

Engineering Innovation and the Creation of Lasting Value

Innovation is fundamental to the sustainability of our New Zealand society.

By innovation I mean the development of new or improved products and services, and better ways of doing things.

Our leaders must strive for innovation or the enterprises they lead will surely wither and die.

If you doubt this assertion think of how corporate New Zealand has changed in the last ten years.

Or the fact that today, America gets more than half of its economic growth from industries that barely existed a decade ago.

For me, this is crude reality. All Beca's major competitors are no longer New Zealand owned. Our long term sustainability is the single most important issue we all face and innovation is the key to sustainability.

That is why I have chosen tonight to talk about engineering innovation and to seek to describe how innovation has pushed boundaries and created lasting value, and increased employment opportunities for many.

I propose to look at three of the achievements of our early engineers and the value their projects added, in one case to the extent of major societal improvement. I will discuss projects with which I have been closely associated, and draw conclusions on the framework within which I believe we should work, if the encouragement of innovation is our goal.

This is an ambitious task and one of which I think Professor Harry Hopkins would have approved.

It is an important task. This is because, for reasons I will present tonight, each of you have a part to play in encouraging innovation.

Why do I think Professor Hopkins would have approved? He was my professor when I studied here and he was quite a close business associate of my father, so I knew him a little. I have restudied recently his book "A Span of Bridges" - a scholarly and fascinating study of engineers' achievements. And I am aware of the care with which he recruited and retained the best as he built up the School of Engineering at Canterbury University. His attention to succession planning is, I believe, the foundation on which New Zealand's civil and structural engineering has achieved such a high international reputation.

I refer, of course, to his protégées Professors Park and Paulay and, a little later, Nigel Priestley, and many other fine educators and researchers.

Professor Hopkins' book demonstrates his fascination with engineering innovation and his understanding of the risks involved as we seek to push beyond the boundaries of the comfort of past experience.

Many professions are taught to be creative thinkers. But only professional engineers are trained to apply their learning to the creation of projects, to innovate and to manage risk. This is why I believe that no other profession has as much capacity to add value to our society as engineering.

I am pleased to find support for this view from Michael Hammer, co-author of "Re-engineering the Corporation". He was a Professor of Computer Science at MIT, and believes the best qualification for innovation is a basic training in engineering. Crucially he says, engineers are taught that design matters; that most things are part of a system in which everything interacts; that their job is to worry about trade offs; and they must continually be measuring the robustness of the systems they set up.

The Economist states ¹ "It may be no coincidence that the greatest corporate leaders in America, Europe and Japan, past and present, trained first as engineers".

Good leadership is a prerequisite for innovation to flourish.

So much has been written on innovation. My interest is engineering innovation – a narrower field.

What is engineering innovation?

What is the environment in which it flourishes?

What value can it add?

What might you do to encourage innovation in your own companies and institutions?

I will seek to answer these questions by discussing examples from my own career as a civil engineer.

But first I want to look back at New Zealand's early engineering innovations.

Earlier this year I went on a four wheel drive back country trek of Canterbury and Otago. This was an unforgettable experience but, in particular, I found the early gold mining infrastructure to be of great interest. The ingenuity with which the early hydraulics engineers led water by canals to provide high pressure water to sluice alluvial gold was very impressive.

This first photograph (**Slide 1**) shows the water wheel that was used to develop the energy needed to "stamp" the gold ore. But what is so impressive is that this wheel was driven by water led some 30 kilometres from an alpine spring.

It is still running water, and in substantial quantities, but now for irrigation, not for gold sluicing.

¹ Business Innovation, Special Report, April 24,2004 The Economist

Regrettably the promoters did not enrich themselves but this is often the way for innovators. However, they created lasting value.

My next example is in a different branch of engineering – but I cannot talk about engineering innovation without mentioning it as it was surely the most important contribution made by our early engineers. This was, of course, refrigeration engineering.

In February 1882 the sailing vessel, Dunedin, pictured here (**Slide 2**) carried 4909 frozen mutton and lamb carcasses from the Totara Estate just south of Oamaru to London. This was a technological breakthrough that led to major social and economic improvement. It made smaller farms viable leading to the break up of large estates, creating opportunities for many young people; the construction of large scale industrial plants; it revived the ports in smaller centres; and led to the development of the dairy industry.

As Michael King writes ² “It is difficult to see how New Zealand could have survived as a viable country ,(for).... the coincidence of refrigeration technology would soon deliver to New Zealanders one of the highest living standards in the world.”

But this venture carried enormous risk. The difficulties encountered and dealt with by the Captain, John Watson, and his engineer, William Soltau Davidson, were many. Not the least of their problems was the common event when they sailed into a new harbour – and they visited many – that the locals mistook their boiler’s smoke which was, of course, providing the energy for the refrigeration, as a fire in their sailing ship, which they used their best endeavours to extinguish.

Just think of the pantomime that must have occurred in each South American port as the crew tried to convince Spanish or Portuguese speaking firemen that their vessel was not at risk

This trip took 98 days, only one carcass was rejected and the price they obtained was twice that prevailing in New Zealand.

And then in the power sector, the hydro dams in the Waitaki (**Slide 3**) of which the Benmore concrete penstocks stand out.

For this was a world first.

The traditional solution was thick steel plate which would have had to be imported.

Whereas precast concrete made use of local skills and resources. It was a remarkable innovation. Not only had it never been done before, it also relied on what was then quite a new technology – prestressed concrete.

My father, Sandy Cormack, played a major role in the introduction of prestressed concrete to New Zealand in the 1950s. He was General Manager of Certified Concrete and established Stresscrete as a subsidiary to manufacture prestressed concrete power poles and bridge beams.

² The Penguin History of New Zealand: Penguin Books (NZ) Ltd 2003

As a young student I worked in Stresscrete's factories and witnessed quite a few tests to destruction of what was a new and exciting material. This was the foundation of my life long interest in prestressed concrete.

I remember visiting the Benmore construction site on a study tour of the final year students from Canterbury in 1962.

It was three years later when I was working in Paris that I learned more about the Benmore Penstocks.

I was in France on a scholarship to study prestressed concrete in the design office created by the great innovator Eugene Freyssinet, often described as the founder of prestressed concrete.

It was here that I met his protégé Yves Guyon. M. Guyon had played a significant part in the development of the concept of the Benmore prestressed concrete penstocks and I studied the calculations he had written himself and his sketches of possible construction details. But the tribute for this engineering innovation³ should go to the Chief Engineer, Power, whose responsibility it was in 1961 to approve the penstock alternative selected at Benmore.

It is interesting that such an innovation gained acceptance for we must remember that forty years ago New Zealand was effectively state controlled. All significant decisions were made by the government. Even the engines that the state owned international airline would put into their planes were decided by the Prime Minister.

For most major projects, their expenditure, design, construction and maintenance were controlled by government employed engineers. They set standards, did most of the design, the professional training, and had little, if any, accountability to the public. This was a mixed blessing. There were some inspiring leaders. There was little personal or corporate accountability. Accountability for professional error was rare. As the state controlled all, paid all, it also carried all risks. Contracts were administered autocratically. Outputs were mixed. There were some outstanding achievements and some cases of deplorably conservative and costly design and decision making.

That a project like the Benmore penstocks could be adopted means that there were real leaders who understood the value that innovation could produce and the need for the management of the concomitant risks.

Risk and innovation are, of course, intertwined. Why of course? Because innovation is doing something new. There is less risk doing or managing things we have done many times before.

I do not accept that a totally risk averse culture, one of "no surprises", leads to sound institutions or sound governance. I believe the contrary. For where there is life there is risk.

³ David Braithwaite: "Construction of Prestressed Concrete Penstocks at Benmore",
NZCS Conference, 16 to 18 September 2004

Perhaps the converse is also true? Where there is no risk there is no life? Or no innovation? What is essential, is to manage risk and take the gain from successful innovation. But there must be a special climate for innovation to flourish. I will come back later to what I believe this should be.

It is important to note that in recent times we have seen a change in how projects are delivered. Perhaps the pendulum has swung too far back? Previously the government was often the client, their advisors were generally experienced engineers, and well informed on good practice.

Now the number of experienced engineers working for central and local government and for many major clients has greatly reduced and perhaps this is why we are seeing a change in risk transfer. Many clients are seeking a no risk position and are seeking unlimited liability from their advisors and contractors.

There is much that could be said about this unfortunate and costly trend. Certainly, it discourages innovation because it is so constraining. For it rejects one of the main drivers of the capitalist system, which is the concept of limited liability. The capitalist system has been of enormous benefit in raising the living standards of the developed world. Innovation thrives when there is clear allocation of risk to those who are best placed to manage that risk and to those who may benefit. Two bad, but not uncommon, examples of environments that stifle innovation are:-

- Firstly seeking to make the designer responsible for the project being fit for its purpose. This means that the owner has no comprehension of his duty to participate in preparing a brief which clearly sets out performance requirements, and has no participation in decision making as the design proceeds. I have met client representatives who refuse to approve any matter, even the brief, let alone the conceptual and subsequent design stages. It is impossible to work with such people. They inevitably produce poor and costly solutions. I urge you not work with them.
- Secondly seeking to use insurance, normally the designers' professional indemnity insurance, to be their backstop in the event of their inability to fairly and knowledgeably allocate risk. Such a business philosophy is not sustainable.

My point for delving into this vexed area is that innovation will only flourish where the working environment encourages respect for each party's role and total clarity of responsibility and communication.

So I have described two ends of the pendulum's swing. One when the client takes all the risk and one when the client seeks to take little risk. Innovation is, I suggest, encouraged best at mid point of this pendulum's swing.

This concept was put into stark relief for me when I was in Viet Nam in 1996 on a trade mission. I had a lengthy interview with the head of one of the Government Engineering Design agencies. He was clearly well educated and clever. He had a Doctorate in Civil Engineering from a Warsaw university.

He had an interest in long span concrete bridge design and he was interrogating me on my experience. I explained to him the necessity of clarity of responsibility and the clear allocation of risk to all the parties involved.

He also asked me about multilateral bank agency work and the conditions they impose on the contracts they fund. As we spoke it became clear to me that he did not comprehend the complex series of instruments we have developed to manage risk - like performance bonds, insurance, liquidated damages, guarantees - as for him the State, his totalitarian State, carried all risks from all sources. This was a chasm between his professional environment and mine. So I asked whether he would support a training mission from New Zealand by a lawyer and a civil engineer to conduct training sessions for his staff, not for him of course, on these concepts of risk management. He was delighted with this suggestion which, with the help of MFAT, we duly supplied. It was indeed a revelation to me of the different attitudes to risk that occur because of the difference in the governance system.

I now ask your indulgence as I amplify this theme of engineering innovation pushing the boundaries allied with risk management by reference to projects with which I have been closely involved. Each of them created significant value for their owner.

My first project is the Aluminium Smelter at Bluff

The potline buildings for aluminium smelters give a wonderful opportunity for innovation because of repetition. The first stage (**Slide 4**) was two 600 metre long buildings comprised of nearly identical frames. Traditionally such buildings were steel structures. When Beca was commissioned in 1969 for the structural engineering for this project, George Beca and the retired Chief Engineer of the Ministry of Works, C W O Turner, argued long and hard with Comalco's engineers, Kaiser Engineering, that they should be precast concrete. This was because in New Zealand concrete was cheaper, its construction programme was more certain and its electromagnetic properties would give better operational performance than steel. Their arguments were eventually effective and Stresscrete in Invercargill manufactured this innovative precast concrete structure. I remember during an early site visit, Ray Nieuwenhuys, the Stresscrete local manager, said to me that there was so much steel in the corbels of the precast columns that he could not physically assemble them. The corbels are that part of each column which support the beams for the heavy fast moving cranes that service the working area and are visible in the lower of these three images.

Ray said the drawings were not in error, there was a place for all the steel, he just could not fit together the jigsaw of pieces. Corbel design was not well codified in those days and there had been a number of well publicised problems with corbels. The problem here was that the draftsman for the columns sat just outside the door to our coffee room. So at least two times a day George Beca would walk past this desk and say to the draftsman, Brian Watkins, "make sure

that corbel has plenty of steel.” Regrettably Brian could not finish the drawing fast enough and so the steel was increased at least twice a day for several weeks. However, we reviewed the design and found a simple solution which permitted rapid construction to proceed.

In 1970 Beca was commissioned for the design of a series of suspended motorway structures of geometric complexity, at Shell Gully in Wellington. **(Slide 5)** We studied many alternatives but it was clear to me at the outset that a form of in situ construction initially developed in Germany, based on the repetitive use of simple formwork, would be the easiest and cheapest to build. And so it proved. The per square metre cost of this bridge was a step change advance on the experience of that time. This cast in situ repetitive formwork/falsework system was unmatched for spans around the 35 metre range.

It was in this project that John Hollings, who was our director in charge, introduced me to the concept of “Capacity Design”. He did not describe it as such and, in fact, I did not meet the “Capacity Design” label until a few years later. To John the requirement was that we needed to study in detail how the structure might behave in earthquakes and then provide such detailing that the structure had the “capacity” to behave satisfactorily with repair if needed being pre-planned.

This philosophy, so simple to state, had a major influence on the bridge concept.

An example of his thinking was what we referred to as the “Hollings Hinge”. This was to provide an inner spirally reinforced core to those concrete columns that could be required to withstand inelastic deformations, a core that could carry the dead load of the bridge so that, if ever necessary, the outer concrete and its steel could be hacked out with safety and repaired. Another was the use of “drop out” panels in the bridge deck that permitted the structure to displace large amounts with carefully minimised damage that is easily repaired.

In the seventies I had the pleasure of leading the design of quite a few bridges in New Zealand, Indonesia, and Malaysia. In the following I have selected those that best illustrate transportation projects that added value.

The first three are rail bridges **(Slide 6)**

The Mangaweka rail deviation replaced a tortuous route along narrow benches, some 100 metres above the Rangitikei River. Steep gradients, tight curves and narrow tunnels made the old route a difficult and costly piece of line to operate and maintain in this geologically unstable and seismically active region.

The new deviation was nearly horizontal with gentle curvature but it necessitated the crossing of three major river valleys.

Value would only be added if the bridges could be built cheaply.

The first of the three bridges was the 315 metre long South Rangitikei Bridge which crossed a 76 metre deep valley.

This bridge, was, I believe, a world first for base isolated structures. It sat on rubber bearings which permits the piers to rock as they are accelerated laterally by earthquake action. As each pier "lifts off" this triggers energy dissipation by specially designed torsion bars which had been extensively analysed and tested by the Department of Scientific and Industrial Research.

This base isolation permits the bridge to remain elastic in very high levels of earthquake shaking. Which permits very slender piers to be selected as the base isolation limits the amount of compression they would be required to carry and thereby reduces the likelihood of buckling failure.

The North Rangitikei and South Kawhatau Bridge (Slide 7) are very similar in profile being 182 m in length with a central span of 110 m crossing 70 m deep ravines.

It was during excavation of the north bank of the Kawhatau Bridge that we found unexpected major fractures in the near vertical soft rock cliff. This called for additional works in the form of excavation of the banks, and ground drainage to improve stability. In addition tie backs and counterweights were provided to assist performance after a very large earthquake.

This unexpected ground problem occurred at only one bank and was perhaps caused by joints being widened by the shock waves of an explosive event in the Taupo region in the distant past.

Slide 8 illustrates the 110 metre central span and the high live loads it carries.

These were unusual structures but what is remarkable was their low cost of construction. The tendered price for each averaged \$1.5 million. In present day costs, the tendered cost of these three major bridges totalled \$13 million. This was remarkably cheap and more than justified the benefits this new deviation would bring.

In fact the final cost was higher because of the foundation conditions referred to above and because a piece of innovation by the contractor of the South Rangitikei Bridge did not come off. He had converted a steel truss used for an earlier precast bridge to be the falsework of the cast in situ bridge. It failed during a concreting operation. This led to lengthy delays and increased costs.

Shortly after these bridges were constructed the National Airways Corporation, later to become Air New Zealand, commissioned Beca for the design of this hangar, (**Slide 9**) which was to house three Boeing aircraft. We did designs in steel and concrete and I prepared the prestressed concrete alternative. I remember Nigel Priestley describing the hangar as "a bridge masquerading as a building" which indeed it was as this was an adaptation of the Kawhatau Bridge I showed earlier. A significant advantage of this concept was fire resistance. The cost of the three aircraft the hangar was to house was very much greater than the cost of the hangar. In fire conditions, notwithstanding deluge fire protection systems, the risk of fire failing the door beam and dropping the roof on to the three planes was judged real. Hence concrete, which was of similar cost to steel, although somewhat more difficult to erect because of the need to counterweight it during construction so the prestressing cables could be tensioned, was preferred as providing better management of risk because of its better fire resistance than steel.

The Eden Park Boxes (Slide 10) were a labour of love for me.

A run down Eden Park in Auckland was desperately in need of funds and received no support from central or local government.

We developed this concept which had to be constructed cantilevering over the top of the existing stand with no access from the field side so that cricket and rugby fixtures were not interrupted. It is effectively a stayed girder cantilever of just under 20 metres, using a mixture of precast and in situ concrete all prestressed together.

Its promotion coincided with the share market crash of October 1987.

The Trust Board gave their approval in these trying times as we could show a positive rate of return from year one with all funding by borrowing when interest rates were 21% p.a.

This project was the start of many at Eden Park and it has been a marvellous source of revenue to help finance much needed improvements for patrons and players.

The key design element was that of deflection of the cantilever beams supporting the boxes. Our calculations showed that the natural period of vibration coincided with the beat that would be produced by some rock concerts. The likelihood of several hundred patrons jumping up and down and exciting resonance was unacceptably high. Our analysis showed, however, that very large deflections, even as much as a metre, could be sustained without damage. So we judged that in the event of resonance causing large deflections, those causing these forcing mechanisms would quickly stop. No deflection problems have been encountered in service.

And then to the Oira Gorge Bridge (Slide 11)

I would argue that this is the most difficult bridge site ever encountered. Why? It is, of course, located in an alpine National Park, in a place of stunning natural beauty, sensitive ecology and strong cultural values. In addition, however

- it is in an area of high seismicity;
- it had to be founded in avalanche debris ranging in size from sand to large slabs, tens of metres in dimension;
- the debris valley has rapidly flowing underground water and in places artesian water. This means all foundations needed to be constructed in the dry;
- the rock debris is very strong, abrasive greywacke sandstone. Its unconfined compressive strength was measured up to 250 MPa. So it is very difficult to drill through;
- this is an avalanche area. Large boulders more than 10 metres in size have fallen from the 700 metre high slope above the valley floor, and more can be expected. Indeed, a 3 metre boulder was released by earthquake action and came to rest on our access track during the site investigation stage;

- it is a site of climatic extremes;
- the bridge requires curvature and is unusually steep.

We engaged Professor Christian Menn of Switzerland as our peer reviewer. This was because our research had shown it is only the Swiss who had built bridges in conditions like these. Most countries would simply, and expensively, tunnel under the site. I remember well Professor Menn's comments when he visited the site. He was in his 80s and came out on his honeymoon. He said, "It is not what I expected. These mountains are too young. We must find bed rock to found on." We tried, but couldn't. The avalanche debris was too deep.

This is our longest concrete span, at 135 metres. The bridge's total length is 440 metres. It is of course the essential vehicular link with the West Coast and it is particularly pleasing to see that the "Coast" is now recording growth well above the New Zealand average and with employment at high levels. I would like to think that this improvement in the infrastructure has contributed to the well-being of "Coasters". However, traffic numbers have not increased sufficiently to justify this conclusion. Certainly the zig zag crossing that it replaced was slow, dangerous and not sustainable.

Sky City and the Sky Tower (Slide 12) are perhaps the most demanding of the building projects with which I have been involved because of the very short time for design and construction and the concentration of buildings into a limited site.

Although the tower's inclusion into this hotel and casino development was a requirement of the Licensing Authority, it has, in fact, given good returns to its owner. It has effectively four revenue streams. The visitors, the concessions (restaurants, shops, action events), communications (not only the space on the mast but also the tenancy areas for communications equipment), and of course the naming rights.

There were many interesting engineering challenges but the mast best illustrates a point I would like to make about responsibility.

Our studies showed that wind induced stress reversals of this slender steel structure presented a particularly severe fatigue case. To dimension this for you, the deflection calculated at the top of the mast under the design wind speed of 60 m/sec was over three metres. Accordingly, we introduced tuned mass dampers (essentially viscous fluid sloshing through baffled annular rings within the mast) to reduce the amplitude of displacement and therefore the quantum of stress reversal. And, of course, we paid careful attention to steel selection, welding techniques, and the avoidance of stress raising details.

A lot of thought was given to how the mast would be erected. For most of the structures civil engineers encounter, it suffices to design the structure assuming instantaneous construction. That is to say, they are designed for the service loads and separate checks need to be made to confirm the structure is not damaged by the method of erection.

For the Sky Tower mast, however, there was the problem that the method of erection, which was the contractor's responsibility, could cause levels of stress that would reduce the number of stress reversals it would be able to resist in the future.

So in this case the division of responsibility between the designer and constructor was not clear. This necessitated extensive study and discussion with a successful conclusion. In essence, the problem was that the contractor wanted to use a tower crane to assemble the mast and to use the partially complete mast to provide lateral support to the crane. This is illustrated here.

Depending on the weather, the crane could impose high loads on the mast. The mast is 90 metres tall varying in diameter from 4.0 metres to 0.5 metres. Successful completion of this demanding task is a tribute to the contractor, Fletcher, who completed the mast erection very quickly in a carefully selected weather "window".

I would now like to move on to two quite different projects, each of which demonstrate what I believe to be world first innovation, and which gave substantial gains to the owner.

The first is "**Mudcrete**" a concept developed largely by Stephen Priestley of Beca and used on many projects in the Auckland Harbour (**Slide 13**). This is a very simple concept of mixing cement with marine muds to create a "soft rock" suitable for use as a construction material.

We have done much testing of this material since 1992 and have now optimised how it should be used. It has been used to convert contaminated silts into construction filling - as shown on the right hand slide - at a lower price than disposing them to landfills or to sea. It has been used to form wave barriers at beaches that give every appearance of natural rock as shown on the bottom slide, and has permitted staged construction of major reclamations at low cost without the need to construct special bunds for wave protection. Given the right mix design it is simple to place in any weather condition, even under water, and is an excellent way of locking up contaminants.

These pictures illustrate some of the uses to which it has been put. This innovation was developed by the urging of a client to find cheaper ways of constructing marine works - a client who was prepared to experiment to see if major gains were possible. Our client contact who pushed for this innovation was not an engineer - he was an accountant which somewhat goes against my earlier comments. However, on the other hand, his chief executive is a professional engineer.

The management of the risk involved is of course fundamental. In this case it was done by starting with small projects, building skills and understanding. The regulatory environmental groups are particularly supportive of this concept - it is clean, "natural" and cheap.

When we first raised this idea we told our client that, although the savings were large, if they approved the idea they were carrying the risk as they were gaining the benefit. Naturally they asked "what is the risk?". We said, after much soul searching, we estimated a 95% chance of success. Does this sound better than a 1 in 20 chance of failure? In any event, mudcrete has proved to be an excellent material.

My other project is the **Repair of the runway at Auckland International Airport (Slide 14)**.

The solution adopted was to upgrade the adjacent taxiway into an alternative runway and then to use the taxiway as the runway while the main runway was replaced. This was a mammoth task of risk management as this necessitated take off and landing 200 metres closer to the terminal and hardstanding areas than permitted in normal operations by regulatory process. The work was completed successfully and the Chief Executive, John Goulter, reported when he deservedly was named New Zealand Businessman of the Year and announced his retirement, that his legacy was the preservation of their main asset – their runway. And separately he told me that concurrently we had solved their greatest single risk which was they had only one runway. Now in the case of an accident that blocked the main runway, the taxiway could be used in these emergency conditions.

The financial savings for the company were of course enormous as the alternative would have been the construction of a second runway many years in advance of its operational need.

The projects I have briefly described tonight have added significant value to their owners or to the communities they serve.

What sort of environment encourages such innovation?

Perhaps it is easiest to describe attitudes and actions that discourage innovation.

Frequently we see clients seeking legal advice on their contracts without giving their lawyers adequate briefing. The result is that in the absence of briefing to the contrary, the legal advice revolves around transferring as much risk as they can think of, on to the party they are contracting with.

This ends up in lengthy, costly negotiations which add no value. So often we hear “Why won’t you sign these conditions, everyone else does!” or “Yes, I know that provision is very onerous but we would never use it!” The obvious reply to the latter is “then why do you want it?” The former is, however, insidious. It means that some are either unaware of their liabilities or have been bullied into submission.

They have entered contracts that may ruin them.

Dissatisfaction with contracts of this sort and their stifling nature is one of the reasons that has led to new forms such as alliancing. In a well negotiated alliance or public private partnership, the risks can be made clear, the pain or gain share is agreed in advance, and a remarkable environment can be created in which innovation and free thinking flourish. Contracts which fairly allocate risk, and reward success, not only add value, they can be a joy to participate in. They can also, however, be unsettling for those who come from a regulatory role and are unused to the creative processes.

The prime purpose of such alliances should not be to raise off balance sheet capital, but to make sure the capital is wisely used. It should come as no surprise but when all parties have their own "skin in the game" the efficiency of the outcomes, the creation of value, can be astonishing.

Central government has an important part to play in the creation of the right environment.

Innovation flourishes where there is respect for success, where there is freedom of choice, certainty of contract, clear property rights, and a payment system that rewards achievement.

The more intensive the controls, or the reporting systems, or the blame mentality when there is a surprise, the more innovation will be stifled. The culture wanted when there is a problem is to seek the best next step. Not to seek to allocate blame.

New Zealand has unfortunately an ever increasing network of regulation and a developing culture that when it is clear a regulation is not working it must be because the regulations did not go far enough. We are presently living through destruction of value caused by the complexity of laws.

Beca has been working in Singapore for 30 years. We could do so much more if New Zealand had their policy settings.

The most positive comment I can make on our New Zealand policies is that others are even worse.

My purpose tonight is not to criticise New Zealand's policy settings, but rather to provoke your ideas on how you, in your own institutions, or in your own businesses might encourage innovation and the consequent creation of value.

I have recounted to you some of my engineering experiences, some innovations which added value. And described, very briefly and inadequately, the experiences of some others. You will have your own experiences.

How do we encourage innovation?

That we must do so is certain because the rewards can be enormous.

I gave two examples of innovation at The Ports of Auckland Ltd and Auckland International Airport Ltd. It is no coincidence that both have created enormous value for their shareholders, and even more important, their improved efficiency has added to the creative endeavours of many others and to the well-being of New Zealand. AIAL has built a market capitalisation close to \$2.5 billion. POAL created close to \$1 billion of assets for its 80% shareholder in the first 16 years of its life. Their performance in value creation is outstanding.

But we must never forget that value can be destroyed even faster than it can be created.

Close to home for me is the environment at Beca. I have had the privilege of working with some outstanding engineers. It is the environment created by George Beca and then followed on and reinforced by Ron Carter that has led to many opportunities for innovation and advancement. Their encouragement of teamwork and technical excellence, their total commitment to clarifying risk, and to managing that risk, is a legacy that we seek to continue.

I believe the role of the Universities in encouraging innovation is clear. Professor Hopkins recruited fine staff and led a proud research based civil engineering school at Canterbury. It is now though of concern that the policy settings for New Zealand's education are unduly restrictive and over-regulated. Increased government control will not encourage better research and teaching. And excellence in both will encourage innovation.

But what is the workplace environment that encourages innovation?

I believe it is the encouragement of many separate incremental improvements in our attitudes, systems, and policies. It is not one big bang like a greatly enhanced R&D budget.

Innovation must become part of normal activity. It may take the form of improvement in processes as well as products and in design; to better, faster, cheaper, more reliable ways of doing things.

What we must avoid is:-

- a culture of blame;
- unnecessary regulations;
- gatekeeping, whereby the brightest are held back;
- the "Not Invented Here" syndrome where good ideas by outsiders are discounted;
- processes and measurements that stifle instead of encourage.

We need to become "learning" organisations whereby we invest in personal upskilling and career development for our people at the same time as we work to improve our businesses. We must continually seek renewal. The four attitudes we must encourage are :-

- Openness so that ideas are scrutinised systematically while they are in the formative stages. This applies to design solutions, procurement policies and business strategies. We must develop the culture of opening our ideas to critical study. This requires an organisational structure and leadership that not only promotes openness but also gives vision and clarity of direction that is continually challenged, verified or redefined.

- Secondly, respect for other's views, especially when they are dissenting. We must encourage the involvement of our brightest and especially younger staff in the development of our ideas as they will help us to not only improve our ideas but will also help us to implement them. Remember also that many ideas for innovation will come from customers or clients.
- Thirdly, good teamwork. Most of us work better in teams. We must encourage collaboration by the quality of our leadership and by the unstinting recognition we give to those who add value. Teamwork is fun. Innovation flourishes amongst groups who enjoy their own company.

and

- Fourthly, seeking technical excellence in all that we do. The thirst to improve and create new things must be the prime focus of our leaders.

I said at the outset that if our leaders do not strive for innovation their enterprises will surely wither and die.

And that innovation is the key to sustainability, but by definition it is new and so carries increased risk.

It is my personal belief that the management of risk needs to be done at two levels.

Firstly, by supporting the attitudes I have described tonight by good procedures and communications.

And secondly at a personal level – by personal commitment. A commitment to ask the right questions at frequent intervals, and insist on a sound answer.

All Beca seniors have made this commitment.

I want my personal legacy to Beca to be a deeply embedded culture of the attitudes and philosophies I have outlined tonight.

I repeat again: Innovation is at the core of our sustainability. It is innovation that brings renewal.

How do my ideas relate to you? To your institution or business?

How will you pick up this challenge?

Gavin Cormack