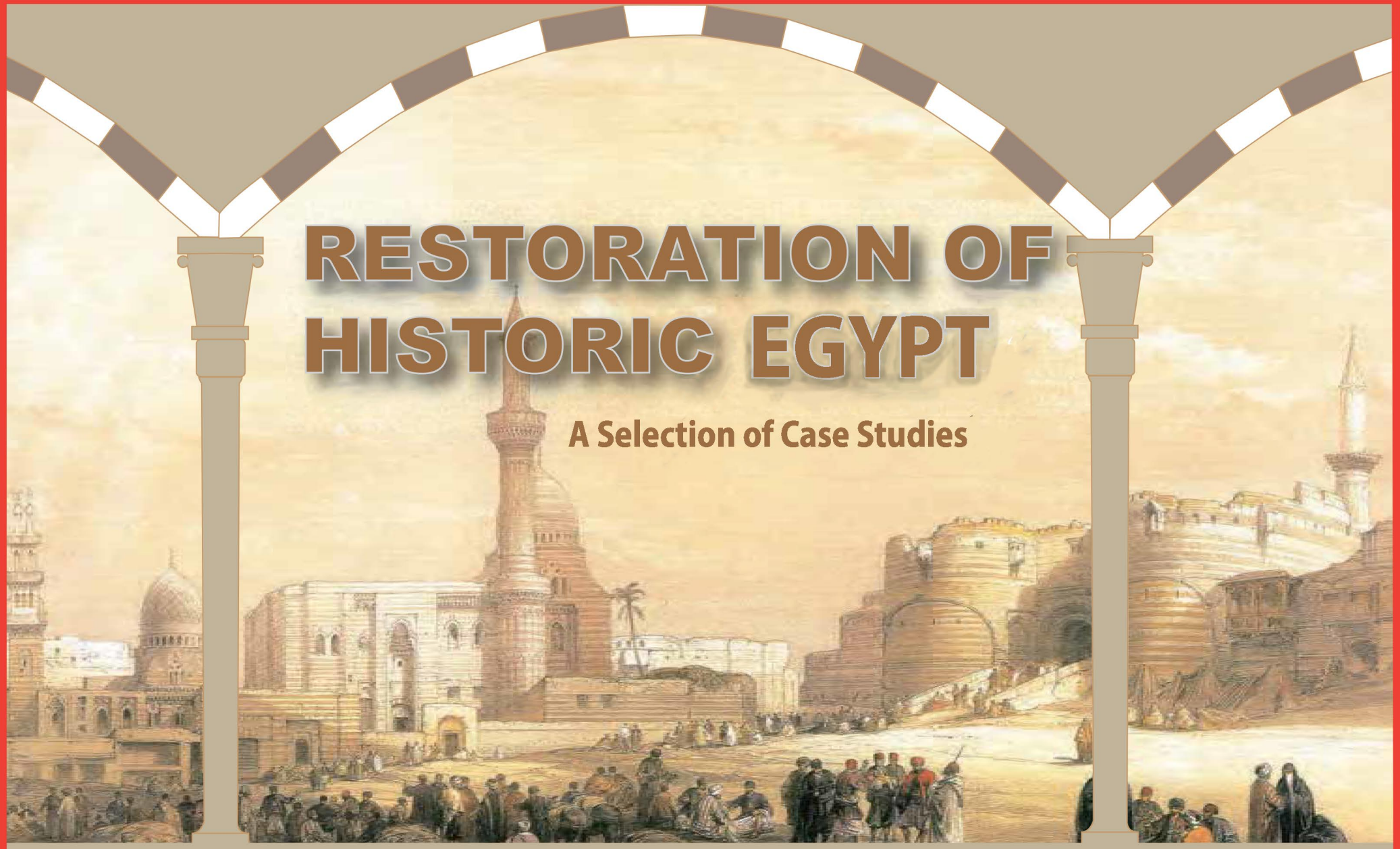


RESTORATION OF HISTORIC EGYPT

A Selection of Case Studies

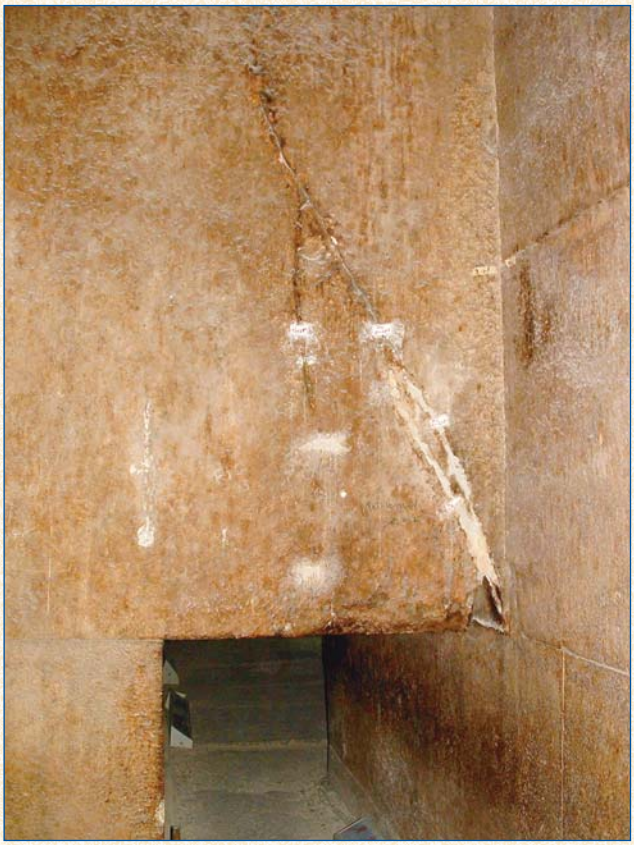
preserving the past for the future

CINTEC

CASE HISTORY

NORTH OR RED PYRAMID AT DAHSHAR, CAIRO, EGYPT

When Sneferu, king of Manetho's 4th dynasty, came to the throne in 2575BC, Djoser's pyramid at Saqqara was the only large royal pyramid that stood complete. Sneferu would become the greatest pyramid builder in Egyptian history by constructing the three colossal pyramids (at Meidum and the Bent and the North, or Red pyramids, at Dahshur). Together with his son and grandson, who built the two great pyraimds at Giza, he was responsible for the constructing the largest volume of stone pyramids in the world. After thirty years of his reign Snefreu abandoned the Bent pyramid as his burial place, instead he began work on the North or Red pyramid which was built to a much gentler slope of 43° 22'.



Front elevation of cracked beam

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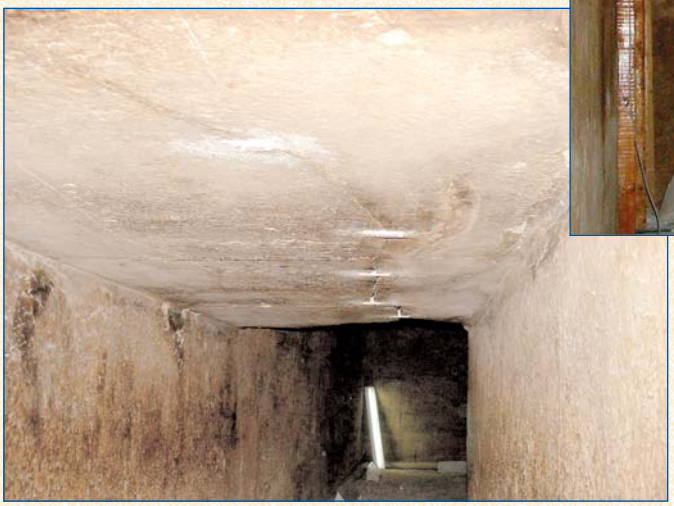
CASE HISTORY

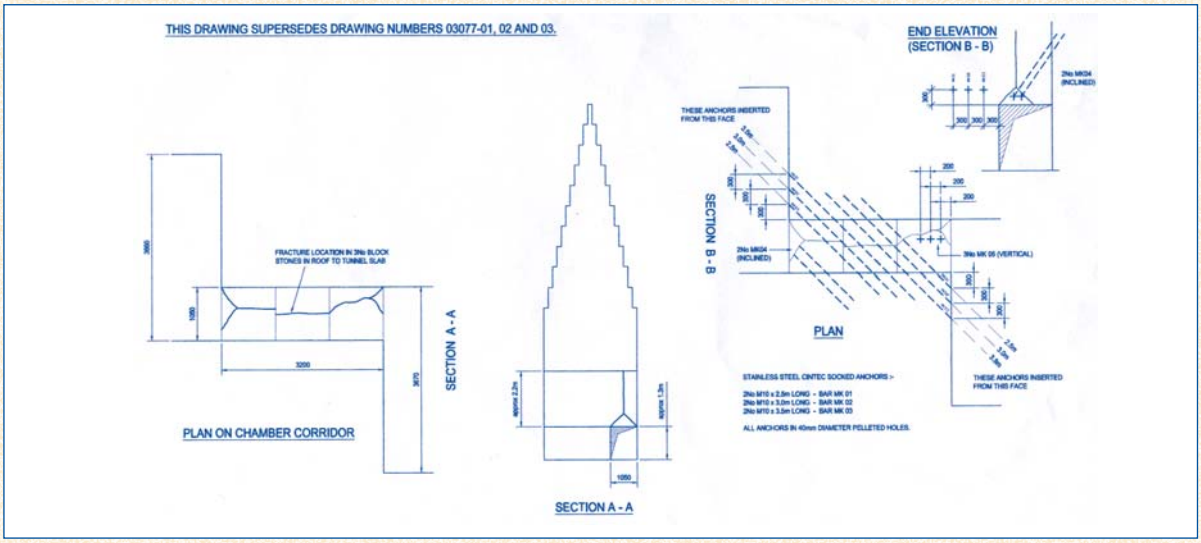
NORTH OR RED PYRAMID AT DAHSHAR, CAIRO, EGYPT - THE PROBLEM

The present problem was not on the exterior of the pyramid but one on the corridor between the corbelled burial chambers. The beams spanning the low corridor opening were cracked, from the base of the stone beams, up through the centre of the beams, to a position just adjacent to the centre at the top of these stone beams. It was impossible to drill at right angles to the corridor due to the mass of the core of the pyramid. However, it was possible to drill at an angle of 43 degrees in the respective burial chambers at both the entrance and exit of the corridor and secure the beam with a row of 20mm diameter Cintec stainless steel consolidation anchors. Work was completed at night after the monument was closed to the public because the position of the burial chamber was some 60 metres down a 45 degree slope and a dust extraction unit and breathing apparatus was required by the operatives.

The high burial chamber



Soffit of cracked beam in the corridor between the burial chambers



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Temple of Khonsu

Karnak Complex

Luxor

Cintec International Limited

Temple of Khonsu Luxor Egypt

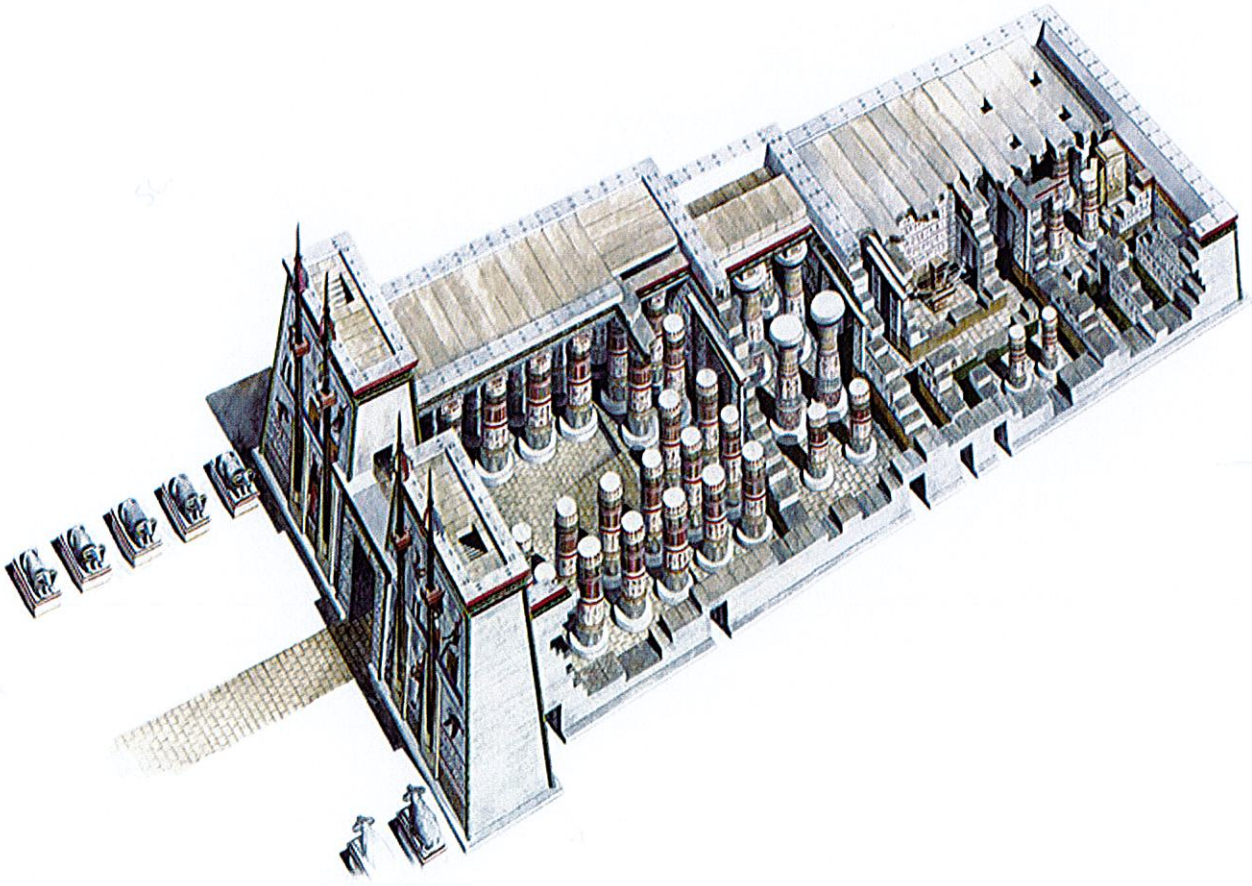
Project:
Stabilising Architrave Stones

Khonsu was the child of Amun and Mut who, as a group, formed the holy triad of Thebes. In addition to being associated with the moon, he was associated with the falcon headed god Horus, another divine child.

Khonsu was often depicted with a falcon's head and wearing a headdress with a lunar disc atop a lunar crescent.

Representations of Khonsu in this form can be seen throughout his temple.

The structure of the Khonsu temple was begun by Ramesses III (ca 1184-1151 B.C.)

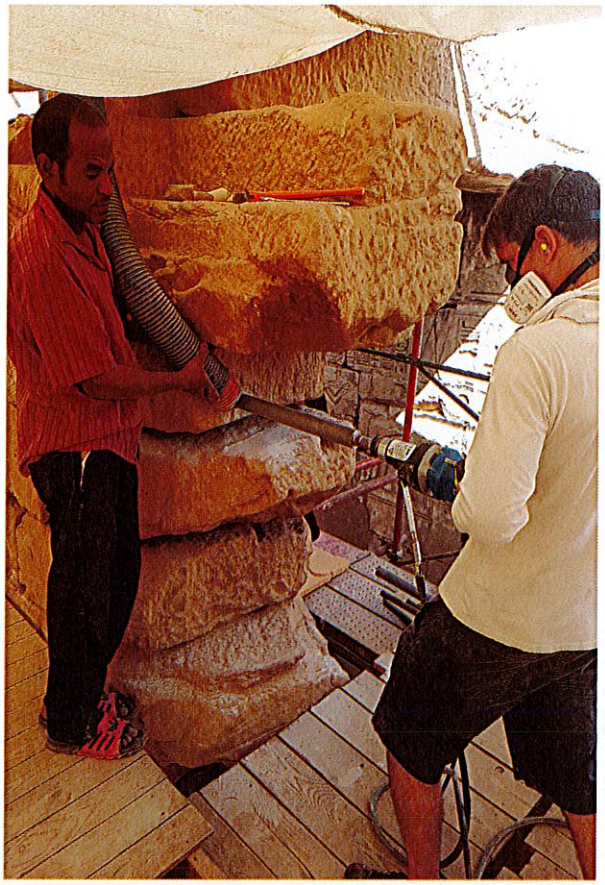


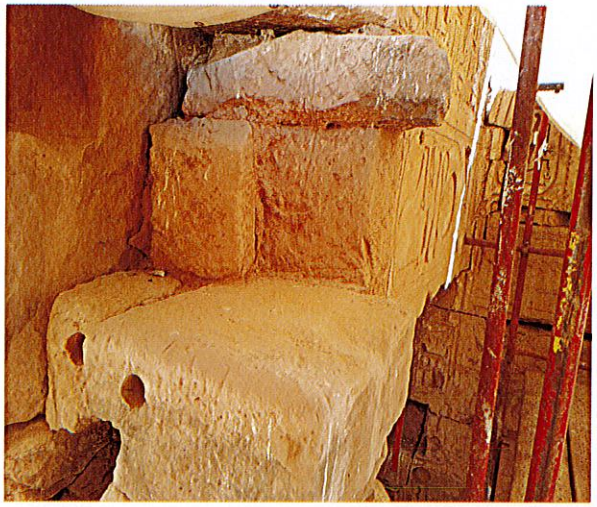
Side elevations and top view of cracked architrave

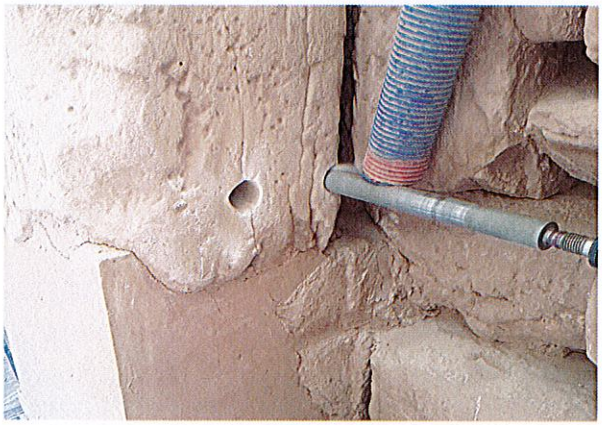
Dry diamond drilling with dust extraction.

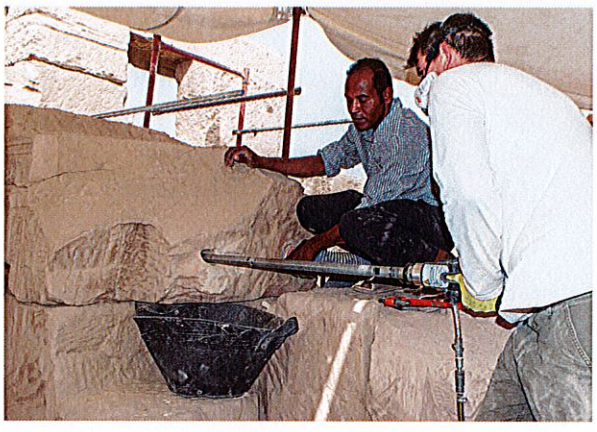
Holes were drilled up to 5mts to bridge the cracks in the architrave.

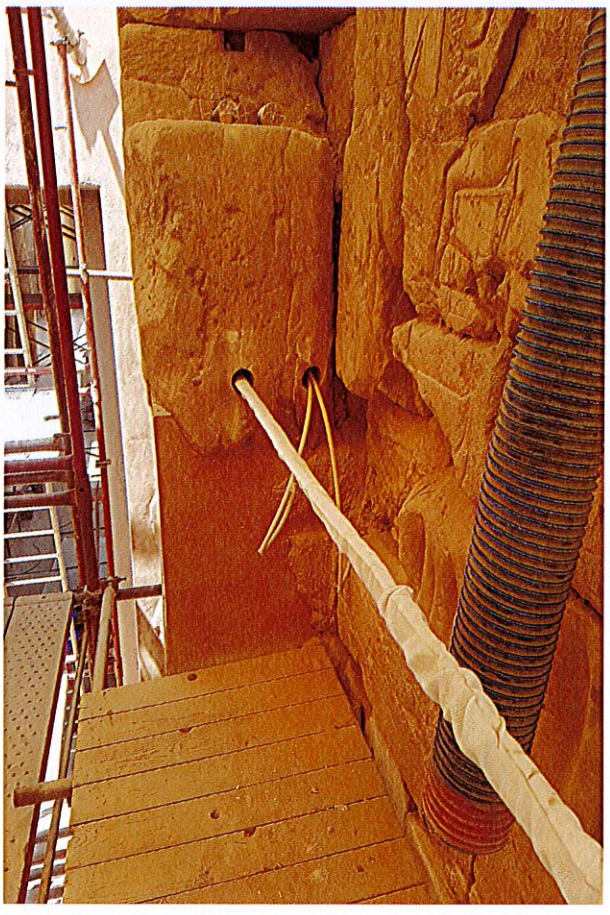
M20 Stainless Steel Socked anchors were then installed

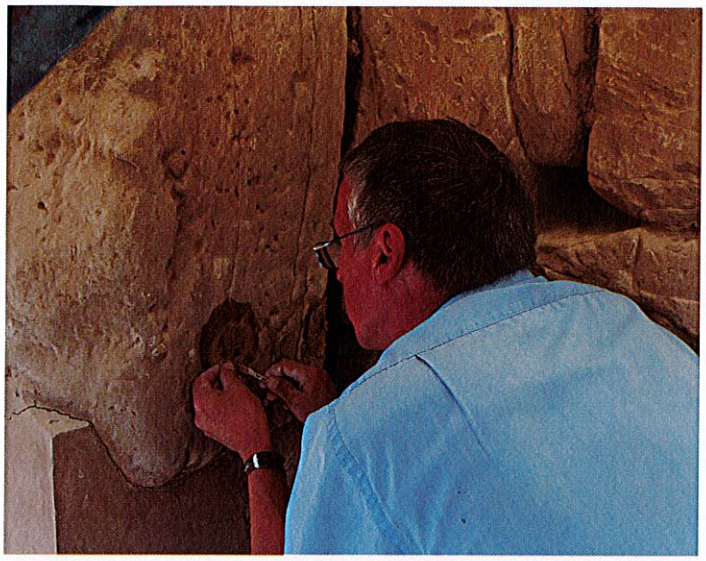




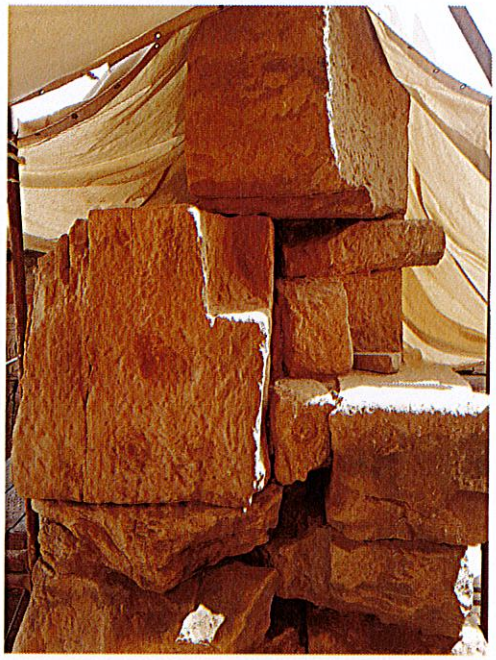


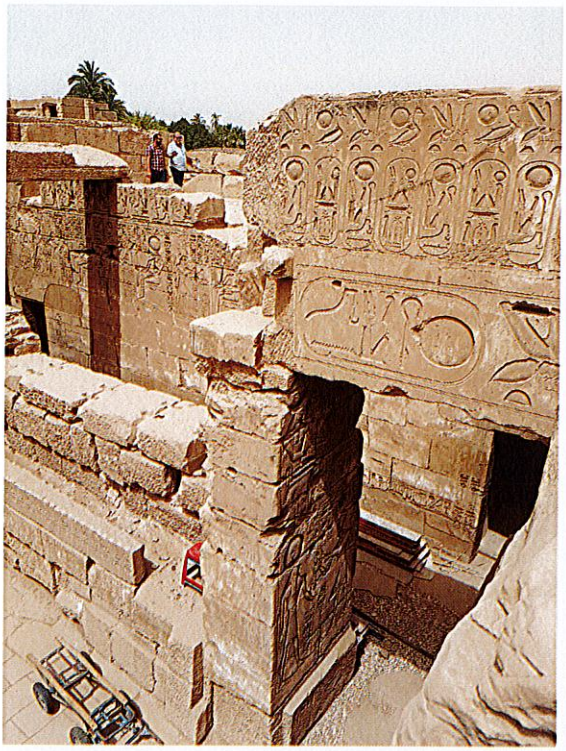


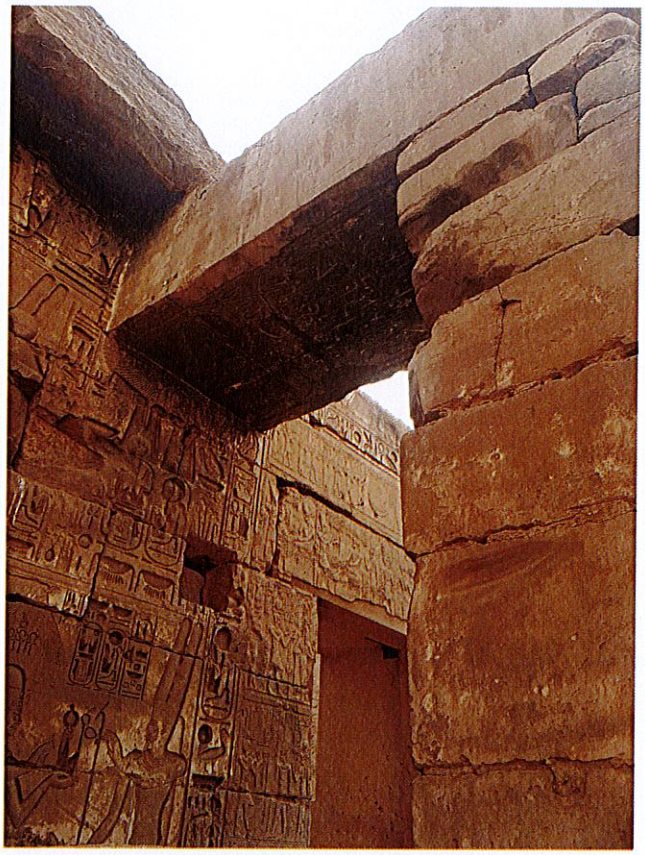




After the anchors were injected with grout. The face core which was numbered and stored was reinstated using the dust collected during the drilling process mixed with hydraulic lime, the face cores were then matched to the surrounding stonework

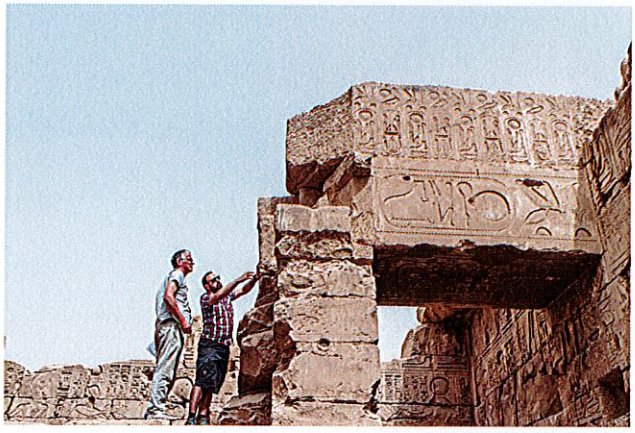




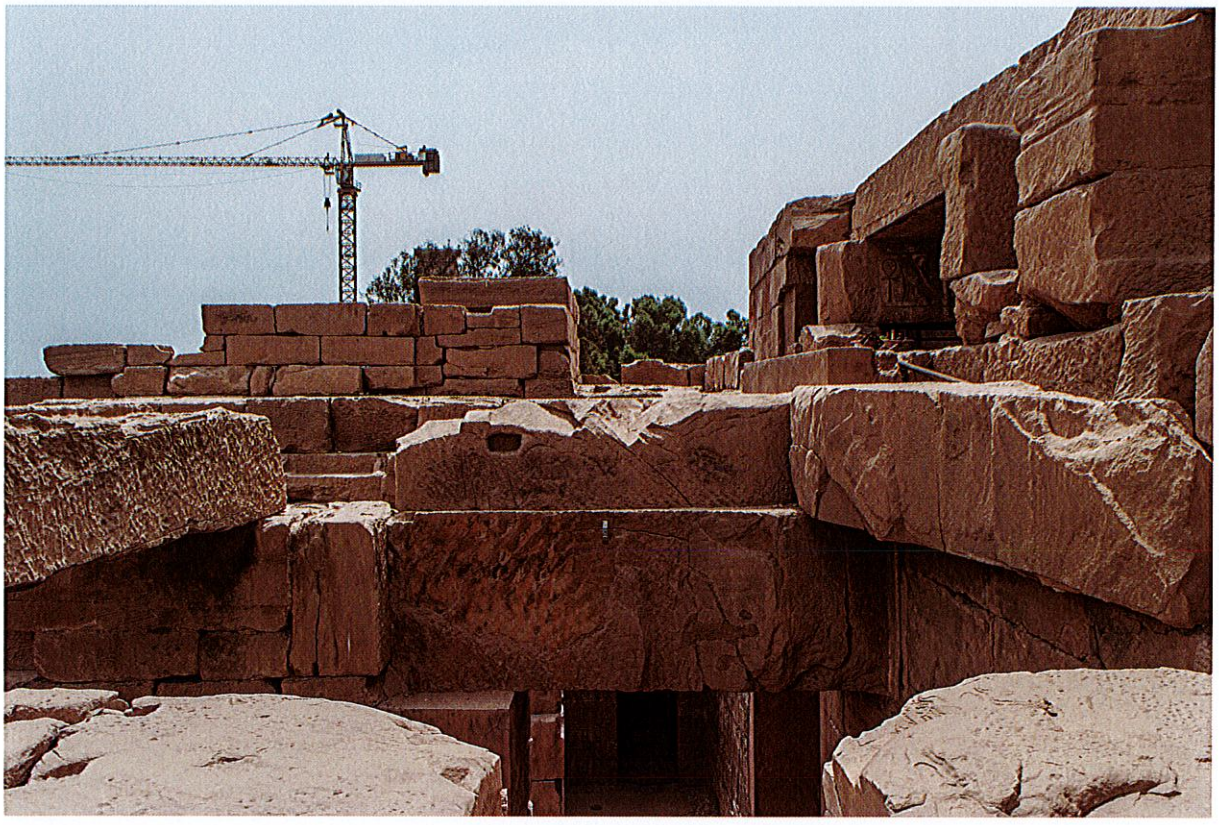


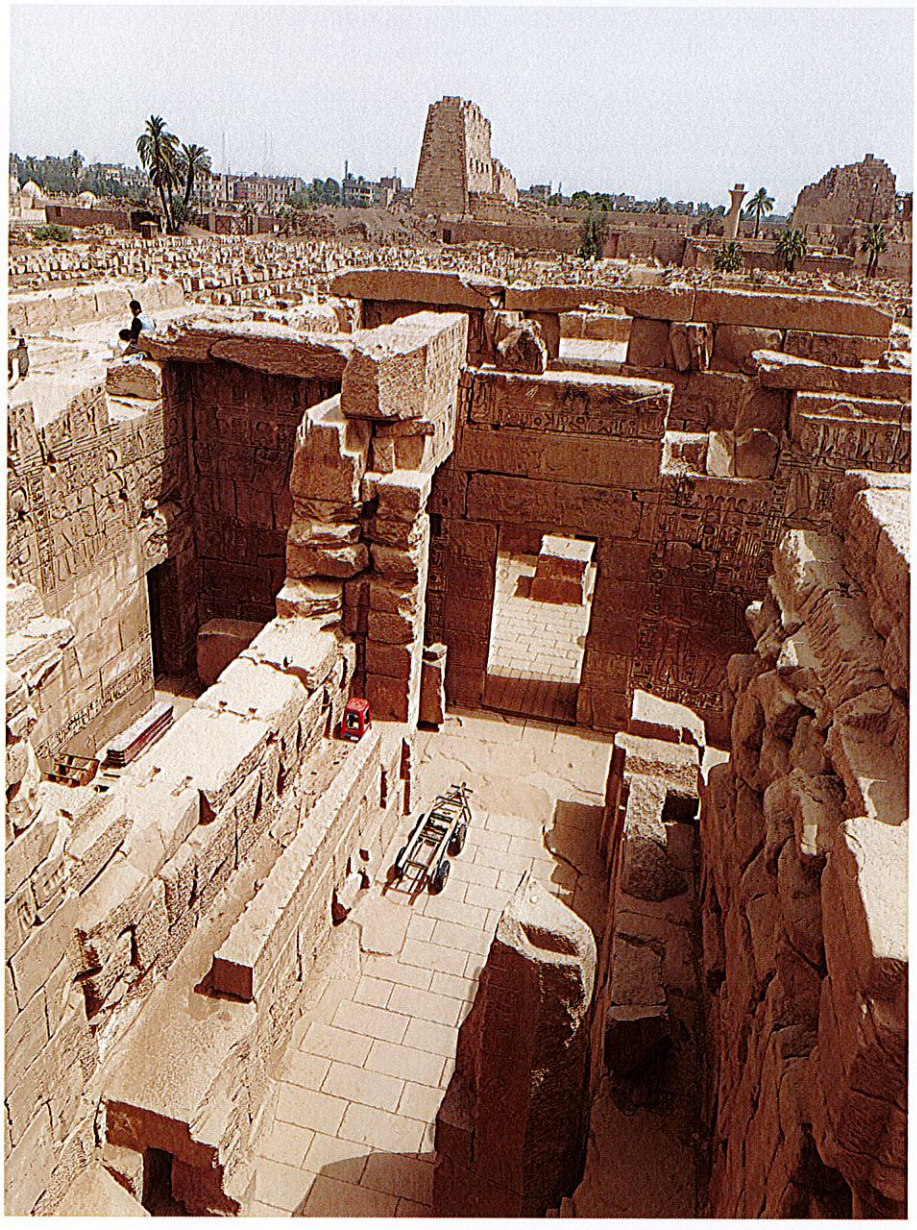
The North architrave from the side and underneath

M20 anchors were installed in The lower part of the architrave In the tension zone, and into the temple wall, increasing the bearing zone on each end of the architrave.



South Architrave, the one face had almost completely delaminated.





Case History

CINTEC™ REINFORCEMENT SYSTEMS

Pyramid of Djoser, Egypt

Egypt's oldest pyramid at risk and a British company has been called in to stop its collapse

By Daily Mail Reporter Last updated at 3:39 PM on 5th January 2011

A British engineering firm have won a lucrative contract to help save the oldest pyramid in Egypt. The 4,600-year-old pyramid of Djoser almost collapsed in 1992 after being hit by an earthquake. But in a bid to preserve the ancient structure, a firm from South Wales has been called in to keep the pyramid standing.

Rescue Operation

A Welsh engineering firm has been called in to save the Pyramid of Djoser in Egypt. A team from Cintec in Newport has been contracted by the High Council of Egyptian Antiques to rescue the landmark, which is also known as the Step Pyramid. The firm worked on Windsor Castle after the fire of 1992 and was also called upon by the Indian government to strengthen a major Delhi bridge ahead of last year's Commonwealth Games.

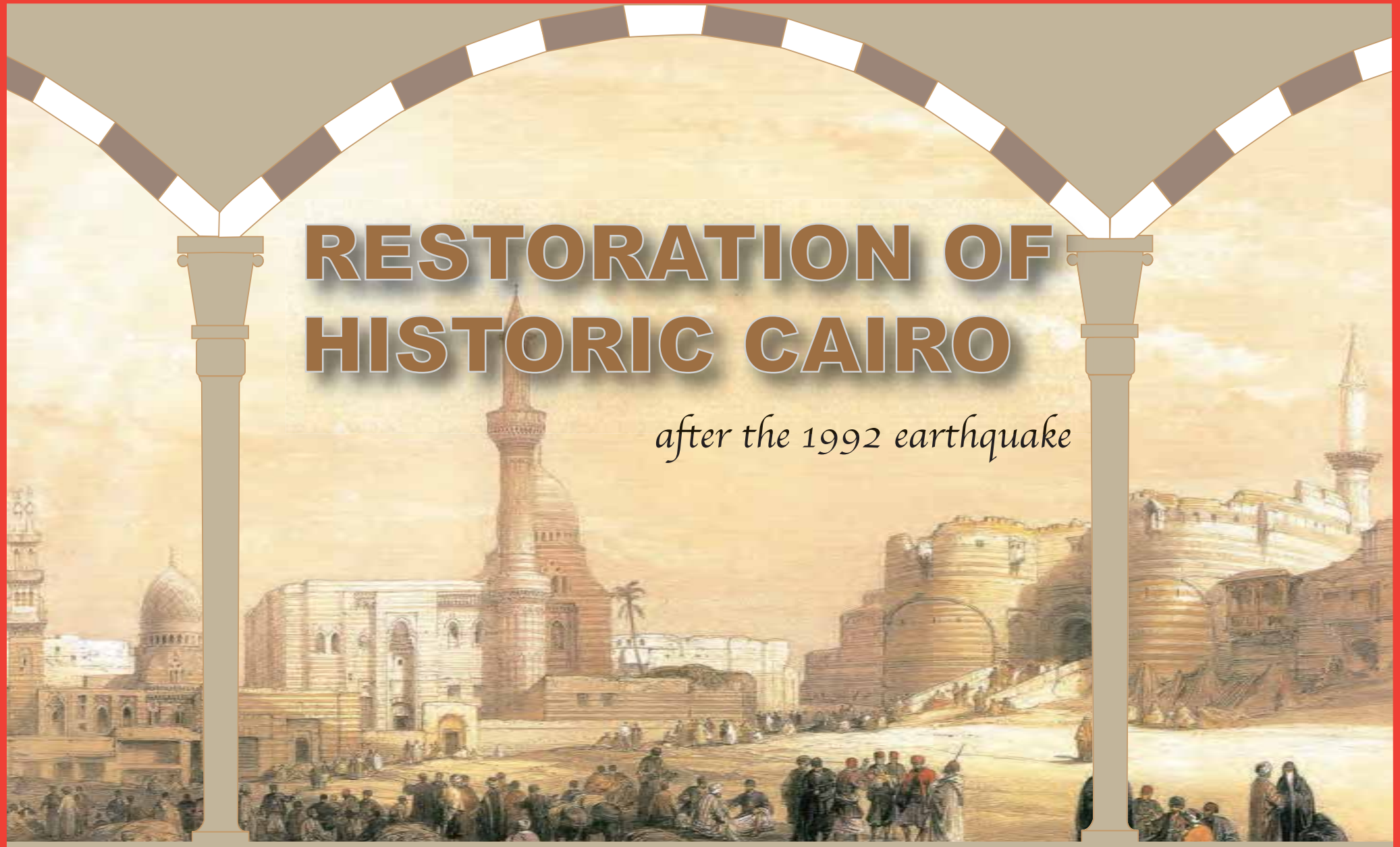
And after building a reputation for preserving landmark structures, Cintec has won an £1.8million contract to save the Pyramid of Djoser.

The engineers will use self-inflating water-filled bags to bolster against the collapse of a damaged ceiling inside the pyramid. Stainless steel structural reinforcement anchors will also be implemented in a bid to secure the strength of the building's central chamber.

The 200ft pyramid was built in around 2650BC.

Peter James, managing director of Cintec, said: 'We are extremely pleased to have been appointed for this project and are always looking for new methods to support and maintain historical landmarks across the globe. We recognize the importance of both historical and religious structures to their cultures and hope to continue to develop advanced reinforcement systems that will preserve archaeological structures for future generations.

'The Step Pyramid project is of particular importance to us as the entire structure could be destroyed at any point due to the damage on the ceiling and roof caused by the earthquake. 'We aim to work as efficiently as possible on this project without comprising the design or strength of the structure.' Built in around 2650BC as a burial place for Pharaoh Djoser, the Step Pyramid can be found in Saqqara, around 19 miles south of Cairo.



RESTORATION OF HISTORIC CAIRO

after the 1992 earthquake

preserving the past for the future

CINTEC

HISTORIC CAIRO

On the 12th October 1992, with an epicentre near Dahshur 35km south of Cairo, an earthquake measuring 5.8 on the Richter scale struck the Egyptian capital.
This seismic event albeit relatively small was unusually destructive causing 545 deaths, injuring 6512 and making 50,000 people homeless. It was the most damaging event to effect Cairo.

The areas of greatest damage were in the Old Cairo, Bulaq and southwards along the Nile as far as Gera, on the West Bank 350 Buildings were completely destroyed and 9000 others severely damaged. Some 216 Mosques and Maqaads were badly damaged particularly the older masonry and abobe structures. This was made worst with liquefraction reported in the epicenter and in the old historic quarter of the city.

Typical damaged facade

Behind the facade

Structures with temporary suppports

SCOPE OF WORK

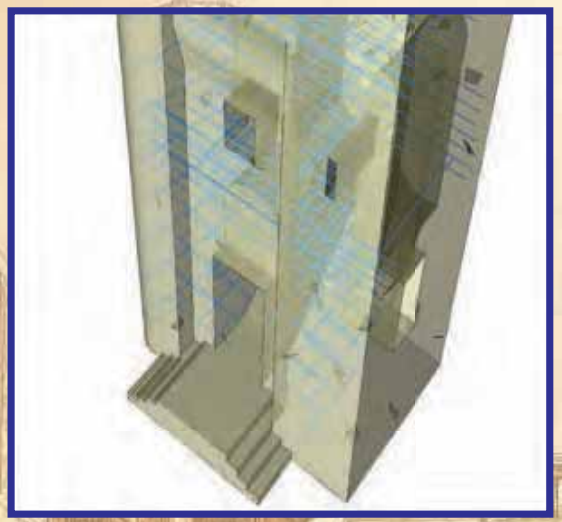
A tender to reconstruct the greater part of old Cairo was prepared. A number of large general contractors were awarded contracts to undertake the demolition of damaged structures and rebuild the structures and monuments where needed. Cintec International Ltd was asked to tender for the specialist anchoring and reinforcing to the damaged structure to save as much of the historic buildings as possible.
The work concentrated on historic mosques and Maqaad's. Each building was carefully surveyed and detailed work schedules were prepared together with structural analysis of the buildings including discrete element mathematical modeling.
The contract was undertaken over a three year period.

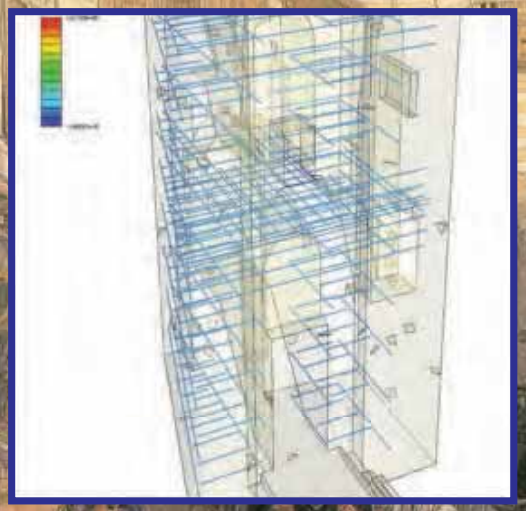
Some of the structures included;

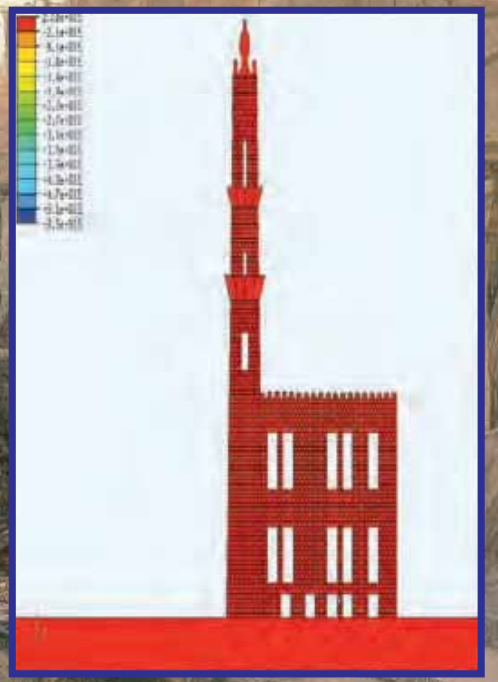
Al Ghory Mosque and minaret
As Silahdar Mosque
Mahmoud Moharam Mosque
Beshtaq Mosque
Sarghitmish Mosque
Pabers Mosque
Maqaad Mamy As Saifi
Maqaad Waqf A L Mulla House
Maqaad Palace of Emir Tas
Maqaad ash Shabshiri House
Maqaad Qayt Bay House.

In total over 15,000 metres of Cintec remedial reinforcement and anchoring

The discrete element analysis was undertaken by Rockfield Software Company using the unique program Elfren. This program was able to provide a three dimensional view of the the existing structure and the resultant damage. It was able to position the reinforcement in the most effective position and confirm its suitablity for future seismic events







Access was provided by the main contractors at each site

Internal cross walls stitched and secured to the external walls.

Positioning anchors in confined areas

Injecting the grout from the rear to the front

The work was carried out under the supervision of the Egyptian Antiquities throughout the project.
All the work was undertaken whilst the normal every day activities by the local population was in residence in and around the historic structures.

Anchor placement

Typical consolidation tie

Installation of the Cintec system

Over 15,000 metres of the unique Cintec sock system was installed both to internal and external walls of the buildings. These comprised in the main of M20 stainless steel anchor bodies, M16 anchor bodies and M12 anchor bodies all in 65mm drilled holes. Smaller consolidation anchors comprising of a 10mm circular hollow section in a 32mm drilled hole. The main grout was a special Presstec White lime grout to match the existing parent material.
The anchors varied in length to match each condition and were from 20mm to 15 metres in length.

Each anchor assembly is filled with grout under pressure from the rear to the front so that the entire anchor body is inflated like a balloon.

Internal and external walls are drilled with diamond core hollow tubes to the desired diameter.

Typical damage caused to exterior walls

Buckling and movement of columns

Drilling at roof level adjacent to previous timber intervention

Corner stitching using diamond drilling rig

Design Concepts

Cintec almost exclusively use stainless steel for any reinforcing intervention.
The designer calculates the size and profile of the reinforcing member depending on type and anticipated loads needed.

THE REINFORCING MEMBER

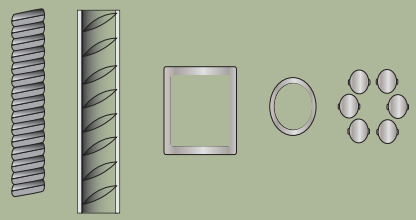
The designer is able to choose from all commercially available sizes and profiles such as solid threaded bar rebar and grip bar. Also from circular, square and rectangular hollow sections and even rolled steel joists.

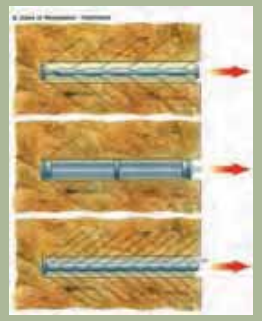
The grade of stainless steel varies according to its use from grade 303, 304 to 316 the relevant standard.

Metal plates can be attached to the ends of the reinforcement and circular and square hollow section can be cripped to increase the cone of compression when loaded.

THE PARENT MATERIAL

The strength of the parent material and /or mortar can govern the anchor capacity. Design checks on the parent material capacity can be based on the resistance strength of the in situ construction to the anchor force according to national standards. When the parent material or mortar strength is indeterminate, the capacity of the material can be determined from in situ tests.





THE DRILLED HOLE

The drilled hole is calculated on the bond strength between the grouted sock and the parent material. A conservative figure used as a standard would be 0.2 newtons per square millimeters. However, the material can be tested in situ where the strength is indeterminable.
It is also necessary to increase the hole diameter proportional to the length of the drilled hole to allow for extra sock and increased size of the injection tubes.

M20

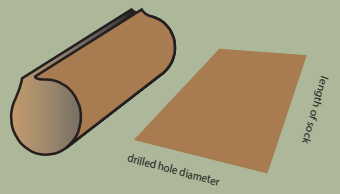
THE GROUT

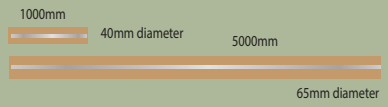
M20

Presstec is a cementitious grout, a factory produced mix with graded aggregates and other constituents which, when mixed with water, produce a pump able grout that exhibits a good strength with no shrinkage.
Presstec is made in accordance with German Din Standards.
The grout has been accelerated age tested for fourty years without any reduction in quality. Also extensive freeze thaw testing has successfully undertaken with good results. It has also achieved a 2 hour fire rating.
Presstec can also be varied to match the parent material and conditions.
A rapid setting grout, a sulphate resisting grout and a lime added grout are available if required.

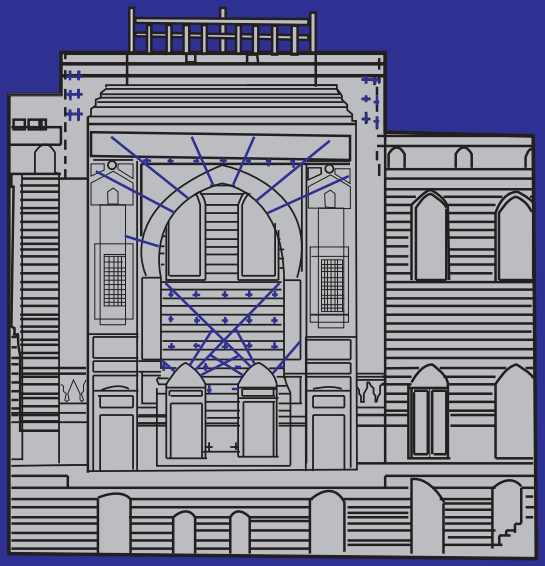
THE SOCK

The fabric sleeve is specially woven polyester based tubular sock with expansion properties to match the diameter of the drilled hole and substrate. The mesh sock is designed to contain the aggregates of the mixed grout while still allowing the cement enriched water (milk) to pass through the sock both sizing and bonding to the substrate. The sock is manufactured in sizes from 20mm to 300mm in diameter and is adjusted to suit each individual application.

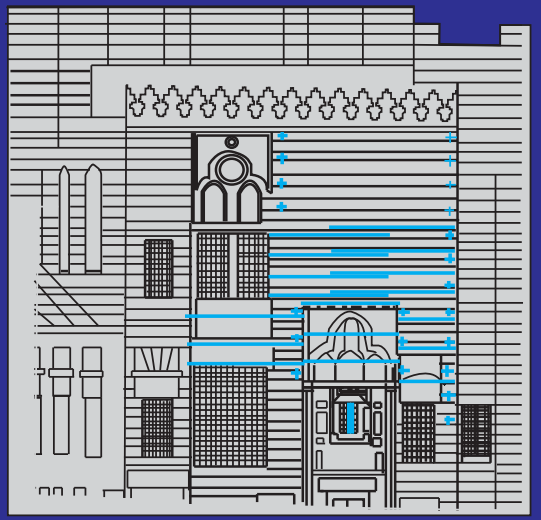




Typical anchor and stitching detail



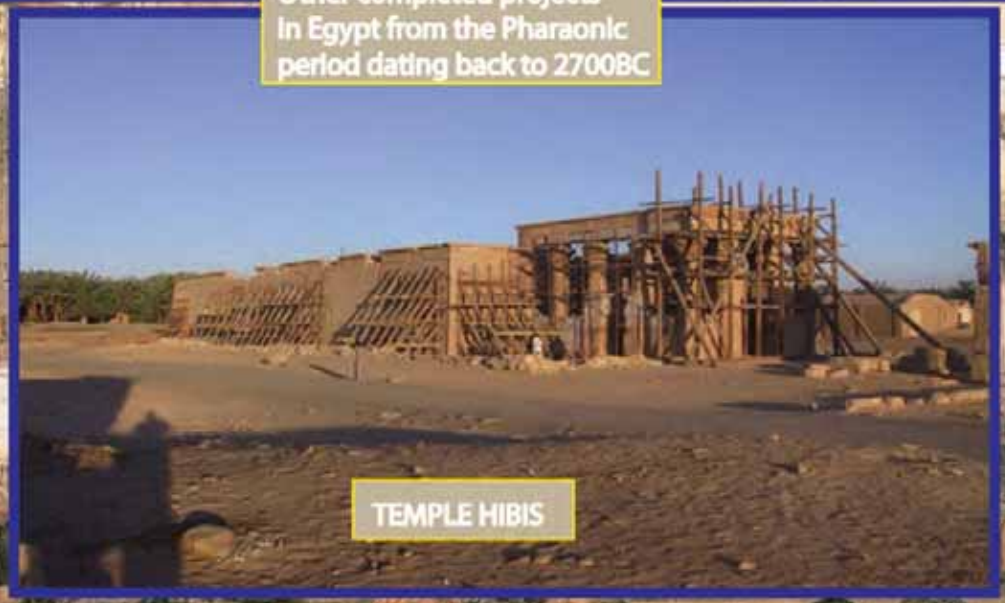
radial and consolidation anchors



Silidar and El Saifi mosques after handover to the Egyptian Antiquities High Committe

Projects completed in Egypt from the Pharaonic period up to 2700 BC
Photographs before restoration work was commenced

Other completed projects in Egypt from the Pharaonic period dating back to 2700BC



CINTEC
Reinforcement Systems

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CINTEC

Case History

CINTEC™
REINFORCEMENT SYSTEMS

The Madrasa & Kanqah Of Sultan Al-Ghuri, Cairo, Egypt

19th Century illustration of Mosque

The Madrasa and Khanqah of Sultan al-Ghouri is one of the Mohammedan monuments under the care of Egyptian Antiquities Organization. It dates back to 909-10 Ah 1503-4 AD.

The Madrasa Mosque with its strong features, bold design, marble panels and intricate geometric design carved into the surface of the arches and ceiling represents the last great flowering of Mamaluk Art.

A massive earthquake in 1992 almost saw the end of the 500 year old treasure. The CINTEC proprietary anchoring system saved this historic gem from being torn down.

The Damage

An inspection of the Madrasa reveal some very severe longstanding problems. The floor of the mosque undultated dramatically, providing evidence of very significant foundation problems of the masonry vaults supporting the floor. Attempts had been made in the past to underpin the sleeper walls supporting the vaults, these had failed. All the walls of the Mosque exhibited very severe fractures. The problems were brought about by earthquake damage in October 1992 and by the rising contaminated ground water. Further problems in the external walls had been caused by the activities of the shopkeepers trying to enlarge the space available for selling their wares.

Seismic damage to decorative arches

As a consequence, sections of masonry have been demolished at ground floor level to create this additional space. The net result of the above was the mosque of al-Ghori was in a very delicate state of equilibrium. Despite having survived for nearly 500 years, the toll of a rising water table, earthquakes and neglect had brought this structure to the point of collapse. Urgent measures were required to reintroduce some structural strength and stiffness into the building.
It was understood that the Madrasa was underpinned by using a system of micropiling. The requirements therefore remained to tie the elements of superstructure together.

Temporary support of the Dikka arches

The very high walls were laterally unrestrained and very vulnerable to lateral forces such as may be produced by the next earthquake.

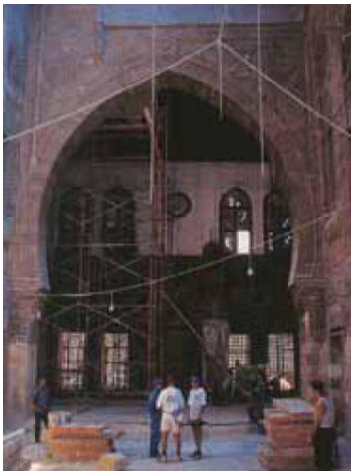
Vertical shear crack

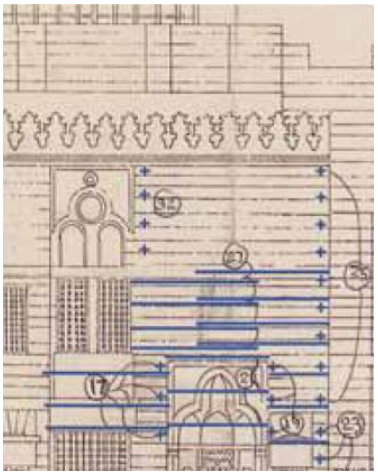
Lintel Stones

The Repair

The Cintec stitching system was extensively used at Al-Ghouri. These reinforcement anchors, up to 12 meters long, serve to stiffen each individual wall immensely. The walls of Al-Ghouri are generally of two facing skins in-filled with a core of rubble. The large arched openings in the mosque are particular points of weakness in the structure.

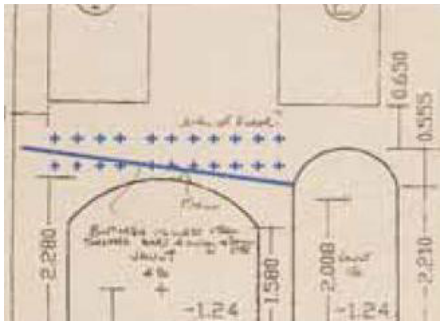
Longitudinal ties in each of the stone facings of the wall above the arch would serve to resist the thrusts naturally produced by the arch as a well as serving to assist the walls to resist the next earthquake. In addition to longitudinal ties, transverse ties of length equal to the thickness of the wall were introduced to increase the strength of the wall.





Dikka arch in the main courtyard

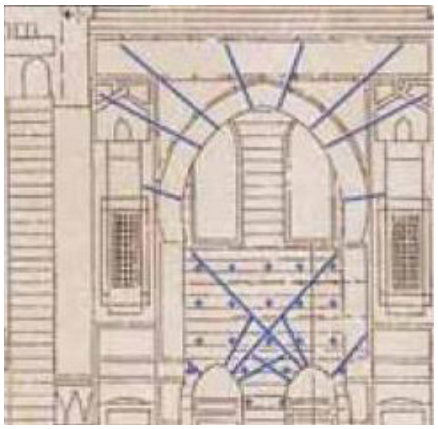
Drilling the vaults.



Typical repair detail for the arched vaults at ground level.

One of the four arches of the court being scaffolded prior to drilling and anchoring.

Decorative panels being drilled ready for installation of consolidation anchors.



Typical anchor placement details for the arches and side walls.

Diamond drilling the arch stone.

The Diamond drilling rig.

Anchor installed & inflated ready for front core to be replaced.

Front core replaced, after anchor installation and made good.

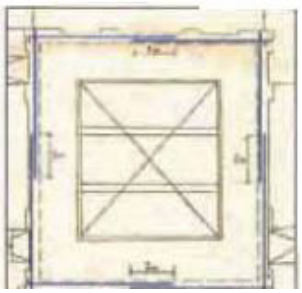
Drilling the stonework after removal of front core.

The CINTEC stitches would also be used to tie the roof structure to the perimeter walls and create a diaphragm action. Again this is an internationally recognized system of introducing greater stiffness and earthquake resistance into a structure. The beauty of the Cintec anchor is that it contains the grout to be used within a sleeve and control of grout flow, and its impact upon the existing structure is therefore very good.

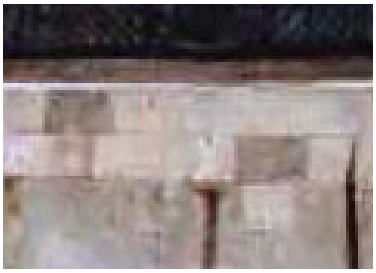
The anchors to be used would be invisible in the repaired structure, eventually over 1200 meters of anchors were installed at al-ghouri. The installation team needed to keep a fine balance between the archaeological project and the Egyptian Authority whilst encountering natural hazards like dust, confined working spaces, insects and high temperatures.

The success in refurbishing this ancient mosque was as a result of combined association of Cintec, Arab Contractors, Intro Trading and the advice and co-operation of the Egyptian Antiquities Organizations thus ensuring the stability of the 500 year old important heritage building.

Roof section above central courtyard



Market place outside Mosque 19th century illustration



Roof consolidation anchors

Installed roof anchor

Typical consolidation anchor prior to grout injection

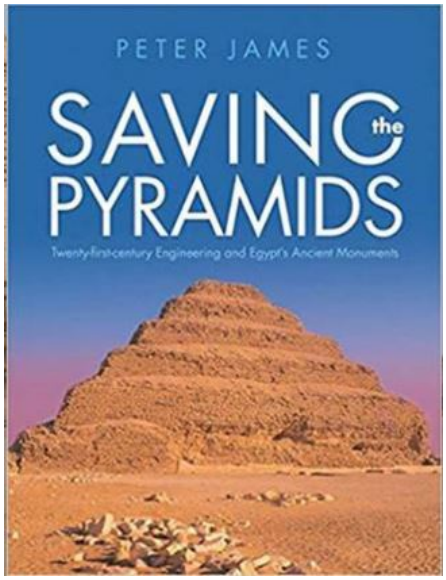
5 meter long vertical anchors at roof level

To find out more on this project and many others by visiting our FaceBook page or by following the links below:

http://www.dailymail.co.uk/news/article-1344204/British-firm-called-save-Egypts-oldest-pyramid.html#ixzz1Ae94ApUd
http://www.bbc.co.uk/news/uk-wales-south-east-wales-12131830
http://www.talkingpyramids.com/
http://ca.search.yahoo.com/search?ei=utf-8&fr=slv8-tyc8&p=djoser%20%2b%20Cintec&type=

CINTEC
REINFORCEMENT SYSTEMS

“Saving the Pyramids” by Peter James Available for purchase online.



Egypt's oldest pyramid has been saved from ruin thanks to a team of Newport engineers. The step Pyramid of Djoser at Saqqara, known as the step pyramid, had been unstable since a massive earthquake in 1992 and was in danger of collapse at any moment. British structural experts Cintec were hired in 2010 to shore up the pyramid, believed to be the first large stone building on earth.

Much of the damage was done when an earthquake hit the pyramid in 1992, and the repair project was agreed by World Heritage and Egyptian antiquities chiefs. Over a period of almost a decade, with a three year hiatus due to the Arab Spring, the team has managed to stabilise the 62 meter high pyramid on the Nile's west bank near Cairo, using giant airbags and some wire mesh left over from a previous project at Westminister Abbey.

Engineering firm Cintec battled extreme heat, vandalism and political unrest in Egypt, but nine years later the firm has completes its mammoth task.