# THE LITTLE BOOK OF CIVILISATION

bigger
longer
wider
higher
deeper
taller
lighter
stronger
cleaner
safer
better

We remember great civilisations such as the Romans, Egyptians and Maya – all were able to develop building techniques and systems to support life. Today, civilisation relies more than ever on teams of **inventive people** to **design**, **build** and **maintain** the sophisticated **environment** that surrounds us.

Infrastructure is the thing that supports our daily life – roads and harbours, railways and airports, hospitals, sports stadiums and schools, access to drinking water and shelter from the weather. Infrastructure adds to our quality of life, and because it works, we take it for granted. Only when parts of it fail, or are taken away, do we realise its value. **This booklet looks at the amazing ways civil engineers overcome the challenges of creating and maintaining our infrastructure for us, and for future generations.**

# How can we...
# support life?

We can't live without water. However, **1 billion of the world's 6.5 billion people have no direct access to drinking water** and millions die each year because of poor sanitation and drought. Pollution and climate change, changes in population, and the destruction caused by wars or natural disasters like the Asian tsunami, threaten supplies of fresh water worldwide. **Less than 1% of the world's fresh water is available for people to use**, but even this tiny percentage is enough for all of us if it is managed. As well as needing fresh drinking water, our health depends on wastewater being treated properly.

## WaterAid Ethiopian people's project

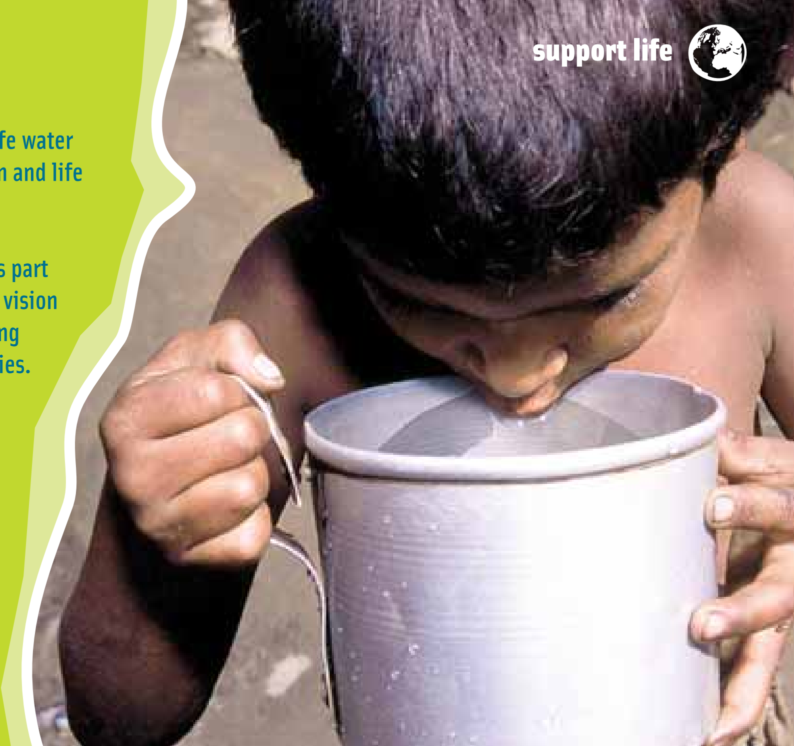
In Ethiopia, only 24% of the country's 62.6 million people have safe water and only 15% have sanitation. Water-related diseases are common and life expectancy is only 43 years.

Civil engineers designed the Hitosa gravity water scheme, which is part of Ethiopia's largest water-supply project. Civil engineers had the vision needed to design and put into practice such a huge scheme, working with 60,000 local people to provide safe water for their communities.

One public water point serving 500 people costs £440 to build. Each family using it contributes around £4.50 to the project and digs 5m of the trench that will carry the water. For civil engineers, solving infrastructure problems in the developing world using appropriate technologies is just as demanding – and rewarding – as solving problems in the developed world.

**Find out more at www.wateraid.org.uk**

Photography: WaterAid/Abir Abdullah



## Cairo wastewater network

Egypt's capital city is one of the largest, most densely populated places on the planet. The population of Cairo (13 million people) has grown so fast that the River Nile and Aswan High Dam can no longer cope with demand. Around 23% of people don't have safe or adequate water. Of the waste going into Cairo's sewers, only 15% is fully treated before going back into the Nile.

Civil engineers predicted what the city's needs would be in the future. They also raised awareness of how to manage and treat water. Their work makes sure that the people of Cairo have clean drinking water, and that their waste is treated safely. This has helped to get rid of disease and improve the daily lives of millions of people.

**Find out more at**
**www.hyderconsulting.com**

Photography: Getty Images

## Key facts

**80%** of Cairo's fresh water is used for **irrigation** (supplying water to land and crops), not drinking.

Cairo produces **56 million $m^3$ of sewage** each year, which is the size of **20 great pyramids.**

Each year, **2.3 billion $m^3$**, or **100 million petrol tankers**, of drainage water full of fertilisers, pesticides and organic material goes back into the Nile upstream from Cairo.

By **2025, 86 million people** will live near the River Nile.

# How can we...
# shelter from harm?

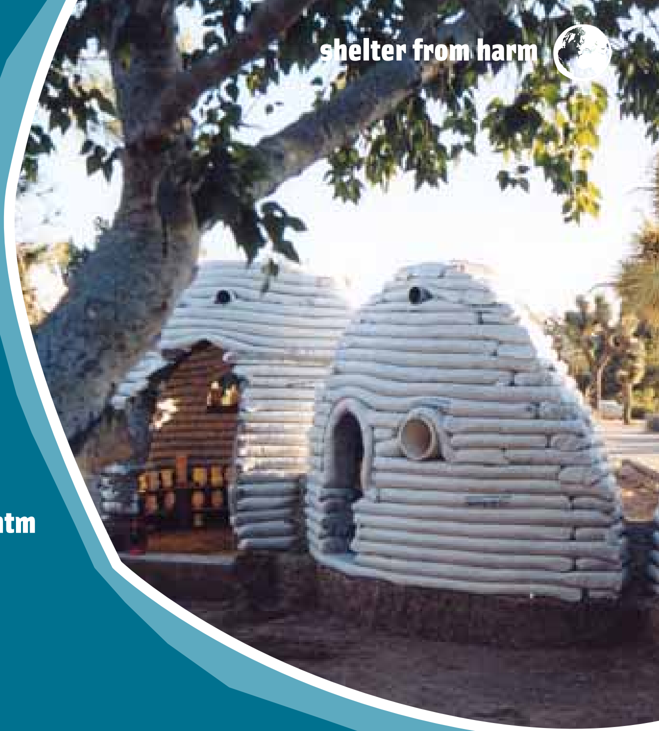
We may have solved the problem of providing safe drinking water but is our habitat safe? Coastal areas can be threatened by being worn away by the sea or floods, and inland sites may be contaminated by previous industrial activities or threatened by subsidence (an area of land gradually sinking or caving in). **Extreme heat and cold, winds, earthquakes and risk of flooding** cause problems, but civil engineers are using their skills to make areas safer.

## Tsunami shelter

'Superadobe' is a beehive-like building developed for future communities on the Moon. It has been adapted to create affordable emergency housing for survivors of disasters like the Asian tsunami.

The Superadobe buildings are built by filling empty sacks with dirt and piling them in coils. Strands of barbed wire then act like Velcro to provide earthquake-proof stability. Simple skills and materials can be used to create safe shelters quickly. These can be made permanent by adding waterproofing and plaster. The cost of a single Superadobe home is around £20.

**Find out more at**
**www.alertnet.org/thefacts/reliefresources/110495007056.htm**




Photography: Khalili/Cal-Earth

## Thames Flood Barrier

The tidal River Thames runs through London, UK, and has a history of flooding. Tidal defences, including the Thames Flood Barrier, protect London from the effects of increased rainfall, dangerous surge tides and the fact that the water is rising by 600mm each century. By understanding how rivers flow and flood, civil engineers have designed the huge barrier that protects the city. It is made up of 10 pivoting gates placed between concrete piers across the river. It can be raised to form a continuous steel wall controlling the flow along the River Thames.

**Find out more at**
**www.environment-agency.gov.uk**
**www.costain.com**

Photography: Environment Agency – Thames Region

## Key facts

Each gate is a hollow steel-plated structure over **20m high**, weighing around **3,700 tonnes**, **(equal to 3,500 Mini Coopers)** and is able to withstand a load of over **9,000 tonnes.**

Gates are raised **90°** from their position on the riverbed to form a steel barrier.

Gates can be rotated to a horizontal position for routine maintenance.

The barrier has a **total span of 520m.**

The **four** main openings have a span of **61m.**

**Two** gates have **31m** openings for river traffic.

## How can we...
# build higher, longer, better?

We might find safe land on which to build, but how do we make best use of this valuable resource?

Civil engineers are constantly developing **new building techniques, using materials in entirely new ways.** The very best solutions perform extremely well and are also very beautiful.

## Millau Viaduct

This elegant bridge, in the Midi-Pyrénées in south-west France, connects the A75 Autoroute from Paris to Barcelona at the point where it meets a wide river valley. In the past, motorists had to drive right along the valley before crossing. Now, at a breathtaking height, cars and lorries can simply drive across, shaving hours off their journey. This doesn't just mean that drivers get a great view. The reduced journey time has a positive effect on trade and tourism in France and Spain.

Civil engineers and architects worked together to create a bridge that spans the 2.5km from one plateau to the other. At 343m high it has the tallest bridge piers in the world, its deck is over 32m wide and suspended on steel cables 270m above the river. Each of its sections spans 350m and its columns range in height from 75m to 235m, which is taller than the Eiffel Tower.

**Find out more at**
**www.eiffageconstruction.com**

Photography: Stéphane Compoint

## The Falkirk Wheel

The Falkirk Wheel, UK, completed in 2002, is the world's first and only rotating boat lift. It was designed to join the Forth & Clyde Canal and Union Canal. By looking at a problem from a new angle, civil engineers designed The Falkirk Wheel to lift boats from one canal level to the other over a distance of 35m, using almost no energy at all. Moving a boat this far would normally need the boat to pass through up to 11 locks. The Falkirk Wheel achieves this in one elegant movement.

**Find out more at**
**www.thefalkirkwheel.co.uk**
**www.butterleyengineering.com**

Photography: Environment Agency



## Key facts

The wheel takes about **15 minutes to rotate.** It used to take 8 hours to go from one level to another.

The **two gondolas** can carry **four boats 20m long.**

It can lift **boats and 600 tonnes of water,** equivalent to **100 African elephants,** over **35m** in under **four minutes.**

It is powered by 10 hydraulic motors using **less energy than 2 boiling kettles.**

## How can we...
# get from A to B?

Transport systems join our communities together. Road, rail, air and sea networks span the world. They help us trade, travel, exchange ideas and information, and gain employment, healthcare and education.

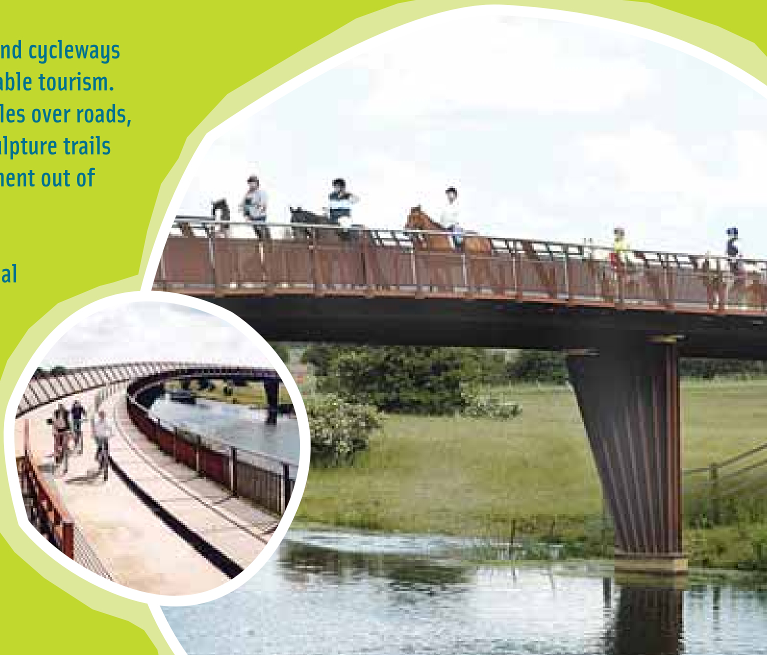
As more of the world becomes developed, it is vital that we create integrated transport solutions. These can **conserve energy and reduce pollution, congestion and accidents.** Civil engineers understand the best ways to move around or across our environment, creating the networks that help take us where we want to go.

## The Peterborough Millennium Green Wheel

The Green Wheel, opened in 2002, is an 80km network of footpaths and cycleways around Peterborough, UK, that encourages 'green travel' and sustainable tourism. It includes a series of bridges to carry horses, people on foot and cycles over roads, railways and rivers. The bridges link nature reserves, picnic sites, sculpture trails and small parks, helping local people and visitors to get more enjoyment out of the area.

The project took five years to complete and was funded by the National Lottery Millennium Commission with support from local authorities, businesses, voluntary and charitable organisations and individuals.

**Find out more at**
**www.royalhaskoning.com**



Photography: Peterborough Environment City Trust

## Gateshead Millennium Footbridge

People in Newcastle, UK, are rediscovering the south bank of the River Tyne, which flows through the city. New cultural developments had to be made accessible to pedestrians on the north.

Designed jointly by civil engineers and architects, the bridge uses a new tilting mechanism to let ships pass below. It is made of two arches, one forming the bridge deck and the other supporting it. It turns on pivots on both sides of the river to open and close like a giant eyelid. It not only performs well, but also looks great.

Each opening or closing of the bridge 'eyelid' takes four minutes and is powered by eight electric motors totalling 440kW, which is more power than eight family cars. But the bridge's energy-efficient design means that it costs just £3.60 each time it opens.

The bridge has many special features. Litter is automatically collected in traps each time the bridge opens, and special steel piles protect the bridge from being damaged by ships. It can withstand a collision by a 4,000 tonne ship travelling at four knots.

**Find out more at www.gateshead.gov.uk/bridge/bridged.htm**
**www.gifford.uk.com**

Photography: i2i/Gateshead Council

## Key facts

The top of the bridge is **50m above river level** and its foundations are **30m deep.**

It weighs more than **850 tonnes,** which **is enough steel to make 64 double-decker buses.**

It sits on **19,000 tonnes of concrete,** enough to **make 600,000 paving stones that would stretch 290km** if laid end to end.

It uses **650 tonnes** of steel.

The Gateshead Millennium Footbridge has the same **25m clearance** above the river as the Tyne Bridge.

## How can we...
# work together better?

Our built environment is increasingly complicated. Ambitious construction projects can only be completed by **teams of people, with different skills, working together.** New working methods and project management techniques make sure that everyone contributes in the right way, at the right time, for the benefit of the project. Effective management also makes sure that risks are predicted and controlled. And when unexpected problems do happen, they can be identified and solved before they cause any harm.

work together better

## Channel Tunnel

Civil engineers designed the 51.5km concrete and steel railway tunnel under the English Channel that runs from Folkestone, UK, to Sangatte in France. It was opened in 1994, cost £11 billion (700 times more expensive than San Francisco's Golden Gate Bridge) and took seven years to construct. One end was started in France, the other in England. Both tunnels had to come together, deep below the seabed, at exactly the right point.

The Channel Tunnel is actually two railway tunnels, a smaller service and emergency escape tunnel and several 'cross-over' passages that allow trains to switch tracks.

It took machines as long as two football pitches, drilling over 76m a day, only three years to drill a tunnel from France to the UK. Trains travel through the tunnel at up to 169km per hour, taking 20 minutes to get from one end to the other and carrying 28 million passengers and 11 million tonnes of freight in its first five years.

**Find out more at**
**www.tunnels.mottmac.com**

Photography: QA Photos

## Hong Kong International Airport

Hong Kong needed a new airport but had no available land to build it on. With the help of civil engineers, one of the world's largest airports was constructed on a man-made island in the South China Sea.

It took eight years from the start of planning until the airport opened in 1998. However, the construction of the island, runways, roads, railway, bridges, passenger terminal and other buildings took just six years and seven months to complete. The design and construction teams included up to 21,000 people and over 20 nationalities.

The new suspension bridge built to connect the airport to Kowloon and Hong Kong is the longest in the world and one of the few to carry both road and railway.

**Find out more at**
**www.hkairport.com**
**www.mottmac.com**

Photography: Kasyan Bartlett/Airphoto; Dennis Gilbert/VIEW

## Key facts

It is **1.27km long** and covers **1,255 hectares**, which is nearly **1,800 football pitches.**

It can accommodate up to **87 million passengers** and currently accommodates **45 million**, more than **six times the number of people in London.**

It has **50,000** employees, **96** aircraft gates, **288** check-in desks, **74** automated walkways, **98** lifts and **70** escalators.

The passenger mall has **200 shops** including **40** food outlets.

## How can we...
# make the most of our resources?

Our civilisation is developing, but so too is our demand for electricity. Civil engineers are committed to protecting our natural resources, **designing structures that use as little energy as possible.** When it comes to providing energy for the entire planet, engineers are using nature to meet the needs of today and tomorrow.

We can use natural sources of 'sustainable power', such as water and waves, wind and solar energy. We are also constantly finding new ways to generate energy that will not pollute our environment.

## Westfield power station in Fife

Chicken farming produces huge amounts of waste, known as 'biomass'. Civil engineers have developed the machinery needed to convert this waste to energy. Each year 111,000 tonnes of chicken litter from Scottish farms is supplied to Westfield power station in Fife, UK, where it is converted into electricity by a process called 'fluidised bed combustion'.

As well as producing 9.8MW of power, which is enough energy to supply 22,000 houses with electricity, the process also creates an ash that can be used in farming as high-quality fertiliser.

Power from chicken waste is so effective that the plant has now successfully tested burning waste feathers to create energy.

**Find out more at**
**www.eprl.co.uk**
**www.mitsuibabcock.com**

Photography: Energy Power Resources

## Itaipú Dam

Itaipú Dam and hydroelectric plant uses the power of the mighty Paraná River on the border between Paraguay and Brazil, and produces enough electricity to power an area the size of California. It is made up of a series of dams that are 7.76km in overall length. The height of the dam reaches 196m and the lake behind it is 170km long, containing over 26 billion tonnes of water. More than 45 million tonnes of earth and rock were moved while it was being built.

Civil engineers must assess the advantages and disadvantages of huge projects to make sure there is an overall benefit. In constructing the Itaipú Dam, both Paraguay and Brazil protected all existing native forest, and planted forests in areas devastated by agricultural practices. More than 20 million tree seedlings were planted in the protection belt around the reservoir.

**Find out more at**
**www.itaipu.gov.br**

Photography: Getty Images



## Key facts

Steel used in constructing the dam could build **380 Eiffel Towers.**

Itaipú Dam uses **15 times** the amount of concrete used in the Channel Tunnel.

**30,000 people,** equivalent to the population of Tahiti, worked on its construction.

The spillway releases **$62{,}200m^2$ of water a second.**

# How can we...
# be sure we're safe?

To reduce the risks caused by building our civilisation, we must constantly improve how we manage health and safety. Big and small construction projects can often create risky conditions for the people working on them. Some projects have particular hazards, such as working at great height or depth, or with dangerous substances.

By learning from the past, and by using computer models to predict project outcomes, we continue to **improve the safety of the most challenging working environments.**

# Subsea manifold

Much of our precious oil and gas reserves is held in wells beneath the seabed. Building, maintaining and staffing oil platforms to extract the oil and gas is expensive and risky. The 'subsea manifold' is a new, efficient way to extract oil or gas without the need for a costly oil platform and drilling rig, and needs no staff onboard.

The manifold is a remote-control unmanned steel structure, engineered to withstand the tremendous pressures experienced at the seabed. It sits directly above an oil or gas well. Valves control the flow of oil or gas from the well into a pipeline where it travels, often over large distances, to a storage or production plant.

Civil engineers are working with mechanical engineers to develop this new technology for extracting oil and gas from beneath the seabed. The availability of advanced installation vessels that can lift, transport and use the subsea manifolds means that we can now pump fossil fuels from even more remote wells.

**Find out more at www.vetcogray.com**

Photography: Vetco Gray

## Jubilee Line extension

The 16km long, £3.5 billion extension to London Underground's Jubilee Line was the UK's deepest and most complicated excavation.

Great care had to be taken to prevent damage to vital services, but these were all unseen, buried beneath the city. Before the first shovel hit the soil, civil engineers used sophisticated imaging technology to 'see' the existing Circle and District Underground Lines, water mains, sewers, power and telecommunications and a high-pressure gas main. Then they mapped a way around them. Above ground, the condition of buildings (including the Houses of Parliament and Big Ben) were continuously monitored to detect the slightest movement caused by the huge excavation.

The new Westminster underground station is 38m under one of the busiest places on earth, and is built below an existing station whilst at the same time providing foundations for a new government building above ground.

Big Ben presented a particular challenge as its foundations are built on a giant slab, which lies on river mud. The area beneath the slab was injected with a stabilising layer of cement grout to prevent the foundations from moving whilst tunnelling took place underneath. It was vital to prevent any movement that would be greater at the top of the tower, causing Big Ben to lean or even collapse.

**Find out more at http://tube.tfl.gov.uk/content/faq/lines/Jubilee.asp**
**www.fabermaunsell.com**



## Key facts

About **130 million people** travel on the Jubilee Line every year.

The Jubilee Line is **36.2km long** and has **27 stations.**

The Jubilee Line is the only route that connects with all other lines.

The project took **six years** to complete.

Photography: Dennis Gilbert/VIEW

# How can we...
# save our past and protect our future?

We should be proud of our civilisation today, and its many great achievements. But which of the great achievements of yesterday are so important to our sense of history? By applying the latest technology, civil engineers can **save structures and monuments** from the distant past so that they can still be enjoyed well into the future.

And what of tomorrow? What are we doing today that will provide enjoyment and education for generations to come? Civil engineers are using designs and materials that will **protect our natural and cultural heritage** for future generations.

save our past and protect our future

## The Leaning Tower of Pisa

Construction on this Italian tower originally began in 1173 and continued for over 200 years. Built on very soft ground, the tower first started to lean whilst it was being built, and by 1990 it was on the point of falling over. To make matters worse, forces within the stonework of the tower were so great that it might have actually exploded outwards.

The Italian government brought together a team of experts to save their historic monument. Not surprisingly, civil engineers were an important part of the team. Before touching the tower itself, the engineers made a virtual computer model of it, which accurately shows how it has leaned over time. The virtual model was used to work out a way of making the tower more stable. Rather than trying to prop up the tower above ground, which would have been unsightly and dangerous, the engineers worked out a method of removing soil from beneath the foundations. This solution gently reduced the tower's lean by about half a metre and rescued it from destruction.

Their tower saved, Italians will be able to take pride in this national treasure for generations to come.

**Find out more at**
**http://torre.duomo.pisa.it/index_eng.html**

Photography: Getty Images

## The Eden Project

The Eden Project in St Austell, UK, was built on the site of a disused clay pit. It recreates different mini environments from around the world within domes. Civil engineers helped to design and build these domes (or 'biomes') to span over 100m without internal supports. This creates a huge open environment inside the biomes for plants to grow. The transparent hexagonal membranes of the biomes are made of 'ethylene tetra fluoro ethylene co-polymer' foil (ETFE), which can be recycled, is anti-static, cleans itself, lets in more light than glass and lasts at least 30 years.

**Find out more at www.edenproject.com**
**www.anthonyhuntassociates.co.uk**

## Key facts

**The site collects and recycles 20,000 bathtubs of water every day.**

**The project used 85,000 tonnes of soil made from recycled waste to support over 5,000 types of plants.**

Photography: The Eden Project

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