIONS

Trust no one

All societies have their own cultural practices and many of these may directly or indirectly lead to corruption in projects. As shown below in the Corruption Perceptions Index from Transparency International, outside of some western countries, corruption is endemic in most of the world.

Corruption Perception Index



And yes, there have been New Zealand companies who have engaged in corrupt practices on World Bank-financed projects and been debarred (https://www.worldbank.org/en/projects-operations/procurement/debarred-firms).

As a result, you need to have checks and balances in all aspects of your work, as well as take a cynical view by verifying what you can in the field.

For example, in one project the design called for one-third of the material to spoil, and two-thirds to fill. When looking at the payments, this had been reversed. An unannounced visit was paid to the consultant's laboratory and all the test results confirming rejection were asked for. Even though the laboratory was ISO 9000 certified, they had "disposed" of the records – a tell-tale sign of collusion between the consultant and the contractor. They were then referred to the World Bank's corruption investigation department.

Reject abnormally low bids

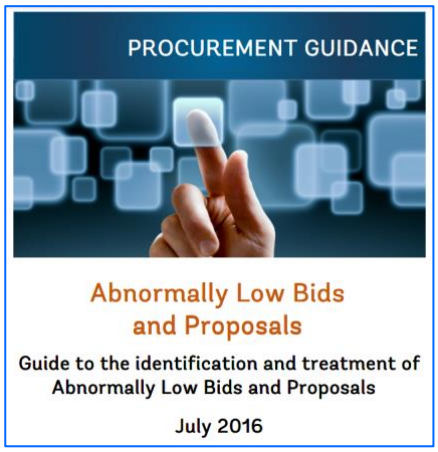
If it sounds too good to be true, it usually is and that especially applies to bids with a low price.

The belief in the integrity of the bidding process and that contractors and consultants would provide rational pricing has been held with almost religious fervor at the World Bank. Even when it was clear to the technical team that there was no way that the work could be done for the price bid, it was virtually impossible to reject the bid.

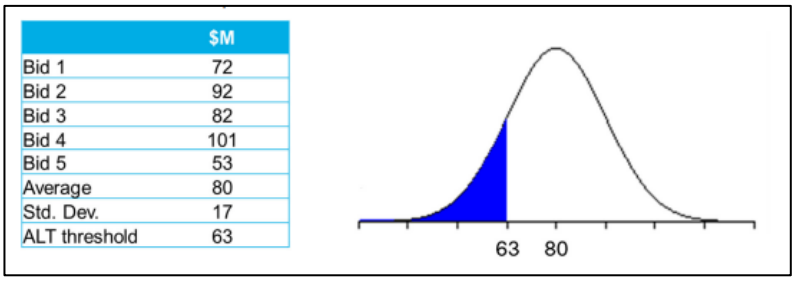
This changed in July 2016 when the World Bank rules were changed so at least there was a process that could be used when receiving abnormally low bids, which is now defined as:

> *"An Abnormally Low Bid/Proposal is one in which the Bid/Proposal price, in combination with other elements of the Bid/Proposal, appears so low that it raises material concerns with the Borrower as to the capability of the Bidder/Proposer to perform the contract for the offered price."*

There is now a mechanism for rejection – although it is not easy to use, at least it is there.



World Bank guidance for Abnormally Low Bids and Proposals



Pay the contractor for what you want them to do

This is perhaps the most singularly important lesson.

There is often friction between the standards of the World Bank, the prevailing standards and practices of the country you are working in, and the contractors whose sole motive is to make a profit.

When trying to impose improved practices, it is not only a matter of training, but of incentivising the contractor to do what you are asking. To this end, it is best to move anything related to social, environmental, and traffic management/health and safety to reimbursables under the contract.

For example, the World Bank has always had trouble getting contractors to put time aside for training workers in health and safety, social issues, etc. But when they stated that contractors could charge an agreed rate for the time that the workers were certified to have attended training—and that this could be charged on rainy days—the compliance went up. The workers were no longer costing them money on rainy days but partaking in revenue-neutral activities.

When the World Bank wanted to improve traffic management standards, the cost was moved to a provisional sum and compliance with the agreed traffic management plan was paid for. This moved the contractor away from doing as little as possible to being paid to implement a proper plan.

In a project in Asia, the contractors didn't want to water the roads as much as was required, so this was moved to a provisional sum with agreed application rates by the consultant. This moved environmental and social compliance from a cost to at least a revenue-neutral activity and made a big difference.

So pay the contractors specifically for what you want them to do and they will be less likely to oppose what you are trying to achieve.

Clear project-specific specifications

Many projects adopt generic specifications but these may run into hundreds of pages that few contractors, and fewer workers, will read or understand – especially if they are not in the local language.

Following on from the specifications, you need to ensure that the contract specifically reflects what you want to achieve. The World Bank tends to use standard contracts on their projects, but often these conditions are generic and may not enable you to have the outcome that you want.

If you can't get the message down to the people on the ground in an effective manner then they won't do things the right way.

Despite all your best efforts, things can still go wrong

Runway after sealing

This is a photo of the runway mentioned in the earlier World Bank project after it was sealed.

The runway, has a water lens below the coral surface which sits on top of a saline layer. The pressure of the water from below coming up through the coral caused the pavement to debond. This wasn't an issue before because of all the cracking. **When I left the Bank, they were still working on a solution.**

The answer to the earlier question 'what is wrong with this picture?'

The tunnel was over 300 m deep at that point of construction. Not only has the contractor not turned on the power to the ventilation system, but the ventilation ducting also ends only a few metres into the tunnel.

WEBINAR QUESTIONS AND ANSWERS

How in a practical sense do you deal with consulting engineers who prefer to work above the minimum standard?

A. I can use the example of a pavement. If you are working in a country where there is no maintenance and the design standard you take your traffic volume and your traffic volume and you say right for 4000 vehicles a day, a chip seal pavement is warranted here. But very few standards reflect the uncertainty of climate change so if you then think about maintenance, say if I do a 35-millimetre asphalt concrete pavement that reduces the risk of negative impacts and lack of maintenance and that makes the pavement more robust. So, although that pavement may be required for say 10,0000 vehicles a day, you can apply it to a lower traffic level if it is economically and technically justified.

How can the consultants justify this additional expense to their clients?

There are two aspects, the technical reason, and the financial reason. Often what happens is the client only sees that this is going to cost them an extra 10 percent, but they won't appreciate that in the medium to long term this reduces your risk for additional costs. This is where the trade-off comes in, it is convincing the client that this is technically justified. The World Bank invented the economic analysis of road projects. We found we could justify that higher standard economically by factoring in the reduction of future risks of maintenance and other issues. This is especially an issue to consider in a time of climate change.

Comment received: Pavement pressure problems abound even here in New Zealand. The best place to see this is the supermarket carpark or a tennis court with no subsoils.

In terms of corruption challenges, what mechanisms do you understand are the most efficient to avoid it in highly corrupt countries?

That's a tough one. Some countries have it built into the remuneration. They are paid a low wage in the expectation they receive baksheesh as part of the job, and it is difficult to try and get around that. So, there is no single answer unfortunately for that. But it is also worthwhile to understand that the impact is different in some countries. A Minister of Science and Technology once told me this story, he said that in one country you can have a $100 million road and, due to corruption, it comes in at $110 million with $10 million coming off the top with various payments. He then said in his own country, for a $100 million road, they build a $60 million road with $40 million coming off as payments. The difference is that the first country gets what it wants but pays a higher price, while the second don't get what they want, and the road fails in two years. What that means is that the impact of corruption is different in those two countries. That was his assessment and I thought it was probably fairly valid. But in terms of a single panacea for corruption, it's an ongoing problem that you have to face, and it's addressing it in the piecemeal way that you can.

Do these types of lessons get captured in World Bank procedures and guidelines going forwards to avoid future problems?

Very much so. During the project we provide 'implementation support' to the clients and document issues. Once construction is over there are still usually at least two more years that you continue monitoring. An independent team then completes an 'Implementation Completion Report' (ICR) where every project has lessons learned. That's why you find a lot of incremental changes over time which improves how you do things. That is a key aspect of every World Bank project.

The ICR, Lessons Learned are then used to refine processes both in the country and sometimes transferable to other countries. For example, the work that we did on gender-based violence in the Pacific was innovative, and that was later used in writing the guidelines for the entire World Bank on how to address gender-based violence on infrastructure projects. In the same way, a small number of us were working on road safety, and we got road safety adopted as a policy for all projects in the World Bank based on experiences in these countries.

Are those lessons learned reports available for anybody to download?

Yes. The way it works is that usually in the World Bank there is a policy that everything must be made public unless there are reasons it can't be. I think these are it is deliberative, legal and a third reason I always forget. So, at the World Bank website, you can pull up any project and you can download that documentation and implementation completion report and it's all on the website. It's not just the World Bank – the Asian Development Bank, and African Development Bank all have the same policies, because we are all owned by the governments of the world and so the people of the world own us as well.

How is the World Bank considering climate change, not on the projects, but of the projects?

Two aspects: firstly the World Bank has a policy where one-third of the World Bank's money must be spent on climate change adaptation or mitigation.

What that means is that we have whole programmes of adaptation where we are trying to, for example, replace fossil fuel buses with electric buses, so that is trying to address that impact. Every project must report climate change co-benefits and specifically address that the project does not contribute towards climate change but makes it better.

And secondly, for mitigation measures, we are trying to look at ways to reduce the impact of climate change.

What is quite amazing is that back when the US Government was full of climate sceptics, the president of the World Bank was appointed by the Americans and they supported this 30 percent plus the requirement of World Bank funding for climate change co-benefits, so it's embedded in projects in all ways possible.

How did the maintenance and operation get allowed for or funded on the projects that you worked on?

Two ways. The World Bank had a policy that it would not fund the ongoing cost of operations so we tended to say we would go in for a short project period and make capital investments. The local people would finance the maintenance afterward. That didn't always work so one way that we addressed it was by pushing out the project periods to include a longer project life to cover the maintenance as well. It depends upon local capacity quite a lot. The second thing which we have done in a small way is that most projects have a 12-month defect liability period as we well know. We push it out to 24 months.

When I worked in India any contractor could build a road to last one monsoon season, but if it could last two monsoon seasons, then it could last five. So, by pushing out to two years, you are getting a better quality of output coming through as well.

We can also finance long-term maintenance, so the World Bank has done quite a few performance-based contracting projects, we have five or even ten years maintenance programmes that we are financing using performance-based contracts. This is quite new, twenty years ago we weren't doing that.

You showed the majority of spending went on social projection, what does this look like recently, especially with the pandemic and supply shortages?

I retired a year ago, so I don't have the most recent information, but I do know that the World Bank is part of the donor programme to support countries with Covid-19. The big problem you are facing is that the pandemic set back development by ten years in many countries due to the impact on societies, so we are all part of the international community to try and address that, but it won't be a big part of what we are doing.