Civil Engineering

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SAISI SAICE

ON THE COVER

Installing piles at Toyota South Africa's billion rand expansion project at Prospecton, south of Durban. With this contract, Ground Engineering (GEL), Grinaker-LTA's geotechnical company, has secured one of its largest precast piling contracts ever

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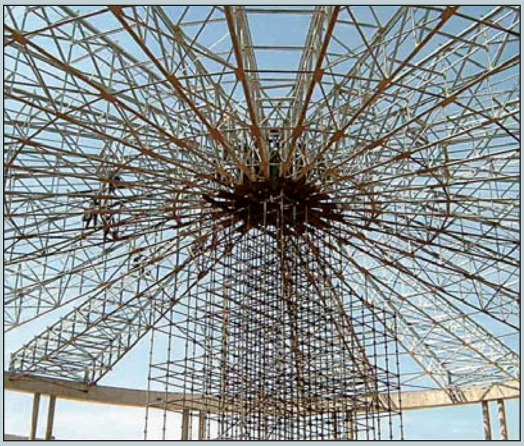

STRUCTURAL

INTERNATIONAL

COMPANY PROFILE

INDUSTRY NEWS

PROJECTS AND PRODUCTS

SAICE AND PROFESSIONAL NEWS

Empowerment status

Grinaker-LTA is a fully empowered South African company with 25 % of its issued share capital owned by a Tiso Group-led BEE consortium, Qakazana Investments Holding (Pty) Limited. The remaining 75% is owned by Aveng Limited.

Preparing steel cages and pile joints for pile manufacture

GEL secures its largest ever precast piling contract

Pouring concrete into precast pile moulds

Loading precast piles for transport

Precast pile storage yard

GROUND ENGINEERING (GEL), Grinaker-LTA's geotechnical company, has secured one of its largest precast piling contracts ever, courtesy of Toyota South Africa's billion rand expansion project at Prospecton, south of Durban.

The R30-million contract to manufacture and install 1 504 precast piles for Toyota's Paint Plant 3, which is just a part of the company's major expansion project, was awarded in November 2004.

The fast-track nature of the contract, which is due for completion in March this year, has called for some innovative solutions to ensure the achievement of the programme.

These include the construction of an on-site facility to manufacture the 350 mm square precast piles, cast in 10 m and 13 m lengths, with 16 precast beds each producing five shafts a day. This is equal to the production of 80 shafts or 1 000 m of piles per day, six days a week – with an overall contract achievement of some 54 km of precast piling.

In order to facilitate the expedited demoulding of the shafts, a concrete strength of 24 MPa is required in 18 hours – this is to enable GEL to turn around the precast beds on a daily cycle. To achieve this, some 120 m^3 of specialised 55 MPa concrete is delivered each day by Lafarge South Africa (Pty) Ltd.

Steeledale.ARC, Grinaker-LTA's re-bar manufacturing company, is supplying approximately 1 100 t for the construction of the piles.

The manufactured piles are transported half a kilometre on flat-bed trucks to the site, where they are driven to depths of between 30 to 45 m by five installation rigs. Two of these rigs represent industry-leading technology in the form of Twinwood hydraulic hammers and Kobelco BM500 crawler cranes which were imported by GEL from Singapore to handle major precast piling projects.

Soil conditions indicated very low SPT values (standard penetration tests) for horizons ranging from 6 to 30 m in thickness prior to dense sand and bedrock, which lies between 28 and 49 m in depth. This necessitates the deep driving of piles and has led to pile joint design becoming a factor, when considering the slenderness of the piles. It has also resulted in adjustments to the installation procedure to enable driving such slender piles.

GEL is using dynamic pile testing technology from Testal in the United Kingdom on the project, instead of conventional compression pile testing. This entails the attachment of electronic instrumentation to the pile to record strain and acceleration capacities, which are transmitted via cell phone to the UK-based analysis centre for feedback and confirmation. Some 50 tests have so far been completed, ensuring that piling is of the highest quality. This method of testing is effective on a heavily congested site were conventional testing is time consuming and bulky.

The team comprising Toyota SA; BKS (Pty) Limited, consulting engineers; Davies Langdon Farrow Laing, quantity surveyors; and GEL employees will see the project through to its completion.

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Text J Duncan and R Mackenzie
Extracted from SAICE Lecture Series 2004

The effects of bolt strengths on connection design

The recently circulated draft Code of Practice SANS 10162-1 has increased the bolt resistance factor ϕ_b from 0,67 to 0,80. This is an increase of nearly 20 %. The factor applied to bolt shear capacity, in the situation where the threaded length of the bolt is bisected by the shear plane, is reduced from 0,75 to 0,70. The net effect is that bolts have become 'stronger' and designers need to revisit connection designs to ensure that possible critical limit states are not exceeded

Extract from draft SANS 10162-1

13.12 BOLTS

13.12.1 Bolts in bearing-type connections

13.12.1.1 General

For bolts subject to shear or tension, ϕ_b shall be taken as 0,80.

13.12.1.2 Bolts in shear

The factored resistance developed by a bolted joint subjected to shear shall be taken as the lesser of

(a) the factored bearing resistance, B_r, given in 13.10(c); or

(b) the factored shear resistance of the bolts, which shall be taken as

$$V_r = 0,60\phi_b \cdot n \cdot m \cdot A_b \cdot f_u$$

When the bolt threads are intercepted by any shear plane, the factored shear resistance of any joint shall be taken as $0,70V_r$.

For lap splices with L   15d, where d is the bolt diameter and L is the joint length between centres of end fasteners, the shear resistance of the bolts shall be taken as $(1,075 – 0,005\ L/d)V_r$, but not less than $0,75V_r$.

NOTE *The specified minimum tensile strength, f_u, for bolts is given in SANS 1700-5, and may be taken as 420 MPa for Class 4.8, 830 MPa for Class 8.8, and 1 040 MPa for Class 10.9 bolts or screws.*

13.12.1.3 Bolts in tension

The factored tensile resistance developed by a bolt in a joint subjected to tensile force shall be taken as

$$T_r = 0,75\ \phi_b \cdot A_b \cdot f_u$$

The calculated tensile force, T_u, is independent of the pretension and shall be taken as the sum of the external load plus any tension caused by prying action.

A high-strength bolt subjected to tensile cyclic loading shall be pretensioned as for friction grip connections (see clause 22). Connected parts shall be arranged so that prying forces are minimized, and in no case shall the prying force exceed 30 % of the externally applied load. The permissible range of stress under specified loads, based on the shank area of the bolt, shall not exceed 214 MPa for Class 8.8S bolts or 262 MPa for Class 10.9S bolts.

In lieu of calculating the actual fatigue stress range, which requires the effect of bolt pretension to be taken into account, the stress range may be simply taken as the calculated stress based on the shank area of the bolt under specified loads, including any prying force, and independent of the pretension force.

13.12.1.4 Bolts in combined shear and tension

A bolt in a joint that is required to develop resistance to both tension and shear shall be proportioned so that

$$\left[\frac{V_u}{V_r}\right] + \left[\frac{T_u}{T_r}\right] \quad 1,4$$

where V_r is given in 13.12.1.2 and T_r is given in 13.12.1.3

The increased bolt shear strength and tension strength impact on the geometry of connections. 'Standard connections' may no longer behave as traditionally expected.

It has been common practice to use the bolt shear strength to define the strength of the connections. Incorrect geometry and changed code requirements may make the strength of the connected materials the critical item in defining the strength of the connection.

To identify modes of failure (limit states) consider a simple tension member. The bolts (if the member is bolted rather than welded) may fail in either shear or tension, depending on the way the member is connected. The member may fail because the cross section is insufficient – the member yields and stretches. The member may rupture – this usually occurs at a change of cross-section, at holes for example. Rupture happens when the ultimate tensile strength is exceeded. The member may fail due to the shearing of a part of the profile – the so-called 'block-shear' failure. Lastly, the member may fail in bearing.

Let us consider a standard M20 Class 8.8 bolt. We must assume that the threads will be in the shear plane (Class 8.8 bolts are commonly 'set screws', that is, threaded to the head) so we multiply by 0,70 and 0,7 x 0,6 = 0,42, then

$$V_r = 0.42\phi_b nmA_b f_u$$
$$= 0,42 \times 0,8 \times 1 \times 1 \times 314 \times 830 \times 1e\text{-}3$$
$$= 87,6 \text{ kN}$$

and

$$T_r = 0,75\phi_b A_b f_u$$
$$= 0,75 \times 0,8 \times 314 \times 830 \times 1e\text{-}3$$
$$= 156 \text{ kN}$$

Bearing capacity is connected-material dependent. The ultimate tensile strength of the connected material determines the bearing capacity. The bearing equations have not changed in the new code.

$$B_r = 3\phi_{br} t d f_u = 3 \times 0,67 \times 1 \times 20 \times 450 \times 1e\text{-}3$$
$$= 18,1 \text{ kN/mm thickness}$$

Here we assumed that the material is Grade 300WA. So to develop the shear capacity of the bolt we need at least 5 mm thick profiles or plate. There is a possibility that all angles smaller than 80 x 80 x 10L will be 'commercial quality' or CQ material. There is no specified yield strength or ultimate strength. It is recommended that f_y = 200 MPa and f_u = 300 MPa for CQ material. So to develop the shear capacity of the bolt we need at least 7,5 mm thick profiles or plate in CQ.

For the member to stretch we use the yield strength and the resistance equation is

$$T_r = \phi Agfy \qquad \text{(Equation 13.2(a)(i))}$$

The rupture mode of failure occurs at the ultimate strength of the material at a position where there is a change in cross-section.

$$T_r = 0,85\phi A_{ne} f_u \qquad \text{(Equation 13.2(a)(ii))}$$

And for 'shear lag' situations

$$T_r = 0,85\phi A'_{ne} f_u \qquad \text{(Equation 13.2(a)(iii))}$$

Let us look at what the draft code says about effective net area.

12.3.3 Effective net area – shear lag

12.3.3.1

When fasteners transmit load to each of the cross-sectional elements of a member in tension in proportion to their respective areas, the effec-

tive net area is equal to the net area, that is,

$A'_{ne} = A_{ne}$

12.3.3.2

When bolts transmit load to some but not all of the cross-sectional elements and only when the critical net area includes the net area of unconnected elements, the effective net area shall be taken as follows:

(a) for all sections with I or H shapes with flange widths not less than two-thirds the depth, and for structural tees cut from these sections, when only the flanges are connected with three or more transverse lines of fasteners,

$A'_{ne} = 0,90\ A_{ne}$

(b) for angles connected by only one leg with

(i) four or more transverse lines of fasteners,

$A'_{ne} = 0,80\ A_{ne}$

(ii) fewer than four transverse lines of fasteners,

$A'_{ne} = 0,60\ A_{ne}$

(c) for all other structural sections connected with

(i) three or more transverse lines of fasteners,

$A'_{ne} = 0,85\ A_{ne}$

(ii) with two transverse lines of fasteners,

$A'_{ne} = 0,75\ A_{ne}$

It is clear that the new code is quite severe on angles connected by one leg only. The revisions to the net effective area considering shear lag as well as the increased shear strength of bolts, incorporated in SANS 10162, suggest that the 'member strength' in direct tension will generally dictate the adequacy of the section.

To consider shear block failure we take an extract from the draft code.

13.11 TENSION AND SHEAR BLOCK FAILURE

The factored resistance of a connected part whose failure mode involves both tensile fracture and either shear yielding or shear fracture shall be taken as:

(a) for gusset plates, for angle cleats and single plate connections, as well as the ends of tension members, the lesser of

(i) $T_r + V_r = \phi \cdot A_{nt} \cdot f_u + 0,60\ \phi \cdot A_{gv} \cdot f_y$ *or*

(ii) $T_r + V_r = \phi \cdot A_{nt} \cdot f_u + 0,60\ \phi \cdot A_{nv} \cdot f_u$ *and*

(b) for notched beams the lesser of

(i) $T_r + V_r = 0,50\phi \cdot A_{nt} \cdot f_u + 0,60\ \phi \cdot A_{gv} \cdot f_y$

or

(ii) $T_r + V_r = 0,50\phi \cdot A_{nt} \cdot f_u + 0,60\ \phi \cdot A_{nv} \cdot f_u$

where A_{nt} *is the net area in tension for block failure*

A_{gv} *is the gross area in shear for block failure*

A_{nv} *is the net area in shear for block failure*

These areas depend on the spacing of the bolts – the pitch and the end distances. Traditional bolt spacings may be inadequate to develop or exceed the bolt strengths. It is recommended that the recommendations of the Southern African Institute of Steel Construction be followed.

CONCLUSION

From the foregoing it is clear that the spacing of bolts, edge distances and the grade of the material can have unexpected consequences, namely modes of failure that are not expected. Relying on the shear values of the bolts can often be an unsafe method of determining the strength or load-resisting capacity of the connection. Historically accepted 'standard' connection details need to be reviewed and brought into compliance with the enhanced bolt strengths and updated code requirements. ◻

Text Victor Booth

How safe are timber roof structures?

THE FAILURE OF ROOF STRUCTURES is of great concern not only to engineers, but also to property owners, both commercial and residential. The cost of a failure can be substantial. This article attempts to convey some truths and dispel some myths about the safety of timber roofs.

In the last few years we have seen both steel roofs and timber roofs fail. Unfortunately, probably more timber roofs have failed than steel roofs, simply because there are far more timber roofs. Many consulting engineers and clients who are nervous about the past failures of some timber roofs have considered using steel roofs on large office blocks and similar developments. A steel roof in that situation is, of course, a very expensive solution and certainly far more expensive than simply ensuring that the timber equivalent is properly designed, properly made, properly erected, and fully inspected by an engineer who is competent in this kind of work.

Most consulting engineers do not want to take responsibility for timber roof structures and exclude them from their fee proposals. This makes good professional sense, because there are very few engineers in South Africa who may be deemed fully competent to carry out the diligent inspection of the timber roof of a large office block or a shopping centre. A typical double-storey office block with a 1 000 m^2 roof area will require some 5 000 separate observations if one is to check everything that is checkable on such a roof. This is a daunting task and probably far more prone to human error than checking reinforced concrete work or structural steel.

A full inspection will entail looking for damaged pieces of timber; checking that the numerous connector plates are all accurately sized and positioned and are fully pressed into the timber; checking that every truss is straight and plumb; and checking that all the connections between the different members and bracing are properly made. The whole operation can be mesmerising and is analogous to looking at a large field of little white flowers and knowing that somewhere, in that field, there are a few pale yellow flowers. The engineer's job, during his/her inspection, is to spot the aberrations, often when they are hiding in the dark recesses. These 'yellow flowers' are the defects which could cause a weakness in the long term and need to be attended to before engineering certification can be issued.

The design of timber roof structures has been honed to a fine art with the development of specialist software by the major international 'system' role players, who also manufacture the connector plates, and which 'system' software has been debugged and fine-tuned over many decades. The only real difference, in structural terms, between the computer algorithms of today compared to 30 years ago is that they are based mostly on stiffness matrix analysis as opposed to simple pin-jointed analysis. In addition, we have far greater knowledge as to how these three-dimensional structures behave as well as an increased knowledge of the behaviour of the local materials from which they are made. So there is a very low probability of design error as long as the old adage of 'Garbage In – Garbage Out' is avoided. Accurate input to the software will result in a reliable design that is in accordance with all the relevant design codes and is fit for purpose.

Unfortunately, virtually all the truss CAD-CAM software, which is mostly developed overseas, is still in 'allowable stress' mode, as opposed to following a 'limit-states' philosophy. This is simply a result of the sunk costs of the existing programs (tens of millions of US dollars!) which, not surprisingly, the truss 'systems' seem reluctant to discard in favour of investing further large sums in developing limit-states-based software.

Having said all that, there is nothing wrong with good old allowable stress design and, notwithstanding the failures that we hear about, there are billions of square metres of timber roof structures that have not manifested problems anywhere near the level of failure as long as they have been designed, manufactured, erected and inspected by competent people.

The lowest grade (ie the weakest grade) of structural timber available in South Africa is known as Grade 5. Grade 7 is available and Grade 10 would be a special order from the lumber mills. Ninety per cent of timber roof structures can be satisfactorily designed and manufactured using Grade 5 material. The other 10 % will require the inclusion of the higher grade commercially available, that is, Grade 7. Timber, being a natural material, has various inherent defects, the presence of which is taken into account when determining the permissible design stresses and the factor of safety for design.

There are three methods of grading timber to ascertain its strength as a natural material. First, visual grading entails looking for any defects and categorising them as being acceptable within the SABS grading rules, or not. Second, mechanical/machine grading entails testing the MOR (modulus of rupture) of each piece and correlating that to various stress modes (timber is anisotropic). In these two methods every piece of timber is graded. The third method is a probabilistic approach using statistical methods based on random sampling of a population. In each method it is possible that some sub-grade timber can slip through the process undetected. However, the probability of a strength-reducing defect occurring at exactly the same point as the highest stressed portion of a framed truss is quite remote and the factor of safety of 2,2, as used in the design, makes the chances of catastrophic failure even more remote. The simple fact is that, in most of the country, pitched roof structures are rarely subjected to their full design load, which includes not only their self weight and dead loads but also the statutory 0,5 kPa imposed loads for 'inaccessible' roofs (snow and hail per SANS 10160), and the remoteness of failure becomes even greater.

SO WHY DO TIMBER ROOFS FAIL?

There are three kinds of defect. The first is a design defect. As mentioned above, such instances are extremely rare owing to the sophistication of the current design software, linked with its simplicity of use. One has only to input certain simple parameters of load, pitch, span, spacings, etc, and the software will carry out a fully optimised design in terms of timber sizes, timber grades, connector plate sizes, bracing requirements; a full layout of all the trusses and girders individually marked and accurately positioned; manufacturing details of all the trusses for the highly mechanised fabrication process including material lists, member lengths to the nearest millimeter along with cutting angles to fractions of a degree; full construction details and specifications for installation … and the price! …. CAD-CAM at its best!

The second reason for failure is a fault in manufacturing during which process it is possible, but highly unlikely, that an incorrect grade of timber might be used. It is possible that a nail plate may be installed undersized or outside the specified positioning tolerances, but as long as that individual fault/defect is not repeated and is only an isolated occurrence (which is usually the case), then any local failure, which may take years to manifest itself, will probably never be noticed unless a detailed reinspection occurs at some future date. The simple reason for this is that the trusses in close proximity to the failure will shoulder the redistribution of the loads as, in the same statistical distribution, over 95 % of the timber in the element is far stronger than the weakest defect on which the strength is based. To illustrate this, the writer had occasion to inspect an old office block roof with 19 m span trusses supporting concrete roof tiles in which the main tension 'king' posts of three adjacent trusses had each broken at a large knot defect within the length of the member. Surprisingly, it was virtually impossible to discern the minor sag in the roof line caused by this failure, although the theoretical design factor of safety had been dramatically reduced. So the failure of a single joint or a single member in an individual truss is rarely a noticeable problem. This, of course, cannot be said if the defect is in a main girder which supports other trusses, and so girders always warrant special attention during final inspection.

The third cause of failure is inadequacies in the installation by inexperienced operatives of what is a complex three-dimensional structure. As engineers, we know that all structures need to be braced against instability/lateral movement and be stiff enough to avoid compression buckling, especially of the very slender members such as these in timber roof structures (the planed timber is only 36 mm thick!). However, it is very difficult to instil these kinds of concepts into roof carpenters and so it is imperative that, as with any building operation, all the necessary details and specifications are easily understood from good-quality construction drawings. It is, therefore, the simple job of the roof engineer to ensure that all aspects of such detailed drawings are complied with on site and that the 'design intent' has been fully met in the construction phase. In other words that there are no 'yellow flowers' waiting to manifest themselves in local failures during the life of the building – for example 50 years.

There are some extremely competent truss designers, some excellent truss manufacturing facilities, and some extremely competent and experienced roof carpenters. The root cause of roof failures may often be found in contractors/developers looking for the cheapest option, always buying 'trusses' from the lowest tenderer, paying the lowest possible installation rates, and not giving proper consideration to the inspection of the completed three-dimensional structure by qualified experts.

Sadly, the timber roof truss has become a commodity in the construction industry and not the value-added, engineered product that it undoubtedly is. The professional team will always try and save money on the unseen roof structure, whilst marble floor tiles and gold-plated taps are an inviolate specification.

The timber roof truss industry is simple, yet complex. Simple and safe when experienced and competent role-players are involved, but complex and dangerous when ill-qualified people believe that timber trusses are just another cheap commodity such as bricks and cement.

Gable roof design aid

Gable to gable roofs up to 10 m span can be designed by the rules and tables in SANS 10400 Part L (currently being revised down to 8 m) or in the NHBRCs 'Home building manual' (8 m maximum span). Any roof that has hip or valley configurations must be designed by a competent engineer, owing to the nature of the heavily loaded girders required to support the other trusses. Any roof over 10 m span also has to be designed by an engineer.

The Institute for Timber Construction (ITC) has a team of trained inspectors who provide, in conjunction with ITC-approved design engineers, certification of domestic timber roof structures in accordance with the requirements of Building Regulation A19. Non-domestic roofs should, without exception, be inspected and certified by specialist engineers to whom a fee commensurate with the professional responsibility imposed upon them should be paid. Structural safety of roof structures should not be a cost-cutting exercise!

What is concrete?

'CONCRETE IS A HETEROGENEOUS SYSTEM of solid discrete, gradiently sized, inorganic mineral aggregates, usually plutonic (feldspathosilicaceous or ferro-magnesian) or sedimentary-calcareous in origin, embedded in a matrix compounded of synthesized polybasic alkaline and alkaloidal silicates held in aqueous solution and coprecipitate dispersion with other amphoteric oxides, this matrix being initially capable of progressive dissolution, hydration, reprecipitation, gelatinization and solidification through a continuous and co-existent series of crystalline, amorphous, colloidal and crypto-crystalline states and ultimately subject to thermoallotriomorphic alteration, the system when first conjoined being transiently plastic during which stage it is impressed to a predetermined form into which it finally consolidates, thus providing a structure relatively impermeable and with useful capacity, when combined with suitable reinforcing, to transmit tensile, compressive and shear stresses.' (Anon)

And you thought concrete was a mixture of sand, cement, stone and water!

Victor Booth

Strucad users excel with 2005

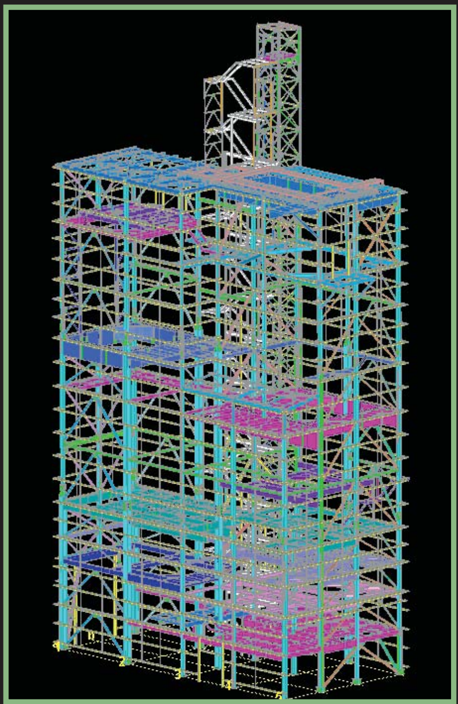
AS THE DEADLINE for the annual Strucad modelling and detailing competition drew near, the South African AceCad staff were delighted with the material that was submitted. Small and large, projects were diverse, covering mining, religious, industrial, cultural and bridge structures.

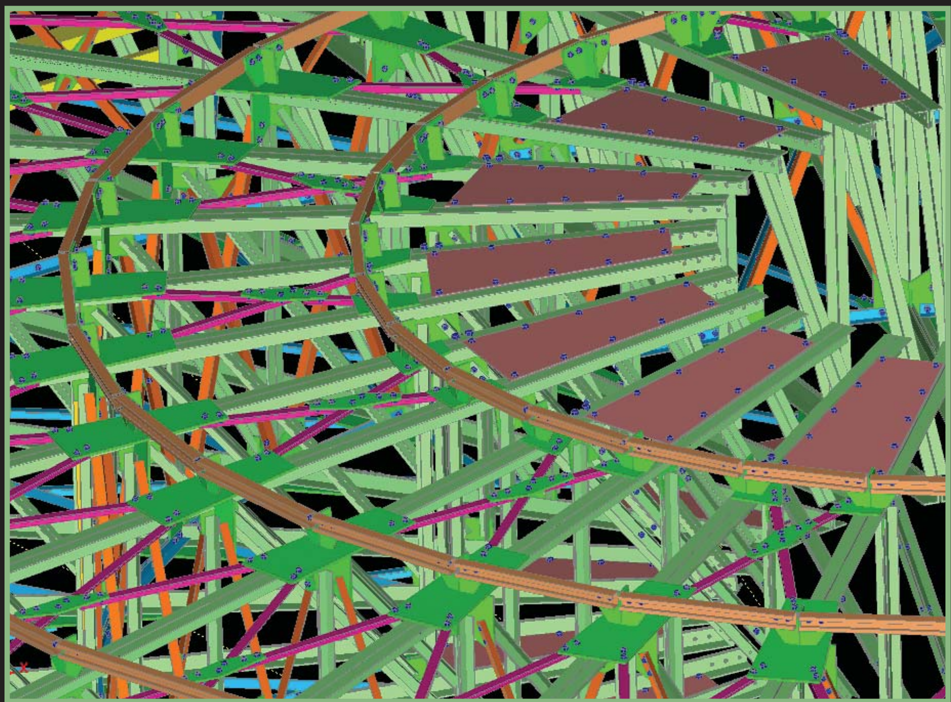
Some of the many interesting structures were:

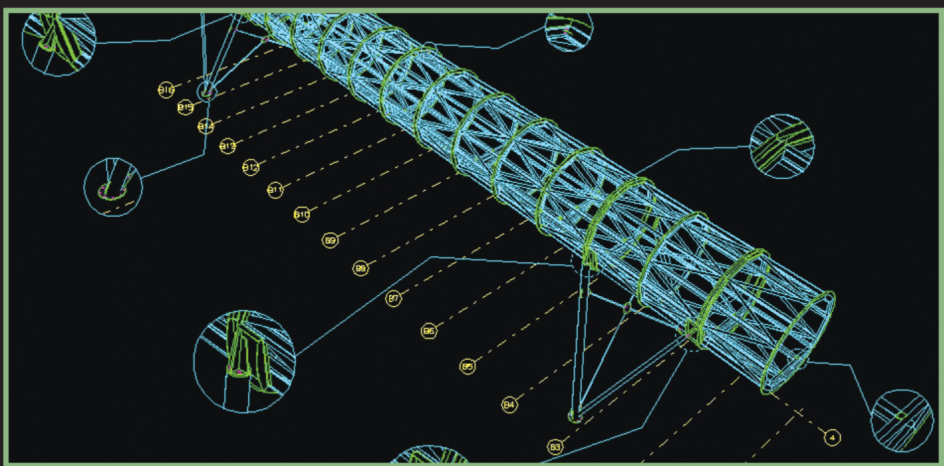
- The new 52 m Sauer Street Skywalk, a 50 t steel bridge linking the Standard Bank properties on Simmonds and Sauer streets at first floor level. This was erected on a Sunday afternoon without any disruption to traffic. A high degree of accuracy in fabrication was required so that the structure could be aligned correctly during erection
- The Impala Platinum 12 North Shaft Headgear, a prize winner in the 2004 South African Institution of Steel Construction awards, which was completed three months ahead of schedule
- The 63 t Mandela Museum, which forms part of the Alexandra renewal programme
- The conveyor structure designed and detailed for Tarkwa Phase IV (Ghana) for Ashanti Goldfields – Headline supplied a total of 700 t for this project
- The 400 t new blast furnace at Ispat Iscor, Newcastle, which is the first furnace in South Africa to incorporate PCI technology
- The 200 t roof for the International Pentecost Holiness Church designed by Archistudio. Here StruCad's ability to model complex elements and connections to produce detailed drawings saved considerable time and effort that would have been otherwise impossible to achieve.

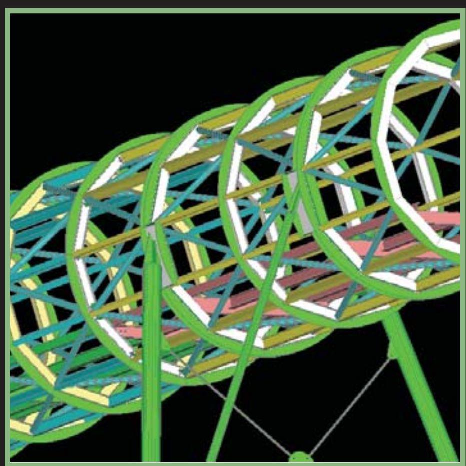
The international competition, which has been in place for 12 years, draws entries from around the globe. Last year over 200 entries were received, and the winner was Hagiva Metal Works Ltd with the Ashdod Concert Hall building in Israel, followed by the Glanmire to Watergrasshill Bypass in Ireland.

Steel construction has increasingly become more competitive with concrete throughout the world and the use of 3D









modelling to detail projects has significantly contributed to its competitiveness. The competition creates the awareness of the efficiencies which are to be gained in using 3D modelling techniques. The competition also allows users to measure their competence against stiff international competition, and encourages innovative use of Strucad, the world's leading steelwork solution. Furthermore, the drawing competition offers the best opportunity in the industry to recognise and celebrate achievement in steel detailing.

Strucad is a 3D modelling system for the detailing of structural steel buildings. The option of using wire frame allows for rapid development of the model. Full solid modelling techniques are used to create and view complex geometry and a virtual reality system provides the facility to view part or all of a structure in fully rendered 3D detail. StruWalker, the freeware viewer, allows clients, engineers and architects to check the model and associated drawings.

Advanced parametric tools are available to automate the process of steelwork detailing. The system includes a comprehensive library of connection types that consist of industry standard and specialised connections.

From the 3D model, high-quality, accurate drawings and CAM data are generated automatically.

Using 3D modelling techniques can effectively increase productivity by 5–15 times compared to manual 2D systems, dramatically reducing project times, one of the contributory factors to the early completion of the Impala headgear.

For more info about the AceCad Product Suite

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The International Pentecost Holiness Church

Left: Some of the roof steelwork

Right: Construction in progress

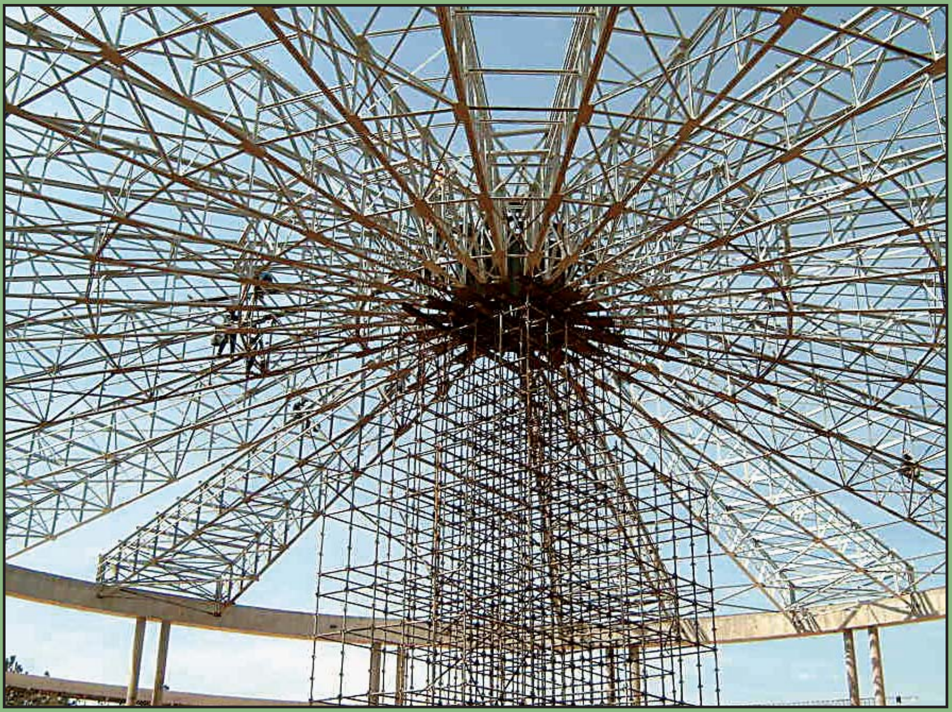
The Iscor Blast Furnace

Far left: A working drawing

Sauer Street Bridge

Bottom left: A working drawing

Bottom right: The steelwork up close



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References on request

Exploding the myths

Hot dip galvanised reinforcement in concrete structures

MUCH DISCUSSION and debate has and continues to take place with regard to the pros and cons surrounding the question of hot dip galvanising of reinforcing bars in concrete. From these debates it is clear that there are a a number of misconceptions and that opportunities to improve structural integrity and service life could be overlooked or lost through a lack of knowledge of hot dip galvanised coating.

It can be theorised that, in coastal areas, for a South African marine environment: 'The life to first annual maintenance of a black bar reinforced concrete structure which failed by "concrete spalling" after about ten years could have been enhanced to over thirty years if the re-bar had initially assumes a concrete cover of 40 mm minimum and > 40 MPa strength concrete (ordinary Portland Cement)'.

FACTORS THAT DETERMINE DURABILITY OF REINFORCED CONCRETE

Environment

As with corrosion of all materials, the environment in which the product is situated will have a major influence on the service life of that product. The external environment is the major factor to be considered when designing all types of structures, and reinforced concrete is no exception. It is the environment that carries the corrosive elements such as oxygen, carbon dioxide, moisture, and chlorides in sea spray and, of course, seawater. It therefore follows that structures located close to the coastline and in particular prevailing winds off the sea are subjected to a greater potential to corrosive attack than inland areas.

Certain marine environments can be less corrosive than others, while inland environments, such as industrial sites, can present highly corrosive substances to a structure. It is not sufficient to apply corrosion protection in marine environments only, but each case must be assessed on specific site conditions. Concrete structures subjected to aggressive salts and gases represent conditions where corrosion can be a problem and therefore requires design attention.

In time, pH levels in the concrete are reduced into a range from 8 to <12 pH, owing to the inevitable ingress of carbon dioxide (CO_2). In this pH range, zinc performs exceptionally well, while the rate of corrosion of unprotected steel would be increasing.

In service the pH level of cured concrete at the concrete re-bar interface is eventually reduced into the range pH 8–12, owing to the ingress of CO_2 and/or chlorides in marine environments. In this pH range corrosion of the hot dip galvanised (zinc) coating is at a minimum, while in comparison the rate of corrosion of unprotected steel is increased considerably, because of the loss of a protective oxide passive film.

Quality of concrete

The quality and permeability of the concrete represent the most important or critical factors to be considered when reviewing the corrosion protection properties of a structure. Permeability is influenced by the following factors:

- *Concrete mix* – Low concrete permeability is a function of the bonding between the aggregate and the cement, water/cement ratio, and size and grading of the aggregate.
- *Compaction* – Adequate and controlled compaction has an influence on both the quality of the concrete and its permeability.
- *Curing* – Site curing procedures also influence permeability and ultimately concrete quality.

Depth of cover

Depth of cover over the reinforcing steel is of major significance when corrosion protection of steel is being considered. Despite the depth of concrete cover required in terms of the specification, the final cover is often determined by practical considerations at the time of the actual placing or pouring of the concrete. The reinforcing steel could shift within the shuttering or formwork and this could remain undetected because of restrictions during the pouring process.

The structural performance of reinforced concrete and the onset of corrosion of the reinforcing steel are therefore largely determined by the quality of the concrete and placement of the steel. It is clear that provision of corrosion protection to the reinforcing steel, by hot dip galvanising, does not replace the requirement for good-quality concrete. The purpose of corrosion protection of reinforcing steel is to extend the ultimate service life of the structure once the corrosive agents present in an aggressive environment have penetrated the concrete.

The cost of galvanising the re-bar far outweighs the cost of repair on concrete spalling that results from the corrosion of uncoated reinforcing steel.

Structural failure due to corrosion

The following sequence of events characterises a typical failure of a reinforced concrete structure as a result of the corrosion of the reinforcing steel:

- In time the corrosive substances will penetrate the concrete. The time taken is a function of the quality of the concrete.
- Once the corrosive elements have penetrated through to the reinforcing steel, corrosion 'rust' will intensify.
- The products of corrosion (ferrous chloride, ferrous oxide and ferrous hydroxide 'rust') will occupy a greater ($2\frac{1}{2}$ times) volume than that of the parent steel from which they are formed.
- The greater volume sets up tensile stresses within the concrete surrounding the reinforcing bars.
- The stress buildup leads to 'cracking' of the concrete, which in turn allows greater environmental access to the steel and an increase in the rate of corrosion.
- This leads to greater stress and ultimately the 'spalling off' of concrete.

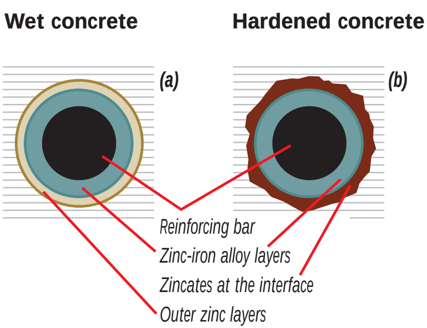
It should now be clear that the quality of concrete remains the most important factor when corrosion protection of a structure is considered. The hot dip galvanising of reinforcing steel is no substitute for poor-concrete quality and the controlled placement of the reinforcing steel. The purpose of hot dip galvanising of reinforcing steel is to extend the service life of concrete structures by delaying the onset of the corrotion of the reinforcing steel. But what happens when reinforcing is cast into concrete? How does the zinc coating react with the newly poured and curing concrete? What reactions take place when corrosion-induced substances penetrate through to the reinforcing steel?

Zinc reaction with newly poured concrete

Zinc is attacked in acid (pH values 0 to 6) and again in highly alkaline conditions (pH >12,5). The fact that zinc corrodes at pH levels >12,5 gives rise to a misconception with regard to the performance of hot dip galvanised reinforcing steel.

Freshly poured 'wet' concrete has a pH of >12,5, which will cause it to react with zinc. This reaction progressively ceases whilst the concrete is curing, and is inhibited when the galvanised re-bar is chromate passivated, as is normal practice, by the galvaniser.

During initial contact of the galvanised reinforcing steel with that of the wet concrete, the outer zinc layer of the galvanised coating reacts to form zincates. This reaction ceases as the concrete hardens, leaving the zinc coating largely intact and able to provide corrosion protection of the reinforcing steel.



(The zinc-iron alloy layers in (b) are not attacked)

Bond strength of concrete to hot dip galvanised reinforcing bars

The results of numerous and extensive programmes of pull-out tests conducted by a number of researchers around the world, as well as the latest series of local tests conducted by Dr R G D Rankine of the School of Concrete Technology, show that the bond strength is not reduced when compared with black re-bar. In fact, an actual increase in the bond strength was observed.

It is also said that the evolution of hydrogen gas at the galvanised surface will reduce the bond strength. This problem does not arise if chromium-containing compounds are naturally present in cement, which is frequently, but not always, the case. As a precaution, chromate passivation has in the past been added to the cement mix when hot dip galvanised re-bar is employed.


Corroded re-bar resulting in the 'spalling off' of the concrete cover

Conclusion

Hot dip galvanising is not used to replace poor-quality concrete, but to add value and longevity to the reinforced concrete structure and overcome practical difficulties in meeting the FULL requirements of a given specification. Hot dip galvanising of re-bar is an economical and cost-effective process that can be expected to substantially extend the useful service life of concrete structures in marine and other corrosive environments. The marginal cost increase (1–2 %) of the total cost of a project is money well spent and will without doubt provide justifiable returns. □

Text Quentin Shaw
ARQ (Pty) Ltd

Turkish RCC with a South African flavour

RCC placement has started on the main dam at Çine in Turkey

Çine dam site, southwestern Turkey (coffer dam in middle ground)

Test fill construction

Coffer dam construction

THE ÇINE DAM and Hydroelectric Power Project is a multipurpose scheme currently under construction in Aydin Province in southeast Turkey. The scheme will provide regulation storage and assurance of supply to downstream irrigators, 38 MW of hydropower electricity, and flood control to assist in mitigating the significant damages regularly experienced as far downstream as the Menderes River valley, just outside Aydin. The name of the scheme is taken from both the river to be dammed and the town a short distance downstream. The project owner and developer is Turkey's state hydraulic works organisation, DSI.

At the site of the dam, the Çine River makes its passage through a series of rolling hills in a relatively deeply incised valley. A few kilometers downstream of the dam, the valley opens out into a wide, low-lying flood plain, where extensive areas of land are farmed under irrigation. The dam drains a catchment of some 1 418 km^2, will impound a maximum storage of 400 million m^3 and must have adequate spillway capacity to pass a probable maximum flood with an inflow peak of 3 580 m^3/s. On completion, the 135 m high gravity dam will contain approximately 1,5 million m^3 of roller-compacted concrete (RCC).

PROJECT DEVELOPMENT

The Çine Dam and HEPP project was awarded to the successful tendering contractor, Özkar Insaat, at the end of 1995, and construction was initiated with the deviation of a section of the Bodrum–Izmir road, the national road along the eastern seaboard of Turkey, which originally ran right through the dam site. At the same time, DSI requested Özkar to investigate an RCC alternative to their postulated clay core rockfill embankment dam design. The primary motivation behind this request was the perceived need to eliminate the necessity for the exploitation of a clay materials borrow area, where significant environmental and social impacts had been determined.

The DSI system of project implementation functions on the basis of tendering preliminary designs prepared by an in-house design division. Implementation costs are estimated on the basis of a DSI directory of construction tariffs and contractors are requested to tender discounts. The successful tendering contractor subsequently takes responsibility for the final design and appoints consultants to prepare outline designs, which are submitted to DSI for approval.

A joint venture of consultants Geoconsult-Gibb-ARQ, of Austria, the UK and South Africa respectively, was appointed to prepare a feasibility study, which concluded that an RCC gravity dam was an attractive and feasible alternative at the Çine site. With DSI accepting these conclusions, the joint venture proceeded with detailed designs and the preparation of specifications.

During 2000, ARQ managed the RCC mix development and testing programme on site, which culminated in the construction of a test fill and the 42,5 m high, 85 000 m^3 RCC gravity upstream coffer dam, which was completed over a period of ten weeks. During these trials, many different RCC techniques and procedures were tested and optimised, including non-continuous layer placements and GE-RCC for facing. The available materials for the Çine RCC were far from ideal, particularly the Class C fly ash and the fully processed dolomitic limestone aggregates. While modifications were made to the crushing plant to improve particle distribution, a high water demand proved unavoidable and total sand production was limited to 24 %. By zoning the dam wall RCC, ARQ designed an 'impermeable' upstream RCC mix with a sand/aggregate ratio of 36 %, 85 kg/m^3 cement and 105 kg/m^3 fly ash (D10), and a general dam body RCC mix with a sand/aggregate ratio of 22 %, 75 kg/m^3 cement and 95 kg/m^3 fly ash (D05). Although the fly ash proved to be of low activity as a cementitious pozzolan, its very low cost implied that it could logically be used as a filler to compensate for the sand deficiency, with an s/a ratio of 22 % being unusually low.

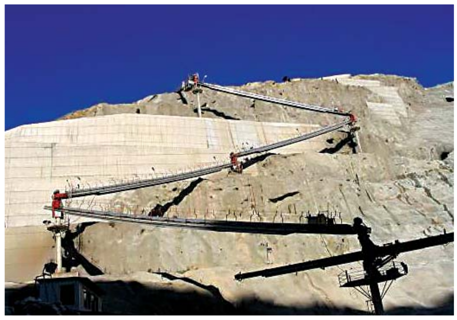
As a consequence of the high water demand of the sand and the relative inactivity of the fly ash, the respective 180 day RCC strengths were found to be relatively low at 21 and 17,1 MPa for D10 and D05

If the 18 m first placement were left to cool for an extended period, before the following placement is initiated, the likelihood of the development of a crack parallel to the dam axis is substantially increased

Çine dam site

Completed coffer dam

Main dam RCC placement



Rotec delivery conveyor system

respectively. As a result of the use of the fly ash as a filler, the average permeability for the 22 % sand mix RCC (D05), as measured on cores recovered from the coffer dam, was just 1,5 x 10-8 cm/s. Negative features of this mix, however, are a tendency to segregate and a rapid gain in maturity without the addition of a retarder.

Since the RCC coffer dam was completed at Çine towards the end of 2000, budgeted funding has only been sufficient for excavations and treatment of a fault that traverses the valley between the main dam and the upstream coffer dam, as well as certain of the hydropower tunnels and other appurtenant works. Although the dam is not the only aspect of the US$450 million project remaining to be completed, the next few years will see a concentrated focus on RCC placement for the main dam construction.

FIRST RCC PLACEMENT FOR THE MAIN DAM WALL

Placement of RCC for the main dam at Çine was initiated during October 2004, with contractor Özkar intending to complete an initial programme of approximately 200 000 m^3 of RCC by March 2005. The first placement for the dam during the cold winter months brings the dam up to the first gallery and instrumentation level, a height of 18 m. ARQ is working closely with the contractor through the main dam implementation phase to optimise procedures and equipment utilisation and to assure that Özkar achieves their objective of a final product of the highest possible quality.

Despite the size of the dam, RCC placement rates are unlikely to exceed approximately 4 000 m^3 per day, owing to budget funding constraints on the part of the dam owner, DSI. Nevertheless, production of over 2 000 m^3 per day is currently easily being achieved with just a single shift. During October, the late warm weather meant that placement was only continued during the nightshift. By late November, however, daytime maximum temperatures of just 5–7 ºC were creating ideal conditions for dayshift RCC placement.

At Çine Dam, all of the state-of-the-art RCC tools and plant are being used and the latest placement techniques and systems have been specifically developed to suit site conditions and materials. Non-continuous RCC layer placement is being used where this demonstrates an advantage, while GE-RCC is proving very successful as a facing system and as an interface against the foundations. The Rotec (aluminium) conveyor system is very efficient, particularly in respect of the delivery swing conveyor that allows the 12 m^3 dump trucks to be loaded in an even manner that avoids segregation. Twin systems of four 2 m^3 horizontal twin shaft mixers ensure a well and evenly mixed RCC at rates of up to 320 m^3 per hour. Production is, however, constrained to 270 m^3 per hour by the capacity of the delivery conveyors.

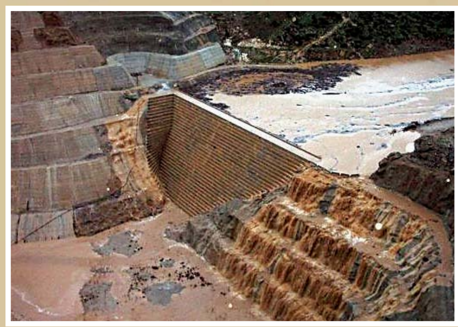
The use of a vibrating blade to install 0,6 mm galvanised crack directors into the RCC layer after a single compaction pass was originally specified. However, the intention was to attempt to delay the director installation until after the completion of full compaction, thus allowing reduced production interference, reduced post installation movement, and better opportunity for the installation of groutable director units. During November 2004, the cutting of joints and the insertion of crack directors after full compaction was successfully tested and site procedures were adapted accordingly.

The use of a broom mounted on a front-end loader and a vacuum clean-up truck have proved very effective in cleaning the 10 000 m^2 placement area between layers and the use of non-continuous layer placement during the early stages of construction allowed the restriction of full cold surface treatment to lift surfaces at 1,2 m-height intervals. A delay of only approximately 2,5 hours between successive placement layers ensures a seamless RCC within each lift.

On start-up, the use of GE-RCC proved difficult to control and a tendency to use excessive quantities of grout was evident. While the GE-RCC technique is substantially simpler in the case of the D05 RCC mix, it has been demonstrated that the best results are achieved when a delay of several minutes is allowed between grout pouring and vibration. Ineffective GE-RCC is quickly evi-

Joint forming in compacted RCC

GE-RCC facing finish



Coffer dam during severe flooding (January 2004)

dent when the immersion vibrator leaves an open hole when removed. While additional grout can be dispensed when such holes remain, the adoption of a delay between grout dispensing and vibration and improved controls has since substantially eliminated the occurrence of this problem. The quality of the final product can only be considered as outstanding.

DESIGN ISSUES

Earthquakes are a reality across most of Turkey and the site of Çine Dam is regarded as a high-risk area. Seismic loadings were accordingly found to develop the critical stresses for the dam design and the structural section finally selected demonstrates a typical broad-base 'seismic section'. As a result of its total base length of 130 m, thermal loading at Çine Dam is critical, particularly at lower elevations, where the constraint of the foundation is most significant. Accordingly a detailed thermal analysis was always envisaged as an essential part of the design, but its completion has been frustrated by the lack of a realistic funding programme. The construction programme is a fundamental parameter in terms of the development and dissipation of thermal stresses. If the 18 m first placement were left to cool for an extended period, before the following placement is initiated, the likelihood of the development of a crack parallel to the dam axis is substantially increased, the effective constraint on the placement above is similarly increased, and differential thermal stresses take on a greater significance. Thermal stresses can accordingly be quite different should the dam be constructed in a single continuous placement, or as a number of smaller placements, interspaced with significant time delays.

Finalisation of the ARQ RCC design programme encompassed the testing of samples recovered from the Çine coffer dam. A total length of approximately 350 m of core was accordingly drilled and logged. A programme of laboratory testing for the properties that could not be determined in the site laboratory was completed at the DSI laboratories in Ankara and the Middle Eastern Technical University (METU) concrete laboratory in Istanbul.

With all of the necessary RCC materials properties available and a firmer idea of the RCC placement programme, the detailed thermal analysis could proceed, although it was considered expedient that the analysis should encompass a range of possible programme scenarios. Furthermore, it has been acknowledged that it may well prove necessary to re-run the analyses at a later stage, should unforeseeable circumstances cause the final programme to differ substantially from the scenarios envisaged during early RCC placement.

PROGRAMME TO COMPLETION OF DAM CONSTRUCTION

After the completion of RCC placement to EL 147,5 m, an extensive programme of consolidation grouting for the dam foundation will ensue, in conjunction with instrumentation installation and a quality assurance core recovery and testing programme. Completion of this work will allow the resumption of RCC placement in October 2005. It is likely that the RCC for Çine Dam will be placed over a subsequent four placement seasons, each probably running from October to April, thereby avoiding the warm summers typical of southern Turkey. Completion of the dam in 2009 is accordingly anticipated.

Other ARQ RCC projects

Other recent and current RCC projects of particular interest in which ARQ is and has been involved include the proposed 281 m high Basha Diamer Dam in Pakistan, the dams for Eskom's Braamhoek pumped storage hydropower scheme, and the 54 m Wadi Dayqah Dam in Oman. For Basha Diamer, ARQ's role involved structural and RCC specialist inputs with the prime purpose of proving the feasibility of a 281 m high RCC gravity dam subject to seismic loading. For Braamhoek, ARQ is leading the dams team for the final design of a 35 m RCC gravity dam and a 40 m dam that may be either rockfill, or South Africa's first hardfill structure. For Wadi Dayqah, ARQ will be assisting Black & Veatch as RCC specialists for design and construction supervision.

Compiled by Sarie Moolman
Editor *Civil Engineering*
Sources Foster and Partners, Eiffage, Enerpac, A75, Road Traffic Technology.com, Wikipedia

Spectacular new viaduct opens in *the South of*

AN ARCHITECTURAL FEAT

The Millau Viaduct illustrates how collaboration between architects and engineers can result in a structure of breathtaking beauty. Although the soaring structure sets a number of records – it is the highest viaduct in the world, for example – its beauty lies primarily in its clarity of expression.

Foster and Partners' design for the new viaduct was selected as the winner of a design competition. The viaduct was designed in collaboration with Michel Virlogeux, who conceived the basic engineering scheme. The design objective was to assure that the huge scale of the viaduct would appear as elegant and harmonious within the dramatic landscape setting.

'We were attracted by the elegance and logic of a structure that would march across the heroic landscape, and – in the most minimal way – connect one plateau to the other,' Lord Foster said. 'We were driven by the scale of the idea and a shared passion for the poetic dimension of engineering and its sculptural potential. During the design process, there were never any conflicts between satisfying the structural demands and our aesthetic ideas; they evolved together.'

The viaduct has the highest elevated roadway in the world. The piers to the underside of the deck have tapering concrete forms whose sectional profile has been 'sculpted' to render them more elegant whilst responding to minimum structural requirements. Split form below deck provides structural stiffness between deck and pier whilst achieving lighter visual form.

Spanning the Tarn Gorge in a single gesture, the design's sculptural quality is apparent in the viaduct's plastic forms, expressed at all scales from the overall structure to the smallest detail, and executed with the minimum possible forms, materials and dimensions.

Subtly lit at night, the Millau Viaduct is a graceful manmade intervention in the natural landscape.

Millau Viaduct in the south of France was officially opened in December last year

Foster and Partners

IN DECEMBER LAST YEAR, the President of the French Republic, Jacques Chirac, officially opened the Millau Viaduct in France's southern Aveyron region.

The spectacular cable-stayed, four-lane bridge set new standards in design and construction – and is the tallest in Europe.

The viaduct completes the A75 motorway across the Massif Central, creating a direct link between Paris and Barcelona. At 2,4 km long and 270 m above the river at its highest point, the Millau Viaduct spans the more than 2,0 km wide Tarn Gorge in the Massif Central mountain range to alleviate the notorious traffic congestion in the area. Despite the length of the structure, journey time is expected to be just one minute.

BRIDGE DESIGN

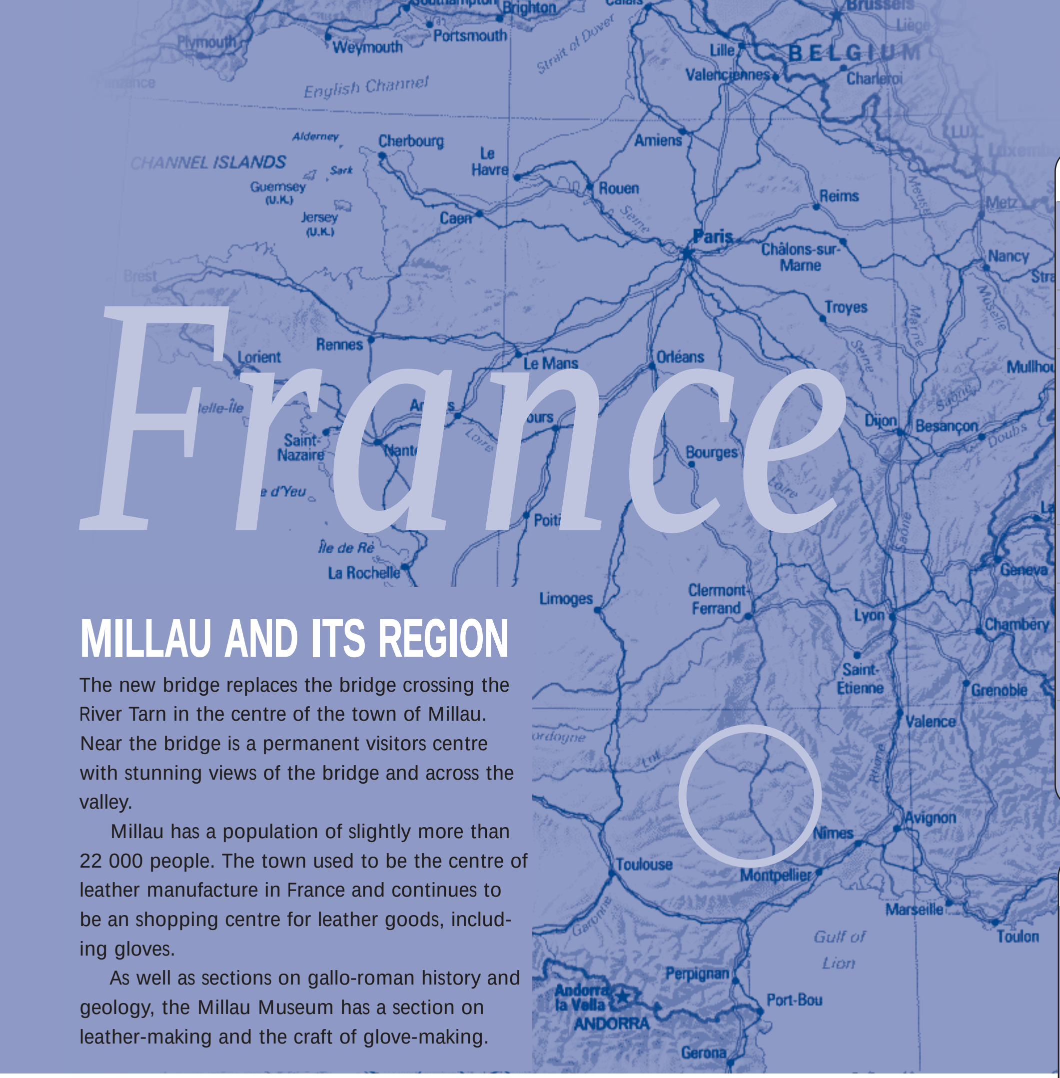
Two major challenges were identified in building the structure: crossing the River Tarn and spanning the huge gap from one plateau to the other. The solution proposed is unique, using seven pylons instead of the typical two or three. The viaduct is several metres taller than another famous French landmark, the Eiffel Tower.

Famous British architect Norman Foster was in charge of the viaduct's appearance. It has been designed to look as delicate and transparent as possible. Each of its sections spans 342 m and its columns range in height from 75 m to 235 m over the river Tarn. It uses the minimum amount of material, which made it less costly to construct: the deck, the masts rising above the road deck and the multi-span cables are all in steel.

SEVEN PIERS

The seven piers of the Millau Viaduct are sunk in shafts of reinforced concrete in a pyramidal shape, being divided in an overturned V, and the shrouds are anchored and distributed in semi harps. Hundreds of high-pressure hydraulic cylinders and pumps were used to push-launch the deck spans in place and a PC-synchronised lifting system lifted the auxiliary piers.

Intriguingly, the Millau Viaduct is not straight. A straight road could induce a sensation of floating for drivers, which a slight curve remedies. The road has an incline of



France

MILLAU AND ITS REGION

The new bridge replaces the bridge crossing the River Tarn in the centre of the town of Millau. Near the bridge is a permanent visitors centre with stunning views of the bridge and across the valley.

Millau has a population of slightly more than 22 000 people. The town used to be the centre of leather manufacture in France and continues to be an shopping centre for leather goods, including gloves.

As well as sections on gallo-roman history and geology, the Millau Museum has a section on leather-making and the craft of glove-making.

Credits

Client
French Ministry of Equipment, Transport, Housing, Tourism and Sea

Architect
Foster and Partners

Project Team
Norman Foster, in association with Kevin Carrucan, Anne Fehrenbach, Alistair Lenczner, Tim Quick, Ken Shuttleworth

Engineering Concept
Michel Virlogeux

Associated Architects
Chapelet-Defol-Mousseigne

Structural Engineers
EEG (Europe Etudes Gecti), Sogelerg, SERF

Landscape Architect
Agence TER

Design/Build/Operate Concessionaire
CEVM (Compagnie Eiffage du Viaduc de Millau)

The highest pier reaches 345 m above the river Tarn (higher than the Eiffel Tower). This is pier no 6

Millau Viaduct spans the Tarn Gorge in a single gesture

3 % to improve visibility and reassure the driver.

BRIDGE CONSTRUCTION

Construction began in October 2001, and by November the following year, the highest pier had already reached 100 m in height. Launching the deck started in February 2003 and was completed by May 2004.

Unusually, the deck is constructed from a new high-grade steel as opposed to concrete. This enabled the deck to be pre-constructed in 2 000 pieces at Eiffage's Alsace factory and GPS-aligned, 60 cm at a time.

The Millau Viaduct is supported by multi-span cables placed in the middle. To accommodate the expansion and contraction of the concrete deck, there is 1 m of empty space at its extremities and each column is split into two thinner, more flexible columns below the roadway, forming an A-frame above the deck level.

The road has two lanes in each direction. A 3 m wide emergency lane provides increased security and prevent drivers from seeing the valley from the viaduct.

As the bridge will be exposed to winds of up to 151 km/h, side screens are used to reduce the effects of the wind by 50 %. The speed of the wind at the level of the road therefore reflects the speed of the wind found at ground level around Larzac and Sauveterre.

Facts and Figures

Location
Millau, Aveyron, France. The new viaduct creates a link in the A75 motorway from Clermont-Ferrand to Béziers (and by extension Paris to Barcelona) across the Massif Central and will relieve a notorious road bottleneck through the old town of Millau at the bottom of the Tarn Gorge. The viaduct extends from the 'Causse Rouge' plateau to the 'Causse Larzac' plateau.

Basic statistics

- Total viaduct length . . . . 2,460 m
- Spans between piers . . . . 342 m
- Deck height above river Tarn . . . . . . 270 m
- Height of tallest pier (P2) . . . . 245 m
- Height to top of tallest mast . . . . 343 m
- Base dimensions of tallest pier . . 25 m wide, ... 17 m long
- Total construction weight. . . . . . . 242 000 t (36 000 t of steel, 206 000 t of concrete)
- The cost was about €400 million (privately funded), which will be recouped by the builder, Eiffage, under a 75-year concession
- The viaduct took more than 500 men just over three years to construct (October 2001 – December 2004)

Structure

- *Support piers:* Multi-span cable-stay bridge supported by seven concrete piers at an even spacing of 342 m
- *Cables:* Eleven cables on either side of each mast fan down to support the deck
- *Deck:* Trapezoidal steel box section supports dual carriageway with safety reservations on each side
- *Side wind screens:* Transparent aerodynamic side screens shelter vehicles from high wind gusts

Award-winning expertise for

Africon received a structural achievement award from the London-based Institution of Structural Engineers (ISE) for their challenging project which involved restoring the severely damaged Pungue River bridge in Mozambique to its former glory. The award ceremony took place in London in November 2004. Africon also received a SAACE Glenrand MIB Excellence Award in 2003 for its involvement in this demanding project

TECHNICAL DETAIL

This elegant bridge structure features 12 pairs of arches spanning a total length of 528 m. Each pair supports five 7,2 m long deck slabs 22 m above the water level. Each deck slab consists of seven precast, post-tensioned concrete panels bonded together by in-situ reinforced concrete infill portions.

Each single span of post-tensioned slab is supported on two transverse seating beams. In turn, each seating beam is supported by two reinforced concrete columns founded on the reinforced concrete arches. The five slabs between the crests of adjacent arches are spliced together into a continuous deck.

During the civil war, five of the 70 deck spans of the bridge were damaged by explosives to such an extent that the structure became unserviceable.

Further attempts to blow up the bridge by detonating explosives at two of the springing points of two pairs of arches posed a serious threat, as the destruction of the arch supports would have led to a catastrophic collapse.

The bridge remained closed for a number of years during the war. In 1986 some temporary structural repairs were carried out, and a single-lane Bailey bridge spanning the four most seriously damaged decks was erected as a temporary measure to allow single-lane traffic. The alternative route was a detour of 400 km on roads in a very bad condition.

RISK OF STRUCTURAL FAILURE

The structural integrity of the damaged bridge was suspect for various reasons:

- The footings were severely damaged. By core drilling it was confirmed that the bottom sections of the arch were completely fractured.
- A detailed analysis of the bridge indicated that any lateral shifting of the arch spring point would lead to unacceptable stresses and possibly to failure of the arch.
- The longest columns, 10,4 m high and

AFRICON WAS RESPONSIBLE for the investigation, design and construction supervision of the bridge repair project as part of the rehabilitation of the only road link between the Mozambican towns of Inchope and Gorongosa.

Built in 1974, the Pungue River bridge has 12 arches spanning a total length of 528 m. Severe damage was caused to this crucial transport link during the civil war in the late seventies and eighties. Explosives damaged the bridge to such an extent that two of the footings of the main arches were severely fractured and several deck elements were completely destroyed.

According to Africon bridge specialist Luuk Hepkema, quality control and safety were prime considerations throughout the project, which posed a host of challenges to the project team. 'In addition to the remote location of the project, there was need to sweep the area for landmines before work could even commence, and the need to continue to accommodate traffic for the duration of the project. Furthermore, the condition of the fractured arches at its spring was critical, which meant that there was also the very real possibility that the damaged arches of the bridge might collapse,' says Hepkema.

From an engineering perspective, a number of extremely demanding aspects had to be addressed, many of which required ingenuity, originality and innovation. These elements – as well as intuitive engineering sense – were apparent in aspects such as the design of technical procedures, construction techniques, and the application of risk-reducing measures to prevent structural collapse and injury to site workers.

As limited original design information was available, repair work could not be carried out through conventional construction methods and activities, and could – in many cases – not be described on drawings or in specifications. Furthermore, problems had to be identified and prevented in unfamiliar surroundings without incurring additional costs or delays.

Despite the host of challenges, the project was completed within budget, within the specified time frame, and without a single fatality or structural failure.

Socio-economic and environmental aspects also enjoyed high priority. For example, the community benefited from job creation on the labour-intensive construction and rehabilitation techniques employed during the project.

On 6 October 2002 the Bailey bridge that was erected in 1986 to span the damaged decks was finally removed and Pungue River bridge stood proud once more. Says Hepkema, 'We realise that such successes are more often than not the result of excellent teamwork and in this regard, we extend our sincere gratitude to ANE Mozambique, USAID and WBHO Construction for their contribution towards the success of this project.'

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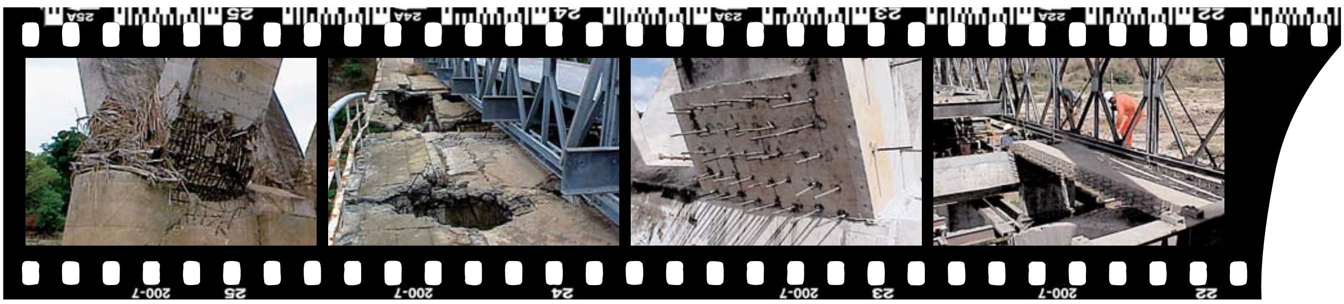


Pungue River bridge

300 mm thick, and cast in at the top and the bottom, were extremely slender. Any reconstruction of the deck would need temporary lateral support to these columns.

- The decks consisted of very slender precast, post-tensioned slabs cast together to act as a continuous slab for five loadings, which made it impossible to repair only a localised section of deck.

REPAIRS

Major repairs were carried out where the arches spring from the foundations, first by casting stabilising layers of concrete around the junctions and then pressure grouting through this layer into the damaged areas behind. The foundations were then encased in a shroud of additional concrete. The decks were repaired, where possible, but four complete deck spans had to be totally reconstructed and two were partially reconstructed.

Location
National Road EN1 between Inchope and Gorongosa, Mozambique

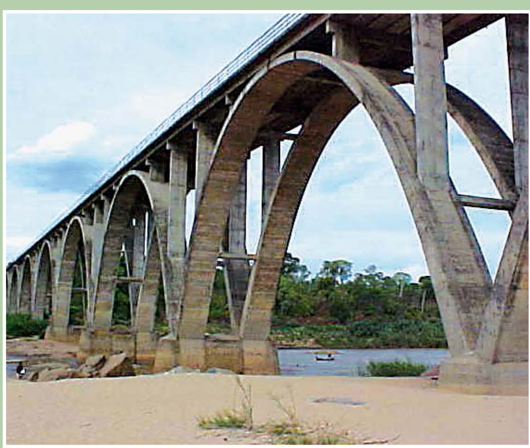
Project
Investigation, design and construction supervision of the bridge repair project

Client
National Roads Administration (ANE), Mozambique

Funding Agency
United States Agency for International Development (USAID)

Consulting Structural Engineer
Africon Engineering International (Pty) Ltd

Contractor
WBH&O Construction



Engineering solutions for Africa

Vision

Bigen Africa subscribes to the vision of 'Engineering solutions for Africa' in the following way:

- Engineering world-class infrastructure, project financing, project management, skills development and the operation and maintenance of facilities.
- Solutions that are comprehensive, cost effective and financially sustainable, meeting the specific needs of clients and communities, provided by skilled and service-oriented employees, creating viable and sustainable human and natural environments.
- For Africa, articulating the company's roots and focusing on development in Africa by Africans.

AWARDS IN THE PAST DECADE

1994 Emerald award at the Construction Industry Productivity and Quality ceremony. Bigen was the first consultancy to receive this honour.

1997 South African Railway Corporation's (SARC) Golden Rail award for excellence for a large housing relocation programme – the first time that a consulting engineering firm received this SARC award.

1998 Housing Development of the Year award for its Nellmapius housing project, which benefited the poor of Tshwane as identified under the criteria set by National Housing.

BIGEN AFRICA STARTED operations in 1971 and has since then evolved into a leading multidisciplinary consultancy offering engineering, management and project finance solutions to a broad spectrum of clients in both the private and public sectors.

The company currently operates from ten offices within South Africa as well as from offices in Gaborone (Botswana), Port Louis (Mauritius), Mzuzu (Malawi) and Lagos (Nigeria). Work beyond the boundaries of southern Africa is undertaken by Bigen Africa Offshore Holdings.

To implement and maintain world-class best practice in providing the best solutions for its clients, Bigen has created three divisions – known as centres of excellence – namely Engineering Services, Management Services, and Project Finance Services.

Engineering Services

This centre undertakes all agricultural, electrical, structural and civil engineering services.

- *Agricultural services:* Agriculture and rural development are closely related cornerstones of economic development in Africa, which Bigen Africa addresses through a variety of projects. Bigen is also committed to the transfer of technology in this field through the establishment of agricultural colleges and research laboratories.
- *Electrical services:* Through its expertise in electricity supply and distribution projects the company offers an integrated and cost-effective service in power system planning, overhead line design, substation design, network protection and control, as well as urban and rural distribution and reticulation, external illumination and economic analysis. Major projects have included electrification and street lighting for Vlakfontein township west of Johannesburg and in the Cabinda enclave north of the Republic of Congo.
- *Structural services:* Keeping abreast of modern developments in structural engineering, this division prides itself in delivering functional and aesthetically pleasing projects with innovative designs. Prestigious projects are Turnberry office park in Bryanston, Johannesburg, the Outsurance head office building in Centurion, Pretoria, effluent treatment plants in Nigeria, and reservoirs forming part of the Vaalkop water supply scheme.
- *Bulk water supply services:* Bigen has extensive collective expertise in water engineering, including water resource development and potable water supply. Construction on the Driekoppies water treatment works, Temba water treatment plant, Roodeplaat water supply scheme, and Rustenburg water and sewage purification plants involved total capex of R700 million.
- *Township services and residential buildings:* The company is involved in both the lower and upper ends of the housing market. Over the years, engineering and township service expertise have been provided for more than 167 000 erven throughout South Africa. Low-cost subsidised townships in which Bigen Africa is involved includes the Durban Roodepoort development and the Lehae housing project in Gauteng. High-cost upmarket residential developments include Montecello country estate in Midrand and Clearwater residential estate in Pretoria East.
- *Road services:* Roadworks and transportation systems is an area where extensive experience has been built up over many years. The completion of a section of the N2 road between Nqadu, east of Umtata, and Qumbu has fulfilled the need for both a national route network between KwaZulu-Natal and the Eastern Cape and providing a crucial distributor function for local communities. By using the turnkey concept, delivery of a road-upgrading project for the Johannesburg Roads Agency (JRA) was speeded up and effective budget expenditure ensured.
- *Construction supervision and monitoring services:* Experienced managerial and site staff ensured that the Oskraal Madidi and environs water supply project, the Eerstefabrieke bridge over the Pienaars River, and the Temba water supply scheme were completed within time, specification and budget.

Management Services

This centre of excellence provides customer-focused management solutions through institutional management, infrastructure management, programme management, and integrated resource management.

Services are provided to central and local government levels as well as the private sector in respect of institutional restructuring, local economic development, service delivery, mechanism development and institutional support.

A joint development forum (JDF) established between the Sekhukhune district municipality and local municipalities, together with various mining companies, reflects the successful implementation of co-operative governance, enabling the region to address the challenges of reconciling social development, economic upliftment and industrial development in an economically sustainable process.

Project Finance Services

The third centre adds an extra dimension to the conventional role that consulting engineers play in the development of projects. Instead of focusing only on technical feasibility, the company has the necessary in-house expertise to structure projects so that risks are sufficiently mitigated and projects are 'bankable'. Since September 2002, when this service was launched, Bigen Africa has assisted two municipalities to raise over R800 million for three different projects.

2000 PMR Golden Arrow award for the Highest Rated Civil Engineering Consultant Overall – another first. Under the same umbrella, Gold Stars were received for project management skills, staff professionalism and expertise, client relationship and ability to adapt to client change needs, safety record, timeous contract completion, environmental management, and customer satisfaction.
2001 SAICE Technical Excellence award for the rehabilitation of sewer reticulation in Atteridgeville, which saved the City of Tshwane up to 20 % on construction costs.
2001 Gauteng Exporter of the Year award in the Services category, recognising the company's success in world markets through innovation, quality products and services, and creative marketing.
2002 Winner of the Institute of Management Consultants' Project of the Year for its municipal assistance programme in the Ukhahlamba district municipality.
2002 Certificate of commendation for Best Housing Project: Project-linked at 2nd National Housing awards for its Kaalfontein focus project development.
2002 BHP Billiton Certificate of Recognition for outstanding services on the Mozal smelter project.
2003 & 2004 Nominated as one of South Africa's Top 300 Companies for its contribution to growth in the economy and job creation.
2003 Joint winner in the Visionary Client of the Year category at the SAACE Excellence Awards ceremony, on behalf of its client, the Joint Development Forum.
2004 SAACE's Business Excellence award for the fourth year in succession, on the basis of overall management and leadership, technical excellence and innovation, financial integrity and performance, mobilisation and optimisation of human resources, marketing and image, social impact, and upholding world-class industry standards.

The finance so raised is limited recourse project finance with tenure. This enables Bigen to develop complete solutions for their clients.

SOCIO-ECONOMIC DEVELOPMENT

Bigen's socio-economic development programme addresses transformation through ownership and management; employment equity, training and development; joint ventures; corporate social investment; and affirmative procurement.

- Thirty per cent of issued shares are held by black professionals who actively participate in management. Eighteen per cent of shares are held by black women, who constitute 20 % of the board of directors.
- Employment equity programmes have numerical goals for senior workforce levels and are driven by internal advancement through mentoring and succession planning.
- Targets have been set to increase spending and procurement from SMMEs owned and managed by blacks and women.

Committed to engineering quality

Bigen has recently received international standard ISO 9001:2000 certification. Says CEO Francois Swart: 'We took our time in ensuring that all internal processes were in perfect order before attempting certification. After six months of hard work we are now proud to announce that we passed the certification with flying colours the first time round.'

Construction charter provides opportunity for unification

THE FORMULATION PROCESS of the BEE Construction Charter has provided a unique opportunity to start unifying a fragmented South African construction sector, Mike Wylie, co-chairperson of the Integrated Management Committee (IMC) of the Construction Transformation Group (CTCG), believes.

Addressing the 101st annual general meeting of the Gauteng Master Builders Association (GMBA) in Midrand, Wylie (who chairs the IMC with James Ngobeni) said the fragmentation in the construction industry – 13 associations now constitute the industry – was a matter that had to addressed in the entire industry's interest.

'The construction sector would be far better off going forward in years to come if it had the unified voice which rationalisation and streamlining would bring. If each of the professional bodies – such as SAFCEC, SAACE, SAICE, and MBSA – could, for example, schedule their 2005 conferences for one venue at one time, the opportunity would be there to arrange government attendance and finalise discussions regarding the charter.'

Turning to the charter itself, Wylie said for an industry relying heavily on trades and specialist skills, the charter would demand clear understanding of all capacity problems. 'The "scorecard' to be drawn up to assess companies' BEE status will focus on the construction industry's unique challenges for the development of management, leadership, and enterprise development.'

To obtain the widest possible participation and input, the IMC had compiled an initial draft charter that is now open for public comment. This is the first in a series of drafts to be released to enable the public to enter the debates until final consensus on a sector-wide charter has been reached.

To add impetus to the consultations, the stakeholders have scheduled a national Indaba for April this year, preceded by a series on mini-Indabas in the various provinces starting in mid-February.

'The IMC has opted for public consultation because we believe that the success of the charter rests on the inclusiveness of its drafting process and on the consequent ability of all stakeholders – including business, government, organised labour, and the community – in partnership to address the transformation challenges confronting the sector,' Wylie added.

Replying to questions from the floor at the GMBA meeting, Wylie said it would in future undoubtedly become almost impossible for construction industry players without an acceptable BEE scorecard to win tenders from major corporations. 'Finance houses, too, will insist on charter conformation. This is already happening.'

Nico Maas, a former president of the Gauteng Master Builders Association – who represents Master Builders South Africa (MBSA) in the charter negotiations – told the meeting that input from members of the GMBA was vital for the charter formulation. 'If we do not participate in the formulation process, the government will simply apply generic BEE scorecards and not one that will be practical for our unique industry.'

Maas said it was imperative that the charter removed any opportunity of 'fronting'. 'We do not want to create BEE millionaires that merely sit on boards,' he cautioned.

Eunice Forbes, who was re-elected president of the GMBA, said the charter was a critical process for the building industry and that GMBA members' input and participation in the formulation were vitally required. She also voiced concern about the current fragmentation in the industry and said the GMBA believed a united front was now more than ever necessary for the sector.

Highveld to change strength of its standard production steel

IN A WELCOME MOVE, Highveld Steel and Vanadium is set to change its standard structural production steel from a yield stress of 300 MPa to 350 MPa, an increase in strength of 16,7 %. As there will be no increase in the price of the stronger steel, the move is expected to have a significant impact on the steel construction industry.

The executive director of the South African Institute of Steel Construction (SAISC), Dr Hennie de Clercq, has welcomed the change saying that the institute has long pushed for it, because of the significant advantages to the industry.

According to De Clercq, the more obvious benefits are:

- Contractors will now be able to use up to 17 % less steel in some structures, making the use of steel more competitive and therefore more in demand.
- The construction of some larger structures, which was impractical with the lower-grade steel, will now become cost effective, as less steel will be required to achieve the same results.
- The stronger grade steel will be able to compete with concrete in certain structures where it has always been assumed that concrete is most economical.
- Fabricated structural steel exports will be boosted, as most projects in other countries demand the higher-grade steel.

'Overall, despite the savings in steel utilised per structure, we expect a significant increase in demand because of increased competitiveness and the boost to exports,' said De Clercq.

According to Highveld's John Ellwood, important production efficiencies will be created.

'The existing range of steel sections will be more effective as it will be able to resist considerably larger forces relative to size. For example, the biggest available 350 WA section will be equivalent to one of considerably larger size at the weaker strength,' says Ellwood.

Consequently, it will less often be necessary to manufacture sections by welding them up from plates, leading to further economies.

'We will soon start manufacturing the new grade steel and flushing the old 300 WA from the market. Customers should understand that if they order the current 300 WA and get the new 350 WA, they will be getting better, stronger steel at the same price with no downside,' says Ellwood.

Ellwood added that all the properties of 300 WA are contained in the new 350 WA grade, including the ability to be bent, welded and galvanised.

The official launch of Grade 350 WA will be in May 2005, when design, specification and other information will be made available so that the new strength steel can be utilised to its full potential. 'In the meantime, the 350 WA steel should be used on exactly the same basis as the 300 WA strength,' says Ellwood.

De Clercq says it is a 'feather in Highveld's cap' to have instituted the advanced quality management programme that has enabled them to reach a yield stress of 350 MPa.

'This is a momentous decision for the steel construction industry,' he concluded.

Contact Info

SAISC
Tel 011-482-8276
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CHRYSO LAUNCHES TWO NEW CONCRETE SOLUTIONS


Chrysofibre S50 contains polypropylene and polyethylene macro-fibres

With an elasticity of 5GPA and tensile strength of 600 MPa, Chryso's new macro-fibre can replace metallic fibres and can be used in much smaller quantities

TWO NEW PRODUCTS for optimum concrete production developed by Chryso in France are now available from Chryso South Africa.

The first, Chrysofibre S50, is a second-generation synthetic macro-fibre that improves the characteristics of hardened concrete after cracking has occurred: the presence of the fibre prevents the cracks from opening.

Chrysofibre S50 consists of polypropylene and polyethylene fibres. With an elasticity of 5 GPA and tensile strength of 600 MPa, Chryso's new macro-fibre can replace metallic fibres and can be used in much smaller quantities. 'In fact, Chrysofibre S50 can be applied at just one-seventh of the dosage for metallic fibres,' said Norman Seymore, MD of Chryso SA.

He said the advantages of Chrysofibre S50 include ease of application; time-saving compared to reinforcing bars; no corrosion; reduced wear and tear on production tools (such as the concrete mixer); improved safety; and compatibility with chlorine-based accelerators.

'Chrysofibre S50 can be used for a variety of pre-cast concrete applications including sight-holes, pipes, and vaults. It can also play an important role in concrete produced for slabs, by replacing the weldmesh, and in the production of Shotcrete,' Seymore added.

The second new product launched by Chryso in South Africa is a chemical addition to Chryso's range of new-generation super-plasticisers: Chrysofluid Optima 206.

'With the increasing emphasis on self-compacting concrete which requirs no power during placing – but calls for maximum fluidity from the concrete leaving the plant to the site – Chrysofluid Optima 206 adds exceptional workability to the ready-mix concrete market,' said Seymore.

'Optima 206 is compatible with a wide range of cements and offers significant savings on the water content of concrete mixes as well as maintaining workability for around two hours.'

Info
Norman Seymore, tel 011-892-5726
www.chryso-online.com

WORLD'S TALLEST BUILDING HAS A STELLAR VIEW

THE WORLD'S TALLEST BUILDING, Taipei 101, opened its observatory and the world's fastest elevators to the public when the 58-billion Taiwan dollar 101-floor skyscraper was unveiled in December 2004 after six years of construction.

It takes just 37 seconds to reach the observatory on the 89th floor of the 508 m tall tower in the elevators.

The light green building, the brainchild of Taiwan's noted architect C Y Lee, resembles the unfolding of a flower's petals, or sections of a bamboo plant rising from the ground.

About 33 % of the building's 198 000 m^2 of office space has been contracted, largely by multinational and leading domestic enterprises. A five-storey shopping mall in the complex was opened in 2003.

CONSTRUCTION OF WORLD'S TALLEST TOWER TO BEGIN

THE CONSTRUCTION OF WHAT WILL BECOME the world's tallest building is set to begin in Dubai, United Arab Emirates. The building contract was awarded to a consortium led by the South Korean Samsung Corporation.

The Burj Dubai tower will stand 800 m tall once completed. That will be nearly 300 m taller than the tallest floored building in the world today, the Taipei Tower in Taiwan.

The super tall Burj Dubai will be the centrepiece of a large scale mixed-use development being developed by Emaar Properties PJSC of Dubai, which will combine residential, commercial, hotel, entertainment, shopping and leisure outlets with open green spaces, water features, pedestrian boulevards, a shopping mall and a tourist-oriented old town.

The design of Burj Dubai is derived from the geometries of the desert flower, which is indigenous to the region, and the patterning systems embodied in Islamic architecture. It combines historical and cultural influences with cutting-edge technology to achieve a high-performance building which will set the new standard for development in the Middle East and become the model for the future of the city.

The tower is composed of three elements arranged around a central core. As the tower rises from the flat desert base, setbacks occur at each element in an upward spiraling pattern, decreasing the mass of the tower as it reaches toward the sky. At the top, the central core emerges and is sculpted to form a finishing spire. A Y-shaped floor plan maximises views of the Persian Gulf.

The design was selected as the winning entry of an invited design competition for the tower held by Emaar Properties PJSC of Dubai in 2003. Construction started in January 2004 and will be completed at the end of 2009.

www.som.com

ANCHORING THE WEST QUAY WALL OF EL HARBOUR

THE NATIONAL PORTS AUTHORITY (NPA) appointed Protekon as the main contractor and designer for the anchoring of the west quay wall for the deepening of the harbour of East London.

The west quay is leased to South African Port Operations (SAPO), which uses the facility to berth ships for the export and import of motor vehicles, mainly associated with the Daimler-Chrysler plant in East London.

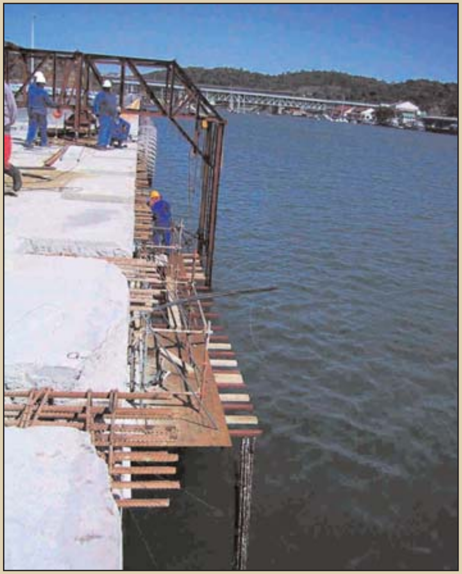
In 1999 a car terminal facility was designed and built in East London for the then Portnet to cater for the requirements of East London's major motor manufacturer. Other facilities in and around the port were upgraded and improvements done to enhance and streamline the cargo-handling capabilities of East London harbour. But the construction of the East London car terminal created a need for a deeper berthing facility at the East London west quay to allow larger vessels to berth closer to the terminal.

Investigations were then carried out by the NPA, who commissioned Protekon Design Services to come up with a solution proposal. Various engineering alternatives were considered. The ultimate proposal was that the quay wall should be extended by a 1,5 m cantilever concrete beam, with fender panels attached to the quay wall, along the west quay. In this way, the berthing depth would be increased and a sharp curve at the hard base of the wall – which hampered dredging – would be eliminated.

Apart from the need to install a cantilever concrete beam, the existing quay wall posed its own challenges in that 100 m of the wall was constructed of caissons on a rock profile embedded on concrete, while the older 150 m was constructed with a mass concrete fill behind the masonry face. This called for different approaches to the fastening of the 1,5 m cantilever beam to the wall.

For the 100 m along the caisson wall, the wall face was scabbled, dowelled, keyed and tied back with rock anchors secured behind the caissons on the landward side of the wall. The beam consisted of a beam 1,5 m wide 1,2 m deep between fender panels 4,5 m long 1,5 m wide and protruding 2 m below the beam at regular intervals of 4,2 m spacing. Each fender panel was tied back with two anchors stressed to 30 t.

For the 150 m along the masonry mass concrete wall, the same cantilever beam profile was continued. This beam and panel profile were held with a rock anchor through each fender panel.



Anchoring the west quay wall of East London harbour called for the installation of a 1,5 m cantilever concrete beam, pictured here under construction

The whole beam was tied back by reinforced concrete tie beams 0,6 m by 0,6 m, to a 1 m wide and 2,1 m deep counterweight anchor beam.

Protekon Construction (Border Civil) was the main contractor and specialist sub-contractor Dura Piling handled the rock anchor installation.

Info: John Powell tel 031-361-6072

FLYING THE AFRICAN GABIONS FLAG

AFRICAN GABIONS RECENTLY CELEBRATED ten years of partnership with Maluti Irrigation, the company's distributor in Lesotho.

On the occasion, Gary Matthews, regional manager of African Gabions in Johannesburg, said: 'Maluti Irrigation and African Gabions have in the past decade substantially increased the awareness of the soil erosion needs in Lesotho. Lesotho might be a small country, but the consequences of soil erosion are huge and affect not only the Kingdom of the Mountains, but South Africa as well. We are proud to have been associated with Terry Fraenkel and his Maluti Irrigation team, and to have been able to offer local customers a consistently wide range of quality products.'

Adriano Gilli, sales and marketing manager of African Gabions, added: 'Terry Fraenkel and his team have achieved tremendous results in the ten years of our association, with the most important project undertaken so far being the gabion retaining walls at Katse Dam. As sub-contractor – with exceptional capability – Maluti Irrigation completed the construction of the highest mass gravity walls in Africa, on time and on budget, and in extremely difficult working conditions.'

Info: Adriano Gilli, tel 031-700-8456

IMPOVERISHED COMMUNITY'S ROUTE TO SELF-ENRICHMENT

THE R7,3-MILLION UPGRADING of Amadiba Road in the Eastern Cape, a 40 km gravel link between the Bizana road and the Mtentu river mouth on the coast, is a feather in the cap of the local community. The road, a vital artery in the life of the people it serves, had progressively deteriorated to the extent that it had become virtually impassable – only tractors and four-wheel-drive vehicles dared tackle it.

The re-construction programme was requested by local residents. Impoverished conditions – 76 % of the community live in poverty – prevailed and a lifeline needed to be set in place to improve the quality of life in this remote yet exceptionally picturesque area. The revitalised road has now exposed the region to tourists – and this means money in the bank for people living within the enclave.

All the work – including the building of the bridge across the Mnyameni River and the rehabilitation of 64 drifts – was carried out by unskilled or semi-skilled community members. Residents living in the immediate vicinity of where the upgrading took place were employed, which obviated the need for transport to and from their homes.

Project Manager Rob Little of CSIR Transportek commented that the cost-effective and streamlined rehabilitation of the drifts along Amadiba Road was largely due to the selection of Kaytech's Multi-Cell 100 system as opposed to the use of a pipe culvert system.

'Using Multi-Cell, it cost R10 000 to rehabilitate each drift. To lay a pipe culvert would have cost double that. The product is easy to install and easily managed and manipulated to accommodate the varying contours of each individual drift. The Multi-Cell panels were manufactured to the sizes required by the drifts and once set out and pegged in place, these panels were filled with concrete that was mixed on site.'

It's a reality!

SAICE BUILDING … for the future

SAICE has purchased a brand new building in Thornhill Office Park, Midrand.

Preparations are well under way to move in by the end of March 2005.

This facility is modest but smart and will serve SAICE members and their activities well into the future. Our call on members to contribute to reduce the outstanding bond has resulted in a small but well-appreciated beginning. A number of our technical divisions and branches have resolved to invest in the building and we also have received a couple of pledges for donations from them.

Please have a look at your SAICE calendar and add your name to the list of contributions. Ensure YOUR place in the roll of registration and buy one or more brick units at:

Bronze	R250
Copper	R500
Silver	R1 000
Gold	R1 500
Platinum	R3 000

We do, however, welcome any amount! The current list looks like this:

Dawie Botha	Platinum
Ria Botha	Platinum
Debbie Griesel	Bronze
Magda Bruyns	Bronze
Daleen Coetzer	Bronze
TTT Africa	Silver
J E Laas	Silver
Louis de Waal	Platinum
L de V Roodt (Louis)	Bronze
G J Lindsay	Bronze
W C Strong	Bronze
N F B Scmidt	Copper
A K van Nierop	Bronze
N E Kenmuir	Bronze

Please note that from 4 April 2005 our physical address will be:

Building 19
Thornhill Park
Bekker Street
Midrand

(just across the street from our current premises).

Also please note that our National Office doors will be closed from 22 March to 1 April, while we move.

More later!

Allyson Lawless and Dawie Botha

BOOK REVIEW

BAIN'S KLOOF PASS: GATEWAY TO THE NORTH, BY SANDRA STEYTLER AND HANS NIEUWMEYER. PUBLISHED BY THE AUTHORS IN ASSOCIATION WITH MARTIN WELLS OF SUMMIT PUBLISHING, CAPE TOWN, 2003

THE AUTHORS HAVE PACKED a lot of careful research into 70 A5 pages. Both Mountain Club members, they were for twenty years responsible for the club's property in Bain's Kloof and travelled through the pass on an almost weekly basis. Their passion for the pass permeates the book. More than that, it drives it right from the very first words: 'We have watched with consternation the environmental deterioration' and 'We have noted the deterioration of Bain's dry stonework – not his foundations, which are superb – but the severe damage to the bridges and other features, and to the kerbstones which are being overturned by big commercial vehicles whose drivers deliberately disobey the signage. The Pass is in a state of disrepair and neglect.'

Neither is a civil engineer (although Nieuwmeyer is a retired mechanical and chemical engineer, now tutoring and teaching at UCT), yet the book is written with appreciation for the construction difficulties. They ask how was it possible to have built retaining walls and bridges, using blocks of stone weighing up to 8 tons each, without machinery? The answer, they conclude, was the superb management of Andrew Geddes Bain.

Statistics are carefully selected: for example we read that in total 15 tons of gunpowder were employed to blast the rocks, at an average of half a pound per hole. Holes were made by driving (by sledgehammer) forged iron 'jumpers' into the rock.

Not the least interesting sections of the book deal with the convicts (on average about 270 present in the pass at any one time). While most were unskilled workers, many were trained on the job to do the drilling and blasting, or as stonemasons. The book describes the personality clashes between the Superintendent of the Convict Station, 'on the whole a useful and correct officer, but [prone to] ride the high horse' (wrote Bain), and Bain, who on occasion gave 'hasty but imperative orders, and persisted in having his orders obeyed' (wrote the Superintendent) with respect to the convicts but without reference to the Superintendent, although the latter was personally responsible to the Colonial Office for them.

It would seem that the convicts were very humanely treated. There was no discrimination between the races in the way they were treated, nor how they were fed and housed nor what work they were given. The emphasis was on rehabilitation – while working on the pass they were given literacy lessons, learnt a trade and received a certificate of expertise – and jobs were found for them on their release. Very few former convicts committed further crimes.

Sadly, the authors conclude, 'the Pass is in a sorry state and there seem to be no funds to fix it'. They have, however, been leading lights in the formation of a group of 'Friends of Bain's Kloof', and proceeds from the sale of the book will go towards the repair and maintenance of the pass.

The bibliography is extensive.

A strongly recommended purchase.

Kevin Wall

Info: Sandra Steytler, tel 021-797-8289

Government's capital investment programme

to be speeded up

... At the same time, we have taken note of the reasons for the delay in implementing some of the announced programmes ...

THE CAPITAL INVESTMENT programme of government will be speeded up focusing on housing, rural and urban infrastructure, the public transport and national logistics system, water and electricity, said President Thabo Mbeki in his recent State of the Nation address.

To facilitate this, urgent steps will be taken to strengthen the public-private partnership mechanism in government by December 2005. At all times these partnerships should involve local communities.

'To ensure properly focused development planning, cabinet is working to align the national spatial development perspective with the provincial growth and development strategies and the municipal integrated development plans,' said President Mbeki.

'To increase the numbers of skilled workers, we have met the target set by the growth and development summit and trained more than 80 000 learners. We have also released the draft immigration regulations for public comment.'

'It is, however, clear that more work will have to be done to raise the skills levels of our people. Accordingly, the government has approved a new national skills development strategy for the period 2005–2010. R21,9 billion over five years will be allocated to fund this strategy, which will include improved cooperation between the SETAs on one hand and the Further Training and Education colleges and the institutions of higher education on the other.

'At the same time, we have taken note of the reasons for the delay in implementing some of the announced programmes. These include the complexities of the tasks to be carried out, the rigour required in planning and implementing these actions across all the spheres, the magnitude of resources demanded, and the subjective capacity of the implementing agents where least financial resources were made available,' he said.

DIARISE THIS!

Event	Date	Venue	Contact
South African Society for Intelligent Transportation Systems SASITS Conference 2005	10–13 May 2005	Cape Town International Convention Centre (CTICC) Cape Town	Carla de Jager Tel 011-805-5947, Fax 011-805-5971 cdejager@saice.org.za
EcoSan 2005 Third International Conference on Ecological Sanitation	23–27 May 2005	International Convention Centre (ICC), Durban	Carla de Jager Tel 011-805-5947, Fax 011-805-5971 cdejager@saice.org.za
Young Geotechnical Engineers and Practitioners YGE 2005	13–15 June 2005	Mpumalanga	stephensonl@ebe.wits.ac.za
Obtaining Environmental Authorization: A Strategy	13–14 July 2005	Midrand	Lungelwa Lamani Tel 011-805-5947, Fax 011-805-5971 llamani@saice.org.za
Assertiveness and Conflict Resolution for Managers	2–3 August 2005	Midrand	Lungelwa Lamani Tel 011-805-5947, Fax 011-805-5971 llamani@saice.org.za
X-Pert Proactive Management and Planning	15–18 August 2005	Centurion	Lungelwa Lamani Tel 011-805-5947, Fax 011-805-5971 llamani@saice.org.za
SAICE Wits/Pretoria Afternoon Lecture Course	3–31 August 2005 7–28 September 2005	SAICE National Office	Lungelwa Lamani Tel 011-805-5947, Fax 011-805-5971 llamani@saice.org.za
Negotiation Skills	25–26 August 2005	Midrand	Lungelwa Lamani Tel 011-805-5947, Fax 011-805-5971 llamani@saice.org.za
The 13th International Conference of Women Engineers and Scientists ICWES 13	28–31 August 2005	Seoul, Korea	www.icwes13.org icwes13@intekom.co.kr
Vaalco Conference	19–20 September 2005	Johannesburg	Lungelwa Lamani Tel 011-805-5947, Fax 011-805-5971 llamani@saice.org.za
Landfill 2005	20–21 October 2005	Durban	Peter Davies nphuntpld@kaymac.co.za