Construction and Project Management

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ON THE COVER
In Luanda, Angola, Franki Africa – part of the JSE-listed Esorfranki group – has completed several projects on five-million-year-old relic beaches, where the sea has receded and building occurs at various levels on ancient beach slopes. The Kinaxixi MXD Complex (seen on the cover) and the Total E&P Office Tower are two of the current projects.

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Over the years Franki has done some landmark geotechnical work, providing interesting, innovative and often brilliant solutions for a vast range of differing geological conditions. But few are more special than its recent successes in Luanda, Angola, where it has completed several projects on five-million-year-old relic beaches where the sea had receded and where building occurs at various levels on these ancient beach slopes. Each position brings with it its own unique geological challenges and appropriate solutions. This story is about two of these current projects.

**TOTAL E&P OFFICE TOWER**

Franki’s connection to the first project, Total E&P Office Tower, goes back at least three years when it was appointed by the client, Bayview, to do the technical investigation, and to assist in the preparation of the foundation investigation report and preliminary design for the lateral support and piled foundations. The project then went out to tender two years ago.

Franki was not successful. At the time its resources were tied up in two major projects in close proximity to the Total Office Tower, which meant factoring in...
the costs of bringing in new resources and machines, resulting in Franki being knocked out on price.

The project was awarded to a well-known European competitor in Angola. This company completed the installation of soldier piles, but its proposed foundation piling solution was not suited to the geotechnical conditions, and hence its contract was terminated.

So Franki was called in again, and successfully negotiated with the client and main contractor, Soares Da Costa – whom Franki had met eight years previously when work first commenced on the Torres Atlantico project, also in Luanda – to redesign the foundation solution and expedite the works to recover the approximately two months’ lost time. Franki, with its prior knowledge of the conditions through its original design input, opted for the piled solution outlined in its initial geotechnical support documentation. “The Continuous Flight Auger (CFA) pile was the optimal solution for these conditions and with the equipment now available, we were able to successfully complete the pile installation and to contribute significantly to bringing the project back on track,” says Franki technical director Gavin Byrne.

Byrne adds that part of Franki’s contract was to also complete the lateral support that had been partially completed by the previous company: “Here it was necessary for us to redesign the anchor tie-back.”

503 no x 650 mm diameter CFA grout piles with a working load capacity of 2 250 kN have been installed on the Tower block and parking area. 58 no Titan micropiles are currently being installed on the Utility block of the project. 155 no, 52/26 Titan lateral support anchors have been installed for the lateral support on the project.

The soil comprised dense, fine and medium beach sand to depths in excess of 40 m, and the pile depth, an average of 16 m, was determined by the load capacity requirement and the overall settlement limitations required by the Tower block.

Rod Schultz, director of Franki África Sucursal Angola, says that one of the challenges on this job was the partially constructed building on the site, dating from before the Angolan Civil War and ultimately abandoned with a basement and its piling structure intact. “We had to accommodate the piles that had been installed for this project into our foundation solution and geometry.”

Byrne adds that another challenge has been the differing cross-cultural design practices. “Countries have differing standards, which must be taken into account. In this case, there were some significant complications with respect to varying interpretations of the validity of the design.”

Ultimately, it was agreed that, to verify the design and to help solve the problem, Franki would constantly monitor the settlement of the structure. “Thus far the pile performance has been completely validated,” says Byrne.

KINAXIXI MXD COMPLEX

With the second project, the Kinaxixi MXD Complex, Franki also has a long history, in particular with the Korean project management team, Space Group, the main contractor, Soares da Costa and the Korean professional design team. As with the Total E&P project, Franki did the geotechnical investigation and assisted the professional team in the design of the lateral support and foundations for the project.

The Kinaxixi MXD Complex is a large development the size of a city block in Luanda, comprising commercial, retail and residential space and up to five basements for parking. The main body of the foundation work involves lateral support for excavation depths up to 25 m below ground level.

While the geology of the Kinaxixi site is similar to the Total E&P site, it is not identical, because it is positioned on the plateau above the Total site. “This site is characterised by a semi-continuous band of hard rock Calcrete/Sandstone up to three metres thick,” says Schultz.

Franki proposed a two-stage excavation operation. The first comprised a soil-nailed solution for the upper six metres, followed by a soldier pile and anchor lateral support for the remaining 10 to 18 m deep excavation.

Schultz explains that this solution was developed to eliminate the costly and time-consuming drilling of soldier piles through the hard rock Calcrete/Sandstone evident in the upper six metres of the soil profile.

“The old, uncharted services, mainly on the east excavation face, are quite a challenge on this job,” Schultz continues, “but the biggest challenge is to accommodate the unforeseen elevated and localised saturated soil conditions, and we have put forward an alternative to cater for these

![Franki Africa installing diameter 650 mm CFA piles for the Total Tower project, with the Three Towers project recently completed using Franki driven cast-in-situ piles in the immediate background, and the Intercontinental Tower in the far left background, also recently completed by Franki](image1)

![Tower block piles for the Total E&P Office Tower project being prepared and trimmed for pile cap construction](image2)
conditions. The lateral support design was modified for these unforeseen conditions and we are currently awaiting approval to mobilise jet grouting equipment to install soil cement columns between the soldier piles to stabilise the excavation face.

**FINAL PHASE**

The final phase of the project is the development of a foundation solution for the tower block structures. Two options – raft or piled foundation – are currently being evaluated by Franki and a decision will be taken once it has determined the in situ soil compressibility and strength parameters on the relevant portions of the site.

The completed phase of the project comprises 1 150 no soil nails, 4 200 square metres of gunite, 310 no micropiles, and more than 370 soldier piles. The remaining work on the second phase comprises the installation of up to five rows of Titan anchors and 7 500 square metres of gunite arches and possibly 90 jet grout columns.

Byrne says that Franki’s wide product range and innovative approach have resulted in appropriate and economical foundation solutions for these contracts. “Each solution is different for each project, as are the modification and installation processes which suit the unique conditions of each site.”

Franki Africa – of which Franki África Sucursal Angola is a subsidiary – is part of the JSE-listed Esorfranki group. The company’s capabilities include piling, soil-investigation, lateral support, ground improvement, micropiling, grouting, cut-off walls and marine works. It has more than 40 production rigs and a staff complement of more than 900. With respect to cross-border work, apart from in Angola where it also pioneered a new method of jetty construction in Luanda harbour, it is active in other African countries and the Indian Ocean islands, where it also used its unique jetty construction for the Seychelle’s Fishing Authorities.
A FEW DAYS BEFORE the World Cup kick-off, Rian Malan, writing in the British newspaper, Daily Telegraph, under the headline "Contrary to all the gloomy predictions, South Africa is well prepared for the World Cup", stated:

“When Fifa awarded South Africa the 2010 World Cup, there were groans of disbelief around the planet… given SA's allegedly manifest inability to host such a complicated event.

Before approving our bid, Fifa made us promise to jump through all hoops of its choosing, and our leaders eagerly complied. We agreed to refurbish freeways, upgrade airports and build elaborate new mass-transit systems. We agreed to build a high-speed train linking our largest international airport to surrounding cities, and most improbably, to erect 10 new world-class soccer stadia.

Many observers thought the task way beyond our capabilities. I agreed. ……[It] seemed foolhardy even to attempt a task of the magnitude Fifa had set us ……

South Africa has an extraordinary ability to make fools of those who attempt to predict its future. As I coasted into the airport’s shiny new parking lot, I realised that I’d shot myself in the foot again. I whipped out my cellphone and sent out an all-points SMS conceding my error and announcing that our organising committee’s slogan – “We’re ready” – seemed against all odds to be coming true.”

The chairman of that same organising committee – and many other prominent South Africans, particularly our political leaders – have justifiably crowed that, by being ready, South Africa has confounded the sceptics.

And so we have. But not one of these eminences has seen fit to pay tribute where the highest tribute is due.

Thanks to whose achievements has this readiness been achieved? Who has been mostly responsible for South Africa being “ready” – for having delivered on its contractual obligations to Fifa and its promises to followers of the Beautiful Game?

Malan gives us the clue, but, it would seem, without making the connection that ought to be obvious. He writes:

"Golden pleasure domes soared skywards. ……In mid-May, I made the run from my home to the airport in 28 minutes, a miracle made possible by extensive reworking of the city’s freeway system.”

Excuse me, but why are these people not seeing – or not willing to acknowledge – whose achievements these are?

The morning after the World Cup kick-off, the Afrikaans newspaper, Beeld, had a one-word banner headline on its front page: “Sharp!”

All credit to Bafana Bafana, yes, for starting so well in the series. But who do the politicians, the sports administrators, the general public et al think it is that has been really “Sharp”?

Against the hype about how South Africa has disappointed those who said we could not stage the World Cup, that we wouldn’t be ready in time with the stadia, and so on and so on, all this infrastructure has been delivered. Where the sceptics have been most emphatically and most spectacularly disproved, has been in respect of the civil engineering.

That we are able to stage the World Cup is a triumph for South Africa, yes. But, much much more, it is actually a triumph of South African civil engineering. All the stadia and associated works were completed on time, despite extremely tight design and construction schedules. Ditto for the major roadworks, substantial upgrading of the three largest airports, and a lot of other infrastructure. Not to mention the Gautrain between the airport and Sandton having opened three weeks ahead of the originally contracted date of 27 June.

Hi, members of the civil engineering profession – it’s us, together with the other built environment professionals, but with the civils in the lead, who have been so “Sharp”!

Dr Kevin Wall
SAICE President 2001
CSIR Divisional Fellow
kwall@csir.co.za

The Institution of Civil Engineers (London) is so impressed by South Africa’s civil engineering preparations for the World Cup that it is featuring our stadia as the cover story in the July 2010 international edition of New Civil Engineer.
The essence of sustainable wealth

THE “REDISTRIBUTION OF WEALTH” has been a major focus in South Africa in recent decades. There is an unstated assumption that wealth creates itself and is unjustly appropriated by certain individuals at the expense of those who justly deserve to participate in that wealth.

Is that a valid thesis?

For more than twenty years I have been seeking to bring “the disciplines of engineering” (consistent and reliably successful outcomes) to the information technology (IT) industry – a journey which has been underpinned by a deeply held belief that engineering provides thought patterns and knowledge that are supportive of successful outcomes by preventing failure and that my training would permit me to indeed establish the requirements for successful IT outcomes.

During the ensuing challenging and at times traumatic journey I have sought among other things to understand the concept of value, the relationship between value and cash and therefore the concept of wealth. I have done this as a participant and observer in life and the events of the decades during which I have been able to engage with the world around me. I hold that if one does not understand how value is created it is impossible to embark on any type of engineering, information technology or other project with any prospect of REAL success, where by REAL success I mean an enduring, sustainable outcome that produces a net GAIN in the quality of life of those it touches.

While this analysis initially was focused only on information technology, and the reasons for the 70% outright investment failure rate for IT and why 19 out of 20 ERP (business computer systems) fail to meet management expectations, I more recently came to realise that these same findings had a bearing on South Africa in the twenty-first century.

This article sets out to summarise some key findings based on an assertion that “wealth” is the concept that best summarises the state of being of human beings that we are all at least nominally striving for. Wealth in terms of this definition comprises state of health (physical and mental wellbeing), security, quality of food, accommodation, finances, etc. If to this we add the concept of “abundance” it is apparent that few people in our society know how to create enduring wealth in their own lives, let alone the lives of a substantial number of people. I suggest for your consideration that the truly wealthy create meaningful employment well above the poverty line for substantial numbers of people.

Wealth is therefore the result of focused and effective human endeavour, enterprise and effort conceptualised and executed by human beings. Assets, whether buildings, farms or cash are NOT wealth and do NOT create wealth. ONLY human beings create wealth. Taking from those who at some level have succeeded in creating some measure of tangible wealth and giving to those who manifestly do NOT know how to create wealth (if they did they would not need the handouts), diminishes the resources available to those who know how to manage wealth and thereby drains the pool of human motivation that creates enduring wealth. The only truly viable means of assisting those of impoverished circumstances is to create opportunities for them to fall under the mantle of those who do know how to create wealth that they may in time benefit… but this is not the essence of my message.

What are the essential components of creating wealth?

Based on my analysis, I suggest as a basis for discussion that the following eight factors are pivotal in creating wealth. Percentages after each point indicate the estimated relative contribution of each factor in creating wealth. The impact that the absence of these factors has on destroying wealth is also shown as a percentage in brackets.

1. Appropriate assets well designed, built, maintained and operated provide a platform that MAY contribute to wealth creation – 2% (22%)
Assets do NOT create wealth, people do. One of the most destructive myths in South Africa today is that assets are wealth. Farms are reallocated and fall to rack and ruin because the farm was NOT wealth. The gainful operation of the farm may have created sustenance and some semblance of wealth, but the land and the plants and the animals were NEVER the
source of that wealth. The effective management by people created wealth.

Football stadiums do NOT create wealth. They are a huge drain on the active capital of the nation and, when funded with loans, represent an enduring burden on the ability of the nation to support those who need some measure of support.

Reallocating the money that should be used to maintain infrastructure (roads, sewerage, water supply, electricity reticulation) is NOT wealth redistribution, it is theft from the wealth of the future to create an illusion of wealth in the present that will finally devastate the future if not rapidly turned around.

On the other hand, the effective application of technology to gear the human and natural resources of a nation or organisation is vital. Every nation that has succeeded in truly raising living standards to high levels and minimising or eliminating poverty has done so through the effective application of appropriate, well maintained and well operated technology to gear the abilities of its people. However, the technology is NOT the source of the wealth. The people who conceptualise, design, build and operate the technology are the source of the wealth.

But, technology that has fallen into disrepair, including all those infrastructure components mentioned above, will eventually become a massive sink, draining prosperity out of the economy as is already starting to happen through the tyre and shock absorber tax (potholes and ravelling road surfaces) and other insidious consumers of effectiveness, efficiency and cash that are progressively subtly dragging South Africa into deeper and deeper future discounted poverty.

Thus assets are vital in creating wealth and in destroying wealth, but other factors are more critical.

2. Ways of doing – policies, methods, procedures, standards, and ways of doing create a framework that MAY contribute to wealth creation – 3% (15%)

The way things are done, methods, policies, standards, etc, contribute to wealth creation but are also NOT wealth. The ability to do these things assist human beings to generate activities that are exchangeable for cash or near cash, which improve the quality of life, but they are not in and of themselves wealth.

As with appropriate assets these factors are a necessary qualifier for a wealthy existence. In their absence the creation of wealth in real terms is all but impossible, but there are other factors which have a more fundamental impact.

Of the items listed here, policies have the greatest ability to destroy wealth, but they do NOT create wealth. Effective policies create a suitable context and may stimulate wealth producing activities, but inappropriate policies can destroy wealth-creating endeavour.

It is a myth that governments create wealth, and the attempts by our present government to present itself as the guarantor of wealth and wellbeing is at best futile and at worst laying the seeds for civil war borne out of increasing poverty and disillusionment.

3. Discipline, accountability, safety, security, crime deterrents, and punishment that fits the crime minimise wealth consumption and wealth destruction and MAY create a context for wealth creation – 8% (24%)

In the current generation we seem to have lost sight of the importance of discipline, accountability, etc.

We abolish the death penalty and when murder rates rise to a level where we cannot possibly accommodate all the murderers in jail with required standards of compassionate care, our politicians fail to own their mistakes or take responsibility for the crime rate in a way that makes any impression. After more than a decade of doing roughly the same things it is time to do something different.

Public calls to “kill the farmer (boer)” and “bring me my machine gun” plant mental seeds that can only add fuel to the fire and at the same time drive more and more of the people who do have even some limited knowledge of how to create wealth from the country. Every well educated and economically active person who leaves the country sheds geared suffering, deprivation and continued lack to the poorest of the poor and even the not so poor. The multiplier effect of one lecturer, teacher, doctor, engineer, etc leaving the country robs the people of this nation of significant potential to create wealth.
Return to the death penalty for murder, and robust and appropriate punishment for robbery, rape, etc., are vital building blocks in any attempt to bring wealth, and that requires that those in positions of leadership in government set an appropriate standard.

4. Ways of being – attitude, motivation, pride, caring, compassion, love, patriotism, commitment to excellence, and leadership accelerate human endeavour towards the creation of wealth – 11% (2%)
Well motivated people can produce far more than demotivated people. The public utterances mentioned above are sapping the morale of the people of this nation. Leaving the country is a constant topic, the fall into decay and disrepair of the infrastructure are all sapping the will of people to invest time and money in building the future. It is not readily apparent, but the seeds of accelerating decay are widely present for those with eyes to see.

However, once decay has set in and is manifesting in rotting infrastructure a change in morale will have little effect on real economic upliftment. It is difficult to create wealth when more and more of your energy is being consumed as a consequence of the failure of government to concentrate on its core responsibilities, including reliable future-focused infrastructure.

When a major mining house that has been central to the creation of wealth in this country for over a century is rumoured to be divesting of its mining assets, because it is negative about the future of the country, it is time to take note!

5. Relationship, communication, and constructive interaction between human beings are vital to creating wealth – 12% (3%)
Relationships, trust, and the effective interaction of human beings with one another are fundamental requirements for wealth creation and a viable nation. Increasing anti-white racism and harsh discrimination, and the resultant backlash, are tearing at the very fabric of the rainbow nation and are everywhere apparent for those not too afraid of being thought politically incorrect to notice.

Effective relationships and partnerships between people are a vital element of creating wealth. Once destroyed it will take a long time to rebuild, and the ability of such rebuilding to influence seriously decayed infrastructure rapidly will be limited.

6. Effective management of time, finances, human resources, and assets is a vital component of creating a net positive gain in the economic dimension that creates tangible financial wealth – 14% (4%)
People who are truly wealthy know how to manage time, finances and other resources and, above all, they know how to manage people.

Only a small number of people truly know how to do this with real effect, such that productive and profitable employment is created for many others. Driving those people out or causing them to turn their endeavours to other shores is one of the most damaging things that is currently happening in this country.

Putting people in charge who do not know how to do these things is a recipe for disaster and has been government policy for the last sixteen years, with the resultant degradation of infrastructure, etc. that has been referred to throughout this article.

7. High value decisions based on appropriate and reliable information, concisely and conveniently packaged and delivered IF well executed will create wealth – 20% (5%)
People who create substantial wealth do so through taking high value decisions. Two people can sit in the same meeting and take totally different decisions. One decision can initiate actions that create wealth, another decision can sabotage or destroy wealth creation.

Few people know how to take high value decisions consistently. Such people must be nurtured and not branded because of the colour of their skin and made to feel unwelcome and unwanted in the land of their birth or their adoptive land.

South Africa is divesting itself of high value decision-makers and that, alone, is enough to tip us over the edge of technological and economic ruin that characterises much of Africa.

8. Relevant knowledge and experience acquired throughout life, but particularly in the first seven years of life, create the platform from which real wealth is acquired – 30% (25%)
In all of the above, relevant knowledge and experience effectively and efficiently employed are at the heart of wealth creation.

Such wealth cannot be redistributed, or confiscated, or nationalised. It is the consequence of a lifetime of learning or not learning, of growing or not growing in wisdom or foolishness.

But there is increasing evidence that the impacts of the first seven years of life are huge, that many who succeed succeed because of what they took on board in those first years, and that most who fail fail as a consequence of what they took on board during that same period.

An official who grew up in an area of rutted tracks will consider himself to be performing well when there are only “a few” potholes, whereas an official who grew up in an environment where potholes were unheard of will consider the situation to be downright dangerous and unacceptable.

In my next article I will elaborate on the importance of early childhood knowledge and experience acquisition in shaping the future of a human being and suggest that this, rather than genetics, is a pivotal factor in determining the ability of a human being to generate wealth. Suggestions will be made for measures that could be taken to greatly improve the ability of the next generation of South Africans, and possibly even the current generation, to create sustainable wealth.

The bottom line is that there are huge problems in this country, BUT that there ARE measures that can and should be taken.

I raise the problems because as an engineer I know that success comes from preventing failure, and in order to prevent failure, I must first acknowledge that failure is an inevitable consequence of failing to prevent every single possible cause of failure from activating in the structure or system that I am responsible for designing.

If South Africa is not to slip into the oblivion and poverty of much of Africa it is now time to take energetic new measures towards wealth creation by removing ALL racial clauses from legislation and policy, and encouraging any person who has some level of knowledge and experience with regard to creating wealth to create wealth in whatever legitimate way they can identify.
INTRODUCTION
Matrix notation is a convenient method for expressing simultaneous linear equations which are used in structural analysis. Young engineers can cope with this notation because they attend special mathematics courses on matrix methods. Mature engineers might have learnt structural analysis without experiencing matrix methods.

WHY SHOULD ONE CARE ABOUT MATRIX INVERSION?
A structural engineer can use equations to find the unknown forces (or deflections) in a truss structure for a certain set of known loads applied on the joints. This would be a one-time solution. But this engineer might wish to find unknown forces which arise due to other sets of loads applied at the joints. He

Matrix Inversion

<table>
<thead>
<tr>
<th>1</th>
<th>Consider the following linear equations :-</th>
</tr>
</thead>
<tbody>
<tr>
<td>4. $x_1 + 3. x_2 + 2. x_3 = 10$</td>
<td></td>
</tr>
<tr>
<td>1. $x_1 + 8. x_2 + 4. x_3 = 5$</td>
<td></td>
</tr>
<tr>
<td>6. $x_1 + 3. x_2 + 5. x_3 = 20$</td>
<td></td>
</tr>
</tbody>
</table>

These can be rewritten in Matrix notation as :-

$$
\begin{bmatrix}
4 & 3 & 2 \\
1 & 8 & 4 \\
6 & 3 & 5
\end{bmatrix}
\begin{bmatrix}
x_1 \\
x_2 \\
x_3
\end{bmatrix}
=
\begin{bmatrix}
10 \\
5 \\
20
\end{bmatrix}
$$

The dot $\cdot$ indicates matrix multiplication. See Figure 2 for definition of multiplication.

<table>
<thead>
<tr>
<th>2</th>
<th>Consider the following linear equations :-</th>
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Matrix A times Matrix B equals Matrix D

<table>
<thead>
<tr>
<th>Matrix A</th>
<th>times</th>
<th>Matrix B</th>
<th>equals</th>
<th>Matrix D</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 3 2</td>
<td>2 0 1</td>
<td></td>
<td>16 -5 6</td>
<td></td>
</tr>
<tr>
<td>1 8 4</td>
<td>2 -3 -2</td>
<td></td>
<td>22 -8 1</td>
<td></td>
</tr>
<tr>
<td>6 3 5</td>
<td>1 2 4</td>
<td></td>
<td>23 1 20</td>
<td></td>
</tr>
</tbody>
</table>

For example the term -5 in Matrix D is obtained by making the first row in Matrix A “dive” onto the second column in Matrix B :-

Thus $\{4 \times 0\} + \{3 \times (-3)\} + \{2 \times 2\} = -5$

Look again at the matrix equation in Figure 1, and note that the same definition of multiplication is used to write the equations into a matrix notation.
could perform the whole analysis again on the basis of a one-time solution for each new set of loadings.

However, if the engineer can find an “Inverse Matrix” while he solves his first loading condition, then he has a more general solution which he can use for all other loading conditions.

This article provides an easy method for Matrix Inversion.

A BEGINNER’S GUIDE TO MATRIX NOTATION

A matrix is merely a group of separate numbers which is laid out in a rectangular pattern or even as a single column. The matrix itself does not have a value. However, the determinant of a square matrix does have a value. The author would rather not use determinants, because they involve lengthy calculations.

Matrix equation represents simultaneous equations

Figure 1 shows how a matrix equation can represent a group of simultaneous linear equations.

Matrix multiplication

Figure 2 depicts the concept of matrix multiplication. To calculate the term which is situated in row “i” and column “n” of the product matrix, one must multiply each term in row “i” of the first matrix with each term in column “n” in the second matrix, and then add these products.

The first step in the solution of a problem is usually stated in the following form:

\[
\begin{bmatrix}
  x_1 \\
  x_2 \\
  x_3 \\
\end{bmatrix}
\begin{bmatrix}
  A_{11} & A_{12} & A_{13} \\
  A_{21} & A_{22} & A_{23} \\
  A_{31} & A_{32} & A_{33} \\
\end{bmatrix}
\begin{bmatrix}
  C_1 \\
  C_2 \\
  C_3 \\
\end{bmatrix}
\]

The values of C are known loadings or deflections. One wishes to find the values of x in the column Matrix. Using the Inverse of Matrix A, one can find each unknown x as follows:

\[
\begin{bmatrix}
  x_1 \\
  x_2 \\
  x_3 \\
\end{bmatrix}
= \begin{bmatrix}
  A_{11}^{-1} & A_{12}^{-1} & A_{13}^{-1} \\
  A_{21}^{-1} & A_{22}^{-1} & A_{23}^{-1} \\
  A_{31}^{-1} & A_{32}^{-1} & A_{33}^{-1} \\
\end{bmatrix}
\begin{bmatrix}
  C_1 \\
  C_2 \\
  C_3 \\
\end{bmatrix}
\]

In other words a value of x2 would be found by “diving” the second row of the inverse matrix A⁻¹ onto column C.

A COMMENT ON MATRIX INVERSION

The use of the inverse of a matrix is shown in Figures 3 and 5. The Inverse Matrix and the column matrix of the known constants can be written on the right-hand side of the equal sign. All the values on the right-hand side of the equal sign are known. Hence it is easy to evaluate, by matrix multiplication, the value of each unknown quantity located on the left-hand side of the equal sign (see Figures 3 and 5).

SOME METHODS USED FOR MATRIX INVERSION

Several methods exist for Matrix Inversion, but some of these are most cumbersome. These methods include the following:

**First Cycle**

\[
\begin{bmatrix}
  4 & 3 & 2 \\
  1 & 8 & 4 \\
  6 & 3 & 5 \\
\end{bmatrix}
\]

\[
\begin{bmatrix}
  17 \\
  0 \\
  0 \\
\end{bmatrix}
\]

\[
\begin{bmatrix}
  4 & 3 & 2 \\
  1 & 8 & 4 \\
  6 & 3 & 5 \\
\end{bmatrix}
\begin{bmatrix}
  17 \\
  0 \\
  0 \\
\end{bmatrix}
= \begin{bmatrix}
  17 & 0 & 0 \\
  0 & 17 & 0 \\
  0 & 0 & 17 \\
\end{bmatrix}
\]

**Second Cycle**

\[
\begin{bmatrix}
  4 & 3 & 2 \\
  1 & 8 & 4 \\
  6 & 3 & 5 \\
\end{bmatrix}
\begin{bmatrix}
  17 & 0 & 0 \\
  0 & 17 & 0 \\
  0 & 0 & 17 \\
\end{bmatrix}
= \begin{bmatrix}
  17 & 0 & 0 \\
  0 & 17 & 0 \\
  0 & 0 & 17 \\
\end{bmatrix}
\]

\[
\begin{bmatrix}
  4 & 3 & 2 \\
  1 & 8 & 4 \\
  6 & 3 & 5 \\
\end{bmatrix}
\begin{bmatrix}
  17 \\
  0 \\
  0 \\
\end{bmatrix}
= \begin{bmatrix}
  17 \\
  0 \\
  0 \\
\end{bmatrix}
\]

**Third Cycle**

\[
\begin{bmatrix}
  4 & 3 & 2 \\
  1 & 8 & 4 \\
  6 & 3 & 5 \\
\end{bmatrix}
\begin{bmatrix}
  17 \\
  0 \\
  0 \\
\end{bmatrix}
= \begin{bmatrix}
  17 \\
  0 \\
  0 \\
\end{bmatrix}
\]

\[
\begin{bmatrix}
  17 \\
  0 \\
  0 \\
\end{bmatrix}
= \begin{bmatrix}
  c_1 = 17/k = 17 \\
  c_2 = 28/9 = 3 \\
  c_3 = 28/14 = 2 \\
\end{bmatrix}
\]

**Value of K**

The value of k is equal to the number of cycles.

\[
\begin{bmatrix}
  4 & 3 & 2 \\
  1 & 8 & 4 \\
  6 & 3 & 5 \\
\end{bmatrix}
\begin{bmatrix}
  c_1 \\
  c_2 \\
  c_3 \\
\end{bmatrix}
= \begin{bmatrix}
  17 \\
  0 \\
  0 \\
\end{bmatrix}
\]

**Trace**

The trace of a matrix is equal to the sum of the terms on the leading diagonal (top left to bottom right) of a matrix. For example, the trace of Matrix A in Figure 2 is 4 + 8 + 5 = 17, and the trace of Matrix B is 2 – 3 + 4 = 3.

**Suggested Check**

Calculate A.A⁻¹. This answer should be equal to the Identity Matrix I (unity on the diagonal, zero values elsewhere).
Cramer’s Rule
Cramer’s Rule uses the determinant of the matrix A. If there are more than four simultaneous equations, this method is too laborious for practical purposes. It should be dropped from mathematical text books.

The Gauss-Jordan Method
A unit matrix I is placed alongside the matrix A. Operations on each line of matrix A are performed in the normal method for solving simultaneous equations. These same operations are performed on the unit matrix. Eventually the matrix A becomes a unit matrix, and the matrix I has transformed to the inverse of A.

Inversion by Partitioning
This method employs sub-matrices and can be messy.

Inversion by using Triangular Matrices
This involves lower and upper triangular matrices and is complex.

USING COMPUTERS FOR THE INVERSION OF MATRICES
Early home computers such as the Apple 2 and the BBC computer did not provide BASIC subroutines for finding the inverse of a matrix. However, the Hewlett Packard small computers did provide a subroutine for finding the inverse of a matrix within the BASIC computer language. Subsequently certain mathematical packages provided programmes for the inversion of matrices. More recently the inversion of matrices is possible by using “True BASIC”. Other systems can be expensive.

SUGGESTED METHOD FOR MATRIX INVERSION
After many years of searching, the author saw mention of a method (by Frame) in the Abstract Bulletin of the American Mathematical Society, Vol 55, p 1045, 1949. However, the Inter-Library Loan System confirmed that the American Mathematical Society does not have a copy of this paper. It seems that the method does not appear in modern text books. The author set about reviving the method, and this is presented in Figure 4.

CONCLUSION
The last matrix in Figure 4 is the required inverse of the matrix A from Figure 1. Hence the equations in Figure 1 can be transformed to the system shown in Figure 5. It will be noticed that it is easy to change the loading conditions by changing the constants in the right-hand column matrix in Figure 5.

An interesting aspect of the matrix method is that the structure is unstable if the determinant of matrix A is zero. 

Using the Inverted Matrix

\[
\begin{bmatrix}
  x_1 \\
  x_2 \\
  x_3 \\
\end{bmatrix} = \frac{1}{79} \begin{bmatrix}
  28 & -9 & -4 \\
  19 & 8 & -14 \\
  -45 & 6 & 29 \\
\end{bmatrix} \cdot \begin{bmatrix}
  10 \\
  5 \\
  20 \\
\end{bmatrix}
\]

Hence

\[
x_1 = \frac{(28 \times 10) - (9 \times 5) - (4 \times 20)}{79} = 1.962 \\
x_2 = \frac{(19 \times 10) + (8 \times 5) - (14 \times 20)}{79} = -0.6329 \\
x_3 = \frac{(-45 \times 10) + (6 \times 5) + (29 \times 20)}{79} = 2.0253
\]

Other sets of constants can be used in the last column above, to yield solutions for other conditions.
GCC 2010 – the SAICE contract document for the future

INTRODUCTION
To provide for conditions of contract in South Africa, construction contracts were initially based on conditions of contract drafted under British Law. These conditions developed into the so-called “blue book” which has been a well respected and widely used document that served the South African industry over many years. The first edition of the current General Conditions of Contract was developed in 2004 and involved a serious revision of GCC 1990, combining it with the COLTO document.

Following on six years of application in construction works, the General Conditions of Contract for Construction Works, Second Edition, 2010 (GCC 2010 for short), has now been revised to clear up responsibilities and to provide for a wider spectrum of construction works.

At the same time, in view of the current state of the construction industry with new emerging role players, revised procurement rules, introduction of different forms of dispute resolution, and so forth, there was a need to produce a guide for the correct interpretation and implementation of GCC 2010.

GCC 2010 Guide is intended for those in the construction industry who occasionally need some guidance when the unexpected happens and the conditions in the GCC 2010 need to be applied to determine the rights and liabilities of the parties to the Contract. This Guide should lead to the reduction of claims and disputes that may arise from misunderstanding GCC 2010.

DEVELOPMENT OF THE GCC
Over the past decades the GCC was frequently updated to prevent misunderstanding of responsibilities – the very purpose of contract conditions. In practice, conditions of contract evolve from a rudimentary to a complete state by a process of continuous evolution. GCC 2010 sets out clearer conditions compared to those set by individuals or international forms of contract. The GCCs have become familiar and understood over the years, and a considerable bulk of case law has been built around them.

OBJECTIVE OF GCC 2010
The main objective of GCC 2010 is to set out fair, equitable, efficient, economic and transparent contract administrative procedures, and the allocation of risks. This is based on the uniformity requirements stipulated in the government’s Green Paper on Public Procurement and the equity requirements set out in the essential and desirable criteria developed by the Inter-ministerial Task Team for Construction Industry Development.

The first important implication of the Green Paper is that each subject in a contract may only be addressed once and at a specific place. The second important implication is that conditions of contract must be used with minimal project specific variations and additions which do not change the intended use. GCC 2010 complies exactly with these requirements.

Based on previous claims experience, the Inter-ministerial Task Team set out the 20 best practice principles around which
the “ideal” conditions of contract should be drafted. Every clause, every paragraph and every word in GCC 2010 was subjected to these criteria to ensure that it provides for a fair, equitable, efficient, economic and transparent administrative procedure and the allocation of risks. The process was not a haphazard concoction of clauses, but an orderly procedure to achieve the desired outcome.

APPLICATION OF GCC 2010
GCC 2010 complies fully with the requirements of the Construction Industry Development Board (CIDB) for the procurement of engineering and construction works. Engineering and construction works include the provision of a combination of supplies and services, arranged for the development, extension, installation, repair, maintenance, renewal, removal, renovation, alteration, dismantling or demolition of structures, including building and engineering infrastructure.

RELEVANCE OF GCC 2010
GCC 2010 is based on the traditional administration and management of construction contracts. As such it is compatible with the established contract administration procedures of Employers and Contractors. It does not require a culture change, increased executive commitment, or new training to be implemented. Contractors do not have to make provision in their rates and prices for conditions with which they are unfamiliar, or which are difficult to assess.

GCC 2010 is suited for the full range of complexity: from straightforward to complicated projects of building and engineering works. Risk appropriation across the full range of complexity remains the same – Employers are not required to accept greater risks for less complex projects and Contractors are not required to accept greater risks for more complex projects.

GCC 2010 is written in plain language which makes it easy for all people to understand the provisions. It is also supported by the GCC 2010 Guide explaining interpretation and implementation matters. These improvements should assist new entrants into construction to comprehend the gist of GCC 2010. It is therefore particularly suitable for contracts in the lower region of a Contractor’s grading, where the emphasis is on community-based and labour-intensive projects.

The management of the Contract is the responsibility of the customary Contractor’s Site Agent and the Employer’s Engineer:

- The Site Agent is authorised to receive, on behalf of the Contractor, all communications from the Engineer, and is also required to submit notifications, requests and claims to the Engineer on behalf of the Contractor.
- The Engineer’s function is to administer the Contract as agent of the Employer, in accordance to the provisions of the Contract. GCC 2010 bestows substantial authority on the Engineer, but with sufficient checks and balances to keep this authority in check.

This time-trusted arrangement of contract management by the Site Agent / Engineer ensures that timeous and well-considered decisions are made, and encourages the parties to take all possible steps to avoid conflict.

CONTENTS OF GCC 2010
GCC 2010 is set out in ten chapters in which the various clauses dealing with similar matters are arranged in a logical sequence for better comprehension. The major new matters dealt with are the Construction Regulations on Health and Safety, greater emphasis on programming of the works, a new performance guarantee, clarification of acceleration of the works, updating dispute resolution with the latest thinking, while various other amendments that were proposed over the past six years, are also addressed.

Chapter 1: General
Chapter 1 sets out the definitions, interpretations and other general clauses that pertain to and have an effect on most of the requirements set out in GCC 2010.

Chapter 2: Basis of Contract
Certain basic aspects that determine the Contract are considered. These include the data and information supplied by the
Employer, and the ensuing investigation by the Contractor, which form the basis for considering the risks of unforeseen adverse physical conditions and obstructions, circumstances that differ from the technical data supplied, and ambiguities and discrepancies found in and between documents. All these factors have an impact on the pricing of the Contract Sum.

Chapter 3: Engineer
The Engineer is the person who manages the Contract as agent of the Employer. He is required to take actions to deal with situations that affect time, money and quality as they arise during construction. However, in dealing with these duties, he may not act in a despotic way. His actions are subject to dissatisfaction claims by the parties. To keep the Engineer’s authority in check, he is obliged to consult with the parties before making a ruling, interpretation or determination, and his functions may be made subject to the Employer’s specific approval. In addition, to reduce prejudice, the previous phrases "to the satisfaction of the Engineer" and "in the opinion of the Engineer" have been eliminated and replaced by measurable criteria.

Chapter 4: Contractor’s general obligations
The basic obligation of the Contractor is to execute and complete the Works in accordance with the Contract. It sets out the general obligations to which the Contractor must comply, such as carrying out the Engineer’s instructions, complying with all applicable laws, subcontracting without the consent of the Engineer, facilities for others sharing the same site, encountering fossils and other general matters.

Chapter 5: Time and related matters
The time at which a contract is concluded is important, because various time limits commence when the contract comes into effect, for example, submitting the health and safety plan, insurance, security, programme, issuing drawings and instructions, handing over the site, commencement of the works and determining the due completion date. The latter, in turn, determines the application of penalties, the release of retention and securities, final payment, and so forth.

Chapter 6: Payment and related matters
The emphasis is on financial matters. The Employer is obliged to pay the Contractor for accepted work in terms of the Contract. Before commencing the Works, the Employer requires security from the Contractor that he will finish the Works. The Contractor may select the type of security he wishes to provide. Provision is also made for instructing additional work not foreseen, or of which the details were unknown at tender stage, by providing for variations, day works, provisional sums and prime cost sums.

Before interim payments can be made, there are a multitude of items that must be considered, ranging from measurement of completed work and price adjustment for inflation, payment and security for materials on site, to tight time limits to deliver and pay the payment certificate.

Chapter 7: Quality and related matters
Quality may be defined as conforming to the specifications. To achieve the standard set in the Contract, workers must build quality into the work itself. No specification, process, test or control will produce the required quality if the workmen are incapable. Conditional acceptance of work not conforming exactly to the specifications at a reduced price is allowed for, but at the discretion of the Employer. Cooperation between the parties is also promoted by allowing for re-testing.

Chapter 8: Risks and related matters
In drafting GCC 2010 it was realised that all too often the general assumption by financial managers is that if the Employer accepts risks, it would be to his detriment. Engineers, however, know that this is not true, because by accepting risks the Employer will not only gain long-term benefits, but also decrease his costs. The basis of risk appropriation in GCC 2010 is not to place heavy risks on the Contractor, which he cannot assess beforehand. This could lead to large risk allowances to his rates and prices. In GCC 2010 the Employer is required to accept the risks that the Contractor cannot assess better than the Employer. In the long run, it is cheaper for the Employer to pay for what really happens rather than for what the Contractor thought might happen in the uncertain areas that the Contractor cannot control.

Chapter 9: Termination of Contract
GCC 2010 provides for termination by either the Contractor or the Employer for a breach of an obligation not performed, performed late or performed inadequately, and also when events occur which are outside the control of the parties, making continuation with the Contract impossible.
The termination of a construction contract is an extreme measure, only to be used as the very last resort. It is advisable for the party who wishes to terminate the Contract to consider whether termination would be in his best interest before embarking on this drastic step. GCC 2010 provides for other less drastic measures to rectify a party’s default. It is compulsory for the Engineer to consult with the parties before certifying the Contractor’s material breach. The Employer may extend the commencement of the Works instead of terminating the Contract when the Contractor delivers late or unacceptable documentation or, instead of terminating the Contract, the Contractor may claim extension of time and additional costs when the Employer fails to comply in good time with the information required to proceed with the Works.

Chapter 10: Claims and disputes

A logical procedure is followed to prevent issues becoming claims, claims becoming disputes, and in the rare occasion when disputes arise, to provide for a speedy resolution by an impartial third party. In the initial phases of issues and claims the Engineer’s ability as a professional who has been involved in the project from the outset and who understands the technical aspects, is utilised. GCC 2010 provides the opportunities for the Engineer and the Site Agent to work together as partners, not as opponents, in achieving the outcome of the contract.

Preventing claims becoming disputes is taken care of by allowing the Contractor to claim his entitlements arising from unforeseen events and delays caused by the Employer. The parties may also raise any dissatisfaction arising from or in connection with the contract. The Engineer is obliged to consult with the parties before giving his ruling on a claim, and amicable settlement is available when the help of an impartial third party is required.

On the rare occasion when the first step to settle the claim is unsuccessful, the dispute is taken care of by submitting it to either ad hoc adjudication where the Adjudication Board is appointed for a particular dispute after the dispute has arisen, or standing adjudication where the Adjudication Board is appointed at the onset of the contract with the primary purpose to avoid claims from developing into disputes, and if this cannot be avoided, to make a decision which is contractually binding on the parties.

If the above-mentioned dispute resolution procedures fail, the final stage is to obtain a final and binding award from arbitration or a court judgement.

CONCLUSION

The greater demand for improved management techniques in construction projects is reflected in GCC 2010. It does not only set out legal terms of rights and obligations, but concentrates much more on the conditions for good project management. This is also the theme of the GCC 2010 seminars that SAICE will be presenting to all Branches.

Find out more about the appropriation of risks, liabilities and obligations of the contracting parties and the management of the contract by obtaining the GCC 2010 and GCC 2010 Guide from SAICE National Office (Angeline Aylward on aaylward@saice.org.za), or attend the GCC 2010 Seminar (see page 84 in this edition of the magazine for details).
ASPIRE to sustainable development

INTRODUCTION
Engineers Against Poverty (EAP), a specialist UK based NGO working in the field of engineering and international development, together with ARUP International Development, recently launched ASPIRE (A Sustainability, Poverty and Infrastructure Routine for Evaluation). ASPIRE is a leading-edge software-based tool with the potential to revolutionise the assessment of sustainability and poverty reduction for infrastructure projects in low and middle-income countries. ASPIRE addresses the four key themes of environment, society, economics and institutions.

Two key innovations which distinguish ASPIRE from any other tool currently available are: (1) it comprehensively integrates sustainability and poverty reduction in one assessment, and (2) fully addresses the important but challenging theme of institutional sustainability, covering project interaction with government, civil society, private sector and the rule of law.

ASPIRE evaluates projects using 96 indicators at the core of sustainable engineering, and presents the outcome in one simple graphic (see Figure 1). It is a non-commercial venture, that was developed with support from the UK Institution of Civil Engineers (ICE) Research & Development Fund.

Infrastructure underpins poverty reduction and sustainable development through multiple channels, but projects are often delivered with the emphasis on technical performance rather than recognising the contribution they can make to a broad range of developmental outcomes. ASPIRE supports project teams in recognising these opportunities, and therein lies its distinction from social and environmental impact assessments, which are focused on mitigating potential negative impacts. ASPIRE’s brief, developed through research and consultation with key stakeholders, is:

- to support the integration of the core characteristics of sustainability and poverty reduction into the project process throughout the entire infrastructure project life cycle, and
- to help those funding, commissioning, designing and implementing infrastructure projects to consider a wider range of issues and stakeholder concerns.
This article describes ASPIRE’s development, including an explanation of the four overarching themes covered by the assessment, and goes on to set out how it can be used throughout the project cycle. This is followed by a case study from Zambia.

**DEVELOPMENT**

ASPIRE is the result of an intensive two-year research, consultation and testing programme. The initial literature review and consultation process led the team to identify key qualities of sustainable, pro-poor infrastructure (see box below), which formed the basis for the development of the ASPIRE indicators. Further steps included analysis and comparison of existing frameworks for sustainability assessment created by groups including the UK Department for International Development (DFID), the Organisation for Economic Cooperation and Development (OECD) and the International Federation of Consulting Engineers (FIDIC), and testing of the first version on nine projects. Partner organisations for testing included the United Nations Office for Project Services (UNOPS), the Private Infrastructure Development Group (PIDG), the Red Cross and the University of Cape Town. Feedback from the testing was an important input into the development of the final version.

Four overarching themes were developed to structure the assessment, which are described in greater detail below:

**Institutions**

The comprehensive treatment of the institutional dimension is a key innovation of ASPIRE. Understanding and engaging with national and local institutions is increasingly recognised as a key element of successful development interventions, although it is also acknowledged to be challenging, particularly where project teams’ skill sets and objectives are focused on meeting technical and financial targets. Beyond simple engagement, working to build the capacity of institutions can leave lasting positive benefits. ASPIRE supports this through analysis under four headings – policy, government, skills and reporting.

**Environment**

Environmental degradation harms the poor disproportionately (OECD, 2006, *Promoting Pro-Poor Growth: Infrastructure, France, OECD*). ASPIRE treats the environment comprehensively, focusing on enhancing the positive, and minimising the negative impacts of infrastructure projects on natural assets – air,
land, water, biodiversity and materials. Energy is included as a sixth theme, recognising the increasing importance of renewable energy sources and energy efficiency.

**Society**
The impacts of infrastructure projects on society are often profound but, similarly to institutions, they are complex and difficult to engage with. ASPIRE supports team members by considering society in terms of project impacts on vulnerability, health, access to services, and culture. The programme also comprehensively treats stakeholder engagement, covering identification and analysis, consultation, participation and accountability. A sixth subject – population – considers issues such as conflict and displacement.

**Economics**
Economic sustainability entails considering the broad picture in terms of financial viability and macro-economic effects, but also analysing local level impacts on livelihoods and equity. ASPIRE covers these four topics, incorporating indicators on subjects such as risk management and carbon pricing (viability), inflation and competition (macro), local sourcing and employment creation (livelihoods) and affordability and land tenure (equity).

**ASPIRE THROUGHOUT THE PROJECT CYCLE**
ASPIRE was developed specifically to be used throughout the project cycle. Its most

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**Table 1 Key findings from Chyanyana Irrigation Project Assessment**

<table>
<thead>
<tr>
<th>Institutions</th>
<th>Economic</th>
</tr>
</thead>
<tbody>
<tr>
<td>The project performed well under institutions, as the appropriate local government, private sector and civil society structures are in place to ensure effective delivery of the project. However, due to the early stage of implementation, no comprehensive health and safety policy was in place. Also, comprehensive monitoring and evaluation systems still need to be established, as the current system is principally tracking financial performance.</td>
<td>Strengths include the integration of robust financial viability analysis since inception, detailed consideration of non-monetary costs and benefits, and that the project is a commercially managed operation with a &quot;for profit&quot; motive. Weaker performance in the Livelihoods theme is due to a potential negative distortion to the future local economy if there is increased immigration to the project area. This may result in increased demand for infrastructure, which has yet to be planned.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Environment</th>
<th>Society</th>
</tr>
</thead>
<tbody>
<tr>
<td>The project’s positive performance overall is due to initiatives such as the incorporation of renewable energy sources, and the development of a full Environmental Impact Assessment carried out to IFC (International Finance Corporation) standards and reviewed by local consultants. The Materials theme scored comparatively lower because the irrigation equipment needed for the project cannot be locally sourced in Zambia, although regional suppliers in South Africa have been selected.</td>
<td>Generally strong performance due to factors such as seeking to improve the food security and nutrition of beneficiaries, improving land tenure for beneficiaries, local stakeholders playing a key part in project decisions, the project being sensitive to socio-cultural issues, and gender equity being integrated into project institutions. Areas for improvement were identified in the Services theme, in particular the need to address communal meeting space and provide better transport links.</td>
</tr>
</tbody>
</table>
important contribution is likely to come in the early stages where the potential to add value to projects is highest. ASPIRE supports team members in considering a broad range of sustainability concerns while developing the project. However, ASPIRE is also designed to be used to monitor progress against objectives at several key stages to confirm that the design intent of a project is being consistently met, as a tool for regular stakeholder consultation, and for final evaluation and lesson-learning. Figure 2 sets out in detail how ASPIRE can be used at various stages of the project cycle.

**CASE STUDY: CHYANYANA IRRIGATION, ZAMBIA**

The ASPIRE assessment of the Chyanyana Irrigation Pilot Project was carried out at the Implementation stage of the project life cycle as a monitoring assessment. The project seeks to combine the land resources of smallholders into a commercially viable cooperative society in which farmers get access to irrigation, technical support and agronomy advice. The assessment was generally very positive, although it highlighted some areas for improvement. The keystone is shown in Figure 3, while Table 1 summarises some key findings.

**SUMMING UP**

ASPIRE goes beyond a mitigation of harm philosophy to support project teams to take a positive approach that recognises the contribution infrastructure projects can make to enhancing the environment, strengthening society and institutions, and acting as a catalyst for economic growth.

Two points frequently mentioned by those who have used and tested ASPIRE are that the programme:

- is more comprehensive than other available tools with similar aims, and
- enables organisations to ‘zoom out’ from technical focus to longer-term sustainability.

**INFO**

1. Lily Ryan-Collins – see contact details on first page of this article
2. A free trial version of ASPIRE can be downloaded from: http://www.oasys-software.com/products/sustainability/aspire/
3. ASPIRE is available free to educational organisations and at a subsidised rate to not-for-profit organisations
4. Arup – aspire@arup.com

**KEY FEATURES OF ASPIRE**

- Integrated evaluation of poverty and sustainability performance
- Includes an institutional dimension
- Applicable throughout the project life cycle
- Supports informed decision-making
- Clear graphical output
- Simple to use and understand
- Flexible, applicable to almost any type and scale of infrastructure, and can be used by a range of actors
INTRODUCTION

For the purposes of the presentation at the Engineering Planet Future Indaba, the future of project management was considered for only the next 15 years, but in this relatively short space of time there may be radical changes in the way projects are dealt with. The intent of this article is to encourage readers to think along alternative and unconventional lines whilst considering the projects they are currently working on.

The engineering and construction industry uses project management methodologies and tools extensively to expedite projects. Project management as a discipline is already used in a wide variety of industries, such as:

- Commerce – The banking industry uses project management techniques to deliver new products to their customers.
- Engineering – The highly projectised engineering industry uses project management techniques to deliver on process, civil, mechanical, electrical and mining engineering projects.
- Non-governmental sector – NGOs worldwide use project management techniques to deliver on health, education and other social needs projects.
- Information Technology – Of all industries, the information technology industry is the most advanced in terms of developing new techniques to suit business needs. With the PMBOK (Project Management Body of Knowledge) and PRINCE2 methodologies already well entrenched, use of Scrum, Agile and other techniques has enabled the complex and rapidly changing industry to deliver projects that look nothing like the original brief as scope changes are often rife.
- Event Management – From large scale sporting events to conferences, project management is used to combine the human resources aspects of these projects which are crucial to delivery within required parameters.
- Scientific, Medical, Academic and other technical research projects are used by teams of a variety of sizes to deliver to targets which are often commercially driven.

From a civil engineering point of view, project management is a comparatively young, exciting, complex and rapidly developing discipline, focused on execution. Innovations and techniques used in other industries can be brought to bear in civil engineering and construction projects. An example of the poaching of...
techniques by one industry from another is the adoption of PRINCE2 techniques by the construction industry since the late 1990s. PRINCE2 (or Projects IN Controlled Environments 2) was originally developed in 1996 from the original 1989 PRINCE methodology by the UK Office of Government Commerce to assist in the delivery of information technology projects.

Similarly, selected attributes of new methods of project procurement known as SMART acquisition, recently developed by the UK Ministry of Defence, may find their way into the local engineering and construction industry in the near future.

In considering the future of project management from a civil engineering point of view, the following questions are pertinent:

1. What innovations are we likely to see in the theory and practice of project management in the next ten to fifteen years?
2. How will efficiency of delivery be improved, and what will be the key elements of project management circa 2025?
3. Will project management as a discipline even exist, or will it have changed so much that it is unrecognisable?

Leading thinkers in the field of project management have the following to say:

“...project management will change progressively in response to the ... demands of a better informed and discerning public and an increasingly better educated work force.” (Max Wideman)

“...the future of PM is all over the map, will involve a variety of application scenarios, and will offer many of us opportunities to create positive change in the world.” (David Pells)

Currently, South Africa is estimated as being between five and seven years behind the most advanced nations in the field of project management in terms of proportion of population certified by recognised associations. Leading the charge are the United Kingdom, Canada, United States and Germany. South Africa ranks 10th after Italy, and is followed by China, Spain, India, Mexico and Russia. Figure 2 indicates projected certification in the field of project management across all industries over the next decade and a half.

So what can we expect over the coming years in this field? A cliché which is regularly heard is that the only constant is change, and project management concerns itself with managing change within a project environment.

This change is accelerating, with deadlines tighter, budgets smaller and quality expectations increasingly stringent. In 2025, then, we can expect our projects to require highly advanced, more integrated systems, fully utilising
information technology and other technological advancements. When considering how the project management landscape may look in fifteen years, the evolving global environment should also be considered, including:

- Cultural factors, e.g. sport events, and the logistical and infrastructure requirements for their delivery.
- Economic factors, e.g. the current and future recessions and their knock-on effects, including delays in the roll-out of new capital intensive projects.

The shift from reliance on fossil fuels to renewable energy and new forms of transport.

- Industrial development and increasing urbanisation.
- Political and social conditions, resource scarcity and their impact on development and human settlement patterns. How do you expect each of the above elements to change the type and methods of the projects you are working on over the coming decade and a half? Significantly or not at all?

Figure 3 outlines the nine project management knowledge areas according to PMBOK. Within each of these areas, changes in client requirements, stakeholder skill levels, available technology, overall project environments and the greater business environment will dramatically affect project delivery over the coming decades.

Internationally, governments in particular are embracing modern project management methods in order to achieve results faster and at lower cost. In the US, local, state-wide and federal governments use IT platforms to enable them to deliver fully integrated infrastructure projects which are transparent, easily monitored via public internet access, and which use systems and methodologies standardised for all tiers of government.

Project management in the public sector is especially pertinent to civil engineering locally. If public sector clients are able to use advanced methodologies to budget, track and implement capital projects, delivery of essential services to those that need them would be more effective.

“No institution [or large project] can possibly survive if it needs geniuses or supermen to manage it. It must be organised in such a way as to be able to get along under a leadership composed of average human beings.” (Peter Drucker)

Project management methodologies can be expected to become more ingrained in organisations, similar to the rapid integration of IT as a business tool. Volumes of available information will increase, technology and tools will change – and at the same time we can expect more technological literacy within the population. Hyper connectivity and the ability to work from home will become a reality. The popularity of Project Management Offices within the public sector according to need is increasing, and more interactivity and transparency for the public will be available.

Similarly, in the private sector, the use of project management methodologies to effectively deliver on business goals AS WELL AS project goals is an untapped area. A strategy, human resources or marketing initiative can be effectively treated as a project and all the tools of modern project management brought to bear in rolling it out.

Client involvement in projects is increasing, and in other industries clients already take an active role, for example in steering information technology projects,
managed using AGILE techniques. The use of an iterative, looping project cycle with regular revision of project scope according to client business and market demands, rather than a straight line, is likely to become reality in the engineering and construction industry.

**POSSIBLE DEVELOPMENTS: PROJECT TIME MANAGEMENT**

As noted previously, client involvement during execution of projects is expected to become more prevalent. As a result, collaborative methods of planning and scheduling, including real-time feedback to clients and incorporating changing business and market needs, are expected.

Time-saving technologies in projects will become more evident, through more effective communications, faster design and construction techniques, and more rapid initiation and planning phases.

The project cycle is expected to become even broader, taking a whole-life project view including broader planning, longer project horizons and using lifecycle costing techniques.

**POSSIBLE DEVELOPMENTS: PROJECT COST MANAGEMENT**

The use of multiple bottom-line reporting is already encouraged for all levels of business reporting according to the King III code published this year. Similarly, reporting using multiple parameters according to the priorities of different types of projects will become the norm.

Metrics such as the following will be used to determine the success of projects:
- Cost in human lives lost of mega-projects over capital expenditure.
- Cost in environmental impact and use of resources; if clean air or water are scarce enough, this also may be more relevant than monetary cost.
- The cost in long-term losses of access to resources, productivity or efficiency.
- Cost in living standards to the surrounding communities.
- Opportunity cost – the cost of doing something else or nothing at all will become benchmarks for KPIs on various types of projects.

**POSSIBLE DEVELOPMENTS: PROJECT QUALITY MANAGEMENT**

Highly developed systems for quality assurance and control are becoming commonplace. With larger and more complex projects bound to arise, a balance between ease of implementation and thoroughness of control will need to be struck.

Already quality management is often seen by many as onerous, and its effectiveness in limiting project cost and time overruns is not appreciated.

**NEW FRONTIERS FOR PROJECT MANAGEMENT**

Despite the significant developments in renewable and ecologically friendly sources of fuel, some estimates of coal reserves estimate there will be sufficient reserves for another 1 000 years. Even in 2035 renewable sources of fuel are expected to contribute only 14% of world energy usage. Coal and oil dependency will remain, with further investment in nuclear, hydro, and other renewable sources of energy.

Energy infrastructure projects over the coming decades will be heavily influenced by important trends:
- Strong growth in energy demand as populations expand and economic conditions improve, especially in developing countries.
- Security of supply concerns, as governments look for ways to source more of their countries’ energy from reliable local sources.
- Environmental issues, especially rising, worldwide concern about the possible causes and effects of global warming.

The future of energy-related projects will be determined largely by the world’s success in balancing these trends. Similarly, resource-related infrastructure projects – specifically water and mining projects – will remain at the forefront of project management in the civil engineering and construction industry.

**TECHNOLOGY AND SYSTEMS**

In terms of project controls and the use of systems, an increased number of more complex unknowns will mean an increased focus on risk management techniques. This will require an in-depth understanding and mitigation of business, economic, environmental and social risks.

New tools and continuing improvements to existing practices are expected. For example, the new ISO international standard for project management is in development, risk and information management tools are being improved and integrated with information technology, and new software and improvements on existing software will be available.

The use of tele-conferencing will increase and technology has enabled "virtual teams" to play a large part in project delivery. The technology required for these, including tele-conferencing, IT and global communications is improving rapidly.

Changes in project controls and management systems, as well as IT tools, are ongoing and the systems and software being used in 2025 will be unrecognisable to those we use today. As evidence of this consider the types of software in use 15 years ago – Windows 95 and Internet Explorer 2.0 released, Doom and Quake computer games released, MSProject v4 released, Primavera Enterprise v3.0 released, and then consider that Moore’s Law claims that the rate of change of computing power is doubling every two years, i.e. the rate of change exponential.

This points to a dramatically different computer and software landscape in 2025.

**NON-TECHNICAL DEVELOPMENTS**

Skills and capacity shortages worldwide, and the dearth of skills in South Africa,
will force project managers to develop new and innovative ways of delivering on their commitments, and South Africa may be forced to move from labour-intensive methods to technology-intensive methods. The need for project teams to achieve improvements in productivity and efficiency improvement will also drive the move towards technology-intensive project methods.

Global growth and interconnectedness is still a factor in many projects, with critical components either designed or imported outside the project country. Already many project stakeholders are not based in the country of the project. The drawbacks to the large movement toward globalisation of the world economy since the 1990s have been exposed via worldwide banking and financial crises, and increased disparity between rich and poor nations. Despite this, project teams will remain dispersed, and project managers will find themselves in a wider range of countries in the course of their work.

With more complex projects and greater protection of workers and consumer rights, an increase in regulations and laws will probably result. The South African legal framework governing project execution may be in place, but the adherence to and policing of these laws and acts are not always adequate. This should improve over the coming decades.

Evidence of contractor specialisation can already be seen in developed economies, where smaller contractors identify a niche and focus only on this, for example rehabilitation of historical structures or construction of water treatment plants. As the South African economy matures and becomes more competitive, this trend is likely to become evident.

Business strategies of client and contracting organisations will adapt. Client business and project strategy trends will result in new ways of allocating risk and will result in changes in contracting strategies.

What do YOU expect will change?

NOTE
The list of references is available from the editor.
Vital tools for effective project management in the modern construction environment

Project management is essentially the management of risk. Some risks we know will occur, some are likely to occur and some are unlikely to occur. This article discusses risk identification and management, and the tools that are available for this purpose.

WHEN WE MANAGE projects we are managing risk.

There is a popular misconception that risks are possible or probable events that have yet to occur. In fact, all aspects of projects contain risk. Let us use the example of concrete. The cost of procuring materials to make concrete is a risk. Maybe the supplier will require a different price for his materials than we have allowed in the budget. Maybe his plant breaks down and we have to use an alternative supplier. The labour necessary to mix and place the concrete is also a risk. Assumptions have been made about what the employment cost would be. Assumptions have also been made about what the productivity would be to mix and place the concrete. If these assumptions prove to be wrong, we are at risk of the contract costing more and/or taking longer to complete.

So what we have in fact are risks that are occurring or threatening to occur all the time by virtue of simply carrying out the work.

We manage these risks (material supply and labour) by entering into formal contracts with our suppliers and sub-contractors and formalising our wage structures directly with our labour force or with the unions. This wage agreement may also deal with matters such as absenteeism and productivity.

Because we do not rationalise what it is we are doing and why we are doing these things, like buying materials or employing labour, we very often do not allocate the priority to these functions that they deserve. For example, most construction projects operate on purchase orders even when entering into agreements with sub-contractors. This can have disastrous consequences.

Purchase orders provide little protection and contain insufficient risk management facilities for anything but the most simple of purchases.

Careful consideration therefore needs to be given when placing purchase orders for critical supply items, and a hybrid purchase/sub-contract agreement must be developed to ensure that such aspects as performance and quality are adequately addressed in important supply contracts.

Other risks may have less certainty of occurring.

We need to identify at the outset of a project what these might be, what the likelihood of their occurring is, and what their potential impact would be. Risks that have little likelihood of occurring and/or which have a small potential impact should be ignored. Risks that are likely to occur and which have a relatively high impact (cost or delay) need to be managed. We need to put measures in place to identify when the risk begins to manifest itself. (Sometimes this will be obvious, like for example ground water; at other times we may need to measure trends, like for instance traffic intensity). We then need to have already devised a response to the risk. For example, we have stand-by pumps available to handle increased ground water, or temporary traffic lights to manage increased traffic flows. By anticipating what risks we need to manage (both the risks that we know will occur, as well as the risks which we think may occur) we empower the project implementation team to manage all eventualities on a project. This is particularly important in an environment like South Africa where skills are at a premium and where there is high likelihood of project staff being less experienced than would be optimal.

So much of what we do is simply part of our day to day operation (“standard procedures”) that we do not appreciate how important these are and why we are doing them.

Generally speaking, when we manage contracts, time risks are addressed because we are forced by the terms of the contract to compile a programme. In practice, however, programming procedures employed on most contracts fall far short of what should be done to properly manage the time risks, the resource...
levels and the productivity either to be achieved or actually achieved. It is a fact that whenever a contract gets into trouble, deficiencies in the programme will be found.

Similarly, most contractors have some system of cost reporting where they compare their revenue earned with the costs that they have incurred. In reality, however, these cost reporting exercises are for the benefit of the accountants at head office and are of little or no assistance to the site team in managing their contracts.

Invariably, the cost breakdown structure and the work breakdown structure do not talk to one another, and this is another major deficiency in the effective management of projects.

The tools available to us to effectively manage our contracts are (these are the building blocks of the project):

- the programme
- the budget
- the specification
- the commercial terms of the contract

We will see that the commercial terms of the contract stipulate the payment entitlement and procedures, the time requirements of the contract and the quality requirements and procedures. The commercial terms are therefore effectively the mortar that binds the whole together.

In project management terms these tools (the building blocks) are used to manage and implement the other aspects of the project management process, namely integration, scope, human resources, communication and procurement management.

Each of these functions has its own discrete risks, as we have seen from the discussion above.

So the process to be followed is to identify the risks that will occur and decide how these are going to be managed. Examples are key material supplies and high risk sub-contracts (like geotechnical works). Having decided to pass a risk on to another specialist contractor (like in the example above, a geotechnical contractor), it is vital that appropriate contract documentation is utilised and that proper records are kept of the risks as they arise and the impact that they have on the cost and time of doing the work. Invariably, specialist sub-contractors are left to their own devices and records are incomplete or not kept at all.

Each risk has to be assessed in terms of the four building blocks of the contract with regard to cost, time, quality and commercial impact, and the implementation plan for the project developed, taking each of these requirements into account.

Risk management is not confined to the physical implementation of the project, but also embraces commercial requirements like notices (both conditions precedent to making claims for time and cost recovery, preservation of the contractor’s right to make a claim once it has been earned and avoiding falling foul of time bar provisions), as well as record-keeping. We should make sure that the records that are kept are in relation to the risks that we have identified.

The construction industry is often criticised for commencing with project implementation far too early in the project cycle at a time when scope is ill-defined and the design is still in an embryonic state. Criticism should also be levelled at contractors, engineers and project managers who do not adequately plan the work to be carried out. Planning is generally confined to the contract requirements, usually a critical path network instead of a comprehensive risk analysis and response plan. Our projects are the poorer for this shortcoming.
The cause of failure of the Massingir Dam – lessons to be learned for designers of reinforced concrete pressure conduits or penstocks

INTRODUCTION AND BACKGROUND
Massingir Dam in Mozambique has a maximum height of 48 m and a gross storage capacity of 2,900 million m³. Completed in 1977, the dam is owned by the Government of Mozambique and administered by Administração Regional De Águas Do Sul (ARA-Sul).

On 22 May 2008 there was a massive bursting failure of the two 8 m x 8 m horseshoe-shaped reinforced concrete conduits that comprise the outlet structure of the Bottom Outlet Works. Prior to the failure, the two downstream radial gates were closed and the reservoir water level was at 122.4 m, which is 7.4 m above the level of the gated spillway sill. Because the spillway gates had only been installed a few years earlier, the hydrostatic pressure in the conduits was then the highest that it had ever been in the life of the dam.

In October 2008 a contractor was appointed to demolish all loose and cracked concrete, and to remove rubble and reinforcement. This work continued well into 2009.

Aurecon was appointed by ARA-Sul to investigate and report on the cause of the failure, and a detailed report was duly submitted in May 2009. This article is an abridgement of that report.

Figures 1 and 2 show the layout of the Massingir Dam Bottom Outlet Works with the area of the failure indicated. Figures 3 to 8 show different views of the outlet structure before and after the failure.

STRUCTURAL ANALYSES
Detailed structural analyses were carried out for conditions just prior to the failure in order to determine the stresses.
The cause of failure of the Massingir Dam Bottom Outlet Works – lessons to be learned for designers of reinforced concrete pressure conduits or penstocks

in the concrete and reinforcement at that time. Several different sections were analysed using 2-D plain strain finite element analyses and the programme "PROKON PS" (Reference 7). Stresses in the reinforcement were calculated on the assumption of the concrete having zero tensile strength. Hydrostatic pore pressures within the concrete were taken into account and this concept is discussed under the heading "Hydrostatic pore pressures within the concrete" later in this article. Two dimensional analyses in the cross sectional direction were considered appropriate for this investigation, as it was clear that the predominant structural action was hoop tension.

The analyses showed that the maximum tensile stress in the reinforcement was 183 MPa and that generally the tensile stress did not exceed 150 MPa. Comparing these values with the yield strength of the reinforcement at 235 MPa indicates that the reinforcement was not overstressed at the time of failure, even on the basis of water retaining code design. Pull-out punching shear stress in the cover concrete under the main reinforcing bars was found to be 0.91 MPa at one point and this was considered to be excessive. Elsewhere this stress did not exceed 0.56 MPa. For the calculation of this stress it was assumed that hydrostatic pore pressure had penetrated the concrete to the depth of the reinforcement. This was considered likely, because cover concrete is usually more porous than the main concrete, and because micro-cracking could well have extended to this depth.
ORIGINAL STRUCTURAL DESIGN
A basic finite element analysis was carried out by the designers of the project in 1969. The only cross section analysed was the one with three conduits together upstream of the outlet structure. This showed all the tensile stress on the inside faces of the conduits and this is presumably why all the main tensile reinforcement was placed on the curved inside faces. No analysis was done for the two conduits in the failed area of the outlet structure.

TESTS ON MATERIALS
Tests on 150 mm diameter concrete core samples and lengths of 40 mm diameter reinforcing bars were carried out by the Laboratorio de Engenharia de Moçambique. These tests showed that:
- The concrete was sound and hard with a compressive strength at failure of 40 MPa.
- The concrete tensile (splitting) strength at failure was 2.3 MPa.
- The average density of the concrete was 2400 kg/m³.
- Quantities of sulphates and chlorides were very low.
- No alkali aggregate reaction potential was detected.
- The tensile strength of the reinforcement was found to comply with stress grade 235 NL, i.e. round mild steel bars with a minimum yield strength of 235 MPa.

INSPECTIONS AND OBSERVATIONS ON SITE
Various inspections were carried out on site with the specific purpose of establishing the extent and mechanism of the failure and the soundness of the remaining concrete structures. Numerous photographs were taken and a few are reproduced here. The main observations were as follows:
- The concrete appeared to be sound and hard, as witnessed by the amount of effort required by the demolition contractor to break it.
- Over the entire length of the failure, the main tensile reinforcement consisted of 40 mm diameter round mild steel bars at 150 mm centres. Longitudinal...
reinforcement was generally 20 mm diameter round steel bars at 150 mm centres and there were no shear links. This is all exactly in accordance with the construction drawings.

The 40 mm diameter reinforcing bars were mangled but generally not fractured and there was extensive removal of the cover concrete caused by the peeling off (tearing out) of the main tensile reinforcement from the inside faces. This was widespread in the failed area as can be seen in the photographs.

In both conduits the steel-lined section downstream of the failed area is generally in excellent condition. However, at its upstream end there is some serious cracking of the concrete surround and some short cracks in the steel liner at the top corners.

THE CAUSE OF THE FAILURE
The cause of the failure of the Outlet Structure of the Massingir Dam Bottom Outlet Works is considered to be deficient reinforcement detailing.

In the light of the investigations that were carried out, it is considered that the structure failed due to the main tensile reinforcement pulling out of the concrete (or the concrete pulling away from the reinforcement) on the curved inside surfaces of the structure. This was evidenced on site by the extensive amount of reinforcement that had been peeled off, but not fractured, and the many concrete surfaces with the cover concrete gone and from which the reinforcement had been removed (see photographs).

It appears that the design did not take account of hydrostatic pore pressures acting within the concrete walls and top sections of the conduits (see discussion below under “Hydrostatic pore pressures within the concrete”). It is also apparent that the designers did not realise that in time these pressures could act behind the line of the reinforcement and not at the inside faces of the concrete. This led to the detailing of the main tensile reinforcement as curved bars on the inside curved surfaces of the structure where it would tend to pull out under load.

It is significant that the failure occurred some six hours after the right-hand downstream radial gate had been closed. Clearly this was the time taken for the full hydrostatic pressure to penetrate...
micro-cracks, joints and pores in the concrete until stresses became excessive and the failure was triggered.

As had been indicated by the test results (see discussion above under “Inspections and observations on site”), the quality of the concrete and reinforcement was found to be good and is not considered to be a contributory cause of the failure.

**REINFORCEMENT DETAILING DEFICIENCIES**

Figure 9(a) shows the original reinforcement details of the outlet structure at Section A-A. The limited space available for this article prevents the inclusion of further sections. From all observations on site subsequent to the failure, the reinforcement was fixed exactly in accordance with these details.

The deficiencies identified in the detailing are:

- That the main tensile reinforcement was curved and placed on the inside curved surfaces of the structure where it would tend to pull out of the concrete under load.
- That in the central wall, these curved bars were the only "vertical" reinforcement.
- That no shear links were provided.

Figure 9(b) shows a preferred, with hindsight, reinforcement arrangement for Section A-A. In this section the main tensile reinforcement has been shown as straight bars crossing over and being well tied back into the concrete to prevent pull-out on curved surfaces. Some shear links have been indicated.

**THE TRIGGER TO THE FAILURE**

Deficient reinforcement detailing has been identified as the cause of the failure of the structure, and the mechanism of the failure has been identified as the main tensile reinforcement pulling out of the concrete on the curved inside faces. It is also apparent that once a failure started in a small “trigger” area that a progressive failure would have occurred very rapidly. Thus the actual trigger that started the failure is of lesser importance than the underlying cause. One possible trigger mechanism is illustrated in Figure 10.

**HYDROSTATIC PORE PRESSURES WITHIN THE CONCRETE**

It is the author’s opinion that hydrostatic pore pressures within the concrete should be taken into account in the design of certain water retaining structures and this concept is illustrated in Figure 11. The effects of pore pressures within the concrete will be significant in thick-walled, relatively small diameter reinforced concrete structures subjected to high pressures for long periods, such as the Massingir Dam Bottom Outlet Works, and it is in this type of structure where this concept should be applied. In thin-walled large diameter structures such as reservoirs, the effects of pore pressures within the concrete are likely to be insignificant.

The main justification for this concept is that this is exactly what is done in concrete dam design. See Reference 1: Section 8, Concrete Gravity Dams, Sub-Section 8.10, Internal Water Pressures, (a) Basic Considerations, and Reference 2: Chapter 3, Design Data and Criteria, Section D-Loads, Sub-Section 3-8. Internal Hydrostatic Pressure. Similar descriptions are given in Reference 3, Section 16, Gravity Dam Design, Internal Water Pressure, and Section 19, Concrete Dam Performance, Drainage, Basic Considerations. It is reasoned that the conduits of the Bottom Outlet Works at Massingir Dam are essentially an extension of the dam in that they are required to contain the same water pressure as the dam.

In dam design there is some controversy about the magnitude of the internal...
pore pressures within the concrete. See Reference 4. Also, readers may be sceptical about this concept on the basis that, although all concrete is porous to some extent, intact concrete is relatively impermeable. However, joints, cracks and microcracks do occur in hardened concrete and the concept of water pressure developing within these flaws is quite comprehensible.

Taking account of hydrostatic pore pressures within the concrete will always result in a more conservatively designed water retaining structure. Also, if a construction joint or a crack that allows the ingress of water pressure should exist, the resulting additional stress in the structure will be catered for.

In spite of carrying out a literature search, no other references to the need to apply hydrostatic pore pressures within the concrete have been found. Instead, all references related to the design of water retaining structures indicate that the hydrostatic pressure should be applied at the face of the concrete. However, Reference 5 clearly states that "this code does not cover dams, pipes, pipelines".

LESSONS TO BE LEARNED FOR DESIGNERS OF REINFORCED CONCRETE PRESSURE CONDUITS OR PENSTOCKS

- If the main tensile reinforcement is to be near circular, sufficient steel to carry the full ring tension should be placed on the outside face. This is in spite of the fact that a finite element analysis of the section may show that the main tensile stresses are at the inside face.
- If the main tensile reinforcement is to be placed near the inside face, the bars should have full cross-overs and anchorages as recommended in Figure 9(b).
- Adequate shear links should be provided.
- Pore pressures within the concrete should be taken into account in the design of the section and its reinforcement, as discussed above under "Hydrostatic pore pressures within the concrete" and illustrated in Figure 11. This can be simply done by first designing the reinforcement on the basis of the water pressure applied at the inside face. The quantity of reinforcement should then be increased to allow for the additional force at any long section assuming hydrostatic pore pressures within the concrete.

REHABILITATION

Rehabilitation of the Massingir Dam Bottom Outlet Works will be accomplished by the installation of 6.4 m diameter steel liners in both of the outlet conduits. These will be encased in concrete and will extend from the upstream side of the dam’s core to within the existing steel-lined section at the outlet structure.

ACKNOWLEDGEMENT

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REFERENCES

INTRODUCTION

Lynnwood Junction is a multi-million rand investment which comprises an upmarket shopping complex, office park and hotel. The new development is located on the north-eastern side of the Lynnwood Road offramp off the N1 highway in Pretoria. Many challenges were encountered during the design and construction of this development. These challenges included problems posed by the construction of the new Lynnwood Road interchange, as well as Meiring Naude Road running along the western side of the site. This project required an excavation of about 12.5 m from original ground level in some sections of the site. In addition to this, Meiring Naude Road had to be raised, which required the construction of a SANRAL retaining wall along this section of the excavation. Figure 1 shows the site during the excavation phase of the project.

The site during the excavation phase
LATERAL SUPPORT

The depth of the excavation ranged from 12.5 m in the south-western corner to 7.6 m in the north-western corner of the site. Both the western and southern faces required geotechnical input to ensure that slope failure did not occur. For the southern slope there were very few constraints, as far as available space was concerned, and therefore it was possible to batter the slopes back to a safe slope angle. A slope angle of 60˚ was used to ensure that a factor of safety of approximately 1.3 for a temporary slope was achieved.

Battering of the western slope was not possible due to the position of the SANRAL retaining wall and the lack of space at the bottom of the excavation. The SANRAL retaining wall was located some 2.5 m from the face of the excavation in some sections and imposed loads of between 201 and 136 kPa. A further problem was the depth at which the retaining wall was founded below the top of the excavation (approximately 2 m). This meant that no (or very short) soil nails could be used in the first 2 m of the excavation. Figure 2 shows a typical section that was analysed.

The shear strength parameters of the in situ materials were back-calculated from information obtained during the initial field investigation and then used in the analysis of the sections. The problem was analysed using both Prokon’s RockPF and Rocscience Phase2 finite element software. The following parameters were used in the analyses:
- \( c = 18 \text{ kPa} \)
- \( \phi = 25^\circ \)
- \( \gamma = 17 \text{ kN/m}^3 \)

Critical sections of the slope were identified and analysed taking into consideration the magnitude and position of the loads applied by the SANRAL retaining wall. The force required to prevent a failure occurring was compared with the maximum force that could be obtained with the use of Y25 soil nails. The force...
required was found to be greater than the force that could be generated by Y25 soil nails at 1.5 m centres, and thus, to compensate, the spacing was reduced to 1.0 m. Even with the reduced vertical spacing, some sections still required marginally more resisting force than could be generated by Y25 soil nails. The use of multi-strand anchors was therefore required. In the sections where excessively high forces were needed, some of the rows of soil nails were replaced with multi-strand anchors. The anchors comprise fixed and free length – the fixed length is found at the end of the anchor and is grouted into the soil/rock such that tension in the strands can be transferred into the surrounding material, while the free length of the anchor is not grouted, which enables the tension of the anchors to be adjusted as required after installation. For this design, both three and four strand anchors were used. Each strand is made up of a 15.2 mm diameter, low-relaxation 7-wire strand, and each strand can be tensioned individually to the required tension up to a maximum of 175 kN. Figure 3 shows a schematic drawing of the anchor.

The results of the Prokon analysis revealed that a minimum force of 1 105 kN was required to generate an acceptable factor of safety of at least 1.3. Figure 4 shows a model that was analysed in the Phase2 finite element analysis program. Phase2 calculates a strength reduction factor which is the equivalent of a factor of safety. Figure 5 shows the results of the finite element analysis of a critical section which had been analysed. This layout generates a maximum resisting force of 1 865 kN and generates a predicted factor of safety of 1.55.

An advantage of a finite element model is its ability to predict movements that will occur. Not only were all sections checked for their respective factors of safety, but also for the expected horizontal movements. The finite element model in Phase2 predicted a maximum horizontal movement of 33.5 mm. The western wall of the lateral support was surveyed on a bi-weekly basis and the results were recorded. The maximum recorded movement that occurred on the western face of the excavation was
32 mm. Figure 6 shows the displacements obtained in the finite element model.

CONCLUSION

Both limiting equilibrium and finite element analyses were used in the design of this challenging project. Appropriate resisting forces using soil nails and a combination of soil nails and anchors, appear to have been correctly assigned, with monitoring results indicating near-perfect fit with predicted values.

ACKNOWLEDGEMENTS

The permission of Dekker and Gelderblom, and Atterbury, to publish this article is acknowledged with thanks.
Stone column construction at O.R. Tambo International Airport’s Midfield Terminal Development

WITH GAUTENG BEING the business hub of Africa, the O.R. Tambo International Airport constantly needs to be upgraded and developed to meet the demands of increasing air traffic.

The Midfield Terminal Development is an attempt to utilise as much of the space still available within the current airport boundaries. Midfield Terminal Apron Phase 1, which forms part of this development, needs to be built in an area underlain by weak alluvium along the Blaawpan Spruit, and the development of the site involves constructing a 6-8 m high embankment.

GEOTECHNICAL CONDITIONS

Findings

From the geotechnical investigation three different zones were identified (Figure 1):

- The ferricrete area which is underlain by hardpan ferricrete at a depth of about 500 mm, with clayey gravel overlying it.
- The swampy area which comprises the area within the reeds along the Blaawpan Spruit and is characterised as very soft, organic clays overlying alluvial clays to a depth of between 5 and 8 m.
- The clay/seepage area which lies between the ferricrete and the swampy areas. In this area the ferricrete is not well developed and is underlain by soft clays.

From Piezocone penetrometer tests (CPTU) performed during the investigation, the E modulus values of the in situ material were as follows:

- $E = 6 \text{ MPa}$ in the ferricrete area
- $E = 2 \text{ MPa}$ in the seepage area
- $E < 2 \text{ MPa}$ within the swampy area
An 8 m fill with an estimated density of say 20 kN/m³ results in a max load of 160 kN/m². Considering the above modulus values and load, the deflection of the fill was estimated to be between 130 mm and 400 mm for the seepage and swampy areas respectively, taking four to five years to occur.

Solution
It was postulated that the best way to combat this range of deflections and extended time period would be to install stone columns to an approximate depth of 5 m at 3.5 m centres. These columns would be overlaid with a high strength geosynthetic and then a blinding platform of 1.5 m thick G6 quality material. The embankment would then be constructed by conventional means. Due to horizontal compaction which takes place, installing stone columns not only provides vertical resistance, but strengthens the in situ materials enabling them to carry the imposed load at reduced settlement. The stone columns also provide an additional drainage path to speed up the dissipation of pore pressures, and thus the settlement time.

Analysis
An analysis was performed with the situation idealised as a piled raft foundation with the stone columns acting as piles and the reinforced upper layer acting as the raft. From prior research (Du Preez et al 2001) the stone column stiffness could be estimated at about 40 MPa. From the analysis, deflections were estimated to be reduced to between 100 mm and 200 mm for the seepage and swampy areas respectively, with the settlements very evenly spread over the site. The main advantage of installing the stone columns, however, is the time needed for settlement to occur. It was estimated that most of the settlement would have occurred some eight months after loading. As construction of the embankment was expected to take more than a year, most of the predicted settlement would therefore have taken place by completion of the embankment.
CONSTRUCTION

Stone columns were specified to have E-values of at least 50 MPa. It was calculated that approximately 15 blows of a 12.5 t pounder falling through 18 m would be required for the task in this Dynamic Compaction (DC) operation. During stone column installation, however, excessive bulking was observed on the surface after 15 blows with the 12.5 t pounder. It is believed that the stone column started to refuse on stiffer clays after about 10 blows, causing the clay to push upwards, resulting in the bulking at the surface. The number of blows necessary was therefore revised and hand calculations and plate load tests confirmed that only 10 blows would be necessary to obtain the specified 50 MPa. Figure 2 shows the dynamic compaction operation.

ALTERNATIVE CONSTRUCTION METHOD

It was suggested by the contractor that a number of the columns in the seepage area be constructed utilising a 12 t Rapid Impact Compaction (RIC) rig (Figure 3) since the in situ clay in these areas is much stiffer than the clay in the swampy areas. To confirm whether the stone columns could be constructed utilising the 12 t RIC machine, trial columns were constructed to determine the depth and integrity thereof.

The RIC machine makes use of hydraulics to deliver blows with much less energy than those applied by dynamic compaction, as the pounder is not dropped from as high. Many more blows are required to drive the rock about 1 m into the ground. This is called one pass. Blows required per pass range from about 20 to 35. From the trials it was determined that the columns, constructed utilising the 12 t RIC machine, were of a very good quality and that the RIC machine could be used for the construction of the stone columns, utilising eight passes.

QUALITY AND PERFORMANCE OF STONE COLUMNS

Plate load tests

Several plate load tests were performed in order to verify that the design requirements of $E = 50$ MPa were obtained for the constructed stone columns. Using the elasticity theory for the settlement of a rigid circular plate presented by Poulos and Davis (1974), the data collected during the plate load tests were used to calculate the E-value for a stress increment of 0-250 kPa. The 0-250 kPa stress increment was used, as the 160 kPa load induced by 8 m fill falls within this range.

Table 1 summarises all the plate load tests conducted during construction. Only one column did not achieve the envisaged E-value of 50 MPa with $E = 48$ MPa. The tests that were done during the dry season had significantly higher E-values than the tests done in the rainy season. The data presented in the table also confirmed the use of the 12 t RIC machine for stone column construction.

A test that was done in the centre of four columns where no compaction had been done, yielded an E-value of 14 MPa. When considering the maximum E-value of 6 MPa that had been determined

<table>
<thead>
<tr>
<th>DATE OF TEST</th>
<th>WET OR DRY SEASON</th>
<th>STONE COLUMN LOCATION</th>
<th>METHOD USED</th>
<th>NUMBER OF PASSES OR BLOWS</th>
<th>POULOS &amp; DAVIS E-VALUE (MPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008/11/26</td>
<td>Wet</td>
<td>K5</td>
<td>DC</td>
<td>15 blows</td>
<td>57</td>
</tr>
<tr>
<td>2008/11/26</td>
<td>Wet</td>
<td>K5</td>
<td>DC</td>
<td>10 blows</td>
<td>48</td>
</tr>
<tr>
<td>2008/12/04</td>
<td>Wet</td>
<td>K5</td>
<td>DC</td>
<td>15 blows</td>
<td>65</td>
</tr>
<tr>
<td>2008/12/04</td>
<td>Wet</td>
<td>K5</td>
<td>DC</td>
<td>10 blows</td>
<td>52</td>
</tr>
<tr>
<td>2009/05/14</td>
<td>Wet</td>
<td>E1</td>
<td>RIC 12</td>
<td>8 passes</td>
<td>57</td>
</tr>
<tr>
<td>2009/05/14</td>
<td>Wet</td>
<td>E2</td>
<td>RIC 12</td>
<td>8 passes</td>
<td>51</td>
</tr>
<tr>
<td>2009/07/28</td>
<td>Dry</td>
<td>M3</td>
<td>RIC 12</td>
<td>8 passes</td>
<td>93</td>
</tr>
<tr>
<td>2009/07/30</td>
<td>Dry</td>
<td>D2</td>
<td>Between columns</td>
<td>8 passes</td>
<td>156</td>
</tr>
<tr>
<td>2009/07/30</td>
<td>Dry</td>
<td>D2</td>
<td>Between columns</td>
<td>14</td>
<td></td>
</tr>
</tbody>
</table>
during the 2007 investigation, one can see that there is an increase of at least 8 MPa in the stiffness of the material between the columns. This is most probably due to horizontal densification which takes place on compaction of the columns.

Column Excavations

Several stone columns were exposed during the construction process, in order to determine whether their integrity and depth-reach were appropriate. This was also done to confirm the adequacy of the 12 t RIC method.

Table 2 shows the depths of the stone columns that were excavated. All of the excavated columns appeared to refuse on the stiff underlying clays. Although the stone columns did not reach the specified depth of 5 m, they were adjudged in all likelihood sufficient to achieve the envisaged requirements.

It was found that the stone columns that had been constructed utilising the RIC machine were of better quality than the stone columns constructed utilising the DC machine, as more intact rock was present at the bottom of the stone columns in the case of the RIC. It is surmised that crushing of the stone occurred during the high energy DC operation.

Trial area

A trial area was constructed in order to verify the time required for the settlements to occur. The trial area consisted of a fill of approximately 8 m high, complete with piezometers and measuring plates.

The piezometers were installed to monitor the dissipation of excess pore water pressures, created by the constructed fill, which is an indication of the consolidation of the material. The consolidation of the material is complete when all excess pore pressures have dissipated. After this, secondary compression (creep) will take place at a gradually decreasing rate.

The measuring plates were installed at the bottom of the fill to ensure that the recorded values are indicative of the settlements of the clay layer. 200 mm uPVC pipes were installed through the 8 m fill at each measuring plate enabling measurements to be taken by placing a rod down the pipe to the measuring plate to survey the height of the plate.

The construction of the fill took about 3 months (end April 2009 to end July 2009). Due to unforeseen
circumstances, measurements could not be taken during this period and the first settlement and piezometer readings were subsequently only taken in August, after all construction had been completed. Further readings were then taken on a regular basis thereafter.

The consolidation process had already started during the construction period due to the load applied by the gradually increasing height of the fill, hence three months of consolidation had already taken place by the time the first measurements were done in August.

Figure 4 shows the settlement against time for each of the measuring plates from August. No settlement occurred from middle October to middle November, which seemed to indicate that consolidation had probably been completed, only six months after the start of construction. The 2007 investigation had predicted that most settlements would occur within eight months from the start of the construction period. Settlements between 5 and 9 mm were observed during the three months of measurements, indicating that most of the settlement had taken place during the construction period.

Figure 5 shows the piezometer readings that were taken after the completion of the fill area. All piezometers, with the exception of piezometers 4 and 5, showed a decrease over the first month and a half of measurements, after which time the readings remained fairly constant. This indicates that all excess pore pressures were probably dissipated five months after construction of the fill had started, indicating that consolidation of the clay layer is complete.

From the piezometer and measuring plate results it is postulated that stone columns within the trial area are performing as had been envisaged. As the trial area is set up in the swampy area, which is the most critical area, it is assumed that the stone columns over the rest of the site will also perform as envisaged.

NOTE

The list of references is available from the editor.

From the piezometer and measuring plate results it is postulated that stone columns within the trial area are performing as had been envisaged. As the trial area is set up in the swampy area, which is the most critical area, it is assumed that the stone columns over the rest of the site will also perform as envisaged.

PROJECT TEAM

Client Airports Company South Africa (ACSA)
Contractor RAS JV with specialist subcontractors RIC Africa for the construction of the stone columns
Consultants PDNA with the geotechnical investigation done by Vela VKE and specialist input from ARQ
INTRODUCTION
ARQ Consulting Engineers have built a trusting relationship with a Windhoek laboratory and a number of Namibian engineering consultancies over the past two decades. The past 20 years have seen Namibia develop into a dynamic and self-sustaining country. The extensive growth of their infrastructure and mining sector has provided a gap for South African geotechnical engineers to play a part in this boom.

This article briefly describes four projects recently completed by ARQ in Namibia, illustrating the role geotechnical engineers can play in the development of neighbouring countries.

PROJECT 1 – 50 MW POWER STATION IN WALVIS BAY
ARQ was awarded the contract to conduct a geotechnical investigation for a new 50 MW diesel generator power station in Walvis Bay.

Due to the dynamic nature of loading induced by the diesel generators, extensive testing was done on the site:
- Core drilling to a minimum depth of 21 m (with Standard Penetration Tests every 1.5 m)
- Dynamic Probe Super Heavy Tests (DPSH)
- Electrical resistivity survey
- Piezocone testing (CPTu)
- Continuous Surface Wave testing (CSW)

Core logging indicated that the site is underlain by a deep-seated layer of fine to medium-grained sand of the Namib Desert. The water table was found to be on average 1.0 m from the surface.

The piezocone and CSW test results revealed very dense layers (cemented sand) interspersed alternately with loose areas. This necessitated numerous attempts to obtain deep penetration of the piezocone. Only two successes were achieved.

The CSW test results obtained were very consistent with $G_u$ modulus (shear stiffness) values generally in the range 20-60 MPa over the top 5 m, 50-300 MPa over the next 5 m and 100-600 MPa from 10 to 15 m.
Piled foundations were recommended for the founding of the vibrating power generating unit. Continuous flight auger piles (CFA), using concrete instead of grout, were adjudged to be the most cost-effective, but vibrating equipment would be necessary for full depth pile steel installation, due to seismic excitation at the site.

**PROJECT 2 – RUACANA HYDRO POWER STATION**

The Ruacana Scheme was initiated by SWAWEK (Suidwes-Afrika Water en Elektrisiteit Koöperasie / South West African Water and Electricity Corporation) in 1973, with construction of the power station completed in 1978.

The scheme essentially comprises the regulation of water from the Kunene River in northern Namibia by means of a series of dams and a diversion weir. From this weir, which is situated in Angolan territory, part of the flow is channelled utilising a 1 500 m long pressure tunnel to a surge head bay on top of the mountain.

From here the water drops nearly 134 m down vertical shafts into the heart of the mountain, where it is used to drive three turbines. Each of these turbines has the capacity to generate 80 MW, thus totalling 240 MW. This is then transformed from 11 kV to 330 kV and fed into the Namibian power grid. Today the Ruacana hydro power station still forms the core of Namibia’s power supply system.

ARQ was approached by Namibia Technical Services (NTS), who in turn had been approached by Aurecon Namibia (formerly Africon Namibia), to conduct a geotechnical investigation for the construction of a maintenance shed at the foot of the mountain. The existing three turbines used to be serviced in a fourth turbine chamber, but plans are to extend the capacity of the plant by adding a fourth 80 MW turbine, thus necessitating an external turbine maintenance facility.

According to the available geological maps of Namibia, the geology of the area comprises porphyroblastic gneiss.
with intercalated schist material. The majority of the test pits excavated did, however, indicate a deep fill horizon consisting mainly of very loose to loose sandy gravel with gneiss and conglomerate cobbles and boulders. This fill presumably stems from the dumping of the 415 000 m³ soil and rock material excavated for the underground chambers of the station.

Due to the high loadings expected to be exerted by the turbines and other machinery (overhead cranes) within the new shed, it was decided to investigate other positions where the shed could possibly be founded upon the bedrock. This endeavour, however, proved to be unsuccessful and it was decided to construct the steel-frame structure on the fill, incorporating spread footings and adequate joints between the frame and the reinforced concrete surface bed.

Although the engineering part of this project was indeed exciting, the thrill of driving in a Toyota Land Cruiser pick-up through areas of northern Namibia that one had only read about in outdoor magazines and heard of through stories from fathers and uncles who had fought on the border in the seventies and eighties, was a priceless experience.

**PROJECT 3 – SANDBERG RIVER EMBANKMENT**

In 1962 the Hardap Dam was constructed in the Fish River just north of the town of Mariental. The purpose of this 300 Mm³ dam is mainly to supply irrigation water to the surrounding agricultural community, as well as potable water to the town.

In February 2006 the second largest flooding of the dam occurred with a sluice outflow rate of 3 000 m³/s. This flood caused widespread damage to infrastructure and farms in and around Mariental. A task force was summoned to investigate and come up with measures to prevent or reduce future flood risks to the town and irrigation schemes. One of the options evaluated was that an embankment should be constructed along the southern bank of the Sandberg River, just north of the town. The embankment was planned to be 1 000 m in length with a maximum height of 3 m.

ARQ was approached by NTS to conduct a geotechnical investigation for this embankment. A total of seven test pits were excavated by means of a TLB. The results of the investigation indicated that dispersivity is most likely to be a problem and some form of modification to the in situ material would be necessary to prevent piping during inundation. This modification was recommended in the form of adding 2% gypsum (calcium sulphate) to the material. The slope of the embankment face was calculated to be safe at 1:1,75, but erosion considerations dictated and the slope was thus flattened to 1:2,5.
ARQ conducted a geotechnical investigation, together with NTS, for extensions to the Carl List Haus building in the Windhoek CBD. Geologically the site is underlain by biotite schist with intercalated quartzite, graphite schist and amphibolites. Two test pits were excavated utilising a 24 t excavator to a depth of 5 m. Refusal was encountered at one test pit at 4.6 m on soft rock schist.

A layer of tufa was found in the sub-surface profile between 2.0 m and 3.1 m. The tufa could be described as moist, yellowish white with black blotches, very soft to soft, shattered silty clay. Tufa is known to possess a low dry density, high moisture content and high void ratio. These qualities are known to be negative for founding.

The tufa layer complicated matters considerably, as founding could not take place above this very weak stratum. Two different founding approaches were suggested, i.e. to either consider adding a basement level and found on pad / strip footings, or to utilise piled foundations.
boring on the schist bedrock. The piled option was chosen due to space constraints.

Seelenbinder Consulting Engineers requested ARQ to design the piles for the extensions. Initially, for the specified column load of 1700 kN, it was decided to employ 750 mm ø auger piles, but this was up-scaled at a later stage to 900 mm ø to facilitate hand cleaning at the base of the hole with casing protection. The average pile lengths were 6 m.

Franki was appointed to install the auger piles. Upon drilling of the auger holes it was discovered that schist bedrock was seated very close to the surface on the eastern side of the site, whereas on the western side the bedrock was much deeper at around 7 m. The rock thus dips steeply from east to west. After considering the situation it was decided that the pile lengths would be shortened towards the east until no piles were necessary and pad / strip footings could be used.

Installation of the piles has since been successfully completed and construction of the super-structure is also making good progress.

CONCLUSION
Although this article has been written from an engineering point of view, we would like to end on a personal note. Few people can deny the thrill of travelling abroad, meeting new people with a similar passion for the work we do, and being tested as professionals on a totally different playing field. We have been blessed with many geotechnical engineering opportunities in Namibia and we are grateful for the invaluable experience gained.

ACKNOWLEDGEMENTS
Pieter de Haan and Jaco Strydom of Namibia Technical Services cc (NTS)
Helmut von Maltzahn of Namibia Power Corporation (Pty) Ltd (NamPower)
Richard Day of Engineering and Exploration Geophysical Services cc (E&EGS)
Axel von Wenzel of Aurecon Namibia (Pty) Ltd
Lothar Redecker, Herbert Lerch and Panganai Chimonyo of Seelenbinder Consulting Engineers cc
Sort out the pavement joints and reduce the cracks in harbours and airports

Concrete pavements are everywhere and play a very important role in the economy of the country, particularly those in harbours and airports where imports and exports would not happen without them.

What then is the role of a concrete pavement, and what stresses have to be resisted by the materials making up this very important structural element? These questions are frequently asked at the commencement of training courses on concrete pavements or floors and the answer invariably given is, “to support the applied loads, to give a smooth working surface, so you don’t get stuck in the mud, etc.” The answers are, of course, frequently wrong!

The purpose of a concrete pavement is to spread the load on the concrete surface in a roughly conical mode, so that it is applied to the supporting material underneath it, over a much larger area that varies according to the depth squared. Even a small increase in depth will decrease the stresses on the subbase substantially. Slab thickness then, should be designed according to the ability of the subbase to carry the stress induced by the load. The concrete only has to cope with a generally low compressive stress as it is squeezed between the surface and subbase.

1. Crack out of saw cut joint and toggle joint detail
2. Cracks due to poor joint details
The subbase has to be able to resist the applied stress, but very importantly, in a uniform manner. Any uneven support, or variation in its ability to support the concrete pavement, will result in the concrete having to resist bending moments or tensile stresses. A well-designed and specified floor would consequently be specified on the flexural strength of the concrete and not the compressive.

Perhaps the most disruptive stress on the pavement is applied only hours after it is completed, and the concrete has not yet had the opportunity to gain sufficient strength to resist. This stress is, of course, the cumulative effect of surface tension forces in the water held in billions of microscopic capillaries. These are open to the surface of the concrete as it loses moisture due to evaporation. The force is tensile and tends to reduce the dimensions of the concrete; if the concrete at that age cannot resist this applied stress it will tear, and very dissatisfied clients are the inevitable result.

Various methods can be deployed to diminish the reduction in dimensions, ranging from informed selection of aggregates, use of admixtures, concrete temperature and type of cement. But elimination of the reduction is impossible. This stress is known as a shrinkage stress and is generated close to the top of the concrete. It is tensile, and causes cracking as it attempts to stretch the concrete to the point where it tears.
If the concrete was free to move, i.e. slide along the subbase with no friction, it would shrink (with a reduction in dimensions) but would not tear, as there is no restraint to hold it back. In the real world there is considerable friction at the subbase/slab interface, and the concrete does tear. If tearing is inevitable and a dissatisfied client is to be avoided, the tears must be artfully concealed.

Tears are concealed by creating straight weakened planes (called saw-cuts) in the concrete surface bed so that hopefully the concrete will tear at the weakest link, rather like the perforations placed in toilet paper for the same purpose. If the effect of the toilet paper perforations was negated by placing sticky tape over them, then it would tear somewhere else, just like concrete when steel mesh is placed across the weakened plane and prevents it from tearing!

As described above, when a load is placed on a concrete pavement it is transmitted to the subbase through a roughly conical shape within the concrete. When that load rolls to the edge of the concrete slab (say a forklift going over a joint) some of the contact area between the slab and the subbase is lost, with a consequent increase in stress placed on the subbase. This is usually overcome by forcing two adjacent slabs to share the load by preventing vertical movement between them or by reducing the stress on the subbase. This is achieved in one of two methods as follows:

- The edge of the slab could be made thicker so that the contact area is restored and the stress once again reduced to acceptable limits.
- Some sort of connection could be formed between the two sides of the tear (or joint) so that the two sides cannot move vertically relative to each other, but have unrestrained horizontal movement. In a crack the two sides are rough and have a perfect male-female fit (whether it is below a saw-cut or unplanned). This prevents vertical movement while the gap width remains within defined limits, and will be lost if the allowable width is exceeded.

Another method is to place a smooth steel bar or steel square across the joint that can slide on one side; this allows horizontal movement to take place and relieve shrinkage stresses, but prevents vertical movement that could fail the subbase. Smooth steel bars (dowels) cannot, of course, be used on two adjacent sides of a single panel of a floor, as then the floor slab will be prevented from moving in either direction and a crack across the corner is inevitable. Even slight misalignment of dowel bars will prevent them from sliding, and the joint will not perform its proper function.

Next time you are walking along a cracked concrete pavement, pace out the distance between cracks (families usually desert practitioners during this exercise); it will be noted that the average spacing is about 4 m. Ideally joints should therefore be placed where the crack is most likely to occur and 4 m is about optimum. The maximum used internationally is 4.5 m.

The above discussion is based on common sense rather than complex mathematical derivation. Judging by the number of times that pavements are designed and constructed without implementing a few, readily available, simple rules, it is obvious that these rules are not well known.

Contractors are usually blamed when the concrete cracks, on the grounds that “they should have known better.” They, in turn, blame the concrete supplier because the concrete was “of poor quality” and hundreds of expensive cores are drilled and tested. The cement manufacturer, admixture supplier or quarry, seldom get off scot-free either. The truth of the matter is that most cracks happen on the drawing board (or latterly computer screen) and are not difficult to predict. Outdated technology, like steel mesh and plastic vapour barriers that actually exacerbate cracks, are still being specified.

More and more cracked slabs are being investigated, both on the ground and suspended. A diagnosis of the cause of the cracks is not always straightforward, but repair is generally not difficult if the subbase is intact. Cracks in pavements are, however, usually of an aesthetic nature only, seldom requiring removal and replacement of concrete.
CONTRIBUTION FROM THE UNIVERSITY OF JOHANNESBURG, DEPARTMENT OF CIVIL ENGINEERING TECHNOLOGY, NATIONAL DIPLOMA S3 CLASS OF 2010

Constructing and testing reinforced concrete beams

INTRODUCTION
The 2010 National Diploma S3 class in the module, Reinforced Concrete and Masonry Design III, at the University of Johannesburg’s Department of Civil Engineering Technology, embarked on a research project to demonstrate the ductility of reinforced concrete beams using three variables – different quantities of reinforcement, different concrete strengths and different loading patterns.

The ductility in reinforced concrete beams is illustrated by comparing the following beams:

- beams with the same concrete strength and different reinforcement quantities
- beams with the same reinforcement quantities and different concrete strength

THEORY BEHIND THE EXPERIMENT
The theoretical maximum bending moments for the beam are determined using the formula obtained from the South African Standard Code of Practice, The Structural use of Concrete Part 1: Design, SANS 10100-1:2000. Please note that the partial safety factors for concrete (1.5) and reinforcement (1.15) have been omitted in the formulas used below in order to obtain an unfactored theoretical moment that will correlate with the experimental moment.
The maximum compressive stress in the concrete beam (σ_c) is obtained by multiplying the 28 day concrete cube crushing stress (f_{cu}) with a factor of 0.67 which relates to the change of the cube stress into bending stress.

\[
\text{Compressive Stress of Concrete (} \sigma_c \text{)} = 0.67 f_{cu}
\]

\[
\text{Compression Force of Concrete (} C_c \text{)} = \text{Concrete Stress (} \sigma_c \text{)} \times \text{Compression Block Area}
\]

\[
= (0.67 f_{cu}) (b \times 0.9 x)
\]

\[
= 0.603 f_{cu} b x
\]

\[
\text{Compression Yield Stress of Reinforcement (} f_{yc} \text{)} = 700 \text{ to } 1400 \text{ d''/d not exceeding } 196.1 \text{ kPa for mild steel}
\]

\[
\text{Compression Force of Reinforcement (} C_r \text{)} = \text{Reinf Stress (} f_{yc} \text{)} \times \text{Area of Reinforcement}
\]

\[
= f_{yc} A's
\]

\[
\text{Tensile Yield Stress of the Reinforcement} = f_y \text{ Coupon test indicates 534 MPa}
\]

\[
\text{Tensile Force of Reinforcement (} T \text{)} = \text{yield Stress Reinf (} f_y \text{)} \times \text{Area of Reinf (} A_s \text{)}
\]

\[
= f_y A_s
\]

\[
\text{Equilibrium of Forces}\]

\[
C_c + C_r = T
\]

\[
0.603 f_{cu} b x + f_{yc} A's = f_y A_s
\]

\[
\text{Therefore} \quad x = \frac{(f_y A_s - f_{yc} A's)}{(0.603 f_{cu} b)}
\]

\[
\text{Theoretical Max Moment Resist (Concrete)}
\]

\[
= f_{yc} A's (d - d') + 0.603 f_{cu} b x
\]

\[
= f_{yc} A's (d - d') + 0.603 f_{cu} b (d - 0.45 x)
\]

\[
\text{Theoretical Max Moment Resist (Steel)}
\]

\[
= T Z_r + C_r (Z_r - Z_c)
\]

\[
= f_y A_s (d - 0.45 x) + f_{yc} A's (0.45 x - d')
\]

<table>
<thead>
<tr>
<th>Table 1 Beam specification and loading system for each group</th>
</tr>
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<tbody>
<tr>
<td><strong>Group</strong></td>
</tr>
<tr>
<td>-----------</td>
</tr>
<tr>
<td>Group 1</td>
</tr>
<tr>
<td>Group 2</td>
</tr>
<tr>
<td>Group 3</td>
</tr>
<tr>
<td>Group 4</td>
</tr>
<tr>
<td>Group 5</td>
</tr>
<tr>
<td>Group 6</td>
</tr>
<tr>
<td>Group 7</td>
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<tr>
<td>Group 8</td>
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</tbody>
</table>
Table 2: Moment Resistance and Shear Reinforcement/Spacing Ratio Results

<table>
<thead>
<tr>
<th>Group</th>
<th>Theoretically Calculated Bending Moment Resistance</th>
<th>Experimentally Tested Bending Moment Resistance</th>
<th>Percentage Difference in Bending Moment Resistance</th>
<th>Theoretically Calculated Shear Reinforcement to Spacing Ratio</th>
<th>Shear Reinforcement to Spacing Ratio due to Provided Reinforcement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 1</td>
<td>122.64 kNm</td>
<td>94.24 kNm</td>
<td>+30.1%</td>
<td>0.86</td>
<td>1.01</td>
</tr>
<tr>
<td>Group 2</td>
<td>130.44 kNm</td>
<td>104.19 kNm</td>
<td>+25.2%</td>
<td>0.37</td>
<td>1.01</td>
</tr>
<tr>
<td>Group 3</td>
<td>20.84 kNm</td>
<td>19.04 kNm</td>
<td>+9.5%</td>
<td>-0.09</td>
<td>1.01</td>
</tr>
<tr>
<td>Group 4</td>
<td>20.92 kNm</td>
<td>19.61 kNm</td>
<td>+6.7%</td>
<td>-0.18</td>
<td>0.67</td>
</tr>
<tr>
<td>Group 5</td>
<td>77.12 kNm</td>
<td>70.42 kNm</td>
<td>+9.5%</td>
<td>0.55</td>
<td>0.5</td>
</tr>
<tr>
<td>Group 6</td>
<td>77.52 kNm</td>
<td>72.14 kNm</td>
<td>+7.5%</td>
<td>0.1</td>
<td>1.01</td>
</tr>
<tr>
<td>Group 7</td>
<td>72.81 kNm</td>
<td>70.06 kNm</td>
<td>+3.9%</td>
<td>0.65</td>
<td>0.5</td>
</tr>
<tr>
<td>Group 8</td>
<td>74.85 kNm</td>
<td>72.15 kNm</td>
<td>+3.7%</td>
<td>0.18</td>
<td>0.67</td>
</tr>
</tbody>
</table>
The maximum experimental moment of the reinforced concrete beam is made up of the following three moments induced by:

- beam own weight
- load spreader weight
- applied load

Experimental
Max Moment (UDL) \( = \frac{w}{8} l^2 + \frac{P_{ls} l}{6} + \frac{P_a l}{6} \)

Experimental
Max Moment (Point Load) \( = \frac{w}{8} l^2 + \frac{P_{ns} l}{4} + \frac{P_{al}}{4} \)

**EXPERIMENTAL PROCEDURE**

The class was divided into eight groups who had to cast their own reinforced concrete beams (2.4 m long, 220 mm wide and 300 mm deep) by constructing the shutters, fixing the reinforcement, designing the concrete mix and casting the reinforced concrete beam. A load was applied to the simple supported beam until failure. Figures 7 and 8 show the two loading applications which were used.

**DISCUSSION OF RESULTS**

Table 2 indicates the results for all groups of students.

It will be noted that the theoretically calculated bending moment resistance of a beam is marginally higher than the experimentally tested bending moment resistance. The differences...
between the calculated and experimentally tested bending moment resistance are all within 10%, except for groups 1 and 2 who used an excessively high amount of tension reinforcing bars (3 Y25) which relates to 2.23% of the cross sectional area of the concrete beam.

The comparison of beams with equal concrete strength and variable quantities of reinforcement with the following loading conditions is as follows:
- Figure 9 – UDL
- Figure 10 – Midpoint load

From both these graphs (9 and 10) the following is evident:
- More reinforcement leads to higher load-bearing capacity and smaller deflection, therefore less ductility.
- Less reinforcement leads to smaller load-bearing capacity and higher deflection, therefore more ductility.

The comparison of beams with equal quantities of reinforcement and variable concrete strength with the following loading conditions is as follows:
- Figure 11 – UDL
- Figure 12 – Midpoint load

Through this hands-on project the S3 class of 2010 gained valuable insight into the ductility of reinforced concrete.
Impala Platinum Mines Refinery Pond
Using software and experience to find solutions

AURECON, SOUTH AFRICA’s largest consulting engineering company, was awarded the R1.5 million contract for the review of the conceptual and detail design, and site supervision of the new 20 000 m³ Base Metal Refinery (BMR) pond complete with associated capital equipment for Impala Platinum Limited. The total capital value of the project, estimated at R15 million, forms part of Impala Platinum’s plans to increase its production of nickel, platinum and other precious metals.

**IMPALA PLATINUM PHASE II**

The BMR Phase II expansion has necessitated the installation of a new double-lined leak detection pond and effluent pump at its Base Refinery located in the Enstra industrial area of Springs in Gauteng.

Aurecon’s project manager on this project, Viren Gajathar, says, "The Base Metal Refinery has to have an additional pond installed to increase its water storage capacity, ensuring that the plant will be able to collect the run-off generated from this new area. A new pond is
furthermore required to allow the BMR to replace the single-liner in the existing BMR pond.”

The conceptual design of the new pond was undertaken in a prior contract between Impala Platinum and the then Africon (before it merged with Connell Wagner and Ninham Shand to form Aurecon).

**DESIGN AND GEOLOGY**

Viren, who has led the design on the Impala Platinum project, noted in his 2009 Design Report that the size of the proposed new dam would be limited due to the land available for development and the topography of the area.

The area selected for the new effluent pond site lies east of the existing one on a location previously used by Afrox. Following the demolition and removal of the old foundations, Aurecon carried out a geotechnical investigation, the results of which showed the presence of dolomites. As part of further investigations, five exploratory percussion boreholes were drilled to determine the subsurface conditions. These were evenly distributed across the site to be representative of the site conditions.

The boreholes/test pits excavated during the investigation indicated fairly good material to a depth of 5 metres. Although the Council for Geoscience and Aurecon’s geotechnical team suggested that the excavations should be limited to about 3 metres, Viren says this was not an option because of the storage capacity requirements of the new pond.

“Two alternatives were considered – the dynamic compaction of the base of the dam material, or over-excavation. It was decided to over-excavate the poor material between the 5 metre depth and solid bedrock, and compact suitable material available between the ground level and 3 metres deep in 300 mm layers to the final design level.”

According to Viren, the soil mat-tress would prevent any settlement that may compromise the liner integrity and provide an impervious horizon that will prevent water ingress into the bedrock in the event of any spillage or leakage from the pond.

**CIVIL ENGINEERING SOFTWARE, CONSTRAINTS AND CALCULATIONS**

Viren, who used the software package Civil Designer to calculate all the earth-works, is an avid user of Knowledge Base software. He says, “I started off with Stardust from the beginning and was really pleased when Knowledge Base took over the development of AllyCAD and improved it further.”

“The pond was designed with 1:2 side slopes and 1:100 base slope,” Viren continues. Because the size of the pond would be limited to the old Afrox site boundaries, a trapezoidal-shaped gravity-fed earth embankment design was agreed upon. “The base slope will slant from the base edge towards the middle of the pond and the flow will be forced to the pump sump of the pond. The lining components will follow the slope of the pond.”

The lining, designed according to the minimum requirements for *Waste Disposal by Landfill*, published by the Department of Water Affairs and Forestry, is composed of several layers with leak detection lining layers that all come together into a leak detection sump. This is then transferred to a leak detection manhole which will be inspected regularly for leaks.

**FLOW CONTROL**

The inlet canal to the new effluent pond will connect to the existing canal at the point where the existing canal bends at a 90º angle to enter the existing BMR pond. A channel gate will be installed in the new canal and in the existing canal immediately downstream of the y-section where the new canal splits off.

A flow control structure will be constructed along the eastern side of the exist- ing canal, beginning approximately 10 m downstream of the manhole. According to Viren the purpose of this structure is to bring the velocity of the flow to 0.4 m/s to allow grit to settle out, and oil and grease to rise to the surface so that these can be removed from the flow control structure before it enters the ponds.

The flow control structure will be an 8 m x 8 m x 3 m concrete basin with a hori-zontal floor and a dividing wall to force the flow in a U-turn. Similar to the canal, this structure will be set in the ground and the top of the walls will be at ground level. The depth of the excavation will therefore be 3 m, which is within the limit advised by the dolomitic surface assessment.

Construction on the project was scheduled to start in February or March 2010 and is expected to be com-pleted by September 2010.

***INFO***

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Bigen Africa asks:

Will greater coordination of effort deliver rural housing better, faster and more sustainably?

THERE IS NO DOUBT that South Africa is committed to housing its nation. The Botshabelo Housing Accord of 1994 bound every segment of our society, morally or politically concerned with housing, to a social pact of unified action to provide people with decent housing and sanitation.

Since then, South Africa’s achievements in this regard have been commendable – 2.3 million houses to nearly 11 million people in 15 years, a scale of delivery second only to China. Currently, 8 000 human settlement projects are under construction, with 219 000 housing units delivered during the 2009/10 financial year.

Yet, despite these significant achievements, the housing backlog has increased from 1.5 million to 2.1 million, and the number of informal settlements to over 2 700. This means that twelve million South Africans are still in dire need of shelter and basic services.

According to Housing Settlements Minister, Tokyo Sexwale, in his budget vote to Parliament earlier this year, “re fatela morao jwale ka khoho” (“in real terms, as a country, we have hardly moved”).

Bigen Africa technical director, Terence van Rensburg, has been involved at the coalface delivery of rural housing for over eight years. “Government’s commitment to indigent housing is evident. They are reaching out to the poorest of the poor, located in the most inhospitable topographical areas imaginable, where the terrain severely impedes access and construction is extremely difficult.”

“Given the significant and ongoing effort in this regard, our mandate should not only be to provide the physical structures, but also to ensure that these are suitable, sustainable and appropriately serviced.”

In addition to the topographical challenges of working in deep rural areas, significant challenges arise from a lack of skills and capacity across the implementation spectrum – from municipal level to the contractors and sub-contractors appointed by municipalities and implementing agents, and among some of the implementing agents themselves, who are appointed by the municipalities or the Department of Human Settlements.

“We need to engender a real understanding across all spheres of the public service that housing is more than providing decent shelter. People also require basic services such as water and sanitation, and they need access roads and the skills to maintain their newly built structures, as well as the infrastructure that provides them with basic services,” Van Rensburg continues.

Meticulous coordination of effort, addressing disparate interests among role players and cooperating as a collective will go far towards creating a real return on the country’s investment in rural housing. Clearly, defining roles and delineating areas of responsibility, will improve cooperation and enable local levels of government and municipalities to work together to implement Government’s new Planning Development Act more effectively. In turn, this will increase the ability of implementing agents and contractors to improve their inputs in the housing delivery programme.

Despite these challenges, communities are already benefitting in a number of ways. “We see it every day,” says Van Rensburg. “The money released into the local labour pool creates jobs and skills training opportunities. People are often enthused to participate in improving their living areas. There is a willingness to cooperate, and problems that occur are usually amicably resolved.”

“Government’s current focus on coordinating housing and basic services initiatives between the three tiers of government, and with civil society and the private sector is heartening. This bodes well for achieving the challenging target of 220 000 housing units annually until 2014. It will also enable role players to optimise their inputs so that outputs are greater than the intended benefits. Only then can we walk away from a project with the satisfaction that what we leave behind is far better than what we found. That is the true spirit of ubuntu.

Bigen Africa looks forward to making a significant and constructive contribution to South Africa’s housing delivery process as we move to 2014, and beyond.
IN BRIEF

SIDE-STEPPING PRECAST CONCRETE STANDARDS – A HUGE THREAT

THE CONCRETE MANUFACTURERS ASSOCIATION (CMA) believes that the exclusion of SABS standards in tender documents issued by local and national government bodies for precast concrete products poses a serious threat to construction standards as a whole, as well as to the community at large.

In some instances, the consequences are immediately apparent, as in the failed Mdanzani affordable housing project in East London. Often, however, the failures take many years to present themselves, for instance in leaking outfall sewers, and are extremely disruptive and expensive to remedy.

The non-specification of SABS-approved precast concrete products by public procurers is being experienced by most CMA producer members and is of deep concern to them. CMA director, Hamish Laing, observes that companies which carry the SABS mark are operating at a competitive disadvantage, as those producers who don’t carry the mark can drop prices by skimping on materials and production procedures.

“Mark holders spend more money in providing products which carry the mark and which are produced in ISO 9001 or ISO 9000 listed factories. If public procurers continue to ignore national standards the time is approaching when it will simply not be worthwhile for major players in the precast concrete industry to subscribe to national standards. We must not allow this to happen, as the type of shoddy construction practice we have recently witnessed in the affordable housing market will spread to the rest of the industry, with disastrous consequences for all South Africans.”

Gerhard Rossouw, technical director of Rocla, says the dropping of national standards by local governments is a huge frustration for those companies that hold the SABS mark. “How does one tell the public that their tax money is being used for something that may very well let them down in five or ten years’ time, rather than lasting for 40 years or longer?”

He continues, “I believe that SABS has lost much of its clout and doesn’t seem interested in backing its permanent mark holders. It’s a statutory body that was established in terms of the Standards Act, 1945 (Act No 24 of 1945), and in terms of the latest edition of the Standards Act, 2008 (Act No 29 of 2008), it operates as the national institution for the promotion and maintenance of standardisation and quality on commodities and services. Surely it is in the public interest for state funds to be spent on goods and services which are subject to these standards and which offer some form of life-expectancy guarantee?”

Paul Deppe, MD of Technicrete, agrees and adds, “Even in cases where SABS standards are specified, manufacturers who do not hold the mark but claim to manufacture to its requirements, often win the contracts on that basis and this makes a mockery of the whole standards process.”

Bosun Brick MD, David Wertheim Aymes, comments that without sound infrastructure, life as we know it is not sustainable.

“It is absolutely critical that when we have the funds we use them prudently. If we don’t, and we don’t get infrastructural construction right, everything else in the national economy will be adversely affected.”

Laing adds that since its inception, the CMA has worked closely with the SABS in the drafting and preparation of standards for the precast concrete industry. “These are in line with best-practice international standards. However, unless they are implemented they are of little or no benefit.”

Gary Steyn, MD of INFRASET, makes the point that standards in the precast concrete industry are actually becoming more stringent and many precast concrete products in South Africa are world-class.

“In most instances the private sector insists that they are applied. However, it is in the public procurement of precast products where the concern lies. Longevity is one of the benefits of precast products, and by ignoring or just paying lip-service to the relevant standards, public procurers are spurning this advantage,” he says.

Fortunately, pockets of excellence still exist in South Africa and as Frank Makamo, General Manager (Mechanical and Materials) of SABS Commercial (Pty) Ltd, points out, the country can still boast some of the world’s best concrete technology.
“However, it would be dangerous to rest on our laurels. Local companies that are still capable of producing to these standards will either cease to exist or move offshore if we don’t reverse the current trend.

“This poses the question as to how we can ensure that local government and the upcoming entrepreneurial class understand the importance of national standards. To this end, an urgent SABS priority under the leadership of the new CEO, Dr Boni Mehlomakulu, will be to invite various government departments to standards workshops. We will engage with them on how best to entrench a culture based on high nationally-based standards, rather than one which is price-driven.

“We intend adopting a strategy which will ensure that the smaller entrepreneur is trained and equipped to produce to SABS standards, while at the same time doing everything in our power to ensure that bodies such as the Department of Public Works and local governments specify the SABS mark in their tender documents. There is no reason why SMMEs should not be able to provide quality products which meet international best practice standards. I am optimistic that we will meet this challenge,” concludes Makamo.

INFO

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WORLD CUP VICTORY FOR COROBRIK

CAPE TOWN STADIUM in Green Point, one of the two semi-final venues for the FIFA 2010 World Cup, is one of the most visually attractive football venues in the country due to its integration with the surrounding urban fabric through the reconfiguration of the Common and the linkages established with the CBD and the beachfront. Millions of Corobrik pavers were used in the creation of this breathtaking setting nestled between Robben Island and Table Mountain.

“We are certainly proud to have been part of this exciting project. Over 2.5 million Autumn 73 mm pavers, 350 500 De Hoop brown and 509 500 De Hoop red 73 mm pavers were used for the stadium and surrounds. This was indeed a massive project, requiring a great many bricks, but quantities are never a problem for us. All pavers were ordered with delivery schedules in place, so we knew in advance when bricks had to be on site,” says Christie van Niekerk, Manager Corobrik Western Cape.

Van Niekerk says that the reason for 73 mm pavers being used for this project was due to the robust usage expected, as well as the fact that the various precincts are in some instances close to the sea, making it a potential sea spray zone and highly corrosive environment. In addition the pavers had to be strong enough to withstand heavy traffic.

“Salt and high humidity levels are usually prevalent in areas close to the ocean. However, our clay pavers offer an excellent resistance to corrosion, both acidic and alkaline. Our 73 mm pavers in particular are extra sturdy and perfectly suited to this type of environment, which experiences both pedestrian and vehicular traffic, and where longevity and sustainability are essential.”

According to Darryl Pryce-Lewis of OvP Landscape Architects, who were responsible for the design and implementation of the Green Point Urban Park and Cape Town Stadium Precinct, the planning of the stadium began in March 2007 and ended in May this year. For the approximately three years of construction 5 million bricks were used over all Green Point projects amounting to about 12 hectares of paving.

“The entire Green Point project consisted of four primary contracts – the stadium and the 18 hectare precinct immediately around the stadium, Green Point Park linking the stadium precinct to the Green Point Light House, Granger Bay Boulevard linking Western Boulevard to the Waterfront, and the Main Road transportation corridor linking Green Point to the CBD via the Fan Mile. In addition there were a number of smaller direct contracts, some of which are on-going to complete the legacy project after the World Cup when FIFA vacates the site.”

OvP Landscape Architects developed a paving theme based on the continuation of the brick paving theme already well established in the
Cape Town CBD and extended this idea to form a linkage between the CBD along the Fan Mile to Green Point Common.

“We previously specified Corobrik pavers in the St Georges Street Pedestrian Mall and the V&A Waterfront developments and have learnt that brick paving offers a tactile and human scale quality to the making of large scale urban spaces. This is especially relevant when dealing with largely featureless sites devoid of character and identity. In addition, the colours of Corobrik’s pavers tend to deepen and improve with age. Three of Corobrik’s pavers were selected specifically for this purpose,” says Pryce-Lewis.

Van Niekerk concludes, “It is satisfying for us at Corobrik to know that our products are not only valued for their durability, but for their appearance, too. For us this confirms Corobrik’s leadership in the manufacture and distribution of clay pavers to key infrastructural developments.”

EUREKA PROJECT COMPLETED IN RECORD TIME THANKS TO NEW ROBOR HYBRID STRUCTURE

A NEW LIGHTWEIGHT ROBOR HYBRID Structure, introduced by the steel tube and pipe manufacturer, accounted for the remarkably successful fabrication and erection of the structural steel of a Eureka DIY 11 800 m² factory in Stormill, Gauteng.

Eureka had very strict requirements and tight project deadlines, which Robor – in conjunction with main contractor Renico Construction, and Entity Architects and Engineering – successfully met thanks to the speed of construction offered by its innovative development. With a footprint of 148,4 m × 79,5 m × 8,8 m high eaves and a total structural steel weight of 147,8 t, the Eureka factory illustrates the power of this Hybrid Structure’s unique combination of materials. Impressively, the structural steel was erected in a three-month period. The project was started at the end of November 2009 and the main structural steelwork was completed in February 2010.

The new Hybrid Structure not only offers construction industry professionals the freedom to customise their products and solutions for a wider range of service, but also presents the opportunity for up to 40% savings in mass, and a major reduction in project delivery times in a very competitive and demanding market.

Supplying a comprehensive range of value-added products and services, Robor worked in consultation with Entity Engineering in developing the highly successful Robor Hybrid Structure as an alternative to the traditional structural steel systems used for mini-factories, factories, warehouses, shopping centres and other types of buildings that rely on structural steel roofing. Entity Engineering’s Andrew Bull says, “The Hybrid Structure used for the Eureka project is an outstanding application of advanced building technology to deliver an efficient, economical and strong building.”

Traditional engineering designs vary from 15 kg/m² to 30 kg/m², sometimes more. Although these structures have evolved over the years, the construction industry is still at times restricted by the limits on the transportable length of steel sections, high erection costs and the ever-diminishing complement of qualified boilermakers and welders. Also, the current worldwide economic crisis has made banks
more reluctant to finance new developments, hence the best way forward seems to be to find cost-effective building concepts that will positively contribute to the growth of the economy.

The Robor Hybrid Structure offers just such a solution through a system that combines Robor-manufactured structural tubing with high-strength, lightweight galvanized steel. System co-designer, Hendrik Beyleveld, says, “This extremely competitive system allows for a much lower rate per square metre cost compared to any other system available on the market.” The new design method and technology have reduced weight per square metre from 22 kg/m² to as little as 12.5 kg/m².

The cold-formed section and structural tubes were chosen carefully to optimise the design and exploit the inherent benefits of each section. Pieter Dorland of Eureka DIY is very impressed with Robor’s new offering: “The light steel design and construction have made a great difference to this project. It has not only enabled us to save costs on the steelwork, but the ease of fabrication and erection has facilitated the project’s completion within very tight deadlines, despite the adverse weather conditions of the first couple of months of 2010.”

One of the greatest advantages of the system is that the rolling and fabrication can be done on site without the need for boilermakers and welders. Where advantageous, long lengths can be rolled on site, minimising the transport costs and the number of joints in the structure. Supervised fabrication using local labour delivers further cost savings, as do lower maintenance requirements. In addition, corrosion protection costs can be reduced as half the structure is made from pre-galvanised steel, as a result of which no further corrosion protection may be required, even in some coastal environments.

Entity Architect’s Almero Retief commends Robor on the outstanding execution of the Eureka project. “The tempo and erection method not only ensured a saving for the client, but also allowed for minimal rain delay during the construction period. It was a real pleasure working with a professional steel contracting team that exceeded all deadline expectations – we will definitely be using the lightweight steel structure in future projects!”

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NEW SAB MILLER BREWERY AND SOFT DRINK BOTTLING FACILITY

SAB MILLER APPOINTED PINTOROUX ARCHITECTS as the principal agent, with Vela VKE as the civil and structural engineering designers, for the development of a new brewery and soft drink facility in Angola. The site is situated approximately 34 km northeast of Luanda on the road between Cacuaco and Funda.
Vela VKE also conducted the geotechnical investigation and the site supervision on the bulk earthworks, while site supervision on the building works was done by the user client, CCBL (Coca Cola Bottling Luanda). The bulk earthworks and building construction tenders were awarded to Chinese contractors.

The building project is valued at approximately $125 million (USD), and the completion date was planned for the first half of 2010. Project development and construction of the bulk earthworks started at the beginning of 2008 and in mid-June 2008 respectively, while the principal building contract commenced in November 2008.

Due to the presence of extensive active clay layers on the site, an engineered blanket fill of 1.5 m thick was imported over an area of 8.25 ha. The full extent of the site was surfaced with concrete surface-bed of which 6 ha was covered by roof. Two 4.3 km pipelines were designed and constructed, one for the delivery of water from the Bengu River and the other for the discharge of treated effluent. The most difficult design element was the coordination of services and foundations, due to restricted space and large equipment loads.

The biggest project challenges encountered in Angola were procuring the services of reliable contractors and material suppliers, and the clearing of equipment and materials through customs. An exaggeration factor of two to three can generally be applied to time and cost components of a project, when compared with a similar project in South Africa.
BEST LINE VISIBILITY IN ITS CLASS

THE GLL 2-50 PROFESSIONAL from Bosch offers professionals and tradesmen laser lines with the best visibility in its class. Levelling in a mere four seconds, the GLL 2-50 projects clearly visible laser lines onto walls, or from the floor to the ceiling. The GLL 2-50 has a levelling accuracy of 0.3 mm/m, ensuring that calculations are as accurate as possible. When used with the Receiver LR 2 Professional, the GLL 2-50 boasts a working range of up to 50 metres.

When the laser beam makes contact with the Receiver LR 2 Professional, the machine not only indicates on the display console, but also sounds acoustically. While expanding the range of operation, the LR 2 also safeguards against miscalculations. The LR 2 features two accuracy levels – users can choose between the standard levelling to within three millimetres, which is performed in seconds, or if higher accuracy is required, the receiver does not respond until the result is accurate to within one millimetre.

Accurate work is guaranteed by the “Out-of-Level” function. The laser line of the GLL 2-50 Professional flashes quickly to indicate unintentional inclinations of more than 4°. The user can fix the pendulum lock if inclined lines are required, and project laser lines at any desired inclination.

The particularly robust housing makes the line laser level insensitive to dust and splash water. Thanks to its pendulum lock, the GLL 2-50 Professional is also perfectly protected against impact when it is transported to the construction site. It remains fully functional when dropped from a height of one metre.

The Line Laser Level GLL 2-50 Professional is available from all fine hardware stores at the recommended retail price of R3 495 (including VAT).
PILE CAPACITY BY SIGNAL MATCHING

PILE DYNAMICS, INC has announced it will be enhancing its flagship instrument, the Pile Driving Analyzer® (PDA), with the iCAP software. Since 1972, Pile Dynamics has provided the world with the PDA – the ultimate in dynamic pile testing systems. When used for pile driving monitoring, PDAs furnish, in real time, information on pile installation stresses, hammer performance, pile integrity and, most importantly, capacity at the time of the test. Today PDAs test piles from Sweden to Australia, from Brazil to China, in a total of 90 countries. PDAs have become an integral part of engineering the best solutions for deep foundation challenges.

Up to now the Pile Driving Analyzer has calculated capacity at the time of the test solely by the Case Method. A CAPWAP® analysis, performed after the conclusion of the test, yields the ultimate bearing capacity. iCAP represents an improvement – it is instant signal matching based on the widely accepted CAPWAP logic. “iCAP instant signal matching leverages 40 years of continued improvement and development of the globally accepted CAPWAP logic”, declares Garland Likins, the president of Pile Dynamics. With no user interaction, iCAP will extract the soil behaviour from dynamic measurements, compute capacity by signal matching, and produce a simulated static load test graph, all in real time during the pile test.

Pile Dynamics produces several other quality assurance and quality control products for the deep foundations industry. The company is located in Cleveland, Ohio, USA, and has commercial representatives on all continents.

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GMBA LEADS DRIVE FOR SECURITY OF PAYMENT FOR BUILDERS

GAUTENG MASTER BUILDERS ASSOCIATION (GMBA) has initiated a move for the introduction of legislation to protect South African building contractors against late- and non-payment.

A Master Builders South Africa (MBSA) task team, led by Colin de Kock, Executive Director of GMBA, is now working towards the establishment of a Security of Payment regime in South Africa after GMBA had put forward a successful motion, calling for the promulgation of Security of Payment legislation in South Africa, at the 2009 congress of MBSA.

Security of Payment legislation operates successfully in many overseas countries, including Australia, New Zealand and the UK.

De Kock says the livelihood of main and sub-contractors has for many years been threatened by erratic or poor payments for building work. Clients, not only in the private sector, but also in all tiers of government, are among the culprits. Sub-contractors also very often are subject to poor payment by main contractors.

“The current economic recession has exacerbated a situation in which not only contractors, but also sub-contractors, struggle to receive full or progress payments on time. In numbers of cases this has led to GMBA members – already hampered by the economic downturn – having to shut operations. Smaller companies, such as tilers, plumbers and emergent contractors, simply cannot survive if they are not paid on time,” de Kock explains.

The proposed new legislation would provide a quick and inexpensive way for contractors to obtain a court order to be paid or recover money owed to them. It would also provide subcontractors with protection against contractors who fail to meet their commitments.

Colin de Kock, Executive Director of GMBA
The task team will report back on progress made regarding the new legislation to the MBSA annual congress in Windhoek in September this year.

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ROCLA ACADEMY COMMITS TO TRAINING AND DEVELOPMENT

PRECAST REINFORCED CONCRETE products are used extensively for infrastructural systems to remove waste and storm water from towns and cities. Although these gravity systems are manufactured to the most stringent quality standards, equal importance is placed on the correct selection, specification and installation processes in order to maximise durability and longevity.

To this end, Rocla, South Africa’s leading supplier of precast infrastructural concrete products, established the Rocla Academy to provide the knowledge and skills to various groups in the supply chain to ensure that the quality of the group’s precast concrete products is complemented from design to installation.

The Rocla Academy offers two one-day courses that have been validated by the South African Institution of Civil Engineering (SAICE) so that engineers and technicians can obtain Continuing Professional Development (CPD) credits. The one course covers the selection, specification and installation of pipes for outfall sewers, while the other course covers the same topics for pipes and culverts used for storm water drains and outfalls.

These courses look at the procedures for determining the size, strength and durability of the products under various operating conditions. The courses are presented by both internal and external speakers who are experts in their fields. More practical courses, which focus on the installation of the products, are offered to contractors, and in particular to emerging contractors.

In addition to these courses, sessions can be arranged that cover specific topics or on-site assistance. These courses have been based on the literature produced by the Concrete Manufacturers Association and are continually updated to keep pace with developments.

Alaster Goyns, facilitator for the Rocla Academy, says, “These certified courses will make a significant contribution not just to the sustainability of South Africa’s infrastructure, but also to the transfer of knowledge, and skills development needed by so many who are involved with the design, construction and maintenance of our infrastructure.”

The Rocla Academy was established in the late 1980s to effectively keep customers informed of the latest product and precast concrete developments, as well as to ensure that correct procedures are followed
in the specification, purchase, use and installation of these products. The academy is also widely known for the transfer of skills to emerging contractors, recently qualified consulting engineers, design engineers, foremen and site managers.

Karen de Vos, marketing coordinator at Rocla comments, “As our contribution towards closing the gaps between the academic institutions and the practicalities of the workplace, and the design office and construction site, the Rocla Academy will continue partnering with industry to develop new courses for meeting the needs in the market place.

“Courses are offered free of charge to all Rocla customers and are run at all eleven of Rocla’s manufacturing sites across South Africa, as well as in areas such as East London and Lesotho where Rocla does not have factories. At these sites, more than twelve training sessions are run per year. The Rocla Academy is the only supplier-facilitated institute that offers skills and competency training to external stakeholders.”

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BEE DEAL HERALDS NEW ERA FOR ASH RESOURCES

PEOTONA GROUP HOLDINGS LIMITED, a Black Economic Empowerment company owned by four women, has acquired a 25% stake in Ash Resources, South Africa’s leading supplier of fly ash to the construction industry.

Founded in 2005, Peotona is owned by prominent businesswoman/politician Cheryl Carolus (executive chairperson), Dolly Mokgatle, Thandi Orleyn and Wendy Lucas-Bull. Mokgatle has now joined the Ash Resources board.

Peotona – which has diversified interests in companies such as Ceramic Industries, De Beers Consolidated Mines, Fenner Conveyor Belting, Reunert, and Western Areas Prospecting – acquired the 25% stake in Ash Resources previously held by Roshcon, an Eskom subsidiary.

Graeme Smith, MD of Ash Resources, says the completion of the BEE agreement and attainment of new BEE status signal a new era for the company. Ash Resources now has a Level 6 BEE rating with Value Added Vendor status which will enable its customers to obtain 75% procurement recognition when purchasing fly ash products.

“In addition, Ash Resources has been introducing other empowerment initiatives, such as preferential procurement policies for suppliers from black-owned companies, and the implementation of vital training and upgrading of employee skills. Developing our people is – and will remain – a key strategic priority. Ash Resources also has an active Corporate Social Responsibility and Investment policy,” Smith states.

“The cement industry has become increasingly competitive since we entered the market 31 years ago. The completion of the new BEE agreement with Peotona means that Ash Resources now consists of a powerful partnership between Peotona and Lafarge, the world leader in building materials. Having access to the financial and technical resources of Lafarge is a unique strength for Ash Resources. It blends global expertise with local delivery – a key factor in the local fly ash industry,” he adds.

Ash Resources converts waste products from Eskom’s coal-fired power stations into environmentally friendly building products. The company operates fly ash processing plants near Eskom power stations at Lethabo, Matla, Kendal, Majuba and Matimba.
WELL, ACTUALLY IT is one thousand and five – all of them participants who have been trained to date during the two-day course Handling Projects in a Consulting Engineer’s Practice, presented by Wolf Weidemann, Pr Eng, under the auspices of SAICE’s Education and Training Panel.

This total was achieved on 24 May 2010 in Port Elizabeth, just short of 15 years after the first two-day course was run in Durban on 20 and 21 June 1995. The course was originally developed at the request of SAACE’s then Committee for Continuing Education (SAACE has subsequently changed its name to CESA, i.e. Consulting Engineers South Africa) and has since been verified as serving the objectives of ECSA’s CPD policy, attracting two credits. It is regarded as a Core Course, i.e. essential for the younger practitioner.

The course gives a unique overview of the consulting engineer’s work, highly condensed yet covering all significant aspects, also addressing those ever important communication and people skills, and giving an introduction to essential financial and legal aspects. Useful procedures and check lists are developed which can be quality-assured. This two-day course is aimed at the core activity of a consulting engineer’s practice, namely the way he executes the Client’s commission, right from the pre-appointment submission or tender, the appointment itself, through the various stages of pre- and final design, tender documenta-
PHOTOVOLTAIC PANELS ON STADIUM ROOFS?
It is with great interest that I read your reports on Soccer City and the Peter Mokaba Stadium (Civil Engineering May 2010, pages 56 – 63).
What strikes me is that – apparently – neither these two, nor other venues such as Green Point for example, seem to be equipped with photovoltaic panels, whereas in Europe it is almost standard practice to install solar power generation units on such large public roof areas.
It goes without saying that the yield of such photovoltaic systems would be much higher in South Africa than in most parts of Europe. Could it be that I’m missing something, or could it be that there is indeed a power shortage in South Africa, but one is not prepared to use all modern means to combat it?

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Wally Mayne, CESA’s Contractual Affairs Manager, states, “Some of the issues that are being addressed include dealing with an inadequate brief, allowing sufficient time from the request for proposals to the closing of the tender, understanding the BBBEE scoring system, understanding the reason why tenders may not be re-issued within a six-month period, the issue of unlimited liability, and the implications of working at risk.”
The CPD accredited technical briefing provides delegates with the opportunity to workshop national and international best practice with experts. The briefing unpacks the procurement of consulting engineering services, and delegates attending the briefing are issued with best practice guidelines in this regard. The content of the manual and the technical briefing focuses on the full life cycle of a project, as well as the role of both the client and the consultant. This includes the monitoring of consulting engineering services by the client. For consulting engineers it deals with framing their responses to these requests, and assisting clients on how to formulate these requests. For clients it empowers them to deal with their service providers from a fully informed position.
The main objectives of this national roll-out are to strengthen knowledge, to see new perspectives, to explore innovative ideas, and to share best practice experiences in order to face the issues and challenges encountered in making our environment sustainable. CESA aims to replace current bad practices with available good policies and practice, thereby achieving value for money and money for value.

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Procurement Policies and guidelines published by the Construction Industry Development Board (CIDB) are among the best in the world. However, for a variety of reasons many clients and consulting engineers do not apply these when procuring service providers.Procurement within the South African infrastructure environment has long been a contentious issue with an array of vastly differing policies and procedures making it difficult for both consulting engineers and their clients to make an informed and equitable decision in this regard.
Consulting Engineers South Africa (CESA) has embarked on a nationwide campaign to inform and educate members and public sector clients on procurement best practice, thus ensuring that our taxes are spent effectively. CESA, in consultation with the CIDB and industry experts, has developed a Best Practice Guideline for the Procurement of Consulting Engineering Services that is in line with the latest legislation, including the Construction Sector Charter.

Public sector procurement – CESA informs and educates
AUSTRALIA’S DR BRIAN SHACKEL, a world leader in concrete block paving (CBP), will be staging four half-day seminars on permeable concrete block paving (PCBP) systems during September and October. He will be teaming up with local paving expert and former Concrete Manufacturers Association (CMA) director, John Cairns, who will demonstrate and expand on local examples of permeable paving installations.

The seminars, which are aimed at engineers, environmental managers, landscape architects and contractors, are being organised by the CMA and will be staged in Gauteng on 30 September, Cape Town on 4 October, Port Elizabeth on 6 October, and in Durban on 7 October.

Dr Shackel will cover global developments in permeable paving and will also report back on the research on permeable paving sub-base materials that Australia’s University of New South Wales, as well as Belgian and German universities, are undertaking under his guidance. This research is being sponsored by the CMA, the CMAA (Concrete Manufacturers Association Australia), Interpave UK, and UNI North America.

Moreover, Dr Shackel will cover the latest updates on PermPave, the software package he and Professor Simon Beecham of the University of South Australia jointly authored for the design of permeable paving systems. LockPave, the software used for designing conventional paving, will also be on the agenda and delegates will be encouraged to discuss aspects they are not sure about.

CMA director, Hamish Laing, says that PermPave was designed for South African conditions and is programmed with South African rainfall data. “It also facilitates the downloading of additional local climate and rainfall information and enables the selection of local paving blocks best suited to a particular application. The designing for specified volumes of water, either for storage and re-use, or for replenishing underground water tables, is another of the software’s valuable attributes.”

In addition to discussing the deployment of permeable paving in South Africa, John Cairns will also explain how the country’s new paving standard, SANS 1058 2010, differs from that of its predecessor.

Dr Shackel is based in Sydney, Australia and has worked as an asphalt, block paving and rigid concrete pavements consultant on many projects worldwide. He is a recognised authority on concrete block paving (CBP) and is the author of numerous research papers and three books on this topic. His work on LockPave won him an Award for Excellence from the Concrete Institute of Australia (CIA).

He is especially recognised for his work on heavy duty pavements including those for ports, container handling facilities and airports. He is also an expert on ecological and permeable pavements and has been involved in environmental research in the pavement arena. He has taught pavement engineering at the University of New South Wales at both undergraduate and post-graduate levels for more than 35 years, and is well known to international audiences, having travelled and lectured extensively in 24 countries including the USA, Canada and Europe.

Dr Shackel has published more than 100 research papers dealing with geomechanics and pavement engineering and his work as paving coordinator for the Sydney Olympics won him a further award from the CIA in 2001.

John Cairns’ experience in concrete block paving is extensive. He is a member of the international SEPT (Small Element Paving Technologists) committee and he represents the CMA on the international group researching sub-base materials for permeable paving systems.

The seminars have been registered with the South African Institution of Civil Engineering (SAICE) and participants will qualify for CPD points. A nominal charge is being levied to cover costs.

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**Why the GCC 2010 seminar?**
Following on six years of application in construction engineering works, the General Conditions of Contract for Construction Works, Second Edition, 2010, has now been revised to clear up responsibilities and to provide for a wider spectrum of construction works. In this regard the Second Edition is suitable for both construction and building works contracts and, although its focal point is on the contracting strategy of design by the employer, it is also suitable for the design and build contracting strategy. Thus, in addition to the traditional civil engineering construction work, it is also appropriate for mechanical and electrical work, as well as for building work. It is ideal to deal with civil, mechanical, electrical and building projects, or a combination of these various types of projects.


In view of the current state of the construction industry with new emerging role players, revised procurement rules, introduction of different forms of dispute resolution and so forth, there was a need to provide a GCC 2010 Guide for the correct interpretation and implementation of GCC 2010.

This seminar will be presented by Willie Claassen who drafted the GCC 2010 and the GCC 2010 Guide on behalf of SAICE.

### Theme
GCC 2010: Promoting effective and efficient management of construction contracts

### Sub-themes

1. Overview of the development and application of GCC 2010
2. Uniformity in construction procurement
3. Guidance on how to apply GCC 2010
4. Handling claims and disputes and the various dispute resolution methods available in GCC 2010

### Who should attend?
The seminar will be relevant to Contractors, Employers, Engineers, and Project Managers involved in construction and building works.

### Dates, venues and contact persons
Please refer to Diarise This above.

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### Diarise This!

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<thead>
<tr>
<th>Date</th>
<th>Event and CPD validation number</th>
<th>Presenters</th>
<th>Contact details</th>
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<tbody>
<tr>
<td>27 – 28 July Bloemfontein</td>
<td>Handling Projects in a Consulting Engineer’s Practice SAICEproj08/00404/11</td>
<td>Wolf Weidemann</td>
<td>Dawn Hermanus <a href="mailto:dhermanus@saice.org.za">dhermanus@saice.org.za</a></td>
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<tr>
<td>29 – 30 July Bloemfontein</td>
<td>Business Finances for Built Environment Professionals SAICEfin08/00405/11</td>
<td>Wolf Weidemann</td>
<td>Dawn Hermanus <a href="mailto:dhermanus@saice.org.za">dhermanus@saice.org.za</a></td>
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<tr>
<td>10 August Johannesburg</td>
<td>Reinforced Concrete SAICEstr09/00432/1/1</td>
<td>Greg Parrott</td>
<td>Sharon Mugeri <a href="mailto:cpd.sharon@saice.org.za">cpd.sharon@saice.org.za</a></td>
</tr>
<tr>
<td>13 September Pietermaritzburg</td>
<td>Bridge Maintenance SAICErail09/00495/12</td>
<td>Ed Elton</td>
<td>Dawn Hermanus <a href="mailto:dhermanus@saice.org.za">dhermanus@saice.org.za</a></td>
</tr>
<tr>
<td>07 – 08 October Midrand</td>
<td>Practical Geometric Design SAICE/07/00139/09</td>
<td>Tom McKune</td>
<td>Dawn Hermanus <a href="mailto:dhermanus@saice.org.za">dhermanus@saice.org.za</a></td>
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For more information on courses, venues and course outlines please visit [http://www.civils.org.za/courses.html](http://www.civils.org.za/courses.html) or contact cpd.sharon@saice.org.za.