Materials and Construction

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I learned about materials and construction from three characters I met during my career:

- Steady Eddy the Irish Ganger in Scotland
- Peter The Meter in Dubai.
- Lancelot Ho from Camelot (HK)

Steady Eddy: The Irish Ganger

When I started working in construction I was 16. I worked on a building site for Comben Homes, Scotland. It was 1972. Eddie the Irish (ganger) taught me how to make concrete. It was as easy as half a bag of cement, 10 shovels of sand and 15-20 shovels of gravel. Whack it in the mixer, stick in some water until its not too wet and still pourable then empty it into a wheelbarrow and place it. Next day it’s hard: magic stuff really.

I also remember standing in the foundations of a school when the ready mix truck came in. This really was flowable concrete. So much so it filled up my boots: I had to climb out the trench without my footwear and suffer serious verbal abuse from the concrete gang.

We tried to add water to ready mix concrete all the time but Eddy shouted at us. Often or not we tried to chuck all the rubbish and rubble into the foundations as well. Who cared – Eddie did, not us. I got paid about HK$260 a week and thought I was the richest kid on the block. Suffice to say I got sacked for “leaning on my shovel” after 8 hours digging foundations. This was despite the fact we had a JCB digger on site (management was not Eddie’s strong point but I probably deserved it). Nobody ever complained about the quality of Eddie’s concrete.

Peter the Meter: A Quantity Surveyor

Several years later at 22, I went to the Middle East; a learned young man full of ideals. I met Peter the Meter, a QS by profession. I rapidly discovered the brutal realities of construction in the Gulf, a very harsh learning environment. It seemed that with Pete’s help construction had got a lot worse in the time I was absent studying. Cement often set on board the ships from India, but that was ok because they reground it and rebagged it before the ships docked. Peter the Meter was sharpening his pencil. He had organized new bags on board just incase. Good as new! Then we had a special sand: it was dug straight from the sabkha and chucked into the mix. None of this fancy washed and processed stuff, that cost Pete money. After all, sabkha has some great properties: it contains about 30% salt (chloride and gypsum) on the surface crust. Pete thought it was good because the concrete set more rapidly. Nobody informed him otherwise.

Then we had serpentenite (a peculiar rock that I still don’t understand) and cherts from the Oman Mountains. Cherts are alkali reactive. As if this was not enough they chucked
in rebar that had been lying directly on top of the sabkha. It was laced with salt before construction started. To add icing to the cake the concrete that was finally produced was cured with seawater (since there was little fresh water available) and left to cook in the sun. Shade temperatures went up to 47°C but in the sun it was about 65°C. Peter the Meter excelled at making money. The concrete lasted about 5 years.

I recount these stories because they really reflect the best and the worst of materials and construction. The worst: we actually did these things in the Gulf. The best: we discovered with time and experience that they were wrong.

Peter the Meter, told me “son, construction is 4M’s: money, men, management and materials” and you only have to worry about the first M. I’ve never forgotten that. Except I also followed materials. No materials, no construction, no money Pete. Only the client’s money entered into Pete’s picture. Like all QS’s he had a short-term fetish about getting in quickly and pulling out as fast as possible afterwards.

**Lancelot from Camelot, The Engineer**

Several years later I came to Hong Kong. I met a chap in search of the Holy Grail of concretes. A concrete that would have eternal youth and last forever His name was Lancelot Ho, the best and purest Knight of all. He worked in an office building called Camelot, in Central. It was a palace of harmony where everything was perfect. He was so well organized his PDA had a detailed plan on how to pursue the girl of his dreams who lived next door: this plan was almost as good as his concrete mix designs. One morning reality came to visit Lancelot: his girlfriend ran away with a contractor and he had to face up to engineering incompetence.

His striving for perfection got him into a lot of trouble : even during the arbitration he couldn’t understand what he had done wrong. He was a lamb to the slaughter. Perfection is impossible the jurors cried: they were right. When I got involved with my first “impossible concrete” on a seriously expensive bit of infrastructure in HK, we had gone to the other extreme. There was never going to be salt in this concrete, not now and certainly not in the next 120 years. It would defy time and stay eternally young. We had computer programmes that told us so. They could check performance to 12 decimal places (0.000000000001) which is cutting it pretty fine. Lancelot lost his shirt and his sword on this job.

I smile when I consider this in the context of Eddie’s mix and my first concrete experience. I’m also pleased that Eddie’s concrete is still standing and doing the occupants of Comben Homes in Scotland proud. It must be a forgiving material. Sometimes I think we have started to live in the virtual world: not the real world. Concrete by computer and committee meeting. No wonder contractors are always at war with consultants and the lawyers get richer. We are not applying commonsense.

We are also suffering from risk aversion: modern construction neuroses. We must codify and prove everything will be perfect before we start: god help anyone who makes a
decision or mistake that affects our project management timelines. Manage risk until it doesn’t exist. You can take a degree in construction risk management now: it takes two year sitting behind a computer screen with a cup of coffee. This is not reality.

In the early days in the Gulf and no doubt in Camelot our forefathers used the materials that were available for construction. They had little choice, but they made it work. So next time we order sand from Australia, silica fume from Norway, surface roadstone from Scotland, Philippine teak and marble from Italy ask yourself why. Was it because it’s the only thing that matches the specification that was written in London or America and copied in Hong Kong.

Could it be that the specification is wrong. Are we striving for perfection but haven’t thought how long the different components will last? Just think about it. We have become McDonaldised: globalised and standardized. Standards which infact may not actually work in different climates or apply to local materials. QA ballistic, problem not solved.

The Partnering Spirit

The stories about Eddie, Pete and Lancelot fits with my pet theory about materials and energy. It goes like this:

“The more energy you put into building something, the greater the potential for deterioration”

Or as Pete Seeger, an American folksinger said:

You need to be clever to keep it simple: any damn fool can make it complicated.

I remember a Chris Page article in nature about “meta stable” materials. A lot of the following discussion was based on his ideas. Basically any material component that goes into a “higher energy state” strives to find harmony with nature. The amount of energy it takes to produce cement or steel is basically the force at which these materials will strive to return to their natural state.

This is not rocket science. It’s just like climbing a set of ladders. The higher you get the worse the energy of the fall. If the sun gets up and you start to get really sweaty and the wind and rain start to affect you, the chances of falling increase even further. Finally, the longer you stay on the ladder, the greater the chance of falling. What I have described are three key components of deterioration: Eddy, Pete and Lancelot.

- Eddy = Materials Energy: the striving for equilibrium and natural harmony.
- Pete = The environmental exposure conditions.
- Lancelot = The 4th Dimension, Time.
I would like to add a fourth: it depends how much you paid for the ladder. We’re back to Peter the Meter again.

So, a four-legged stool, one leg for each of these parameters, might be considered to represent the force of deterioration. This applies to all materials: rock, glass, concrete, and wood, plastic, whatever. If one leg of the stool is missing, it might be forgiving for a while, but don’t sit on it. Also, Pete’s got a say in two of the legs.

**Materials Energy – Steady Eddy**

Materials energy can be thought of as a hierarchy of increasing complexity. Like Steady Eddy, its in-built and there’s not too much that can be done about it.

Simple materials like rock last through geological time: through the millennia. They are in harmony with the environment that created them until some other environmental force affects them.

To turn this rock into aggregate requires a lot of energy: blasting and processing at the quarry and finally transportation and handling. The rock is now in a metastable state, a higher state than its natural state. The rock is no longer a primary material: it has entered a secondary condition. The same applies to cement. It is produced in a kiln from limestone and clay (silicates). A huge amount of energy is required to do this. Consequently the cement is metastable and represents a combination of primary resources that are now in a secondary energy state. Steel produced from iron ore is another example.

If the cement, water and rock are mixed together in concrete an exothermic reaction occurs. These “secondary” materials combine to form concrete: an even higher energy “tertiary” material that strives to an even greater extent for natural harmony.

Pre-cast concrete is subject to handling and construction (more energy). It is integrated with different materials in a complex structural component system (more energy): e.g. cladding systems, steel decking etc. The finally constructed system is therefore in an even higher energy state than its “tertiary and secondary energy state” constituents. In a sense this provides a quaternary energy state: a 4th state in the deterioration-energy hierarchy.

This final condition provides integrated composite components that are only capable of spanning an engineering time frame: perhaps 20-50 years. Compare this to the primary constituent rock that is probably over 200 million years old before we start to “energise” or “excite” it.

The concept of a residual material energy hierarchy applies to everything we use in construction (Table 1 and Figure 1).
### Table 1: The Materials Heirarchy

#### Increasing Energy Input

![Materials Heirarchy](image)

#### Figure 1: Material Performance Risk Heirarchy

![Figure 1: Material Performance Risk Heirarchy](image)
The Exposure Conditions – Peter the Meter

This is an old song that materials engineers have been singing for years. It still lands on deaf ears. If you don’t wear sun tan lotion you will get fried. I don’t intend to go into long protracted diagrams: I would rather present Pete with some football scores that he can understand:

The Big League (Macro-environment)
UK - 1      HK – 3      Arabian Gulf - 5

The Little League (Meso-environment)
Rural - 1    Coastal - 3       Seaside - 10

If you multiply the Big league country score by the Little league location score you can roughly assess the general materials exposure risk (the relative speed of deterioration for constructing in that environment, in relative terms). If you live in a cottage in the UK like I do, the score is typically 1. If you own a piece of reinforced concrete that splashing in the sea in the Arabian Gulf, you scored 50.

These are obviously gross oversimplifications and the scores are only indicative but they get the message across. I hope there are designers and specifiers listening.

Time: Lancelot and Holy Grail

Time with a capital T, the great healer: except in the case of our buildings and infrastructure. The influence of time on materials deterioration can be considered in several contexts:

- Engineering time – perhaps 20 to 200 years
- Geological time – several hundred years to eons
- Biological and chemical time – instantaneous (some cases) to eons

Clearly these are all closely interrelated and distinction is oversimplification. I’ve tried to put this slant on this issue so engineering time can be viewed from the proper perspective. Some structures represent a combination of these factors, e.g. old castles are engineered structures made from rock that will probably be durable for many thousands if not millions of years. It’s not the rock itself that fails but structural integrity: e.g. the arches from overloading, the walls (from settlement etc). We’ve all seen old cottages with piles of rock rubble around them.

I have a house that is 412 years old: at least that’s what the Scottish National Trust advises. The walls are 3 feet thick and made of 400 million year old sandstone. The outer render was replaced 20 years ago and covered with a long-lasting stone paint that has given reasonable service. However, the render has delaminated, the paint faded and the down pipes are rusted and holed.
This reflects the other misconception: that all material components are expected to last the same time. I haven’t seen many architects or engineering specs that say the tiles and render should be replaced at 15-20 years, the pipes etc removed and replaced at 10 years, waterproofing renewed every 10 years etc. Nor have I seen designs that plan for this beforehand. The question is why and the answer is simple: the influence of time has not been considered or priced in the design. This enables the cheapest “generic” components to be used and replaced a few years later at the client’s expense.

Yes, we have extremes like our big infrastructure projects which demand seemingly “impossible” requirements often when commonsense could have prevailed. We seem to have a polarized view on what should be done; nothing or everything.

My proposal is to find the middle ground: simple buildable components that do their job. Polarisation leads to arbitration and claims and is counter to the partnering concept of today’s building industry. I would bet on an improved version of steady Eddy, give Pete a miss by a mile and shudder while Lancelot impales himself on his sword.

![Graph showing the relationship between Materials, Energy State, Environmental Dynamism, and Time Factor](image)

NB: Bottom Left Blue is minimal deterioration force while top right square is maximum.
Money

So what do materials cost? Put it another way if we spend twice as much on material costs at present and this doubled the life of our structures or even extended it by 50% and slashed maintenance costs, what would the markup be on overall job costs. The answer is an incredibly small amount, ask a good QS. The problem is negative margins in these days of sub-economic survival. Clients with short-term price-driven strategies don’t help either.

If it was my house you wouldn’t see me living with the cheapest materials. I grudgingly put up with this when I rent a property but sometimes, landlord permitting, change the fixtures. Why do we seek the finer things in life but apply an alternative philosophy to local buildings and infrastructure.

I lived in a particularly bad flat in Pokfulam for many years. The skirting boards were falling off, everything in the toilets was corroded, and the surface render in the rooms was cracked and flaking. In the wet season it leaked like a sieve. Water permanently dripped from the bathroom ceiling accompanied by spalling render. I imagine this sounds familiar to everyone, yet the building was only 10 years old. I estimated the materials used in construction of the flat cost less than HK$100K. Currently it is valued at about HK$5M while in 1997 it was worth over HK$10m.

Boring you say, this is HK. Whatever you call it, its poor construction, lack of attention to detail, bad design and use of the cheapest materials. A conspiratorial short-term strategy that promotes rapid urban decay.

We must ask ourselves why buildings are still being constructed using the cheapest materials, without proper movement joints? And also why do clients not wish to pay for proper supervision of construction? It gets back to money: you get what you pay for.

Many of us think of property as an investment. At least we used to in HK. It serves no other purpose if we don’t live in it. Therein lies the problem. Do we really care how long it lasts. If the answer is no, then we should build as cheaply as possible with the understanding that the building will need to be replaced when it reaches 15-20 years old and other people will be living in it anyway. This is very provocative thinking but who would invest in it? If this argument is carried through to its logical conclusion, marketing portrayal of permanence is simply ripping off homebuyers. I suspect there is an underlying truth here, which I’ll leave you to answer yourself.

For the most part we are not adopting this approach when it comes to major infrastructure because a long-term commitment is required. This is an important clue on how to resolve these issues. HK is about speed with no tomorrows. This pre 97 mind-set no longer applies to our society. Lancelot was right. Unfortunately failed to identify the realities of life.
Sustainability

Nothing in life is sustainable except the force of deterioration. We may slow it down but it is inviolable. The key to sustainability is balancing primary resource usage with minimal energy input against cost-effectiveness and durability performance. Generally speaking, the less-energised the material product, the cheaper, simpler and more durable it becomes. A corollary to this is that although highly energized waste products exist, we can incorporate them in our material products and make them valuable commodities. To me this is what sustainability is about – not wasting primary resources and not expending unnecessary energy.

There are many opportunities that exist today in HK. Green concrete produced by combining waste rock with PFA (waste ash from power stations) is one example where two waste products combine to form an important construction product. This is a real win-win situation. I know from personal experience we have to fight very hard to try and get these new ideas accepted in HK. We seem to be 10 years behind in our approach to these and similar issues. PFA was a classic example of this. We embarked on a study in 1988 to prove to the HK Engineering fraternity, that PFA was not detrimental to concrete: infact it is good for concrete since it improves performance. Some 14 years later there are still segments of the public sector that prohibit the use of this valuable waste product. I always thought HK was an advanced vibrant city, brimming with new ideas and entrepenuers.

I want to close by laying a challenge down to the Government: open your minds to new opportunities, explore the use of new materials, particularly those that would otherwise end up as waste products. Be bold: you won’t advance otherwise and HK will be left further behind.

Conclusions

Pretty simple really: Eddy, Pete and Lancelot should form a team that:

- Thinks about the local materials and waste products with the aim of saving money and the environment at the same time. Idealised perhaps, but feasible.
- Prescribes the periods that different material component are meant to last and remain durable. If the basic question about design life can’t be answered, how can the component by applied in the first place and more importantly, how can it be sold.
- Considers the environmental exposure conditions. “Don’t stick your hand in the fire unless you have asbestos gloves on”.
- Thinks about money and spends a bit more now on better quality products with the objective of reducing recurring expenditure.
- Has a longer-term mind-set, or conversely an appropriate short-term view that is transparent and open and taken into account in design (a no-surprise mentality).
Has the ourage to challenge itself with new materials technology. Finally thanks for the opportunity of letting me bark about my pet subject. Enjoy the conference.

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November 2002